OCS Study
BOEM 2013-01163

Information Synthesis on the Potential for Bat Interactions with Offshore Wind Facilities

Final Report

U.S. Department of the Interior
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ABOUT THE COVER

White Island Lighthouse, Isle of Shoals, New Hampshire. Photo courtesy Steven K. Pelletier, Stantec.

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PREFACE

The possibility that bats may regularly occur miles offshore is a source of revelation and surprise to many, including those already familiar with the behavior and seasonal traits of these same species on land. There exist, however, numerous long-standing records and accounts of individual bats and flocks of varying sizes occurring up to several hundred miles offshore that have been logged by fishermen and seafarers over time. Whether these bats or flocks were actively undertaking a regular seasonal migration or simply hapless victims of errant winds has to-date been only a matter of conjecture and speculation.

Additionally, concerns over potential mortality risks associated with bat/turbine collisions at terrestrial wind energy facilities has sparked parallel questions among offshore wind developers, resource agencies, and public/private entities concerned with avoiding adverse impacts to bat populations. These concerns have been further enhanced with the recent proliferation of White Nose Syndrome in eastern North America.

This document provides a comprehensive compilation and summary of known available literature and recorded observations related to bats in offshore environments. It examines potential threats related to offshore energy development, and identifies critical gaps in information requiring further research and study. Investigations into the proclivity of bat occurrence offshore and potential turbine collision risk include a compilation and statistical analysis of existing offshore and terrestrial acoustic data sets from which comparisons are drawn regarding bat activity and presence at inland, coastal, and offshore locations.

These efforts were funded by a federal contract administered by BOEM. This document provides a fundamental base of information regarding an otherwise little-known topic and offers a series of specific recommendations designed to advance that base over time. It further sets a stage for future analysis that will enable a more definitive understanding of offshore bat activities and seasonal presence, and in so doing, support balanced decision-making in the management and development of renewable energy in the offshore arena.

Abstract

The current scope of scientific knowledge regarding the presence and behavior of bats offshore is restricted by a variety of physical and logistical constraints. These constraints are largely associated with the general inability to directly observe activities of nocturnal species that occur over large expanses of open water; our current limited understanding of individual species distributions and movements over land; and a general lack of existing scientific inquiry on the subject to date. At the same time, certain bat activity patterns and incidences of mortality at terrestrial wind facilities are comparatively better understood. Concerns over population-wide impacts to bats associated with commercial wind facility mortality, habitat loss, and, in particular, the continued spread of White-Nose Syndrome have in the meantime prompted the US Fish and Wildlife Service to consider expanding the current list of federally protected bat species. Similarly, interest to increase our collective understanding of bat activities in offshore regions is expanding among federal and state resource agencies as efforts intensify to develop offshore energy sources.

The Bureau of Ocean Energy Management (BOEM) manages the exploration and development of the nation's offshore resources and is responsible for authorizing renewable energy activities on the Outer Continental Shelf (OCS). On the Atlantic, BOEM's jurisdiction on the OCS generally begins 3 nautical miles [nm] off the coast and extends at least 200 nm from the coast. In an effort to enhance the current knowledge base, BOEM requested Stantec develop a baseline record of bats occurring in the offshore environment. Existing opportunities to obtain and quantitatively analyze comparative data from sites on the OCS was restricted to a single site (a buoy) on the OCS. Consequently, the analyses presented are based on available data sets and in accordance with inland, coastal, and offshore as defined in this report. We anticipate a future analysis of activity within BOEM jurisdiction on the OCS will become available in the near term as additional shipboard and buoy data references become available.

The overall purpose of the study was to synthesize existing information on bats and their potential interactions with offshore wind facilities relative to bat activity on land. Specific tasks included: 1) a literature review to compile and summarize available historic records, publications, and studies regarding bats' presence and behavior offshore, as well as potential impacts to bats associated with offshore wind projects, and to identify critical information gaps requiring further study; 2) a compilation of offshore and terrestrial acoustic studies conducted within the northeastern and mid-Atlantic coastal states regions of the US; and 3) a statistical comparison of acoustic bat activity data gathered from inland, coastal, and offshore sites within that region.

The literature review is organized by broad categories relating to the presence of bats offshore, behavior of bats offshore, and potential impacts to bats from offshore wind projects. Studies were categorized as offshore, island, and coastal as appropriate in order to make use of as much available literature as possible while maintaining focus on the offshore environment. Relevant literature and information gaps are summarized for each category. Sufficient data exist to suggest bats migrate offshore and use islands, ships, and other offshore structures as opportunistic or deliberate stopover sites, yet many questions remain as to the seasonal frequency, extent, and type of use by various species, as well as how activity patterns such as foraging may differ from onshore locations.

Available acoustic data was gathered from sites located extending from interior inland areas to the coast and offshore as far as 13 nautical miles beyond the US Submerged Lands Act boundary. Ultimately, distance from shore was defined in three discrete classes: inland, coastal, and offshore. The assembled database consisted of over 980,000 acoustic call files collected from 61 sites over 37,614 detector-nights between 2005 and 2012. After examining geographic, annual, and regional replication, data from 33 sites were ultimately used to examine whether acoustic activity patterns differed among location types.

Bat activity was modeled in two ways: (1) bat presence indicated as recording at least one call in a night (nightly occurrence), and (2) number of calls recorded per detector night (nightly intensity). Bat activity was observed at all inland, coastal, and offshore survey sites, indicating bats were active offshore at least as far as the most remote detectors. Levels of observed offshore activity were comparable between migratory and non-migratory species, and migratory bats were about equally as likely to be recorded offshore as at coastal or inland sites. In contrast, non-migratory bats were less likely to be recorded at offshore sites relative to observed levels of activity at coastal and inland sites.

Efforts were funded by a federal contract administered by BOEM. Results of these combined study efforts will contribute to the knowledge base necessary for public officials and offshore energy developers to pursue balanced decision-making in the management and development of renewable energy and alternate use projects on the federal waters of the Outer Continental Shelf. Recommendations for continued study are provided.

This report has been reviewed by the Bureau of Ocean Energy Management (BOEM), and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Bureau, nor does mention of the trade names or commercial products constitute endorsement or recommendation for use.

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Abbreviations, Acronyms, and Symbols

km	kilometer
m	meter
m/s	meters per second
nm	nautical mile
AIC	Akaike's Information Criterion
BABA	barbastelle bat (*Barbastella barbastellus*)
BBSH	big brown bat (*Eptesicus fuscus*) or silver-haired bat (*Lasionycteris noctivagans*)
BIC	Bayesian Information Criterion
BOEM	Bureau of Ocean Energy Management
cpn	bat calls recorded per detector-night
CORA	Rafinesque's big-eared bat (*Corynorhinus rafinesquii*)
EPA	Environmental Protection Agency
EPFU	big brown bat (*Eptesicus fuscus)*
EPNI	northern bat (*Eptesicus nilssonii*)
EPSE	serotine bat (*Eptesicus serotinus)*
EWEA	European Wind Energy Association
HFUN	high frequency unknown
LABL	western red bat (*Lasiurus blossevillii*)
LABO	eastern red bat (*Lasiurus borealis*)
LACI	hoary bat (*Lasiurus cinereus*)
LAEG	southern yellow bat (*Lasiurus ega*)
LAIN	northern yellow bat (*Lasiurus intermedius*)
LANO	silver-haired bat (*Lasionycteris noctivagans*)
LASE	seminole bat (*Lasiurus seminolus)*
LFN	low frequency unknown
LRT	likelihood ratio test
MCINWR	Maine Coastal Islands National Wildlife Refuge
MTR/VF	Mountaintop Removal and Valley Fill
MYAU	southeastern myotis (*Myotis austroriparius*)
MYBR/MY	Brandt's bat/whiskered bat (*Myotis brandtii/mystacinus*)
MYDAS	pond bat (*Myotis dasycneme*)
MYDAU	Daubenton's bat (*Myotis daubentonii*)
MYLE	small-footed bat (*Myotis leibii*)
MYLU	little brown bat (*Myotis lucifugus*)
MYNA	Natterer's bat (*Myotis nattereri*)
MYSE	northern long-eared bat (*Myotis septentrionalis*)
MYSP	bats of the *Myotis* genus
NEPA	National Environmental Policy Act
NERACOOS	Northeastern Regional Association of Coastal and Ocean Observing Systems
NJDEP	New Jersey Department of Environmental Protection
NYLE	lesser noctule (*Nyctalus leisleri*)

NYNO	noctule bat (*Nyctalus noctula)*
NYHU	evening bat (*Nycticeius humeralis*)
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Act
PESU	tri-colored bat (*Perimyotis subflavus)*
PINA	Nathusius' pipistrelle (*Pipistrellus nathusii*)
PIPI	common pipistrelle (*Pipistrellus pipistrellus*)
PIPY	pygmy pipistrelle (*Pipistrellus pygmaeus*)
PLAU	brown long-eared bat (*Plecotus auritus*)
RBTB	eastern red bat (Lasiurus borealis) or tri-colored bat (*Perimyotis subflavus*)
SLA	Submerged Lands Act
TABR	Brazilian free-tailed bat (*Tadarida brasiliensis*)
TBC	time between calls
USFWS	United States Fish and Wildlife Service
VEMU	parti-colored bat (*Vespertilio murinus*)
WNS	White Nose Syndrome

1.0 Introduction

This summary report is funded by a federal contract administered by the Bureau of Ocean Energy Management (BOEM) and includes a technical summary of three previous efforts, including: 1) a literature review to compile and summarize available historic records, publications, and studies conducted to date regarding bats' presence and behavior offshore, as well as potential direct and indirect impacts associated with offshore wind projects, and to define specific information gaps requiring further study; 2) a compilation of offshore and terrestrial acoustic studies conducted within the northeastern and mid-Atlantic coastal states regions of the US; and 3) a statistical comparison of acoustic bat activity data gathered from inland, coastal, and offshore sites within that region.

Results of these combined study efforts will contribute to the knowledge base necessary for public officials and offshore energy developers to pursue balanced decision-making in the management and development of renewable energy and alternate use projects on the federal waters of the Outer Continental Shelf (OCS).[1]

2.0 Project Description

2.1 BACKGROUND

The 1953 Outer Continental Shelf Act (OCSLA) and its subsequent amendments require the Secretary of Interior to balance the nation's energy needs with the protection of the human, marine, and coastal environmental, while ensuring that the concerns of coastal states and competing users are taken into account. BOEM, a bureau within the US Department of the Interior, has jurisdiction over all mineral resources on the OCS, and is charged with conducting OCS lease sales, as well as monitoring and mitigating unwelcome impacts that might be associated with resource development.

In 2005, the Energy Policy Act amended Subsection 8(p) of the OCSLA, giving the Secretary discretionary authority to issue leases, easements, or rights-of-way for renewable energy projects on the OCS. Under this new authority, BOEM may issue leases on the OCS for potential renewable energy projects. BOEM has recognized that new and future uses of the OCS, including renewable energy development, should be managed in a deliberate and responsible manner, addressing both the nation's energy needs and concerns for the marine environment.

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[1] The **Atlantic OCS** includes submerged lands beyond the limit of state ordinance (generally 3 nautical miles [nm]) out to 200 nm from the coast, between Maine and Florida. In association with the OCS, the **US Submerged Lands Act (SLA) boundary** is located 3 nm from the coast, and defines the "seaward limit of a state's submerged lands and the landward boundary of federally managed… lands" (http://www.data.gov/ocean/datasets/atlantic-nad83-submerged-lands-act-boundary).

The impact of land-based wind energy development to bats is relatively well understood compared to offshore wind energy development. Recent surveys for bats along the Atlantic OCS (e.g., Maine, Rhode Island, and New Jersey) suggested bat use may be an order of magnitude less than on land. However, no formal statistical comparison had been conducted to determine if that assessment is appropriate. The extent of scientific knowledge regarding the presence and behavior of bats in the offshore environment, defined by the BOEM to be beyond three nm from any shoreline, is limited due to a variety of factors that primarily involve logistical constraints associated with monitoring bats offshore, our incomplete understanding of bats' distribution and movements on land, and a general lack of scientific inquiry on the subject. Concerns over population-wide impacts to bats associated with mortality at commercial wind facilities, habitat loss, and in particular the recent devastating effects of White-Nose Syndrome (WNS) have led the US Fish and Wildlife Service to consider federal listing for additional bat species, and similarly led BOEM and the US Department of Energy to undertake a compilation and analysis of available data of bat occurrence in offshore regions.

2.2 PURPOSE

The overall purpose of this study was to synthesize existing information on bats and their potential interactions with offshore wind facilities relative to bat activity on land. The results of this study will contribute to the knowledge base that is needed for public officials to pursue balanced decision-making in the management and development of renewable energy and alternate use projects on the federal waters of the OCS.

Given the authority of BOEM under the Energy Policy Act, and the various points it must consider under the OCSLA and the National Environmental Policy Act, BOEM needed to develop a better understanding of the potential impacts to the environment from the development of offshore renewable energy projects, and to identify specific mitigation measures that can be taken to reduce or avoid such impacts as offshore energy development proceeds in the future.

2.3 GOALS AND OBJECTIVES

This study synthesized existing information on bats and their potential interactions with wind facilities relative to bat activity on land. The study included three broad objectives:

a) A thorough **literature review** of scientific studies of the potential direct and indirect impacts of offshore wind energy development on bat species, including avoidance and attraction behaviors, and the cumulative impacts of multiple wind facilities;
b) A **compilation of past and ongoing studies** documenting bat occurrences over the Atlantic OCS; and
c) A **statistical comparison** of bats detected at land-based wind facilities (potential or existing) and bats detected on the OCS.

The findings of the study, described in this report, can be used to inform future decision-making processes at BOEM with regard to renewable energy projects on the OCS.

2.3.1 Geographic Focus Area

Although active interest in developing offshore wind energy broadly exists along the Atlantic and Pacific coastlines and within the Great Lakes and Gulf of Mexico, current offshore development efforts are primarily focused within the northern to mid-Atlantic coastal state regions where large, concentrated population centers can be linked with high energy, offshore wind resources. Interior ridgeline and high plains areas currently support numerous commercial wind facilities throughout both of these regions, while coastal states from Maine through North Carolina actively assess opportunities for expanding offshore energy production. Consequently, BOEM's commissioned focus on comparisons of terrestrial and offshore bat activity was more readily supported in the northeastern and mid-Atlantic coastal state regions of the US where both active development interests exist, and where pre- and post-construction data are relatively more readily available.

3.0 Summary of Findings

3.1 LITERATURE REVIEW

Stantec conducted a comprehensive and in-depth literature review of available historic observations and scientific studies to assess potential direct and indirect impacts of offshore wind energy development on bat species, including observed avoidance and attraction behaviors and the cumulative impacts of multiple offshore wind facilities (Appendix A). The literature search was conducted to identify, acquire, and review available published and unpublished environmental and technological literature, including national and international sources. Information acquisition was conducted through reviews of existing databases and scientific references, index searches, and personal contacts with other researchers.

Given the limited amount of published literature regarding bats offshore and the associated risks of impact at offshore wind projects, one primary purpose of the literature review was to define specific information gaps requiring further study. Studies were categorized as offshore, island, or coastal to allow use of as much literature as possible while maintaining focus on the offshore environment. The presence of bats offshore was summarized and included (a) species accounts, based on information from anecdotal accounts and focused surveys, and (b) a comprehensive summary of studies, including comparison of geographic range and survey methodologies. The behavior of bats offshore was also summarized, including foraging, migration, and roosting.

Information on the presence of bats offshore consists largely of historic reports of varying detail and rigor, some of which have been compiled into peer-reviewed publications, records from lighthouses and ships, numerous anecdotal reports, and a small number of recent surveys focused on bats. Offshore behavioral information has largely been drawn from the timing and location of bat observations and has not been studied systematically due to a variety of issues. However, sufficient data exist to suggest that bats migrate offshore and use islands, ships, and other offshore structures as opportunistic or deliberate stopover sites. Bats may also forage offshore either during migration, perhaps to avoid competition or to exploit certain food sources.

Potential impacts to bats from offshore wind projects have not been adequately studied at existing offshore wind projects, although physical mechanisms of collision that have been well documented at onshore wind projects would presumably apply to bats offshore. Similarly, the potential attraction of bats to wind turbines that has been suggested onshore would likely apply and may be exaggerated offshore where turbines would present a considerable contrast to the surrounding water. Depending on the degree to which bats are more susceptible to mortality from exhaustion or accident in offshore habitats or are well adapted to traveling long distances over water, long-distance visual attraction of bats to offshore wind projects could result in mortality of bats drawn away from terrestrial habitats.

Although bats have been confirmed to occur offshore and appear to migrate and possibly forage offshore, little is known about species-specific patterns, the number of bats offshore relative to onshore, or the potential for offshore wind projects to impact bats directly or indirectly. Most studies mentioning bats offshore have identified as many or greater questions than answers, which will likely be a pattern for some time to come. However, advances in understanding of the interactions between bats and onshore wind projects and the results of a small number of recent focused surveys have helped identify specific gaps in knowledge that could help address potential risks. Articulating these gaps will then help focus subsequent monitoring and research efforts on the gaps that, if filled, could help address potential impacts to bats at offshore wind projects.

3.2 COMPILATION OF STUDIES

Stantec compiled available survey results of bat activity on the Atlantic OCS from published and unpublished studies, including results from ongoing studies, internet searches, telephone inquiries, library visits, personal contacts, and other means as necessary. In addition, Stantec made direct contact with 21 additional entities to assess availability and opportunities for acquiring acoustic data that had been previously recorded at coastal or offshore survey locations. Entities varied and included federal regulatory and review agencies, academic and non-governmental institutions, commercial entities, and private consulting firms.

Included in the compilation are the results of standardized acoustic surveys conducted by Stantec at 42 inland sites surveyed between Virginia and Maine from 2004 through 2011, and 19 offshore/coastal sites off the coast of New England from Kent Island, New Brunswick southward to a Northeastern Regional Association of Coastal and Ocean Observing Systems (NERACOOS) buoy location off the coast of Gloucester, Massachusetts. In addition to Stantec's New England-based research, another Stantec biologist, Angela Sjollema, recently completed a mid-Atlantic coastal bat study as part of her graduate work at the University of Maryland. Her studies involved collecting terrestrial and boat-based acoustic data along the mid-Atlantic coast from spring 2009 through fall 2010, and include coastal sites in New Jersey, Delaware, and Maryland.

This effort faced various challenges in the compilation of survey results, primarily related to the limited amount of available acoustic data offshore relative to onshore sites. Certain available offshore datasets were also collected sporadically, using unsuccessful methods, and were not directly comparable to more robust datasets. In addition, many acoustic datasets were collected using private funding and therefore were not readily available for this analysis and/or were collected during irregular timeframes and/or using standards inconsistent with other surveys. Datasets were therefore limited to those meeting certain methodological, regional, and seasonal criteria, which eliminated most of the data received from non-Stantec entities.

3.3 STATISTICAL COMPARISON

In order to geographically compare the influence of large bodies of open water on bat activity, Stantec compared acoustic bat activity across a gradient from inland sites to the coast and as far as 13 nm beyond the SLA boundary (Appendix B). Sites were ultimately classified based on their distance from the SLA boundary, as well as the proportion of land area (vs. water) encompassed by a 3-nm circle around the site (Figure 2-1). **Inland** sites were more than 20 miles inside the SLA boundary; **coastal** was an intermediate class comprising sites within 20 miles of the SLA boundary with more than 1 percent land within the 3-nm circle around them, and **offshore** sites had less than 1 percent land (or 99 percent or more ocean water) within the encircling 3-nm limit.

Because the SLA boundary bulges or bubbles around even the smallest islands, by definition all US territorial land is within the SLA boundary. If we had distinguished coastal from offshore for every site by using the SLA boundary, then 3 sites located on the smallest islands far off the coast of Maine would have been assigned a coastal classification simply because these islands have exposed land. For these 3 sites where the SLA boundary formed a bulge or a bubble around the island, we drew a straight line pinching off the bulge and classified these sites as offshore. To calculate the distance to the SLA boundary, we measured the orthogonal distance from the straight line to the site. Where a site was in a bubble of the SLA boundary, we measured the shortest orthogonal distance to the boundary around the mainland.

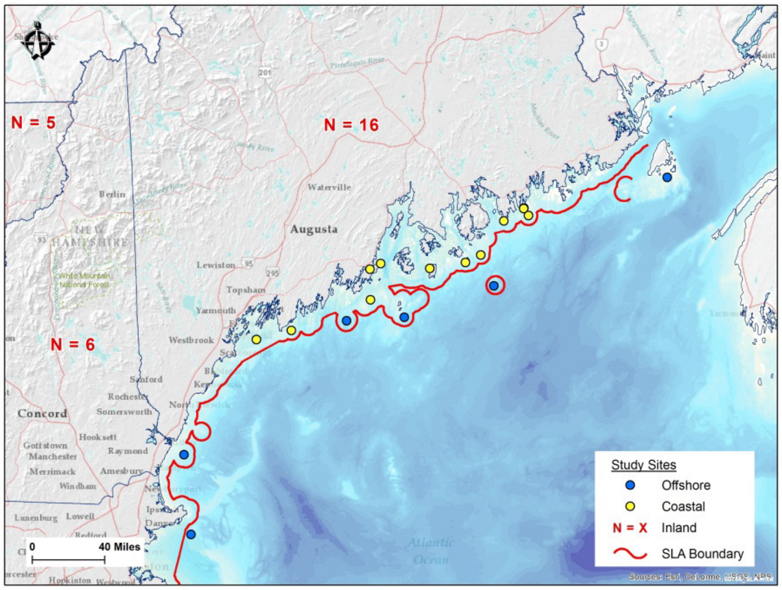

Figure 3-1. Coastal and offshore classifications as they relate to the SLA boundary. Note three sites within the SLA boundary are classified as "offshore" for the purposes of this analysis. Only the most southerly 'offshore' location however occurs within federally regulated waters.

Stantec assembled a database of 983,167 acoustic call files collected over 37,614 detector-nights from 61 sites monitored over the years 2005-2012. The geographic range of all sites extended from the Bay of Fundy to West Virginia (Figure 2-2). After examining geographic, annual, and regional replication, data from 33 sites were used to examine whether acoustic activity patterns differed among location types. The pared-down database comprised 9,534 detector nights from 17 inland and 16 offshore/coastal sites. Recordings totaled 218,525 calls representing *Myotis* spp. (32.8%); big brown bat (*Eptesicus fuscus*) or silver-haired bat (*Lasionycteris noctivagans*) (24.1%); eastern red bat (*Lasiurus borealis*) or tricolored bat (*Perimyotis subflavus*) (21.9%); and hoary bat (*Lasiurus cinereus*) (4.33%). There were 86,379 calls attributable to hibernating species (39.5%) and 26,891 calls attributed to migratory bats (12.3%).

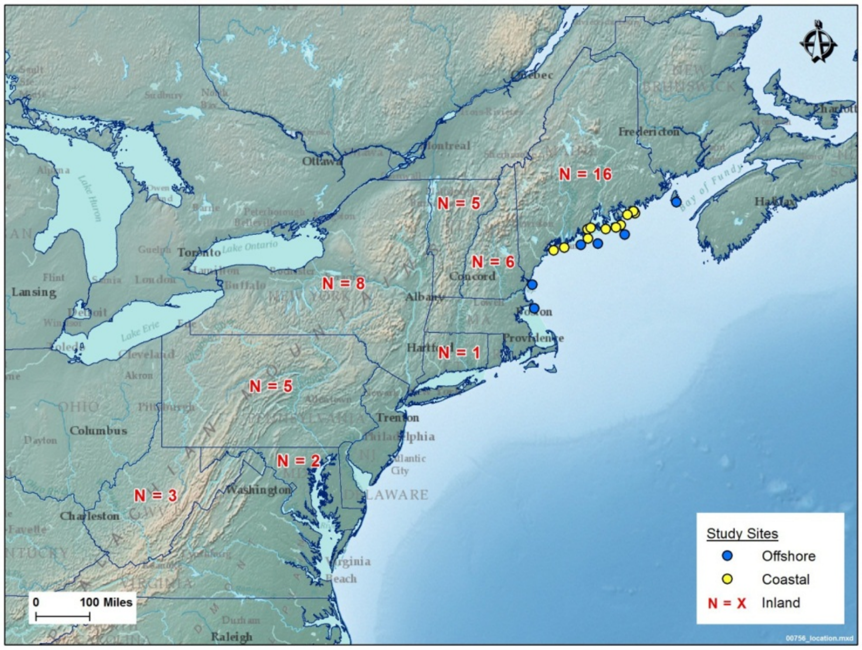

Figure 3-2. Initial Offshore, Coastal, and Inland Study Site Locations included in the statistical comparison. Inland sites are represented by the total number of sites within each state in order to maintain anonymity.

4.0 Presence and Behavior of Bats

4.1 BAT ACTIVITY — LITERATURE REVIEW

Studies have investigated factors relating to bat activity over water but few have focused or mentioned offshore regions. The aerodynamic advantage of flying close to the surface of the ground or water is well documented as aerodynamic ground effect (Siemers 2001). All microchiroptera use echolocation for spatial orientation, as well as food acquisition (Schnitzler 2003), and recent evidence suggests that they innately recognize waterbodies for foraging, drinking, and orientation (Greif and Siemers 2010). Rydell (1986) found that in Sweden, the northern bat (*Eptesicus nilssoni*) typically flew 2 m to 5 m above the surface of lakes, and attributed this to two conditions of open water: (1) a lack of obstacles over water may make insects easier to capture, and (2) the temperature over large bodies of water is more stable over time, thus when temperature drops over land and insects become less active, higher temperatures above water may result in sustained insect activity. Ahlén et al. (2009) observed 11 of 18 European bat species known to occur in the southern Baltic Sea flying at low elevations over the sea. Even the normally high flying Common Noctule (*Nyctalus noctula*) flew lower than 10 m above the surface and often used lower frequency calls then when over land (Ahlén et al. 2009). More study is needed on other species and in additional parts of the world to determine if this is true for all species moving over water.

Quantitative data on bat activity in the offshore environment are scarce. At this time, acoustic surveys provide the best method for assessing bat activity, as researchers can adapt lessons learned from terrestrial deployments to the offshore environment. Acoustic data have been relied upon in terrestrial locations to inform environmental assessments at most proposed wind facilities, so it is a logical next step to collect and compare similar data from the offshore environment. However, offshore acoustic data collection is in its infancy compared to the long history of terrestrial acoustic data collection.

4.2 STANTEC ANALYSIS OF ACOUSTIC BAT ACTIVITY

Stantec modeled bat acoustic activity in two different ways in order to look for differences in activity relative to the coastline and the offshore environment: (1) as a binary variable with bat presence indicated as having at least one call file recorded in a night (nightly occurrence), and (2) as a continuous variable calculated as the number of call files recorded per operational detector night (nightly intensity) or per 10-night period.

Bat activity was observed at all inland, coastal, and offshore survey sites, indicating bats were active offshore at least as far as the most remote detectors. Levels of observed offshore activity were comparable between migratory and non-migratory species, and migratory bats were about equally likely to be recorded offshore as at coastal or inland sites. In contrast, non-migratory bats were less likely to be recorded at offshore sites relative to observed levels of activity at coastal and inland sites.

When nightly occurrence was examined, bats were more likely to be observed in the coastal environment than at inland sites. There was also no detectable difference between offshore sites and either coastal or inland sites, which was partly due to great uncertainty about the estimate for offshore sites. Non-migratory bat species were most likely to be detected at coastal sites and least likely to be detected at offshore sites. Migratory bat species were more likely to be detected at both coastal and offshore sites than inland sites, but there was no difference between detectability at offshore and coastal sites. For the two more specific classes of bats, uncertainty, particularly for offshore sites, was even greater.

The statistical comparison generated similar results in both the nightly occurrence and nightly intensity analyses, generally indicating a higher amount of bat activity at coastal sites. Because data at inland sites were collected for the purposes of pre-construction surveys at proposed wind facilities, inland sites were generally located on high elevation forested ridgelines. While it is difficult to speak to “good bat habitat” for all species found in the Northeast overall, it is likely that warmer, lower elevation sites with access to nearby water sources and larger insect populations would be utilized by bats more often than high elevation ridgelines (Grindal et al. 1999; Cryan et al. 2000). Therefore, in comparing activity between inland sites and coastal sites, an increase in occurrence and intensity along the warmer, lower elevation coastline could be explained in part by what may be considered preferred habitat located along the coast.

The statistical comparison could not detect a difference between probability of detection at offshore and inland sites. This indicates that patterns of nightly presence, at least in the post-breeding and fall migratory seasons, were indistinguishable between inland and offshore locations. The lack of significant difference between inland and offshore sites could also be due to the variability in acoustic data overshadowing what may be a small effect. The comparison found that the inherent variability in bat acoustic data made it difficult to discern patterns among coastal classes. Bat activity recorded at individual detectors was more variable than bat activity recorded among different sites; bat activity recorded at a single detector was more variable on a night-to-night basis than bat activity recorded at the same detector site in different years. This striking result meant that there was a large amount of noise in the data that tended to obscure patterns that the comparison was intended to observe. Therefore, the comparison included several steps to control this variability.

The comparison accommodated for variability in four ways: (1) variability within detectors, sites, and nights to accommodate the prevalence of zeros in the dataset; (2) regional variability (i.e., assumed broad differences in latitude between New England and other Mid-Atlantic states could lead to differences in seasonal timing of migration, parturition, volancy, and foraging behaviors); (3) seasonal variability (i.e., overall lack of spring and summer data sets); and (4) data collected during and after 2009 and the potential influence of WNS exposure.

The comparison could not detect a difference between probability of detection at offshore and inland sites. This indicates that patterns of nightly presence, at least in the post-breeding and fall migratory seasons, were indistinguishable between inland and offshore locations.

Although habitat and topography are very different between inland and offshore classes, an important conclusion is that both non-migratory and migratory bats were present in both types of sites. Both inland and offshore classes represent proposed areas for wind energy development, so it is appropriate to compare results of acoustic detector surveys between the two classes even though there may be different factors that contribute to the presence of bats in each class. Since there is both acoustic presence and mortality at wind facilities located inland (Kunz et al. 2007a, 2007b), it is likely that acoustic presence in the offshore environment will lead to the potential for mortality offshore.

At the outset of this analysis, Stantec was aware the volume of existing and available data from offshore and coastal sites was highly restrictive. While a higher volume of data was originally anticipated to be available from other organizations, a greater reliance was required on existing Stantec data sets. The analysis ultimately included approximately the same number of offshore and coastal sites combined as inland sites. However, due to having deployed numerous detectors at inland sites, sampling inland was considerably more intense. Fewer than 20% of detector-nights were from offshore sites while approximately 40% of detector-nights were from coastal and inland sites.

Despite the caveats placed on interpreting the results of the comparison, the overall message is clear. There are bats active offshore at least as far out as the most remote detectors were deployed, i.e., as far as 12 nm beyond the SLA boundary. Migratory bats were about equally likely to be recorded offshore as at coastal and inland sites. In contrast, non-migratory bats were substantially less likely to be recorded at offshore sites relative to observed levels of activity at coastal and inland sites. Offshore, the maximum-likelihood estimate of nightly occurrence for both migratory and non-migratory bats was about 0.2; in contrast, non-migratory bats had maximum likelihood occurrence of about 0.7 to 0.9. The observed level of activity offshore, however, was comparable between migratory and non-migratory species, so it would be incorrect to conclude that risk of collisions with wind turbines is limited to migratory bats.

5.0 Current Information Gaps and Future Research Needs

There is still much to learn about the basic biology and ecology of bats in the offshore environment. The results of BOEM's investigations regarding the presence/absence and seasonal activities of bats offshore provide a critical baseline of information and momentum toward creating an enhanced understanding of potential risks associated with the development of offshore wind energy.

Following are key questions that should be more fully resolved to ensure BOEM's understanding of potential direct and indirect impacts that may arise from the siting and operation of offshore renewable energy projects. These questions also help identify specific mitigation measures that may be taken to reduce or avoid such impacts as offshore energy efforts expand in the future.

Habitat:

1. Are bats reliant or influenced by the presence of offshore islands and structures? If so, to what degree?
2. How does the use of offshore islands and structures by bats vary with size? By distance from coastline shore? By extent of surrounding open water (i.e., what is the influence of adjacent "stepping stone" islands or structures)?

Migration:

3. Do offshore migrants travel specific pathways, or is migration better characterized as a broad front?
4. What is the seasonal timing of offshore migration?
5. To what extent do bats use offshore islands and structures as stopover roosts during migration?
6. How does weather influence seasonal migration? What weather conditions are more typically associated with peak offshore migratory movements?
7. At what elevation above sea level does bat migration typically occur?

8. What distances can individuals travel in the offshore environment before roosting?
9. Do offshore migratory patterns observed in Europe hold for North American species?

Foraging:

10. Does offshore foraging occur regularly, seasonally, or only opportunistically?
11. Does offshore prey availability influence bat activity? What factors are associated with prey availability?
12. Is offshore migration influenced by prey availability, or are prey consumed incidentally?
13. Do offshore foraging patterns observed in Europe also hold for North American species?

Species:

14. Do responses vary between species for each of the questions listed above? If so, how, and to what degree?

6.0 Recommendations

To begin to address each of the questions above requires an expanded, systematic approach and select set of investigative tools capable of providing quantitative data on the seasonal activities of individual bat species in offshore and coastal locations. Many of the acoustic-based tools and methodologies needed to generally census bat activity at varied locations are presently available and similar to those described and employed in the comparative analyses section of this document. Information required to support a viable analysis, however, will require a regionally synchronized and strategic deployment of detection equipment at a variety of offshore and coastal locations. Further, how individual detector units are deployed and operated, and how resultant data are analyzed and reported, are also key investigation factors in order to control variability amongst detector units between sites and over time. Finally, surveys should occur over a multi-year period to better assess annual variation.

Efforts to understand the seasonal activities and movements of bats between specific locations, the duration of stopover or stay at a particular site, or flight movements relative to height above water requires advanced monitoring efforts and expanded use of available tools. These include (active) telemetry and (passive) Nano-Tag transmitter technologies that enable detection and tracking of individual bats at site and regional levels, as well as night-vision equipment and marine radar. These tools, used in combination with the broader acoustic-based censusing deployments, provide a more apt and efficient means of documenting individual behavior patterns and the seasonal activities of nocturnal species in remote locations. As importantly, they help document relative risk of bats associated with offshore energy development, as well as aid in identifying potential operational and mitigating options for avoiding and minimizing that risk.

Inherent to any systematic survey effort is the understanding that data should be collected in a manner that minimizes costs while effectively allowing comparisons with existing data sets. To do that requires a systematic and standardized implementation of detector settings during deployment and a common approach to the subsequent data analysis. Opportunities to take advantage of other ongoing bat-related research efforts (e.g., research on WNS) should also be pursued as able to further minimize investigative efforts and costs.

A brief series of specific recommendations that can be undertaken to overcome current information gaps (linked to listed 'Questions' above) are provided below.

- Develop and utilize a standardized monitoring approach that readily captures available past, existing, and future offshore and coastal survey data sets (Questions 1 through 14).
- Conduct a sustained regional collection and analysis of seasonal (remote/passive) acoustic data at strategically located coastal and offshore locations. Studies should be maintained over a multi-year period to adequately assess the extent and influence of annual variability (Questions 1 through 6, 8, 9, and 14).
- Expand the current (remote/passive) offshore acoustic survey effort to include the Cape Cod to Delaware Bay area, southern Atlantic states, Gulf of Mexico, and Pacific coast regions (Questions 1 through 6, 8, 9, and 14).
- Investigate timed and seasonal movements of individual bats between discrete offshore and coastal locations through the networked use of regionally deployed digitally encoded receivers and coded radio tags (NanoTags) (Questions 1 through 6, 8, 9 and 14).
- Investigate movements and behavior patterns of individual bats at offshore sites to assess periods of residency and influence of standing structures. These observations are best served by utilizing a combination of tools and active monitoring techniques including radio-telemetry, night vision equipment, and marine radar. Properly employed, these tools can also provide information regarding individual flight heights relative to ground and water surfaces, and prominent vertical structures (Questions 4, 5, 7, and 10 through 14).
- Coordinate regional offshore data collection with ongoing efforts to assess the spread and influence of WNS on hibernating bats (Questions 3 through 6, 9, and 14).

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Appendix A

This report is a comprehensive literature review that summarizes and compiles all known available studies conducted to date regarding bats' presence and behavior offshore, as well as potential direct and indirect impacts from offshore wind projects.

Appendix A

Information Synthesis on the Potential for Bat Interactions with Offshore Wind Facilities[1]

LITERATURE REVIEW

Abstract

The extent of scientific knowledge regarding the presence and behavior of bats in the offshore environment, defined by the Bureau of Ocean Energy Management (BOEM) to be beyond three miles from any shoreline, is limited due to numerous factors, including the logistical constraints associated with monitoring bats offshore, an incomplete understanding of bats' distribution and movements on land, and a general lack of scientific inquiry on the subject. However, concerns over population-wide impacts to bats associated with mortality at commercial wind facilities, habitat loss, and in particular the recent devastating effects of White-nose Syndrome have led the US Fish and Wildlife Service to consider federal listing for additional bat species, and similarly led BOEM and the US Department of Energy to undertake a compilation and analysis of available data of bat occurrence in offshore regions.

This literature review is the first component of an effort funded by a federal contract administered by BOEM and is intended to summarize and compile all available studies conducted to date regarding bats' presence and behavior offshore, as well as potential direct and indirect impacts associated with offshore wind projects. Given the limited amount of published literature regarding bats offshore and the associated risks of impact at offshore wind projects, a primary purpose of the literature review is also to define specific information gaps requiring further study.

The literature review is organized by broad categories relating to the presence of bats offshore, behavior of bats offshore, and potential impacts to bats from offshore wind projects. Relevant literature and information gaps are summarized for each category. To make use of as much literature as possible while maintaining focus on the offshore environment, studies have been categorized as offshore, island, and coastal as appropriate.

Information on the presence of bats offshore consists largely of historic reports of varying detail and rigor, some of which have been compiled into peer-reviewed publications, records from

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[1] This report was prepared by Stantec Consulting Services Inc. for US Department of the Interior, Bureau of Ocean Energy Management. The material in it reflects Stantec's judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third parties. Stantec accepts no responsibility for damages, if any suffered by any third party as a result of decisions made or actions based on this report.

lighthouses and ships, numerous anecdotal reports, and a small number of recent surveys focused on bats. Behavioral information regarding bats offshore is largely drawn from the timing and location of bat observations and has not been studied systematically due to a variety of issues. However, sufficient data exist to suggest that bats migrate offshore and may use islands, ships, and other offshore structures as opportunistic or deliberate stopover sites. Bats may forage offshore either during migration, perhaps to avoid competition or to exploit certain food sources. Potential impacts to bats from offshore wind projects have not been adequately studied at existing offshore wind projects, although physical mechanisms of collision that have been well documented at onshore wind projects would presumably apply to bats offshore. Similarly, the potential attraction of bats to wind turbines that has been suggested onshore would likely apply and may be exaggerated offshore, where turbines would present a considerable contrast to the surrounding water. Depending on the degree to which bats are more susceptible to mortality from exhaustion or accident in offshore habitats or are well adapted to traveling long distances over water, long-distance visual attraction of bats to offshore wind projects could result in mortality of bats drawn away from terrestrial habitats.

Although bats have been confirmed to occur offshore and appear to migrate and possibly forage offshore, little is known about species-specific patterns, the number of bats offshore relative to onshore, or the potential for offshore wind projects to impact bats directly or indirectly. Most studies mentioning bats offshore have identified as many or greater questions than answers, which will likely be a pattern for some time to come. However, advances in understanding of the interactions between bats and onshore wind projects and the results of a small number of recent focused surveys have helped identify specific gaps in knowledge that could help address potential risks. Articulating these gaps will then help focus subsequent monitoring and research efforts on the gaps that, if filled, could help address potential impacts to bats at offshore wind projects.

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1.0 Introduction

Although still beset by many unknowns, the impact of land-based wind energy development to bats is relatively well understood compared to offshore wind energy development. Nonetheless, due to the escalating interest in offshore energy, potential resource conflicts, including those of local and migratory bats, remain a key ecological concern to federal and state review and resource agencies, developers, and general members of the public.

This literature review is the first component of an effort funded by a federal contract administered by the Bureau of Ocean and Energy Management (BOEM). The overall purpose of the study is to synthesize existing information on bats and their potential interactions with offshore wind facilities relative to bat activity on land. Also scheduled subsequent to this synthesis effort is an analysis of regionally gathered acoustic bat data from available offshore, coastal, and terrestrial-based sites interior. The results of these combined study efforts will contribute to the knowledge base that is needed for public officials to pursue balanced decision-making in the management and development of renewable energy and alternate use projects on the Federal waters of the Outer Continental Shelf.

This report is a comprehensive literature review that summarizes and compiles all known available studies conducted to date regarding bats' presence and behavior offshore, as well as potential direct and indirect impacts from offshore wind projects. Given the limited amount of published literature regarding bats offshore and the associated risks of impact at offshore wind projects, a primary purpose of the literature review is also to define specific information gaps requiring further study.

2.0 Methods

Stantec conducted a comprehensive and thorough literature review of available historic observations and scientific studies to assess potential direct and indirect impacts of offshore wind energy development on bat species, including observed avoidance and attraction behaviors, and the cumulative impacts of multiple offshore wind facilities. The literature search was conducted so as to identify, acquire, and review available published and unpublished environmental and technological literature, including national and international sources. Information acquisition was conducted through reviews of existing databases and scientific references, index searches, and personal contacts with other researchers.

In addition, the literature review included results and direct observations of Stantec's prior and ongoing coastal and offshore research studies regarding the potential seasonal presence/absence of bats in the offshore environment. These studies include an ongoing 3-year (2009-2011) offshore bat research effort involving synchronized acoustic (Anabat) detectors deployed at a series of coastal, island, and offshore buoy locations (Pelletier et al. 2011). Relative to that effort are over 160 seasons of regionally and terrestrially based acoustic surveys conducted by Stantec within the northeast and mid-Atlantic coastal states and other locations within the continental US.

The literature review also included findings from Stantec's review of more than 60 available scientific studies and historic documented observations on bats in offshore regions (Pelletier et al. 2011; Peterson et al. 2011). That investigative effort was recently further bolstered by Stantec's direct research, authorship, and May 2011 submittal of a Fact Sheet entitled *Bats and Offshore Windpower in the U.S,* developed on behalf of the American Wind Energy Association in concert with the Offshore Wildlife Working Group, Wildlife Issues Subcommittee, Fact Sheet Task Force.

The literature review was prepared with consideration for these long-term goals:

- Synoptic organization of existing knowledge;
- Synthesis of the knowledge into functional relationships;
- Identification of information gaps in need of further study; and
- Presentation of data for planning and management of BOEM-related offshore activities and updating of existing information databases.

All anecdotal and survey evidence of species accounts are summarized by geographic area in Exhibit 1 of this Appendix, and all references included in the Literature Cited are attached in Exhibit 2.

3.0 Results

3.1 AVAILABLE LITERATURE

Several categories of literature are included in this review, including peer-reviewed journal articles, technical reports, conference presentations, and unpublished datasets. Individual sources are included in the following sections.

3.2 PRESENCE OF BATS OFFSHORE

3.2.1 Species Accounts

Literature includes both anecdotal accounts and results of focused surveys documenting species presence.

3.2.1.1 Anecdotal Accounts

Observations not associated with an organized study were considered anecdotal. Most anecdotal accounts were made on a single day, or were incidental observations generated over the course of a season. Many reports also involved historical accounts, although a few are dated as recently as 2004. Particular attention was paid to accounts that included information on where the observation occurred, either in the form of a description (e.g., “145 kilometers [km] from the coast of Brazil”) or through geographic coordinates. Anecdotal accounts of species present were derived from published reports in journals and scientific bulletins. Occasionally these publications reviewed information originally printed in newspaper articles or gathered through personal communications.

The following sections divide anecdotal accounts into those made offshore, on islands, along the coast, or on an inland lake. Following the BOEM definition, “offshore” will refer to observations made over water at least 3 nautical miles (4.8 km) from the nearest land mass (either continent or island). Therefore, island observations include those observations made on islands as well as those made over water within 4.8 km of an island. Coastal observations are those made along mainland coasts, over water within 4.8 km of the mainland, or on an island or peninsula within 4.8 km of the mainland.

3.2.1.1.1 Offshore

Offshore accounts are those occurring over water at least 4.8 km from the nearest land mass (either continent or island). Therefore, most anecdotal offshore observations were obtained from ships at sea. The earliest anecdotal account of a bat offshore appeared in a 1902 newspaper clipping later cited by Allen (1923). The article described an observation of a “large migration of bats” (of unknown species) 16 km off the coast of Delaware, made by a captain aboard a British steamer.

Twelve anecdotal accounts in eight published articles were found of offshore observations in the Atlantic Ocean (Griffin 1940 and Peterson 1970 included information on several accounts initially reported elsewhere). For those observations with reported dates, all occurred between August 17 and October 7. The first report appeared in 1902, as mentioned previously, and the latest report was from 1969. Four observations either did not mention the species observed, or reported that the species observed was unknown. All other anecdotal observations were of eastern red bats (*Lasiurus borealis*) and silver-haired bats (*Lasionycteris noctivagans*).

There were three anecdotal reports of bats offshore that did not come from the Atlantic Ocean. On March 15, 1960, a southern yellow bat (*Lasiurus ega*) was observed 335 km from the coast of Argentina (Van Deusen 1961 as cited in Esbérard and Moreira 2006). In 2002, a male southern yellow bat was observed by a ship 145 km off the coast of Brazil. In Europe, observations of several European bat species made on offshore drilling platforms in the Dutch sector of the North Sea were summarized by Boshamer and Bekker (2008). These observations were collected between 1988 and 2007 on offshore platforms 60 km to 80 km from the northern North Sea shores.

See Exhibit 1, Table 1 for a list of species observed in the offshore environment and associated observation locations, observation notes, and citations.

3.2.1.1.2 Island

True offshore accounts are rare, as they rely upon documentations made by ships or other human encounters in the open ocean. Island observations can be considered indirect observations of offshore activity over open water as long as the observations are of non-resident individuals. Individuals that appear on a remote island during typical migratory periods and depart the island to continue migration, or that appear on a remote island for the winter and depart for the summer, can be assumed to have traveled over the offshore environment to arrive and depart from that island. Also, patterns of island use by bats can inform the ways in which bats are using the surrounding offshore habitat. This section discusses observations of migratory individuals on islands located from 8 km (5 miles) to 61 km (38 miles) from the nearest land. Islands within 8 km of the mainland are considered part of a coastal system and are discussed in the next section.

The earliest anecdotal account of island observations comes from Merriam (1887). Mount Desert Rock, a remote island 48 km (30 miles) off the coast of Maine, has no vegetation but does have a lighthouse. The lighthouse keeper observed that "… a few small dark-colored bats visit the place during the migrations, every spring and fall" (p. 87). Several specimens were identified as silver-haired bats.

Most anecdotal observations come from the island of Bermuda, approximately 1,078 km (670 miles) from the coast of the US. The earliest observation was of a silver-haired bat on October 8, 1850 (Jones 1884 as cited in Van Gelder and Wingate 1961). Eight anecdotal accounts in six published articles were found of bats on Bermuda (several articles included information on accounts reported elsewhere). These accounts were of migratory species (eastern red bats, hoary bats [*Lasiurus cinereus*], silver-haired bats, and Seminole bats [*Lasiurus seminolus*]), and all accounts were of observations made during the fall migratory period.

Southeast Farallon Island, 48 km (30 miles) west of San Francisco, California, has a long history of hoary bat observations during the migratory season. A 1966 journal article cites observations during the first week of April 1961 and in early fall of 1965 (Tenaza 1966). Daily observations of bats made incidentally during routine censuses of birds and marine mammals from 1968 to 2005 were summarized by Cryan and Brown (2007). Hoary bats were observed on 295 days between August 10 and November 11 during all but 2 of the 38 autumns that records were kept, and were also observed on 7 days during late April and early May, 1990.

See Exhibit 1, Table 2 for a list of species observed in the offshore island environment and associated observation locations, observation notes, and citations.

3.2.1.1.3 Coastal

Coastal observations include those made on peninsulas or islands within 4.8 km of the adjacent mainland and those made on the mainland itself. Offshore activity cannot be directly assumed from coastal observations; however, coastal observations can indicate important pieces of information such as migratory timing and species presence adjacent to the offshore environment.

Anecdotal observations of species on the coast can be further divided into visual observations and observations derived from museum records. Merriam (1887) collected visual observations of hoary bats and silver-haired bats during fall migration along the east coast from New York to South Carolina. These observations occurred as early as September 10 in Maplewood, New Jersey. Although the general trend was for more southerly observations to occur later in the year, a hoary bat was observed on December 12, 1841, on Long Island, New York.

Eastern red bats, hoary bats, and silver haired bats were observed over several years at the Highland lighthouse in Cape Cod, Massachusetts. The lighthouse is located in a sandy and sparsely vegetated type of coastal habitat at the tip of the Cape Cod peninsula, but separated from the mainland to the east and northeast by 40 to 80 km (25 to 50 miles) of water. These species were never observed during the summer months, but Miller (1897) collected numerous observations from late August to early September in 1890 and 1891. Of note is the location. The lighthouse is located on a steep bluff that rises immediately from the beach to a height of 45 meters (m). Bats foraged around the bluff face, feeding on insects blown there by southwest winds, and were not observed flying over the beach below nor around the lighthouse grounds. The author was unable to locate any daytime roosts in the lighthouse buildings or in deserted bank swallow holes in the bluff, and noted that it is possible, though unconfirmed, that they used the scattered and stunted oak scrub at the top of the bluff as roosts.

Additional anecdotal evidence of coastal presence comes from two extensive reviews of the dates and locations associated with specimens in museum collections. Cryan (2003) found evidence of migratory pathways for eastern red bats, western red bats (*Lasiurus blossevillii*), hoary bats, and silver-haired bats near the east and west coasts of the US during the autumn months. According to museum specimens, eastern red bats occur throughout coastal areas along the Atlantic Ocean and Gulf of Mexico, extend inland in the spring, and then migrate south along the Atlantic coast in the fall. There were also records of the western red bat along the Pacific coast during spring and fall migration, indicating coastal migration. While silver-haired bats were located year-round along the Pacific Coast, specimens were collected during the autumn on the Atlantic coast, indicating coastal migration in the east. Evidence of coastal migration for hoary bats was limited to the west coast, where museum specimens indicated a northward dispersal for males in the spring and a southward dispersal for females in the fall.

Menzel et al. (2003) also conducted a review of museum specimens, along with capture records and submissions to the public health department for rabies testing, to examine the presence of species in South Carolina. Twelve species were present in coastal counties at some point during the year. However, the timing of the observations is unknown, so migratory versus resident status cannot be determined.

See Exhibit 1, Table 3 for a list of species observed in the coastal environment and associated observation locations, observation notes, and citations.

3.2.1.1.4 Long Point on Lake Erie, Ontario, Canada

Long Point is a 35-km long peninsula that extends from the northern shoreline into Lake Erie. Lake Erie itself is as much as approximately 90 km wide, but the use of the peninsula during migration as a stopover site can reduce the over water crossing distance by half (Dzal et al. 2009). Anecdotal evidence of bat presence came as early as 1929, when three eastern red bats, a hoary bat, and perhaps a silver-haired bat (referred to as "silver gray bat") were collected at the Long Point lighthouse along with over 600 birds (Saunders 1930). Mist netting and acoustic surveys on the peninsula have documented big brown bat (*Eptesicus fuscus*), eastern red bat, hoary bat, silver-haired bat, little brown bat, northern long-eared bat, (*Myotis septentrionalis*), and tri-colored bat (*Perimyotis subflavus*) (Dzal et al. 2009; McGuire et al. 2012).

See Exhibit 1, Table 4 for a list of species observed on Long Point, and associated observation locations, observation notes, and citations.

3.2.1.2 Focused Surveys

Focused surveys provide evidence of species presence in the offshore environment, even if species identification is not the primary objective of the research. European studies in offshore, coastal, and islands of the Scandinavian Peninsula and southern Sweden and Denmark have resulted in detection of 11 species (out of 18 potential species) flying over the ocean up to 14 km from shore (Ahlén 2006; Ahlén et al. 2007, 2009). Observation sites ranged from 11.8 km to 19.1 km from the nearest land (Ahlén 2009). These studies utilized direct observation (via spotlights and thermal imaging cameras), as well as acoustic monitoring to detect bat species, and radar systems to identify flight routes and altitudes for the largest, most identifiable species in Europe.[2] Studies took place from July to October of 2005, 2006, and 2008 in offshore, coastal, and island environments. Acoustic detectors recorded bats at all (12) offshore wind turbines monitored. The most common bat observed at departure sites and over the ocean (pygmy pipistrelle [*Pipistrellus pygmaeus*]) is also a species not considered to be migratory in Scandinavia and not previously recorded on islands in the middle of the Baltic Sea. The authors conclude that migration and foraging over marine environments are common.

During approximately 520 hours of nocturnal surveys over 56 nights in March, April, May, and October 2008 and May 2009, a total of 15 offshore bat detections were documented from 1.5 km to 16.1 km off the shore of New Jersey, using barge-mounted Thermal Imager (camera) (20 degree field of view) and Vertically Pointing Radar (beam width 15 degrees). Nine foraging bats were detected in spring 2008, six were detected in fall 2008, and none were detected in spring 2009 (NJDEP 2010).

An associated acoustic study was conducted during the March, April, May, June, August, September, and October 2009 shipboard surveys (NJDEP 2010, Sjollema 2011). Bat activity was observed from (1) ships running transects perpendicular to the New Jersey coastline; (2) locations from Buzzards Bay, Massachusetts to Cape Hatteras, North Carolina; (3) ships running transects perpendicular to the Maryland coast; (4) locations from coastal New Jersey to North Carolina; and (5) ships 166 km off the mid-Atlantic coast. Eastern red bats, hoary bats, bats belonging to the big brown/silver-haired bat guild, and bats of the *Myotis* genus were recorded in the offshore environment; coastal observation points recorded the same suite of species as well as tri-colored bats. Ships traveled an average distance of 20 km, 12 km, 18 km, 6 km, and 85 km from shore, respectively, and bat activity was recorded an average 8.7 km from shore (maximum: 21.9 km from shore; Sjollema 2011).

Hoary bats have been regular visitors to the Southeast Farallon Island in the Pacific Ocean, 32 km south of the nearest island and 48 km west of the California shoreline. Daily observations from routine censuses of birds and marine mammals were noted in standardized journals and included incidental observations of hoary bats. Hoary bats were observed during all but 2 of the 38 autumns that records were kept (from 1968 to 2005). In all, there were 295 days of hoary bat observations between August 10 and November 11, and an additional 7 observation days during late April and early May, 1990. Presence on the island was associated with dark phases of the moon, low wind speeds, low barometric pressure, and cloudy skies (Cryan and Brown 2007).

A late summer/fall 2009 study by Stantec of two coastal and 10 offshore islands occurring over an approximate 209-km coastal transect in the Gulf of Maine documented 14,548 acoustic detections during 9,948 survey hours over 829 detector-nights using acoustic (Anabat) detectors.

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[2] Simultaneous visual and radar observations were used to distinguish bats from other radar targets. Visual observations were made from a boat using a bright spotlight to follow a bat, which was also tracked on the radar screen.

Each of the 12 sites documented bat activity with at least one site, Mount Desert Rock, located approximately 33 km offshore of Mount Desert Island, recording bat activity as late as November 11, 2009. Eastern red, silver-haired, and *Myotis* species were observed at all 12 locations, with hoary bats recorded at all but one site. Big brown bats were documented at 6 of the 12 locations, although the big brown/silver-haired guild was observed at all 12 sites.

Seguin Island, located only 3.9 km offshore, documented an uncharacteristically high number of detections in 2009, constituting 8,476 (58%) of the total calls. As part of this survey, lighthouses were utilized at several sites to elevate acoustic detectors above ground level in an attempt to better document migrating bats moving past offshore islands. However, the Seguin Island light was the only lighthouse included in the survey where the beacon was constantly lit and did not flash. The constant light source likely affected local bat activity by attracting insects.

Stantec conducted a similar effort at eight Gulf of Maine islands in late summer/fall 2010, stretching a distance of approximately 282 km from Petite Manan Island in the downeast region of the Maine coast, to Appledore Island in the Isle of Shoals, 10 km off the New Hampshire coast. For that effort, acoustic detectors at one coastal peninsula and eight island locations documented 27,223 detections during 8,916 hours over 743 detector-nights. Bat activity was again documented at each of the survey sites, with detections recorded as late as November 12, 2010. Silver-haired bats were observed at all nine detector locations, *Myotis* species were recorded at all sites except at the Isle of Shoals detector, and red bats were recorded at every site except Great Duck, which only operated for six nights. Hoary bats were recorded at every site except Matinicus Rock and Mount Desert Rock. Big brown bats were only documented at Isle of Shoals and the Seguin detector; however, the big brown/silver-haired guild was observed at all sites except Great Duck and the Mount Desert Rock detector. Similar to the 2009 survey, the Seguin Island detector recorded the highest level of bat activity, and calls from that site represented 77 percent of all calls recorded during 2010.

A third year of offshore acoustic monitoring was also conducted by Stantec in 2011. Six acoustic detectors were deployed along an approximately 400-km coastal transect on five islands and on one weather buoy, located 10 km off the coast of Massachusetts. Five of the six detectors documented 11,421 detections during 6,024 hours over 502 detector nights. To date, analysis is not complete on data collected from the Seguin Island site, which typically accounts for the majority of calls recorded each season. Bat activity was again detected at each of the survey sites, including the Gloucester weather buoy detector, which recorded 84 bat calls during 123 nights of recording. Half of the calls recorded by the Gloucester detector were from high-frequency unknown calls, followed by low-frequency unknown, eastern red, hoary and silver-haired bats. Not including data from the Seguin detector, *Myotis* calls represented more than half of all calls recorded during the 2011 survey period, and the majority of *Myotis* calls were recorded by the most northerly detector located on New Brunswick, Canada's Kent's Island (Stantec 2011, 2012).

3.2.2 Summary of Studies

Historically, bats are known in the coastal and offshore environments primarily from lighthouse counts (Merriam 1887; Miller 1897), sporadic North American oceanic records (Esbérard and Moreira 2006; Griffin 1940) and European offshore studies (Ahlén 2006; Ahlén et al. 2007, 2009). Merriam relayed reports from Mount Desert Rock that "a few dark-colored bats visit the place during the migrations, every spring and fall" while Miller reported three species of migratory tree bat from Highland Light, Truro, Massachusetts over the course of two autumns of observations. European studies (Ahlén 2006; Ahlén et al. 2007, 2009; Hutterer et al. 2005) have documented significant bat migrations across portions of the Baltic Sea between Scandinavia and mainland Europe, as well as bats foraging around offshore turbines and possibly on crustaceans on the sea surface. Intensive acoustic studies in the Gulf of Maine have documented nightly and seasonal activity patterns of most North American species at locations up to 42 km from the mainland coast, with acoustic detectors deployed on lighthouses, portable and permanent towers on islands, and weather buoys (Stantec 2012).

3.2.2.1 Geographic Range

True offshore accounts of species presence range from the Atlantic Ocean (off the eastern coasts of the United States and Canada), to the North Sea (off the coasts of the Netherlands, the United Kingdom, Norway, Denmark, and Germany), and the waters of the Öresund, Kattegat, and Kalmarsund Seas (areas in the southern Baltic Sea off the coasts of Sweden and Denmark; see Exhibit 1, Table 1). Two offshore accounts were also found in the Atlantic Ocean off the coasts of Argentina and Brazil (see Exhibit 1, Table 1). Island accounts of species presence on Bermuda, Southeast Farallon Island, and Mount Desert Rock indirectly indicate species presence offshore, and add presence in the Pacific Ocean to the aforementioned areas where offshore species presence has been observed (see Exhibit 1, Table 2).

The maximum distance from shore from which observations were made was frequently difficult to assess. It is however likely that a bat observed on September 7, 1937, 805 km (500 miles) from Cape Race, Newfoundland, was the farthest from shore of those found (Griffin 1940). An eastern red bat was found 386 km (240 miles) east of Cape Cod, Massachusetts on August 17, 1929 (Norton 1930). Three silver-haired bats were found 210 km (130 miles) southeast of Nantucket Island, Massachusetts (Griffin 1940). An eastern red bat was found on September 1, 1920, on a ship "inbound from South Africa, when she was three days out of Philadelphia" (Haagner 1921 as cited in Griffin 1940); however, it is unclear where exactly this ship was and therefore how far offshore the observation occurred.

3.2.2.2 Survey Methodologies

Methodologies used in the focused surveys include acoustics (Ahlén 2006; Ahlén et al. 2007, 2009; Sjollema 2011), direct observation using portable spotlights or infrared thermal imaging cameras (Ahlén 2006; Ahlén et al. 2007, 2009), and radar systems to track the largest, most identifiable species in Europe (Ahlén 2006; Ahlén et al. 2007, 2009).[3] Acoustic bat detectors have been attached to offshore wind turbines (Ahlén 2006; Ahlén et al. 2007, 2009), ships (Ahlén 2006; Ahlén et al. 2007, 2009; Sjollema 2011), lighthouses (Stantec 2012), portable and permanent towers (Stantec 2012), and weather buoys (Stantec 2011).

In addition, historic coastal and island observations have been made using primarily visual observations of mortalities at lighthouses, of roosting individuals, or of individuals flying at dusk. Acoustic bat detectors and mist nets have also been used during focused studies at coastal and island locations to determine species presence.

3.3 BEHAVIOR OF BATS OFFSHORE

Studies have investigated factors relating to bat activity over water but few have focused or mentioned offshore regions. The aerodynamic advantage of flying close to the surface of the ground or water is well documented as aerodynamic ground effect (Siemers et al. 2001). All microchiroptera use echolocation for spatial orientation as well as food acquisition (Schnitzler et al. 2003) and recent evidence suggests that they innately recognize waterbodies for foraging, drinking, and orientation (Greif and Siemers 2010). Rydell (1986) found that in Sweden, the northern bat (*Eptesicus nilssoni*) typically flew 2 m to 5 m above the surface of lakes, and attributed this to two conditions of open water: (1) a lack of obstacles over water may make insects easier to capture, and (2) the temperature over large bodies of water is more stable over time, thus when temperature drops over land and insects become less active, higher temperatures above water may result in sustained insect activity. Ahlén et al. (2009) observed 11 of 18 European bat species known to occur in the southern Baltic Sea flying at low elevations over the sea. Even the normally high flying Common Noctule (*Nyctalus noctula*) flew lower than 10 m above the surface, and often used lower frequency calls then when over land.

More study is needed on other species and in additional parts of the world to determine if this is true for all species moving over water.

3.3.1 Foraging

Visual observations have been recorded of migratory and non-migratory bats hunting over water in the United States and Europe (Ahlén et al. 2007; Miller 1897). Miller (1897) observed bats

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[3] Simultaneous visual and radar observations were used to distinguish bats from other radar targets. Visual observations were made from a boat using a bright spotlight to follow a bat, which was also tracked on the radar screen.

flying along bluffs and over the water on the western side of the Cape Cod Peninsula, feeding on unidentified insects. In Sweden, 10 different bat species have been observed foraging close to offshore turbines in the Baltic Sea. Feeding bats were seen at heights ranging from just above the water surface to the upper part of wind turbines. All individuals hunted when there was opportunity, even the bats that appeared to be migratory (Ahlén et al. 2007).

Although literature regarding insect distribution offshore is limited, numerous types of insects occur offshore (Cheng and Birch 1978), providing a potential food supply for bats and possibly influencing distribution of bats offshore. Several studies have documented large-scale insect migrations occurring in coastal areas and offshore (e.g., Russell et al. 1998; Srygley and Dudley 2008; Wikelski et al. 2006). These insect migrations coincide seasonally with the bat migration period, again potentially influencing the distribution and timing of bat migration offshore. Insects available for forage over the Baltic Sea included primarily chironomids (flying midges), which are produced in the aquatic environment. However, also present were terrestrial insects that had drifted across the water (Ahlén et al. 2007, 2009). Bat prey species are well-documented in the literature, and these references are likely applicable to the topic of foraging in the offshore environment.

Insects may not be the only prey item available offshore. Ahlén et al. (2009) observed two bat species gaffing prey from the water surface where net samples collected no insects. However, net samples collected an abundance of crustaceans, and the authors conclude that these bats were likely feeding on the crustaceans.

Foraging has been documented both during the migratory season, as well as during summer residency. European studies documented offshore activity and foraging during the summer months (Ahlén et al. 2007). Radar data showed *N. noctula* foraging at sea and returning to the same land areas before dawn (Ahlén et al. 2009).

Researchers found an increase in feeding activity at the end of the summer. One possible explanation for this phenomenon is that the distance to find prey over the water is too great for nursing females in early summer, but when pups begin to fly and feed independently, bat activity over the water increases. August is also typically when migrant bats begin their southern movement, and a period when bats would likely take advantage of migratory paths over bodies of water between Sweden and southern Europe (Ahlén et al. 2007).

3.3.2 Migration

Anecdotal evidence of bats offshore were most often made during the fall and spring migratory periods, and were observations of species considered to be long distance migrants (Carter 1950; Griffin 1940; Mackiewicz and Backus 1956; Nichols 1920; Norton 1930; Peterson 1970; Thomas 1921). Often, these historic accounts were accompanied by an explanation that the weather at the time was calm, so the assumption was that weather conditions at the time did not cause the observed individuals to be blown from their intentioned migratory path (i.e., their migratory path and not extreme weather was bringing them into the offshore environment). For example, an eastern red bat was discovered on a ship approaching the shore of the Carolinas about an hour after sunrise, and the bat "could then not have been driven off-shore by heavy weather" due to the existing calm weather (Nichols 1920). In another account, an eastern red bat was observed on a ship 386 km (240 miles) from the Massachusetts coastline, and "as no offshore gales have been reported… this bat would seem to have been an early migrant" (Norton 1930).

Another notable early observation of bat migration activity occurred in September of 1949. A captain of a steamship traveling 105 km (65 miles) off the northern Atlantic shore saw an estimated 200 red bats flying by, and later roosting on his vessel (Carter 1950). These high numbers of migratory bats are early evidence that bats offshore were not merely incidental, but that seasonal migration could occur many miles out at sea.

In Europe, scientists are striving to understand offshore bat migration. This effort is being made because wind turbines have caused many bat fatalities onshore (Arnett et al. 2008; Kerns and Kerlinger 2004), and many large scale offshore wind facilities are presently built. Band recoveries in the 1980s provided strong evidence that bats were flying across the vast bodies of water between the Scandinavian Peninsula and lower European countries. Two Nathusius's pipistrelle (*Pipistrellus nathusii*) and one common noctule were marked in Sweden and later recovered in Germany and Belgium (Gerell 1987 as cited by Ahlén 1997). The Baltic Sea has since been the location of several studies on bat migration (Ahlén 1997; Ahlén 2006; Ahlén et al. 2007, 2009). Initial observations at selected sites on the southern Swedish coast showed an increase in bat activity and species richness during migration seasons. Some swarming events over the sea were also evident. Over 50 bats were seen accumulating near a coastal point in Sweden, and departing over the sea in the same direction (Ahlén 1997). A similar study, using radar and acoustic monitoring in coastal Sweden, and from boats and lighthouses in the Baltic Sea, found 11 of 18 endemic species of bats frequently flew offshore up to 14 km from land (Ahlén et al. 2007, 2009). An increase in migratory bat activity was found across the study area in early autumn, and the peak for all migratory species occurred in late August (Ahlén et al. 2007, 2009). The offshore bat activity ended in early October (Ahlén et al. 2009).

Ahlén et al. (2009) found that the majority of migrating bats flew low above the water surface. *N. noctula* is considered a species that flies high and fast and has been observed foraging at altitudes up to 1,200 m high over land (Ahlén et al. 2007). However, most observations of this species migrating over the ocean occurred at less than 10 m above the water surface. The authors postulate that bats fly low over the water to remain oriented during migration by means of echo-locating off the surface of the water. Alternatively, lower wind speeds at the water surface may make low altitude flight more favorable. However, when bats were near tall vertical structures such as ships, bridges, or wind turbines, they rapidly changed altitude (Ahlén et al. 2007, 2009).

3.3.3 Roosting

Ahlén et al. (2009) observed roosting activity along migratory flights over the offshore, coastal, and islands of the Scandinavian Peninsula and southern Sweden and Denmark. Roosting occurred on structures such as wind turbines, ships, bridges, and lighthouses. Individuals were observed roosting on a group of wind turbines 5.8 km offshore and regularly foraging over the surrounding waters. Further, service technicians observed bats roosting in turbine nacelles.

3.3.4 Theoretical Models of Offshore Bat Migration and Collision

No formal models for offshore bat migration or collision were found. Stantec found two models predicting avian collision mortality that were applied to offshore wind facilities in North America and Europe. A model developed by Bolker et al. (2006) was used to estimate avian mortality at the proposed Cape Wind offshore wind facility in Massachusetts (Hatch and Brault 2007). The so-called "Bolker model" used turbine characteristics, patterns of avian movement across the turbine area, and simple geometry to predict avian collision rates. A model developed by Desholm (2006) was applied to an offshore wind facility in the Baltic Sea to estimate mortality of Common Eiders (*Somateria mollissima*) and various species of geese. This used radar and thermal imaging data to determine the migration volume, the proportion of flocks entering the wind facility, the proportion within horizontal and vertical reach of turbine blades, and various variables related to avoidance, safe passage, and number of turbines passed. Other avian collision risk models have been applied to terrestrial wind facilities (Band 2000; Band et al. 2005; Podolsky 2003, 2005; Tucker 1996a, 1996b). These terrestrial models, along with avian models used to predict collision at offshore facilities, may or may not be applicable to bats.

Models predicting offshore migration or collision will require information on the factors leading to presence offshore. Two important factors are flight height and flight path. Intensive visual and remote observation of bats in the southern Baltic Sea allowed for the determination of migratory pathways and movement patterns. However, it is unclear whether specific pathways are always used, or whether bats in other parts of the world would follow a more "broad front" migratory pattern for long-distance movements. In the Baltic Sea, bats generally flew close to the surface, often between 0 m and 10 m above sea level (Ahlén et al. 2007).

Also important for predicting presence offshore are the weather factors associated with offshore activity. Cryan and Brown (2007) found that hoary bat presence on Southeast Farallon Island was associated with dark phases of the moon, low wind speeds, low barometric pressure, and cloudy skies. Sjollema (2011) found that wind speed was the only factor that was associated with bat acoustic activity recorded up to 22 km offshore, with activity decreasing as wind speed increased. Bats flew over the Baltic Sea in winds up to 10 meters per second (m/s), although most activity took place at wind speeds less than 5 m/s, and all observations of foraging were made during "suitable weather" (calm weather or a light breeze; Ahlén et al. 2007).

Presence of prey items likely plays a large role in presence of bats offshore. Bats roosted and foraged on and near existing turbines in European studies, and insects were found to accumulate around turbines (Ahlén et al. 2007, 2009). Insect surveys collected primarily chironomids (non-biting midges), but other flying species were also captured (including terrestrial species that were drifting into the offshore environment) and evidence was found of bats feeding on crustaceans (Ahlén et al. 2007, 2009).

3.4 INFORMATION GAPS

There is much still to learn about basic biology and ecology of bats in the offshore environment. Anecdotal accounts of bats offshore provide limited data on which species are present, but more information is needed on factors that are associated with bat activity offshore. Questions to be tentatively addressed by the subsequent regional acoustic data analyses are identified with an asterisk (*).

Migration:

- What is the seasonal timing of offshore migration? (*)
- Do offshore migrants travel along specific pathways, or is migration better characterized as a broad front? (*)
- What are the weather conditions associated with offshore migratory movements? (*)
- Is offshore migration influenced by prey availability, or are prey consumed incidentally?
- How far can an individual travel in the offshore environment before roosting?
- What is the maximum distance a bat will travel offshore?
- How do offshore migratory patterns differ between species? (*)
- Do offshore migratory patterns observed in Europe also hold for North American species?

Foraging:

- Does offshore foraging occur regularly, seasonally, or only opportunistically? (*)
- Does offshore foraging only occur during migration, or do coastal or island residents forage in the offshore environment as well?
- If so, what are the factors that are associated with prey availability?
- Does prey availability influence bat activity?
- What is the maximum distance a bat will travel offshore?
- How do offshore foraging patterns differ between species? (*)
- Do offshore foraging patterns observed in Europe also hold for North American species?

Habitat

- Is the offshore environment inherently a hostile environment? If so, does the offshore environment act as a sink, with lower natural mortality rates?
- On the other hand, is the offshore environment selected as primary habitat by coastal and island residents? (*) If so, is there a benefit to foraging or migrating offshore? How does that affect natural mortality rates?
- To what extent do bats use offshore structures as stopover roosts during migration?
- To what extent do bats seasonally use offshore islands as habitat? (*)
- Do any of these factors differ by species?

Direct impacts are associated with collision mortality; however, collision mortality rates at offshore turbines are unknown. It will be difficult to measure offshore mortality, and quantitative methods have not yet been developed. Indirect impacts are also little-understood. Beyond any (presently unknown) impacts caused by associated development, activity, and infrastructure (i.e., shoreline development, increased ship traffic and associated noise and lights), bats may be attracted to turbines for roosting or foraging opportunities. Attraction could result in longer migratory pathways with unknown impacts on survival rates.

In order to predict impacts to bats, we must first know where bats are in the offshore environment by answering some of the questions outlined above. Further, population size must be better known in order to more fully understand the impacts of offshore wind on bat populations (this information gap plagues terrestrial wind facilities as well). Data on population size is necessary to estimate a proportion of individuals that could be expected to be active offshore, and also to determine the impact of mortality on the species. Similar to terrestrial facilities, offshore impacts may be greatest to long-distance migratory species (eastern red bat, hoary bat, silver-haired bat) as these species are most commonly observed in the offshore environment. Population sizes for these three species are probably the least-understood of all species in North America, which makes it very difficult to determine direct, indirect, and cumulative impacts.

However, studies in the Gulf of Maine have also shown presence of species other than the three long distance migrants. While not typically observed far offshore, *Myotis, Eptesicus,* and *Perimyotis* species have been readily observed in island and near-shore environments. These species may also be at least seasonally present in areas where turbines are proposed to be built; alternatively, turbine attraction could lead to impacts even though these species are not in offshore habitats prior to construction. Of particular note is the increasing concern over White-nose Syndrome, a disease caused by a non-native fungus, *Geomyces destructans,* which since 2006 has been directly responsible for the loss of an estimated 5.7 million bats in the eastern US (USFWS 2012). Should bat populations continue to plummet in response to the disease, patterns of offshore activity may become more difficult to detect for these species, and potential impacts associated with offshore turbine development more difficult to assess.

3.5 RISK OF DIRECT EFFECTS

In the context of the National Environmental Policy Act (NEPA), direct effects are those that are caused by the action and have an immediate effect on a species or its habitat. Bats are very slow to reproduce, with most North American species having only one pup per year; therefore, bats are at risk to population-level effects as a result of collision mortality, whether from onshore or offshore wind turbines. Because no offshore wind facilities have yet been constructed in North American waters, the only opportunity to study potential direct impacts to bats from offshore wind has been from existing offshore wind facilities in Europe. As of the end of 2010, 45 offshore wind projects ranging from 1 to 100 turbines (2 to 300 megawatts) each were installed in European waters, with an additional 11 projects under construction in 2011 (EWEA 2011). Despite the relatively large amount of offshore wind development in Europe, studies attempting to document impacts to bats consist of a limited number of radar, acoustic, and visual surveys. The most comprehensive study of bats at an offshore wind facility occurred in 2005 and 2006 at the seven-turbine Utgrunden wind facility and nearby lighthouse in the southern portion of the

Kalmar Sound off Sweden (Ahlén et al. 2007). Bat flight behavior was documented using radar and visual surveys, and acoustic surveys documented activity patterns on shore as well as at the base of turbines (Ahlén et al. 2007). Bats typically flew at heights of less than 40 m above the surface, although bats were observed foraging up to the top of wind turbines, with flight height presumably dependent on insect distribution (Ahlén et al. 2007). Bats were also observed to increase flight height around other structures such as ships and bridges in addition to wind turbines (Ahlén et al. 2009). Bats appeared most active when wind speeds were low, and bats often appeared to forage in close proximity to turbines and were also observed resting on turbine structures (Ahlén et al. 2007). However, collision mortality rates could not be determined using these methods.

European studies have confirmed that bats forage and migrate offshore, exposing them to risk of collision mortality. Bats have been shown to be attracted to offshore wind turbines (Ahlén et al. 2007). A number of hypotheses for attraction of bats to onshore wind turbines have been identified, including roost attraction, landscape attraction, heat attraction, and visual attraction (Kunz et al. 2007). Each of these hypotheses would likely apply to offshore wind facilities, where turbines present a dramatic visual and structural contrast to the surrounding water. Rydell et al. (2010) suggest that prey concentration at turbines may be a primary cause of bat attraction based on analysis of bat mortality patterns documented at European wind facilities. This is consistent with observations of bats at offshore wind facilities mentioned above, where insects were observed to be concentrated around turbines (Ahlén et al. 2007).

While mortality rates of bats have not been quantified at offshore wind projects, mortality patterns documented at onshore wind projects in Europe and North America suggest that bats are susceptible to collision mortality and/or barotrauma whenever they are present in the landscape. The limited studies that have been conducted in Europe have confirmed that bats forage and travel in close proximity to offshore wind turbines and appear to be attracted to the turbines, particularly when insects become concentrated around turbines (Ahlén et al. 2007). Thus, the potential exists for collision mortality and/or barotrauma at offshore wind projects. While bats are presumably less abundant in offshore environments than onshore, attraction of insects and therefore bats to offshore wind facilities may concentrate bat activity near offshore wind facilities.

In addition to collision mortality/barotrauma, bats potentially attracted to the presence of offshore wind turbines could divert from traditional migration routes or foraging areas, thus increasing energy demands and possibly exposing them to greater risk of drowning from exhaustion by being drawn into unsuitable habitat lacking safe roosts and adequate water supply. No studies have attempted to study this potential risk, and the interactions between temporary roosting habitat and insect concentration provided by turbines versus risk of mortality from collision or barotrauma may not be straightforward.

3.6 RISK OF INDIRECT EFFECTS

In the context of NEPA, indirect effects are those that are caused by the action at a later time or at a distant location, but still are reasonably certain to occur. In the context of offshore facilities, indirect effects could come from increased ship traffic for construction and maintenance activities, shoreline infrastructure, noise and vibrations from operating turbines, or avoidance of wind facilities. No literature was found that discussed the influence of indirect effects. Some literature discussed potential indirect effects to birds (Goodale and Divoll 2009; Wilson et al. 2010), but if bats are discussed, it is to say that there is little information on which to determine indirect effects.

Offshore turbines could act as either a barrier or filter to movement, or as an attractant. Either case could result in an altered migratory pathway. In turn, this alteration could result in increased migratory flight distances, increased requirements for prey consumption, and ultimately could influence survivorship. Indirect effects are complex, poorly understood, and difficult to study both in onshore and offshore settings. As a result, information gaps are abundant. Most information on avoidance of or attraction to turbines is anecdotal or observational, and therefore cannot be used to definitively support or refute any of the suggested hypotheses. However, basic information on migratory patterns and use of the offshore environment in the absence of wind turbines is necessary before indirect effects of turbines can be quantified.

3.7 POTENTIAL BENEFITS OF OFFSHORE WIND FOR BATS

Conversely, offshore wind turbines may attract insects which in turn could provide additional fuel for migrating bats. Similarly, offshore wind turbines could provide new roosting locations for migrating bats. However, risk of collision mortality could likely undermine these benefits.

The expansion of wind energy may have beneficial effects on biological resources. Increases in renewable energy, including wind power production and consumption, will help to reduce reliance on fossil-fuels and will reduce carbon dioxide emissions. Increased carbon dioxide and other greenhouse gases emissions are resulting in global climate change that includes rising temperatures and changes in temperature regimes, precipitation patterns, fire cycles, storm severity, and sea level rise, among other effects (EPA 2009). Bats may be negatively affected by a number of manifestations of climate change, including changes to temperature and moisture regimes within hibernacula and roost trees; reduced availability of insect prey or mismatched phenology of insect availability relative to times of peak energy demand; range shifts; increased forest fires and associated removal of roosting and foraging habitat; flooding; and changes in species composition within forests.

Other by-products of non-renewable energy extraction can negatively affect bats, including habitat destruction and degradation, and water and air pollution. Combustion of fossil fuels produces air pollutants such as nitrogen oxides, sulphur dioxide, volatile organic compounds, and heavy metals that could negatively affect bat health and viability. There are, in addition to indirect pollutant-related effects on bats and bat habitats, direct impacts associated with fossil fuels through surface "area" mining and in particular, mountaintop mining with valley fills (MTR/VF). This type of activity, authorized under Section 515(c)(1) of the Surface Mining Control and Reclamation Act of 1977, involves the removal of extensive tracts of deciduous forests that are cleared and stripped of topsoil. Peer-reviewed studies of the extent of coal related bat habitat loss are currently limited (Buehler and Percy 2012). Nonetheless, Palmer et al. (2010) revealed that there is a “preponderance of scientific evidence that impacts are pervasive and irreversible and that mitigation cannot compensate for losses.” Bats are both directly and indirectly impacted by MTR/VF through the removal and degradation of summer roosts, winter hibernacula, and foraging habitats, as well as by valley fill activities that degrade and destroy streams and prey species (EPA 2005). Coal mining and coal burning will likely continue to contribute towards the loss of forested habitat at a regional scale and to the pollution of air and water sources, all of which can negatively impact bats.

While development of offshore wind energy alone is not expected to individually slow, halt, or offset the negative effects of climate change or other by-products of non-renewable energy extraction, it provides a viable alternative to a larger state and national strategy targeting a reduced reliance on carbon-emitting fuel sources, and in turn, helps limit and minimize the negative effects of fossil derived fuel sources to regional and local bat populations.

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Exhibit 1

Species Accounts

Exhibit 1, Table 1

Anecdotal and Survey Evidence of Bat Species Present Offshore

Species*	Season or Date	Location	Observation Type	Notes	Citation
unknown	first week in September, 1902	10 miles off “the Delaware [River]”	anecdotal	ship encountered a "large migration of bats"	newspaper clipping cited in Allen 1923
unknown	September 6, 1907	5 miles off Sandy Hook, NJ	anecdotal	"… probably a silver-haired bat…"	Murphy and Nichols 1913 as cited in Griffin 1940
LABO	September 3, 1919	“…approaching the Capes of the Carolinas from the North, no land yet in view…”	anecdotal	observed on ship “about an hour after sunrise”, bat “could then not have been driven off-shore by heavy weather” due to calm weather	Nichols 1920
LABO	September 1, 1920	"...ship inbound from South Africa, when she was three days out of Philadelphia…"	anecdotal	individual found on a ship, with "… no possibility that the bat had accompanied the ship away from the coast."	Haagner 1921 as cited in Griffin 1940
LABO, LANO	September 3, 1920	approximately 20 miles off the coast of NC	anecdotal	flock of “…about a hundred which caught up with and settled on Mr. Cheeseman’s ship…"	Thomas 1921
LABO	August 17, 1929	“… near the eastern end of George’s Bank, about 130 miles south by west from Cape Sable, Nova Scotia, or about 240 miles east of Cape Cod, Massachusetts, approximately in latitude 42° north, longitude 66° west.”	anecdotal	“As no offshore gales have been reported from the regions bordering the Gulf of Maine during the month of August, this bat would seem to have been an early migrant.”	Norton 1930
unknown	August 18, 1929	5 miles NNW of Provincetown, MA	anecdotal	individual "boarded a fishing vessel."	MacCoy 1930 as cited in Griffin 1940

Exhibit 1, Table 1. Anecdotal and Survey Evidence of Bat Species Present Offshore

Species*	Season or Date	Location	Observation Type	Notes	Citation
unknown	September 7, 1937	45°07'N 42°36'W (500 miles from Cape Race, Newfoundland, 85 hours out of NY)	anecdotal	bat "… flew within 15 or 20 feed [of the ship] but could not be captured."	Griffin 1940
LANO	August 25, 1938	39°09'N, 70°22'W (130 miles SE of Nantucket Island, MA)	anecdotal	three bats captured on the *Atlantis*	Griffin 1940
PLAU	November 1948	45 miles northeast of Spurn Point, Yorkshire, UK	anecdotal	"group" of bats apparently traveling southwest, which "alighted on a ship"	Blackmore 1964 as cited in Corbet 1970
LABO	September 29, 1949	40°10'N 71°00'W about 65 miles offshore	anecdotal	approximately 200 seen flying about the ship	Carter 1950
LABO	October 7, 1952	150 miles south-southeast of Liverpool (42°42'N, 62°58'W)	anecdotal		Brown 1953 as cited in Peterson 1970
LANO	August 19, 1953	"39°36'N, 71°03'W (about 95 miles SSE of Montauk Pt., Long Island, the nearest land)"	anecdotal	individual "…circled the ship several times before coming to rest."	Mackiewicz and Backus 1956
LABO	August 25, 1953	39°38'N, 70°19'W (about 90 miles SSE of Montauk Point)	anecdotal	individual captured in ship rigging	Mackiewicz and Backus 1956
LAEG	March 15, 1960	335 km from Argentina coast	anecdotal		Van Deusen 1961 as cited in Esbérard and Moreira 2006
PLAU	27 October 1968	52° 35' N, 1° 41' E, about 30 miles east of Yarmouth, Norfolk, UK	anecdotal	Male found dead on Smiths Knoll lightship. Occurrence coincided with large flock of migratory birds originating from Scandinavia	Corbet 1970
LABO	October 1969	90 miles south of Yarmouth (42°30'N, 66°10'W)	anecdotal	adult female aboard ship	Peterson 1970
LAEG	April 9, 2002	145 km from Brazil coast	anecdotal	adult male landed on a ship	Esbérard and Moreira 2006

Exhibit 1, Table 1. Anecdotal and Survey Evidence of Bat Species Present Offshore

Species*	Season or Date	Location	Observation Type	Notes	Citation
EPNI, EPSE, NYNO, PINA, VEMU	spring and fall, 1988 to 2007	offshore platforms in the Dutch sector of the North Sea	anecdotal	observations were reported from 27 offshore platforms; most observations from platforms 60 to 80 km offshore	Boshamer and Bekker 2008
EPNI, EPSE, MYDAS, MYDAU, NYLE, NYNO, PINA, PIPI, PIPY, PLAU, VEMU	July to October 2005, 2006, and 2008	Over the water of the Öresund, Kattegat, and Kalmarsund Seas	survey	Distance from nearest coast to observation sites ranged from 11.8 km to 19.1 km	Ahlén 2006, Ahlén et al. 2007, Ahlén et al 2009
LABO, LACI, BBSH, MYSP	Mar to June and Aug to Oct 2009; spring and fall 2010	Ships used: (1) transects perpendicular to the NJ coast; (2) locations from Buzzards Bay, MA to Cape Hatteras, NC; (3) transects 1-8 km from shore (max 7-12 km from shore), perpendicular to MD coast; (4) locations from coastal NJ to NC; (5) 166 km off mid-Atlantic coast, originating from Lewes, DE.	survey	acoustic survey; ships traveld an average distance of 20, 12, 18, 6, and 85 km from shore, respectively (max: 73, 26, 24, 16, 166 km, respectively); bat activity recorded an average of 8.7 km from shore, max of 21.9 km from shore	Sjollema 2011

*BBSH = big brown bat (*Eptesicus fuscus*) or silver-haired bat (*Lasionycteris noctivagans*); EPNI = northern bat (*Eptesicus nilssonii*); EPSE = serotine bat (*Eptesicus serotinus*); LABO = eastern red bat (*Lasiurus borealis*); LACI = hoary bat (*Lasiurus cinereus*); LAEG = southern yellow bat (*Lasiurus ega*); LANO = silver-haired bat (*Lasionycteris noctivagans*); MYDAS = pond bat (*Myotis dasycneme*); MYDAU = Daubenton's bat (*Myotis daubentonii*); MYSP = bats of the *Myotis* genus; NYLE = lesser noctule (*Nyctalus leisleri*); NYNO = noctule bat (*Nyctalus noctula*); PINA = Nathusius' pipistrelle (*Pipistrellus nathusii*); PIPI = common pipistrelle (*Pipistrellus pipistrellus*); PIPY = pygmy pipistrelle (*Pipistrellus pygmaeus*); PLAU = brown long-eared bat (*Plecotus auritus*); VEMU = parti-colored bat (*Vespertilio murinus*)

Exhibit 1, Table 2

Anecdotal and Survey Evidence of Bat Species Present on Islands

Species*	Season or Date	Location	Observation Type	Notes	Citation
LANO	October 8, 1850	Bermuda	anecdotal	"Only one specimen of this Bat is known to have occurred in the Bermudas. It was taken alive near Hamilton…"	Jones 1884 as cited in Van Gelder and Wingate 1961
LACI	autumn	Bermuda	anecdotal	"…observed occasionally at dusk during the autumn months… but as it is never seen except at that particular season it is clear that it is not a resident…"	Jones 1884 as cited in Griffin 1940
LABO	unknown, October (respectively, by citation)	Bermuda	anecdotal		Allen 1923, Van Gelder and Wingate 1961
LACI	autumn, unknown, November (respectively, by citation)	Bermuda	anecdotal		Merriam 1887, Allen 1923, Van Gelder and Wingate 1961
LANO	October, unknown, October and November (respectively, by citation)	Bermuda	anecdotal		Merriam 1887, Allen 1923, Van Gelder and Wingate 1961
LASE	August, 8 February 2007 (respectively by citation)	Bermuda	anecdotal	February observation: male found roosting in a cherry bush	Van Gelder and Wingate 1961, Wingate 2007
PESU	November 5, 2004	Bermuda	anecdotal	not clear whether it arrived on island with human assistance	Wingate 2005a, 2005b as cited in Grady and Olson 2006

Exhibit 1, Table 2. Anecdotal and Survey Evidence of Bat Species Present on Islands

Species*	Season or Date	Location	Observation Type	Notes	Citation
LANO	spring and fall	Mount Desert Rock, 30 miles off coast of Maine	anecdotal	"…a few small dark-colored bats visit the place during the migrations, every spring and fall."	Merriam 1887
LACI	first week of April 1961	Southeast Farallon Island (30 miles W of San Francisco, CA)	anecdotal	this species regularly appears on the island (Cryan 2003)	Farentinos and Hawkins unpubl. data as cited in Tenaza 1966
LACI	early fall 1965	Southeast Farallon Island (30 miles W of San Francisco, CA)	anecdotal	this species regularly appears on the island (Cryan 2003)	Tenaza 1966
NYLE	24 July 1968	Nissetter, Ollaberry, Shetland	anecdotal	Male found on the ground, outside normal range; authors suggest it may have followed favorable down-winds from the direction of eastern England or the southern North Sea.	Corbet 1970
LACI	295 days of observations between August 10 and November 11 during all but 2 of the 38 autumns that records were kept (1968 - 2005); also on 7 days during late April/early May 1990	Southeast Farallon Island (30 miles W of San Francisco, CA)	anecdotal / survey	summarized daily observations from routine censuses of birds and marine mammals noted in standardized journals	Cryan and Brown 2007

Exhibit 1, Table 2. Anecdotal and Survey Evidence of Bat Species Present on Islands

Species*	Season or Date	Location	Observation Type	Notes	Citation
BABA, MYBR/MY, MYNA	July to October 2005, 2006, and 2008	Gotland, Öland, Bornholm, Falster, Lolland, Saltholm, and Peberholm Islands (of the Scandinavian Peninsula and of southern Sweden and Denmark); approximately 54° - 57°N and 11° - 19°E)	survey	true island observations from Gotland (38 mi from land), Öland (5 mi from land), and Bornholm (23 mi from land); remaining islands should be considered "coastal" observations by definitions in this review	Ahlén et al 2009

*BABA = barbastelle bat (*Barbastella barbastellus*); LABO = eastern red bat (*Lasiurus borealis*); LACI = hoary bat (*Lasiurus cinereus*); LANO = silver-haired bat (*Lasionycteris noctivagans*); LASE = seminole bat (*Lasiurus seminolus*); MYBR/MY = Brandt's bat/whiskered bat (*Myotis brandtii/mystacinus*); MYNA = Natterer's bat (*Myotis nattereri*); NYLE = lesser noctule (*Nyctalus leisleri*); PESU = tri-colored bat (*Perimyotis subflavus*)

Exhibit 1, Table 3

Anecdotal and Survey Evidence of Bat Species Present on the Coast

Species*	Season or Date	Location	Observation Type	Location Type	Notes	Citation
LACI	November	Weehawken, NJ	anecdotal	coastal		Merriam 1887
LACI	December 12, 1841	Long Island, NY	anecdotal	coastal		Merriam 1887
LACI	autumn 1885	Staten Island, NY	anecdotal	coastal		Merriam 1887
LACI	October 1885	New Lots, Long Island, NY	anecdotal	coastal		Merriam 1887
LACI	September 10, 1883	Maplewood, NJ	anecdotal	coastal		Merriam 1887
LACI	September 30, 1878	Riverdale, NY	anecdotal	coastal		Merriam 1887
LACI	November 1887	Baltimore, MD	anecdotal	coastal		Merriam 1887
LANO	October 1885	Staten Island, NY	anecdotal	coastal		Merriam 1887
LANO	November 12, 1885	Washington, DC	anecdotal	coastal		Merriam 1887
LABO	9 observation nights between August 21 and September 12, 1890; and 14 observation nights between August 25 and September 13, 1891	Highland Light, Cape Cod	anecdotal	lighthouse is on peninsula but is separated from mainland to east and northeast by 25 to 50 miles of water	approximately 31 individuals observed over 9 nights in 1890; approximately 50 individuals observed over 14 nights in 1891	Miller 1897
LACI	9 observation nights between August 21 and September 12, 1890; and 14 observation nights between August 25 and September 13, 1891	Highland Light, Cape Cod	anecdotal	lighthouse is on peninsula but is separated from mainland to east and northeast by 25 to 50 miles of water	approximately 13 individuals observed in 1890; approximately 3 observed in 1891	Miller 1897

Exhibit 1, Table 3. Anecdotal and Survey Evidence of Bat Species Present on the Coast

Species*	Season or Date	Location	Observation Type	Location Type	Notes	Citation
LANO	9 observation nights between August 21 and September 12, 1890; and 14 observation nights between August 25 and September 13, 1891	Highland Light, Cape Cod	anecdotal	lighthouse is on peninsula but is separated from mainland to east and northeast by 25 to 50 miles of water	approximately 13 individuals observed in 1890; approximately 28 observed in 1891	Miller 1897
LANO	October 28, 1889	Highland Light, Cape Cod	anecdotal	island or coastal (see above)	killed at lighthouse	Miller 1897
LACI	October 26, 1952	Santa Rosa Island, FL, a barrier island with a maximum distance of 2 miles from the mainland	anecdotal	island	found dead in an advanced state of decay	Cooley 1954
LABO	November 24, 2006	Eastern Shore of Virginia National Wildlife Refuge, at southern tip of Delmarva Peninsula, VA	anecdotal	coastal	mating observed	McConnell 2007
LACI	spring	west coast, US	anecdotal	coastal	males disperse north along the west coast	Cryan 2003
LACI	autumn	west coast, US	anecdotal	coastal	females disperse south along the west coast	Cryan 2003
LABO	winter	east coast, US	anecdotal	coastal	occurs throughout coastal Atlantic and Gulf of Mexico regions (spring migration expands inland)	Cryan 2003
LABO	autumn	east coast, US	anecdotal	coastal	high densities on Atlantic Coast after June may indicate shoreline migration	Cryan 2003

Exhibit 1, Table 3. Anecdotal and Survey Evidence of Bat Species Present on the Coast

Species*	Season or Date	Location	Observation Type	Location Type	Notes	Citation
LABL	spring, autumn	west coast, US	anecdotal	coastal	records along coast during spring and fall migration	Cryan 2003
LANO	autumn	east coast, US	anecdotal	coastal	records along northern Atlantic Coast indicate some migration along coastlines.	Cryan 2003
LANO	year round	west coast, US	anecdotal	coastal	consistent museum records exist along Pacific Coast	Cryan 2003
PESU	unknown	Charleston county, SC	anecdotal	coastal	museum records	Menzel et al. 2003
NYHU	unknown	Charleston, Beaufort counties, SC	anecdotal	coastal	museum records, literature review, capture record, rabies record	Menzel et al. 2003
MYAU	unknown	Charleston, Beaufort counties, SC	anecdotal	coastal	capture record, museum record	Menzel et al. 2003
MYLU	unknown	Beaufort county, SC	anecdotal	coastal	literature review, museum specimen	Menzel et al. 2003
CORA	unknown	Georgetown, Charleston, Beaufort counties, SC	anecdotal	coastal	museum records, literature review, capture record	Menzel et al. 2003
LANO	unknown	Charleston county, SC	anecdotal	coastal	museum records, literature review	Menzel et al. 2003
LABO	unknown	Horry, Georgetown, Charleston, Beaufort counties	anecdotal	coastal	museum records, literature review, capture records, rabies records	Menzel et al. 2003
LASE	unknown	Horry, Georgetown, Charleston, Beaufort counties	anecdotal	coastal	museum records, literature review, capture records, rabies records	Menzel et al. 2003
LAIN	unknown	Georgetown, Charleston, Beaufort counties, SC	anecdotal	coastal	museum records, capture records, rabies records	Menzel et al. 2003

Exhibit 1, Table 3. Anecdotal and Survey Evidence of Bat Species Present on the Coast

Species*	Season or Date	Location	Observation Type	Location Type	Notes	Citation
LACI	unknown	Horry, Georgetown, Charleston, Beaufort counties	anecdotal	coastal	museum records, rabies records	Menzel et al. 2003
EPFU	unknown	Horry, Georgetown, Charleston, Beaufort counties	anecdotal	coastal	museum records, rabies records	Menzel et al. 2003
TABR	unknown	Horry, Georgetown, Charleston, Beaufort counties	anecdotal	coastal	museum records, rabies records	Menzel et al. 2003
BBSH, LABO, LACI, MYLU, MYSE, PESU, RBTB	late May, mid-June, mid-July, and early September	Kejimkujik National Park, Brier Island, and Bon Portage Island	survey	Nova Scotia, Canada, is a peninsula but is separated from the mainland to the south by 30 to 50 miles of water. Brier Island is separated from NS by about 8 miles; Bon Portage Island by about 2 miles.	acoustic and mist netting survey; BBSH, LACI, MYLU, MYSE, and RBTB were observed in early September, other observations during the summer months	Broders et al. 2003
MYLU, MYSE	summer to early fall	Bay of Fundy National Park, NB, Canada	survey	coastal	135 and 142 captures, respectively	Broders et al. 2006
LABO, BBSH, LACI, PESU, MYSP	Spring 2009 to fall 2010	Lakewood, Ocean Co., NJ; Cape May Co., NJ; Lewes, Sussex Co., Delaware; Worchester Co. MD	survey	coastal	acoustic monitoring	Sjollema 2011

Exhibit 1, Table 3. Anecdotal and Survey Evidence of Bat Species Present on the Coast

Species*	Season or Date	Location	Observation Type	Location Type	Notes	Citation
MYSE, MYLU, LABO, LACI, PESU, EPFU, LANO	April to October survey	Martha's Vineyard, MA (4 miles from mainland)	survey	island	MYSE, MYLU captured during mist netting; remaining species identified from acoustic surveys	Buresch 1999
EPFU, LABO, LACI, LANO, PESU	July - Aug 2005, June 2006, Oct 2006	Assateague Island National Seashore, MD (ranges from <1 km to 8 km off coast of MD and VA); 38° 10'N, 75° 10'W	survey	island	mist netting and acoustic monitoring	Johnson and Gates 2008
EPFU, LABO, LACI, LANO, PESU	July 2005 through December 2006	Assateague Island National Seashore, MD (ranges from <1 km to 8 km off coast of MD and VA); 38° 10'N, 75° 10'W	survey	island	acoustic monitoring	Johnson et al. 2011
MYLU, MYSE, EPFU	sometime during May to September survey	Mount Desert Island, ME (2 miles off coast)	survey	island		Zimmerman 1998
MYLE	sometime during May to September survey	"Schoodic Site" (which could be Schoodic Peninsula, Corea Heath, or Big Moose Island)	survey	island or coastal		Zimmerman 1998
LACI	sometime during May to September survey	"Schoodic Site" (which could be Schoodic Peninsula, Corea Heath, or Big Moose Island)	survey	island or coastal		Zimmerman 1998

Exhibit 1, Table 3. Anecdotal and Survey Evidence of Bat Species Present on the Coast

Species*	Season or Date	Location	Observation Type	Location Type	Notes	Citation
BABA, MYBR/MY, MYNA	July to October 2005, 2006, and 2008	Gotland, Öland, Bornholm, Falster, Lolland, Saltholm, and Peberholm Islands (of the Scandinavian Peninsula and of southern Sweden and Denmark); approximately 54° - 57°N and 11° -19°E	survey	island or coastal	true island observations from Gotland (38 mi from land), Öland (5 mi from land), and Bornholm (23 mi from land); remaining islands should be considered "coastal" observations by definitions in this review	Ahlén et al 2009

*BABA = barbastelle bat (*Barbastella barbastellus*); BBSH = big brown bat (*Eptesicus fuscus*) or silver-haired bat (*Lasionycteris noctivagans*); CORA = Rafinesque's big-eared bat (*Corynorhinus rafinesquii*); EPFU = big brown bat (*Eptesicus fuscus*); EPNI = northern bat (*Eptesicus nilssonii*); EPSE = serotine bat (*Eptesicus serotinus*); LABL = western red bat (*Lasiurus blossevillii*); LABO = eastern red bat (*Lasiurus borealis*); LACI = hoary bat (*Lasiurus cinereus*); LAEG = southern yellow bat (*Lasiurus ega*); LAIN = northern yellow bat (*Lasiurus intermedius*); LANO = silver-haired bat (*Lasionycteris noctivagans*); LASE = seminole bat (*Lasiurus seminolus*); MYAU = southeastern myotis (*Myotis austroriparius*); MYBR/MY = Brandt's bat/whiskered bat (*Myotis brandtii/mystacinus*); MYDAS = pond bat (*Myotis dasycneme*); MYDAU = Daubenton's bat (*Myotis daubentonii*); MYLE = small-footed bat (*Myotis leibii*); MYLU = little brown bat (*Myotis lucifugus*); MYNA = Natterer's bat (*Myotis nattereri*); MYSE = northern long-eared bat (*Myotis septentrionalis*); MYSP = bats of the *Myotis* genus; NYLE = lesser noctule (*Nyctalus leisleri*); NYHU = evening bat (*Nycticeius humeralis*); NYNO = noctule bat (*Nyctalus noctula*); PESU = tri-colored bat (*Perimyotis subflavus*); PINA = Nathusius' pipistrelle (*Pipistrellus nathusii*); PIPI = common pipistrelle (*Pipistrellus pipistrellus*); PIPY = pygmy pipistrelle (*Pipistrellus pygmaeus*); PLAU = brown long-eared bat (*Plecotus auritus*); RBTB = eastern red bat (*Lasiurus borealis*) or tri-colored bat (*Perimyotis subflavus*); TABR = Brazilian free-tailed bat (*Tadarida brasiliensis*); VEMU = parti-colored bat (*Vespertilio murinus*).

Exhibit 1, Table 4

Anecdotal and Survey Evidence of Bat Species Present on Long Point, Lake Erie

Species	Season or Date	Location	Observation Type	Notes	Citation
LABO	September 9, 1929	Long Point on Lake Erie	anecdotal	three killed at lighthouse along with 600 birds	Saunders 1930
LACI, LANO (?)	September 24 and 25, 1929	Long Point on Lake Erie	anecdotal	LACI and "Silver Gray Bat" killed at lighthouse along with birds	Saunders 1930
Unknown	October and November	Long Point on Lake Erie	anecdotal	killed at lighthouse	Saunders 1930
EPFU, LABO, LACI, LANO, MYLU, MYSE, PESU	June and August	Long Point on Lake Erie	survey	PESU, MYSE documented by mist netting, other species documented by both mist netting and acoustic surveys	Dzal et al 2009
LANO	August 20 to September 17, 2009	Long Point on Lake Erie	survey	used telemetry to determine that migration occurred in two waves (late August and mid-September), with most bats staying 1-2 days. Half the bats departed across Lake Erie (minimum crossing distance 38 km), half departed along the shoreline.	McGuire et al. 2012

*EPFU = big brown bat (*Eptesicus fuscus*); LABO = eastern red bat (*Lasiurus borealis*); LACI = hoary bat (*Lasiurus cinereus*); LANO = silver-haired bat (*Lasionycteris noctivagans*); MYLU = little brown bat (*Myotis lucifugus*); MYSE = northern long-eared bat (*Myotis septentrionalis*); PESU = tri-colored bat (*Perimyotis subflavus*).

Exhibit 2

Catalog of References

[Electronic copies of all references are included on DVD]

Appendix B

This report is a statistical comparison of acoustic bat activity data gathered from sited defined as three distinct classes: inland, coastal, and offshore. After examining geographic, annual, and regional replication, data from 33 sites were used to examine whether acoustic activity patterns differed among location types.

Appendix B

Information Synthesis on the Potential for Bat Interactions with Offshore Wind Facilities[1]

REPORT OF STATISTICAL COMPARISONS

Abstract

Though still largely undefined, bat activity patterns and incidences of bat mortality at terrestrial wind facilities are relatively well understood when compared to available information gathered to date in offshore regions. In order to aid future decisions on the siting and operation of offshore wind facilities, Stantec compared acoustic bat activity data gathered from sites located across a broad regional gradient extending from interior inland areas to the coast and offshore as far as 13 nautical miles (nm) beyond the US Submerged Lands Act (SLA) boundary. Ultimately, distance from shore was defined as three distinct classes: inland sites were more than 20 miles inside the SLA boundary; coastal sites were an intermediate class comprising sites within 20 miles of the SLA boundary with more than 1 percent land in the 3-nm circle around them; and offshore sites had less than 1 percent land within a 3-nm circle around them.

We assembled a database of 983,167 acoustic call files collected over 37,614 detector-nights from 61 sites spread across the regional gradient and monitored from 2005-2012. After examining geographic, annual, and regional replication, data from 33 sites were used to examine whether acoustic activity patterns differed among location types. Bat activity was modeled in two ways: (1) bat presence indicated as recording at least one call in a night (nightly occurrence), and (2) number of calls recorded per detector night (nightly intensity; also accumulated over 10-night periods).

Bat activity was observed at all inland, coastal and offshore survey sites, indicating bats were active offshore at least as far as the most remote detectors. Levels of observed offshore activity were comparable between migratory and non-migratory species, and migratory bats were about equally likely to be recorded offshore as at coastal or inland sites. In contrast, non-migratory bats were less likely to be recorded at offshore sites relative to observed levels of activity at coastal and inland sites.

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[1] This report was prepared by Stantec Consulting Services Inc. for US Department of the Interior, Bureau of Ocean Energy Management. The material in it reflects Stantec's judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third parties. Stantec accepts no responsibility for damages, if any suffered by any third party as a result of decisions made or actions based on this report.

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1.0 Introduction

Bat mortality at a terrestrial wind facility currently affects nearly a quarter of all bat species occurring in North America and increasingly evident as land-based turbines have increased in total height and size (Barclay et al. 2007; Ellison 2012). Although still beset by many unknowns, the impacts of land-based wind energy development and operation on bats are relatively well understood when compared to those associated with development of offshore wind energy projects. Consequently, as interest in offshore energy escalates, potential resource conflicts — including collision mortality of local and migratory bats — remain a key ecological concern to federal and state resource agencies, developers, and general members of the public.

Stantec compiled available long-term acoustic bat datasets gathered from sites located across a regional gradient in order to quantitatively compare bat activity levels and patterns of movement among offshore, coastal and inland sites. Sites ranged from interior inland areas to the coast and as far as 13 nautical miles (nm) beyond the federally regulated Submerged Lands Act (SLA) boundary. Data sets were limited to those meeting certain regional and seasonal criteria and inspected to ensure adequate quality and consistency during the data collection process. Bat activity levels and patterns were modeled to estimate the effect of the inland-coastal-offshore gradient taking into account variability within and among individual acoustic detectors, sites, and nights, as well as regional and seasonal variability. While anecdotal reports in the scientific literature reveal the sporadic occurrence of bats offshore, this document represents the first attempt to quantitatively compare regional bat activity levels onshore and offshore.

This analysis and statistical comparison is the second component of an effort funded by a federal contract administered by the Bureau of Ocean and Energy Management (BOEM), and builds on the knowledge gained through the literature review and study compilation completed by Stantec in June 2012. The results of these combined study efforts will contribute to the knowledge base necessary for public officials to pursue balanced decision-making in the management and development of renewable energy and alternate use projects within federal waters of the Outer Continental Shelf (OCS).[2]

2.0 Methods

2.1 SITE DATA ACQUISITION – COMPILATION OF STUDIES

Stantec compiled survey results of bat activity on the Atlantic OCS from published and unpublished sources and studies, including results from ongoing studies, through internet

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[2] The Atlantic OCS includes submerged lands beyond the limit of state ordinance (generally 3 nm) and extends at least 200 nm from the coast.

searches, telephone inquiries, library visits, personal contacts, and other means as able. Stantec contacted 21 additional entities to assess availability of acoustic data from coastal or offshore survey locations, with limited response. Entities varied and included federal and state regulatory and review agencies, academic and non-governmental institutions, commercial entities, and private consulting firms.

Included in the compilation are the results of standardized acoustic surveys conducted by Stantec at 42 inland sites surveyed between Virginia and Maine from 2004 through 2012, and 19 offshore/coastal sites off the coast of New England from Kent Island, New Brunswick southward to a Northeastern Regional Association of Coastal and Ocean Observing Systems (NERACOOS) buoy off the coast of Gloucester, Massachusetts. In addition to Stantec's own Gulf of Maine based research, another Stantec biologist, Angela Sjollema, recently completed a mid-Atlantic coastal bat study as part of her graduate work at the University of Maryland. Her studies involved collecting terrestrial and boat-based acoustic data along the mid-Atlantic coast from spring 2009 through fall 2010, and included coastal sites in New Jersey, Delaware, and Maryland. Other survey data utilized in the analysis were provided by US Fish and Wildlife Services' (USFWS) Maine Coastal Islands National Wildlife Refuge (MCINWR).

Throughout this report, the physical locations of detectors on the landscape (i.e., mapped latitude/longitude coordinates and elevation above ground) are individually referenced as "detectors." Multiple detectors placed within close proximity to each other within the boundaries of a project area (i.e., a proposed or operating wind facility) are referred to as "sites" throughout this document. Therefore, a site could include a single detector (as with most coastal and offshore sites), or a site could include multiple detectors (as with inland sites). At sites with multiple detectors, detectors were deployed no further than 10 miles apart.

We faced various challenges in the compilation of survey results, primarily related to the limited amount of available acoustic data offshore relative to onshore sites. Certain available offshore datasets were also collected sporadically, using unsuccessful methods, and were not directly comparable to more robust datasets. In addition, many acoustic datasets were collected using private funding and therefore were not readily available for this analysis and/or were collected during irregular timeframes and/or using standards inconsistent with other surveys. Datasets were therefore limited to those meeting certain methodological, regional, and seasonal criteria, which ultimately eliminated most of the data sources.

2.2 ACOUSTIC BAT EQUIPMENT AND DEPLOYMENT METHODS

Acoustic bat surveys that met the criteria for inclusion in the dataset were conducted primarily using Anabat ZCaim, SDI and SD2 detectors (Titley Electronics, Queensland, Australia) configured to record data continuously at night for extended periods. These detector types are commonly selected for acoustic data collection based upon their widespread use for this type of survey, their ability to be deployed for long periods of time, and their ability to detect a broad frequency range, which allows detection of all species of bats which could occur in the surrounding habitat. Anabat detectors are frequency division detectors, dividing the frequency of echolocation sounds made by bats by a factor of 16, and then recording a zero-crossing output onto removable compact flash cards for subsequent analysis.

One dataset was also collected using a full-spectrum SM2+ bat detector with data converted to zero-crossing format using WAC2WAV conversion software (Wildlife Acoustics, Concord, MA). Wildlife acoustics detectors are full-spectrum detectors which record the entire sound onto removable compact flash cards for subsequent analysis.

Detectors were deployed in meteorological towers, lighthouses, or other permanent towers; in portable guyed towers; on short tripods or trees, or on the structure of an anchored buoy.

2.3 ACOUSTIC CALL SEQUENCE IDENTIFICATION

Ultrasound recordings of bat echolocation may be broken into recordings of a single bat call or recordings of bat call sequences. A call is a single pulse of sound produced by a bat, while a call sequence is a combination of two or more pulses recorded in a zero-crossing Anabat file. Recordings containing less than two calls were eliminated from analysis as has been done in similar studies (Arnett et al. 2006). Call sequences typically include a series of calls characteristic of normal flight or prey location ("search phase") and capture periods (feeding "buzzes").

Call files collected from the Anabat detectors were extracted from data files using CFCread software. The default settings for CFCread were used during this file extraction process, as these settings are recommended for the calls that are characteristic of bats in the East. This software screens all data recorded by the bat detector and extracts call files using a filter. Using the default settings for this initial screen also provides for comparability between data sets. Settings used by the filter include a max TBC (time between calls) of 5 seconds, a minimum line length of 5 milliseconds, and a smoothing factor of 50. The smoothing factor refers to whether or not adjacent pixels can be connected with a smooth line. The higher the smoothing factor, the less restrictive the filter and the more noise files and poor quality call sequences that are retained within the data set.

Following extraction of call files using either CFCread, each file was visually inspected using AnalookW software (© Chris Corben) for species identification and to determine that only bat calls were included in the data set. Insect activity, wind, and interference were removed from the data set. Call sequences are easily differentiated from other recordings, which typically form a diffuse band of dots at either a constant frequency or widely varying frequency. Relatively accurate identification of bat species can be attained by visually comparing recorded call sequences of sufficient length to bat call reference libraries (O'Farrell et al. 1999; O'Farrell and Gannon 1999).

Call sequences were classified to species whenever possible, based on criteria developed from review of reference calls collected by Chris Corben, the developer of the Anabat system, as well as other bat researchers, as described in Johnson et al. 2011. To prevent misidentification of files, call sequences with less than five distinct call pulses, or those with ambiguous detail, were labeled as unknown calls and further dichotomized as either "high frequency unknown" (HFUN) for sequences with a minimum frequency above 30 to 35 kHz, or "low frequency unknown" (LFUN) for sequences with a minimum frequency below 30 to 35 kHz. In the northeast region, high frequency low quality calls labeled as HFUN may represent a *Myotis* species, eastern red bats, or tri-colored bats, while calls identified as LFUN may represent big brown, silver-haired, or hoary bats. Table 2-1 summarizes the hierarchy of call identification present in the dataset included in our analysis. Coding of identity was standardized as part of the data cleaning effort. Migratory and non-migratory categories were assigned to individual species groups as indicated in Table 2-1.

High quality call recordings with a minimum of five call pulses were identified to species whenever possible. While there are some general characteristics believed to be distinctive for several *Myotis* species, call characteristics within the genus *Myotis* often overlap (Table 2-1). To prevent misidentification of *Myotis* species, calls with characteristic parameters were placed in a single *Myotis* species guild (MYSP).

Although divergent in both size and prey preferences, significant overlap may occur between the calls of the red bat and tri-colored bat; however, within their call repertoire both bats often exhibit diagnostic calls making them easily identifiable to species. In cases where species differentiation was not possible, a call was given an intermediate guild label of RBTB signifying either a red bat or tri-colored bat. Big brown and silver-haired bats produce lower frequency calls, providing a second example of two species with frequently overlapping call characteristics. However, once again both species are capable of producing a call unique to that species. Calls with overlapping characteristics of big brown and silver-haired were assigned a guild label of BBSH. Lowest on the frequency scale, hoary bat calls are usually distinguished from those of big brown and silver-haired bats by a variable minimum frequency extending below 20 kHz. Calls had been identified at various levels in the hierarchy are outlined in Table 2-1. Coding of identity was standardized as part of the data cleaning effort. Migratory and non-migratory categories were assigned to individual species groups as indicated in Table 2-1.

Table 2-1

Bat Call Identification.

Calls were identified to species as able, others were ambiguous between two species (e.g., big brown and silver-haired bat), and others were identifiable only as high-frequency or low-frequency bats

Superguild Code	Guild Code	Species Code	Genus	Species	Common Name	Migratory
HFBAT	MYSP	MYSP	Myotis	spp.	eastern small-footed myotis (*M. leibii*), northern myotis (*M. septentrionalis*), little brown myotis (*M. lucifugus*), or Indiana myotis (*M. sodalis*)	No
HFBAT	RBTB	LABO	Lasiurus	borealis	eastern red bat	Yes
HFBAT	RBTB	PESU	Perimyotis	subflavus	Tri-colored bat (eastern pipistrelle)	No
HFBAT	RBTB	unknown			eastern red bat or tricolored bat	
HFBAT	unknown	LAB5			probably eastern red bat but with fewer than 5 pulses	
HFBAT	unknown	NYHU	Nycticeius	humeralis	evening bat	
HFBAT	unknown	unknown			unidentified high-frequency bat (*Myotis* spp., eastern red, or tricolored bat)	

Table 2-1. Bat Call Identification. Calls were identified to species as able, others were ambiguous between two species (e.g., big brown and silver-haired bat), and others were identifiable only as high-frequency or low-frequency bats.

Superguild Code	Guild Code	Species Code	Genus	Species	Common Name	Migratory
LFBAT	HB	LACI	Lasiurus	cinereus	hoary bat	Yes
LFBAT	BBSH	EPFU	Eptesicus	fuscus	big brown bat	No
LFBAT	BBSH	LANO	Lasionycteris	noctivagans	silver-haired bat	Yes
LFBAT	BBSH	unknown			big brown bat or silver-haired bat	
LFBAT	unknown	LAC5			probably hoary bat but with fewer than 5 pulses	
LFBAT	unknown	LAN5			probably silver-haired bat but with fewer than 5 pulses	
LFBAT	unknown	unknown			an unidentified low-frequency bat (hoary, big brown, or silver-haired bat)	
unknown	unknown	unknown			an unidentified bat	

2.4 DATA IMPORT AND CLEANING

Data recorded and stored in each deployed detector included files of individual acoustic recordings, as well as files representing detector operation (e.g., times when each detector turned on each night and off each morning). Information from individual files recovered from detectors was summarized into tables. Each site had one (or more) "detector status" table(s) and one (or more) "acoustic analysis" table(s). If a site's data for a given year were divided into more than one file (e.g., spring and fall seasons, or by subsets of detectors), data were appended into a single table as they were imported and data standardization was implemented on the entire table.

Detector status tables listed the nights each detector was deployed at a site and whether the detector operated properly each night (i.e., a "1" for a full night of successful operation, and a "0" for a night of unsuccessful operation). From those data, a simple table was extracted listing the nights each detector operated. Acoustic analysis tables had a record for each bat call and essential fields naming the detector that had recorded the call, the time the call was recorded (precise to the second), and the identity of the bat to species, guild, or superguild (Table 2-1).

Data were read into R software (R Core Team 2012) from the project's data directory using automated scripts that ensured standardized fields and formats. Data were cleaned within R to standardize names of sites, detectors, and dates. For each year within each project site, the table representing the acoustic data was merged with the list of detector-nights. Nights when the detector was documented to have operated properly but no calls were recorded were retained in the merged table with NA in fields for the identity and time of bat calls. Calls that were recorded when the detector was not documented to have operated properly were omitted (see Section 2.4.1, Data Omissions, below).

Detector identity was re-coded as *xyz.factor* representing latitude, longitude, and altitude above the ground, which ensured that detectors deployed in essentially the same airspace had the same identity across years. This coding method designated detector identity as a nested factor within sites for random effects modeling to ensure that no level of *xyz factor* occurred in more than one site. Detectors within sites were no more than 10 miles apart.

Information about project sites and detectors deployed within projects, i.e., metadata, was also assembled in a Microsoft Excel spreadsheet, which was imported to R. We omitted rows from the metadata table associated with detectors that had already been omitted.

2.4.1 Data Omissions

Records were purposely excluded from the analysis in certain instances for particular reasons, including cases where records were included from detectors that were deployed as duplicate pairs. In such cases, records from the detector that operated successfully on more nights were retained while records from the duplicate detector were omitted. Records from detectors deployed higher than 50 m (i.e., on wind tower nacelles) were also omitted, due to a lack of replication across inland sites, and the complete absence of data collected at similar heights in coastal or offshore classifications. Finally, there were 5,364 calls in the database that were attributed to nights when the given detector was not documented to have been operating properly (for example, the detector may not have operated properly for a full survey night due to issues with battery power), and such calls were not included.

2.4.2 Coastal Classification

The federal SLA boundary is located 3 nm from the coast, and defines the "seaward limit of a state's submerged lands and the landward boundary of federally managed… lands."[3] On the Atlantic, BOEM's jurisdiction on the OCS generally begins 3 nm off the coast and extends at least 200 nm.

For the purposes of this study, sites were classified based on their distance from the SLA boundary (Figure 2-1), as well as the proportion of land area (vs. water) encompassed by a 3-nm circle around the site:

- "inland" sites were more than 20 miles inside the SLA boundary;
- "coastal" sites consisted of an intermediate class comprising locations within 20 miles of the SLA boundary but with more than 1 percent land in the 3-nm circle around them; and
- "offshore" sites had less than 1 percent land in the 3-nm circle around them, i.e., that circle encompassed 99 percent or more ocean water (Exhibit 1, Table 1).

Because the SLA boundary bulges or bubbles around even the smallest islands, by definition all US territorial land is within the SLA boundary. If we had distinguished coastal from offshore for every site by using the SLA boundary, then 3 sites located on the smallest islands far off the coast of Maine would have been assigned a coastal classification simply because these islands have exposed land. For these 3 sites, where the SLA boundary formed a bulge or a bubble around the island, we drew a straight line pinching off the bulge and classified these sites as offshore. To calculate the distance to the SLA boundary, we measured the orthogonal distance from the straight line to the site; where a site was in a bubble of the SLA boundary, we measured the shortest orthogonal distance to the boundary around the mainland.

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[3] http://www.data.gov/ocean/datasets/atlantic-nad83-submerged-lands-act-boundary

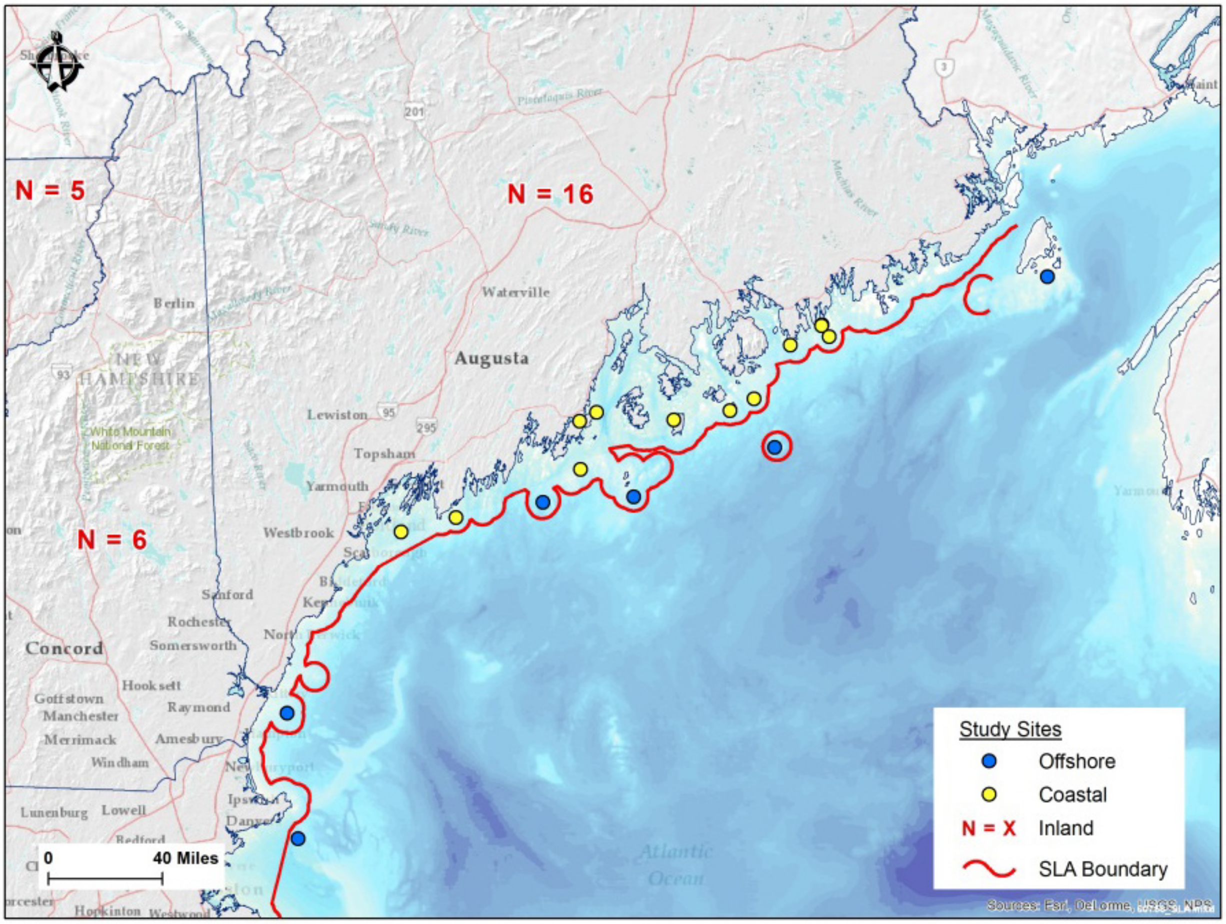

Figure 2-1. Coastal and offshore classifications as they relate to the SLA boundary. Note three sites within the SLA boundary are classified as "offshore" for the purposes of this analysis. Only the most southerly 'offshore' location however occurs within federally regulated waters.

2.4.3 Assembled Database of Bat Calls

The fully assembled database comprised 37,614 detector-nights from 61 sites monitored over the years 2005-2012. The geographic range of all sites extended from the Bay of Fundy to West Virginia (Figure 2-2). The total number of bat calls recorded was 983,167. Of that total, 499,048 (50.8%) were *Myotis* spp.; 145,665 (14.8%) were big brown bat (*Eptesicus fuscus*) or silver-haired bat (*Lasionycteris noctivagans*); 102,061 (10.4%) were eastern red bat (*Lasiurus borealis*) or tri-colored bat (*Perimyotis subflavus*), and 34,147 (3.47%) were hoary bat (*Lasiurus cinereus*). Grouping identified bats by hibernation and migratory behavior, 530,459 calls (54.0%) were attributed to hibernating species, 72,076 (7.33%) were attributed to migratory bats, and the remainder were indeterminate. This fully assembled database was then limited for the final analysis based on the following sections.

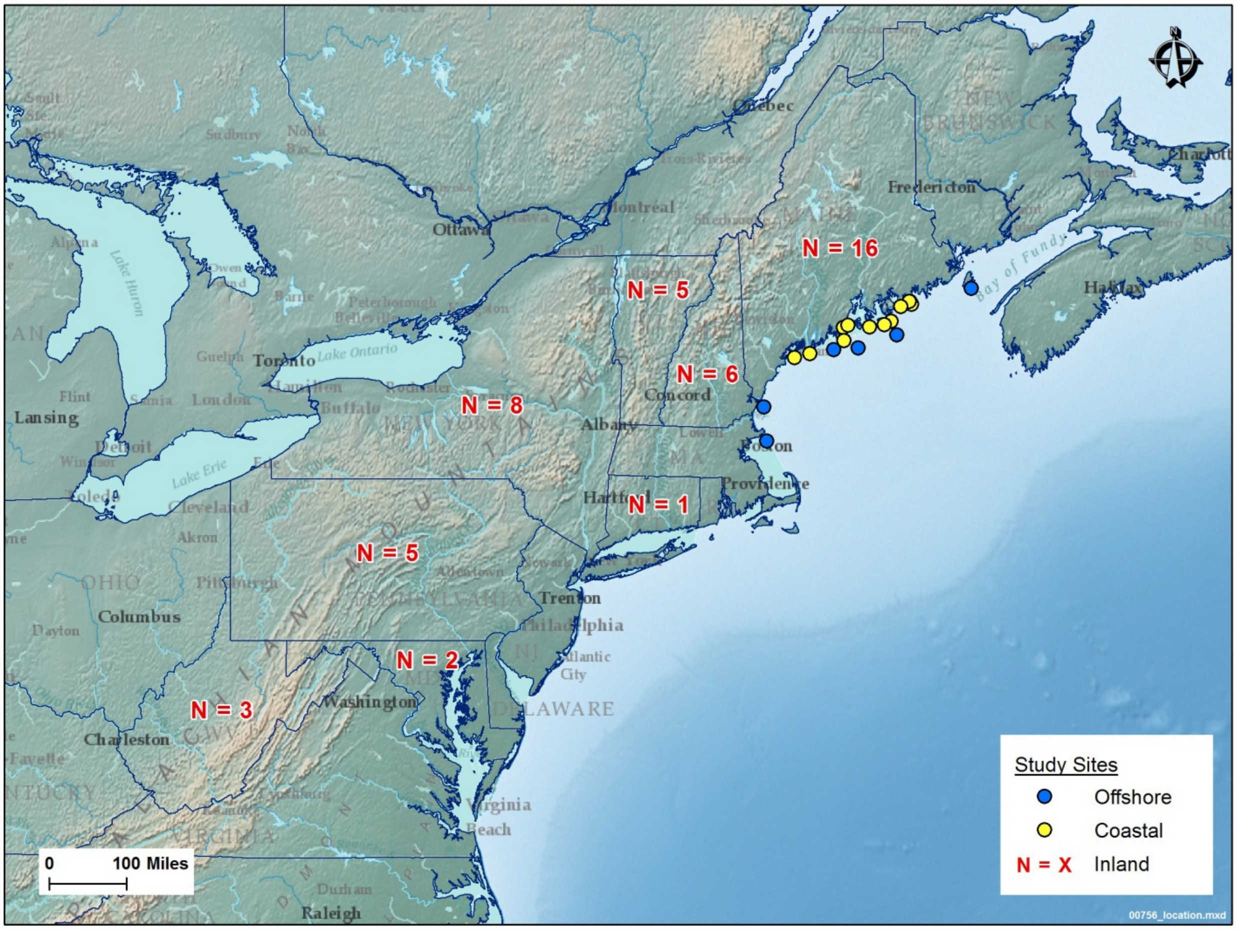

Figure 2-2 Initial Offshore, Coastal, and Inland Study Site Locations. Inland sites are represented by the total number of sites within each state in order to maintain anonymity.

2.5 DATA LIMITATIONS

2.5.1 Seasonal Limitations

To facilitate identifying seasons and modeling variation in bat activity across the seasons, nights were assigned to half-months with the first half of each month being from the night of the first through the night of the 15th and the second half being from the night of the 16th through the night of the 30th or 31st. We considered a detector to have captured representative data if it operated 10 or more of the 15 or 16 nights in a half-month. Conversely, detectors that were deployed near the end of a half-month, or that were removed from the field early in a half-month, or that experienced technical difficulty and recorded calls on 9 or fewer nights were not considered to have captured representative data. A large majority (65%) of detectors operated for 15 or 16 nights per half-month, and another 10% operated for 10-14 nights. The number of detector-nights lost due to excluding data from half-months that were poorly represented was 3,703, representing less than 10% of total detector-nights.

Detectors were deployed at coastal and/or offshore sites in 2009, 2010, and 2011. For the most part, they operated from after the summer maternity season through the fall of each year. Detectors were not removed from two sites[4] at the end of 2010, and they continued to operate into the spring of 2011.

Detectors were deployed at inland sites according to project needs but were seldom left operating into the month of November. Quantitative comparison of bat activity among offshore, coastal, and inland localities was therefore largely limited to early August through the end of October for the years 2009, 2010, and 2011.

2.5.2 Regional Limitations

Despite efforts to acquire data from coastal and/or offshore sites in the Mid-Atlantic States, our database was limited to data from coastal and offshore sites off the New England coast from Kent Island at the mouth of the Bay of Fundy to a buoy off Gloucester in Massachusetts Bay. Considering differences in the bat community between New England and the Mid-Atlantic region, we chose to omit data from inland sites in New York, Pennsylvania, Maryland, and West Virginia. We assumed that differences in latitude between New England and other Mid-Atlantic states could lead to differences in climate patterns. These differences in turn likely affected seasonal timing of bat migration, parturition, volancy, and even foraging, as insect activity timing and duration could vary among regions (Bradshaw and Holzapfel 2008; Wolda 1988). Ultimately, nightly and seasonal timing of activity could be inherently different among Mid-Atlantic and New England states, and it did not seem appropriate or useful to compare inland acoustic activity in New York, Pennsylvania, Maryland, or West Virginia with offshore activity hundreds of miles away in the Gulf of Maine.

White Nose Syndrome (WNS), an emerging fungal pathogen, was first detected in New York during the winter of 2006-2007 and spread across the region during the period represented by these data. It has since spread rapidly, killing more than 5.7 to 6.7 million bats in eastern North America (http://whitenosesyndrome.org). Its presence introduced a potent compounding variable since it likely did not influence offshore and coastal sites until 2010 at the earliest. We have found that the impact of WNS is not observed in acoustic data until 2 or more years after WNS reaches an area (Boyden et al. 2013; Watrous et al. 2011), yet in the database assembled for this analysis, the only sites representing 2 or more years after WNS arrived are all inland sites. Particularly for the hibernating species (big brown bat, *Myotis* spp., tri-colored bat), it may be necessary to explicitly model the impact of WNS on presence and activity levels, or to restrict the included data to years prior to the known arrival of WNS in an area (county). The impact of WNS was modeled 2 ways: either as a continuous predictor representing the number of years since WNS was first reported in the county where the detector was located (non-negative) or as a binary indicator of WNS presence. It should be noted, however, that the two representations do not differ substantially, particularly when viewed in the context of the coastal classification,

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[4] Great Duck Island (4/1-5/31) and Mount Desert Rock (4/1-9/17)

because whereas about half of the inland data come from site-year combinations one to four years after the arrival of WNS almost all of the coastal and offshore data are from before WNS hit. Therefore, they are represented by a 0 for both variables.

2.5.3 Analyzed Database of Bat Calls

The fully assembled database of call files contained data from 61 sites. Restricting the analysis to New England states diminished the number of sites to 43. Further restricting the database to call files recorded between 2009 and 2010 diminished the number of sites to 36. Finally, restricting the database to half-months where at least one inland and at least one coastal or offshore site were represented pared the final database down to 33 sites (Exhibit 1, Table 1). The pared-down database comprised 9,534 detector nights from 17 inland and 16 offshore/coastal sites. The number of detectors deployed at inland sites was generally three to nine, while data were obtained from only one detector at coastal and offshore sites[5] except for Kent Island where two detectors were used. The periods covered are: 2009, early August through late October; 2010, mid-July through late October; and 2011, early July through mid-October. These records included 218,525 calls in total: 71,668 (32.8%) *Myotis* spp.; 52,596 (24.1%) big brown or silver-haired bats; 47,869 (21.9%) eastern red or tricolored bats; and 9,460 (4.33%) hoary bats. There were 86,379 calls (39.5%) attributable to hibernating species and 26,891 (12.3%) attributable to migratory bats.

There were also data from two offshore/coastal sites and 4 inland sites collected in the spring of 2011 (mid-April through late June). These data were not included in modeling but were reported descriptively.

2.6 STATISTICAL DATA MODELING

Statistical data modeling and graphical data presentation were performed in the R environment (R Core Team 2012). Package Lattice (Sarkar 2008) was used in exploratory analyses to visualize acoustic bat activity with respect to independent variables and covariates as well as to prepare some of the figures in this report. Package lme4 (Bates et al. 2012) was used to fit linear and generalized linear mixed effects models; package MASS (Venables and Ripley 1999) was used to fit negative binomial regression models.

Model selection was based primarily on Akaike's Information Criterion (AIC) but also with reference to likelihood ratio tests (LRT) and the Bayesian Information Criterion (BIC; Johnson and Omland 2004).

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[5] Where detectors were deployed in pairs, data were retained only from the one of each pair that operated the greater number of nights.

3.0 Results

3.1 DATA DESCRIPTION

The number of bat calls recorded by each detector was highly variable (Figure 3-1). Continuously operating detectors recorded tremendous variability with changes in call activity night-to-night as large as 1,000-fold (e.g., 1 call recorded one night followed by 966 the next). Additionally, there was a great deal of variation in the number of calls recorded on a given night by detectors deployed within a single site with 1,000-fold differences between detectors on a given night (e.g., two detectors separated by about 1 mile, both 5 m above the ground, recorded 1 and 1,016 bat calls one night; both detectors fluctuated across the range 1-1,000 throughout that half-month period). Few sites were observed over multiple years,[6] but those that were observed revealed broad similarity of bat activity from year-to-year within a site. Variance components attributable to site, detector nested in site, year, and night nested in year are reported after the candidate models are described and one of the models is selected.

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[6] Three locales were observed over three seasons (in Figure 3-1: c:812, c:813,o:805); eight were observed over two seasons (i:299, i:522, i:532, c:802, c:803, c:806, c:811, o:809).

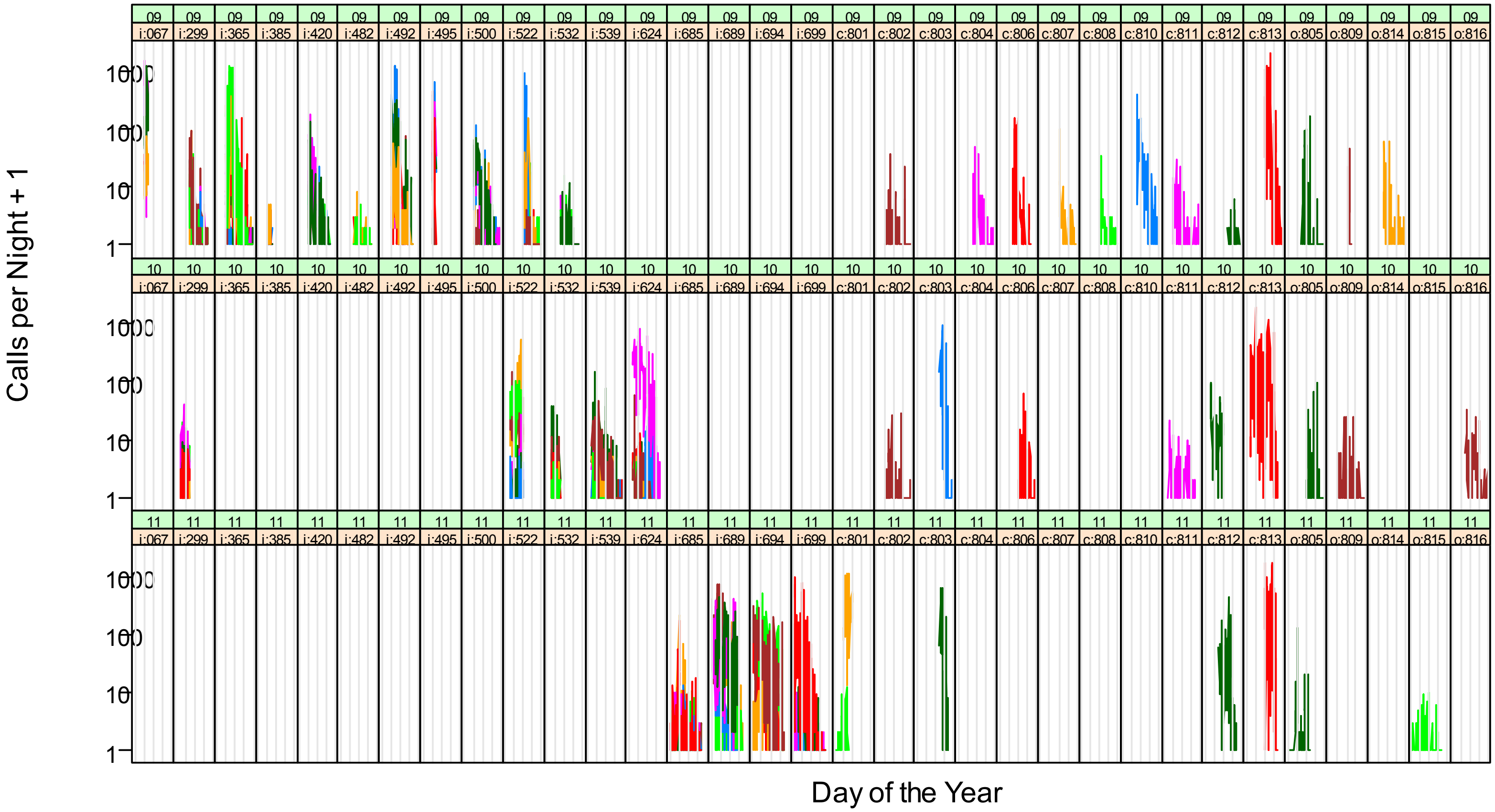


Figure 3-1 Time series plots of calls per night by site and year for seasons and sites representing inland, coastal, and offshore classes. On the y-axis, calls-per-night + 1 was used to enable plotting 0 counts on log scale. On the x-axis, day of the year from July 1 through November 1 was used with the first of each month indicated by the gray line. Sites are coded with first letter of inland, coastal, or offshore with a three numeral identifier (see Appendix A Table 1); inland sites leftmost columns (17 sites), offshore sites rightmost (5 sites), coastal sites in between (11 sites). Data from 2009 in top row, 2010 middle, 2011 bottom. Color coding indicates different detectors; note multiple detectors deployed at all inland sites (median 6, range 3-13) but generally one at coastal and offshore sites (exception: 2 detectors at c:801). Total detector-nights depicted: 9,534.

3.2 NIGHTLY OCCURRENCE OF BAT CALLS

A set of candidate models was fit to nightly occurrence data for all bats. The response variable was a binary indicator, 1 meaning that one or more bat calls were recorded by the detector and 0 meaning no bat calls were recorded. Each model in the candidate set had fixed effects of detector altitude and season, and they all had random effects of site, detector nested in site, year, and night nested in year. In addition, terms that were considered included WNS, geographic relationship with the coast, and elevation.

Several ways of representing bat activity across seasons were tried but ultimately the most satisfactory was to model half-month as a factor, permitting probability of detecting bats to vary freely among half-months. Modeled that way, the basic probability of detecting bat calls within a night, i.e., that probability at an inland site using a detector placed 10 m above the ground or lower and free of any random effects, peaked in late July and early August and declined to a very low level by the end of October (Figure 3-2). Detectors placed higher than 10 m were less likely to record bat calls than ones placed 10 m or lower, which was captured by the models.

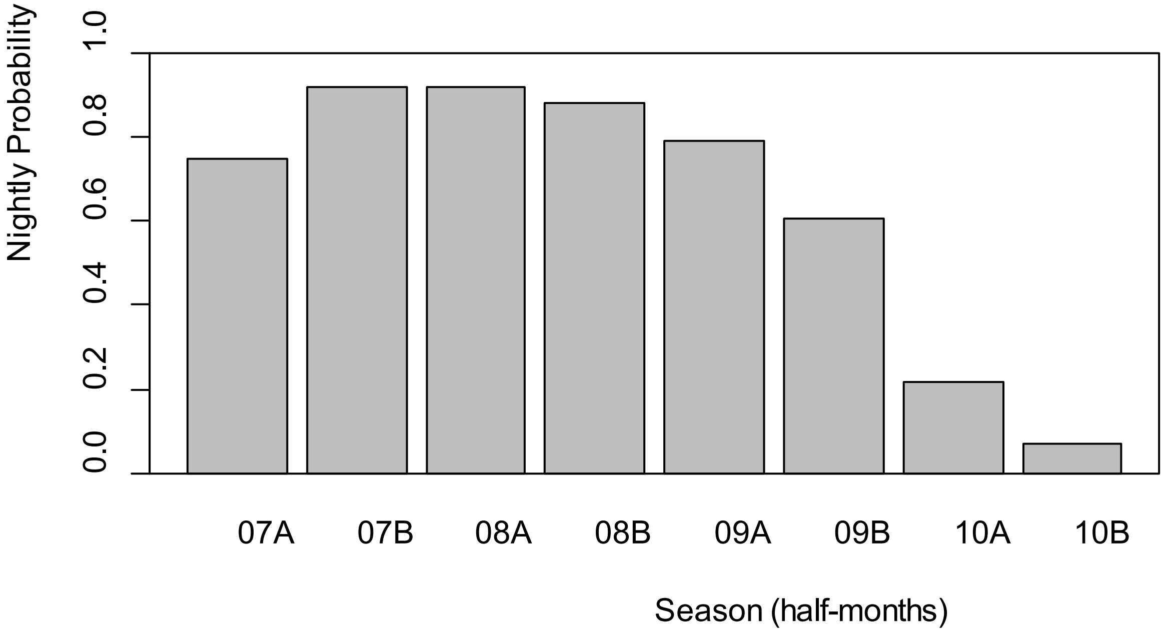


Figure 3-2 Model-based maximum likelihood estimates of the nightly probability of recording one or more bat calls by season. Season identified by half-month, July = 07 through October = 10 (first half = A, second half = B). Illustrated are estimates from a model with an additional fixed effect of altitude (estimates are implicitly for low detectors) with random effects as described in text. Data assembled from detectors at 33 sites (17 inland, 11 coastal, 5 offshore), 147 detectors (generally 1/ coastal/offshore site, median 6 detectors/site inland), for a total of 9,534 detector-nights.

The inland-coastal-offshore classification (See Exhibit 1, Table 1 for each offshore site's distance from the SLA boundary) was supported as a predictor of the probability of detecting bats (Figure 3-3). Bats were more likely to be detected at coastal sites than inland sites, but there was no significant difference at offshore sites relative to inland sites both because the effect was small and the standard error was large. The magnitude of those estimates depended on what other terms were included in the models, but the general pattern was consistent across models. For the model that included fixed effects of season (half-month) and detector altitude (low and high), as well as random effects of site, detector nested in site, year, and night nested in year, the effect size on the logit scale for coastal sites relative to inland sites was 0.992 (SE = 0.472, p = 0.036) but for offshore sites was -0.152 (SE = 0.673, p = 0.821; Table 3-1).

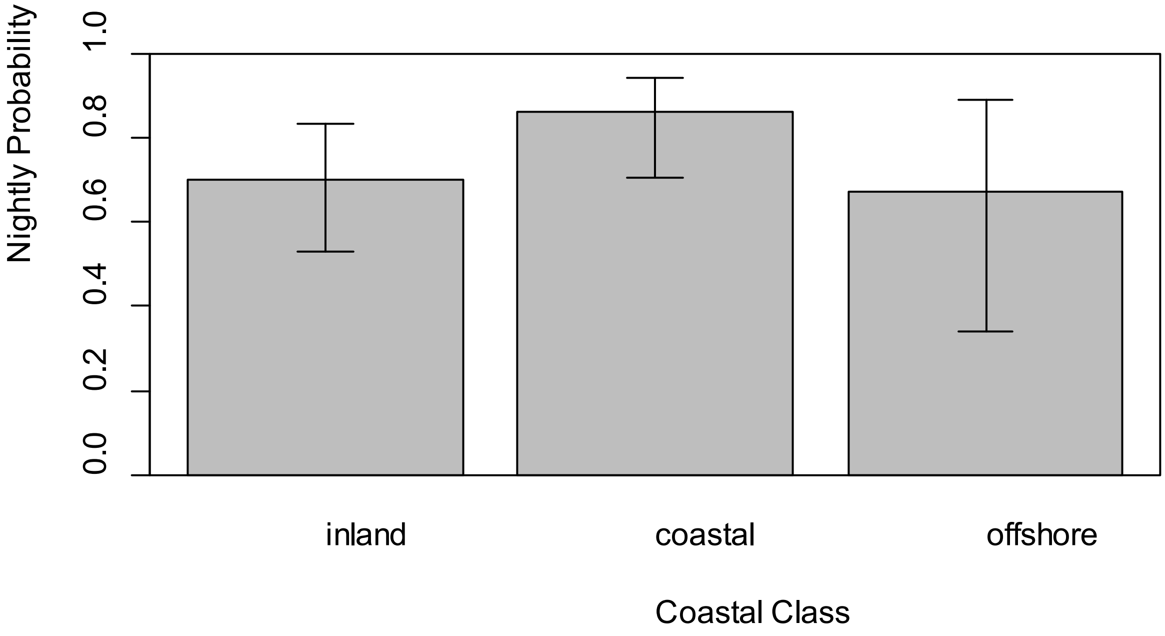


Figure 3-3 Model-based maximum likelihood estimates with 95% confidence intervals of the nightly probability of recording one or more bat calls by coastal class. Data based on detectors at 33 sites (17 inland, 11 coastal, 5 offshore), 147 detectors (generally 1/ coastal/offshore site, median 6 detectors/site inland), for a total of 9,534 detector-nights. See text for model formulation.

Table 3-1

Maximum likelihood estimates and standard errors for differences in occurrence probability on the logit scale associated with coastal and offshore sites relative to inland sites.

Data gathered from detectors at 33 sites (17 inland, 11 coastal, 5 offshore), 147 detectors (generally 1/ coastal/offshore site, median 6 detectors/site inland), for a total of 9,534 detector-nights.

Parameter	Estimate	Std. Error	z value	Pr(>|z|)
Coastal	0.992	0.472	2.099	0.036
Offshore	-0.152	0.673	-0.226	0.821

Collapsing coastal sites with inland sites was not supported by the data, nor was representing sites' relationships to the coastline or their ocean surroundings by the distance from the SLA boundary alone or just by the proportion of land (Table 3-2, Models 3-5).

The data also supported explicitly modeling the impact of WNS, more so when the impact was represented as a simple binary indicator (Model 7) than when the impact was represented as the duration (Model 6) since WNS was first reported in the area. However, using the simple impact indicator, WNS was estimated to have had a positive impact on probability of detecting bats, which may have been a spurious result resulting from the WNS indicator being confounded with some unknown factor. Modeling the duration since WNS impact resulted in an estimated negative effect of the disease, which was more plausible.

Noting that coastal sites were also lower elevation than most inland project sites, we included the effect of elevation in the candidate set of models in addition to or in lieu of coastal class. However, models including both coastal classification and elevation did not converge except when the WNS indicator was also included (Model 8), but that model continued to represent a spurious positive impact of the disease. Models with elevation in lieu of coastal class (Model 10) were approximately equally well supported as the model with the coastal classification alone.

Table 3-2

Model selection for mixed effects logistic regression models fit by maximum likelihood to nightly bat call occurrence, all bats.

All models had fixed effects of detector altitude (low = 10 m or lower, high = higher than 10m) and season (half-month), and all had random effects of site, detector nested in site, year, and night nested in year except where indicated. *k* = number of estimated parameters; -logL = negative log-likelihood; models ranked by AIC; *w* =Akaike weights. Data based on detectors at 33 sites (17 inland, 11 coastal, 5 offshore), 147 detectors (generally 1/ coastal/offshore site, median 6 detectors/site inland), for a total of 9,534 detector-nights.

Model	Additional terms	k	-logL	AIC	ΔAIC	W
8	Coastal class + WNS impact + Elevation	17	4434	8903	0	0.482
7	Coastal class + WNS impact (pre-impact vs. post-impact)	16	4436	8904	0.740	0.333
9	Coastal class + WNS impact Dropping random effect of year	15	4438	8905	2.07	0.171
6	Coastal class + WNS duration (years since impact, pre-impact = 0)	16	4440	8913	9.94	0.00335
2	Coastal class (offshore, coastal, inland)	15	4442	8914	10.7	0.00230
10	Elevation (low vs. high)	14	4443	8914	10.7	0.00228
1	None	13	4444	8914	11.1	0.00184
5	Proportion land within 3nm (continuous predictor)	14	4443	8915	11.7	0.00138
4	Distance from SLA boundary (continuous predictor)	14	4443	8915	11.8	0.00129
3	Coastal class (offshore vs. land [coastal and inland collapsed])	14	4444	8916	12.8	0.000812

To avoid being misled by the variable we had represented as WNS impact, which may have been confounded with some unknown variable, we fit models 1 and 2 to a restricted data set omitting site-years known to have WNS present. The data still supported the effect of coastal class following the same qualitative patterns described above.

We based further inference on model 2. For the selected model, the largest component of variance was attributable to detector, which was nested within site; the next largest were night, nested within year, and site (Table 3-3). Year contributed a relatively minor component with residual variability also contributing a minor component. That reflects the tremendous variability among detectors within sites and among nights within years.

Table 3-3

Variance components and proportions of total variance at various levels of random effects as well as residual variance.

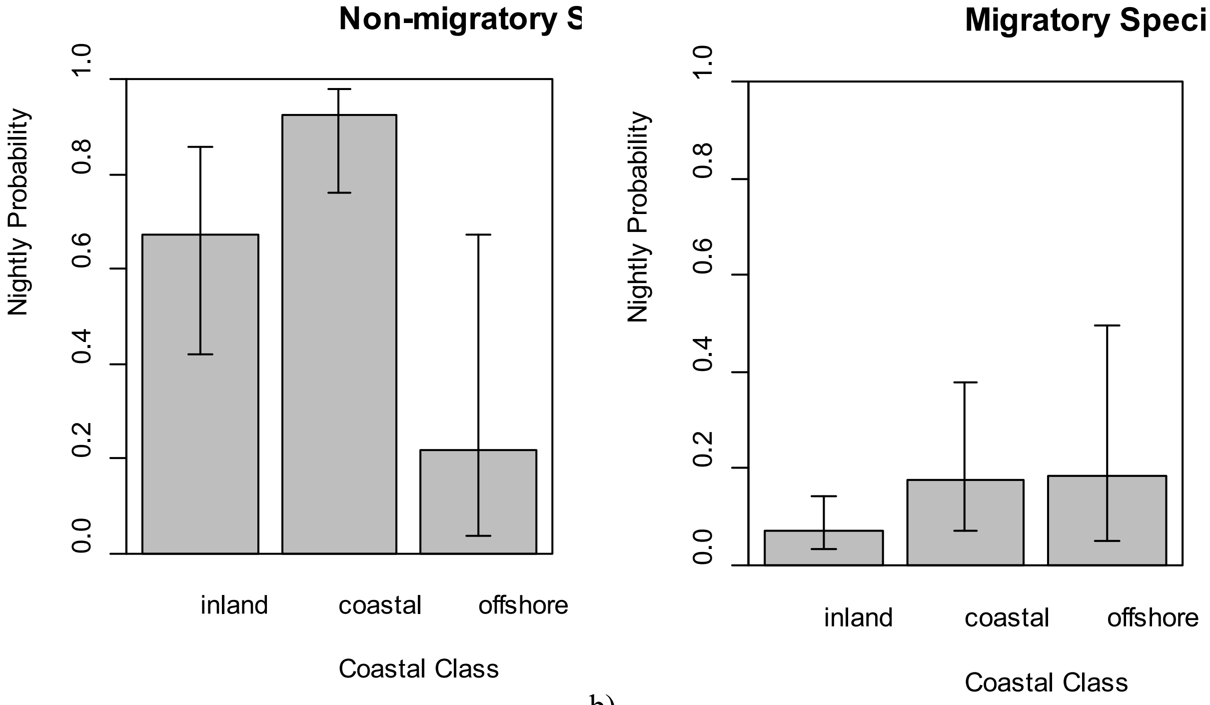
Data assembled from detectors at 33 sites (17 inland, 11 coastal, 5 offshore), 147 detectors (generally 1/ coastal/offshore site, median 6 detectors/site inland), for a total of 9,534 detector-nights.

Variance Component	Variance	Proportion
Site	0.538	20.9%
Detector (nested in Site)	1.17	45.4%
Year	0.112	4.33%
Night (nested in Year)	0.708	27.5%
Residual	0.0499	1.94%

3.2.1 Comparison of Non-migratory and Migratory Species

Similar analyses were performed separately for non-migratory and migratory bats. Calls identified as having been made by one of the non-migratory species made up 39.5% of the calls in the analyzed data set while migratory bat calls were only 12.3% of calls. Bat calls recorded as RBTB or BBSH (guilds with similar calls but representing different migratory behaviors), as unknown high-frequency or low-frequency bats, or as unknown bats could not be included in this analysis. This excluded nearly 50% of calls. While there were a grand total of 5,190 nights with *some* bat call(s), there were only 2,818 nights with one or more non-migratory bat calls identified and only 1,885 with one or more migratory bat calls.

Non-migratory bats were more likely to be detected at coastal sites and less likely to be detected offshore than inland. Non-migratory bats were only recorded at the offshore sites on 16 of 576 detector-nights. Migratory bats were more likely to be detected at coastal sites than inland but, due to large standard error, their probability of detection was not significantly different offshore (Figure 3-4, Table 3-4). In the context of the overall lower probability of detecting migratory species, the lack of a significant difference among migratory bats may be misleading: migratory bats were relatively unlikely to have been detected at the offshore sites. The maximum likelihood estimates for non-migratory and migratory bats were both approximately 0.2.



a) b)

Figure 3-4 Model-based maximum likelihood estimates with 95% confidence intervals of the nightly probability of recording one or more bat calls identified as having been made by non-migratory (a) or migratory species (b). Data based on detectors at 33 sites (17 inland, 11 coastal, 5 offshore), 147 detectors (generally 1/ coastal/offshore site, median 6 detectors/site inland), for a total of 9,534 detector-nights.

Table 3-4

Maximum likelihood estimates and standard errors for differences in occurrence probability on the logit scale associated with coastal and offshore sites relative to inland sites for non-migratory bats.

Data gathered from detectors at 33 sites (17 inland, 11 coastal, 5 offshore), 147 detectors (generally 1/ coastal/offshore site, median 6 detectors/site inland), for a total of 9,534 detector-nights.

Subgroup	Parameter	Estimate	Std. Error	z value	Pr(>|z|)
Non-migratory	Coastal	1.79	0.635	2.82	0.005
	Offshore	-2.01	0.967	-2.08	0.038
Migratory	Coastal	1.03	0.496	2.07	0.039
	Offshore	1.10	0.707	1.56	0.119

3.3 NIGHTLY INTENSITY OF BAT CALLS

We attempted to model the number of bat calls recorded per detector-night (cpn). Random dispersion count data can be modeled using Poisson regression, but these data were highly overdispersed with a high prevalence of zeros, which called for negative binomial regression. However, mixed effects are not implemented for negative binomial regression models. Therefore, we fit fixed effects negative binomial models to the data aware that we could not account for the known large sources of variability, i.e., detectors, sites, and nights.

Modeling calls by all bats, we fit a negative binomial regression model with factors representing coastal class, site, altitude class (≤10 m vs. >10 m), year (as a factor, not a continuous predictor), and season (half-month). The models were parameterized in such a way that the coastal class effect was reported for a low detector in early July at one of the inland sites, i.e., the effects other than coastal class were estimated as differences. The first coefficient representing inland sites is straightforward to interpret; the second two coefficients representing coastal and offshore sites respectively must be interpreted as the fitted value for the first level of sites *as though that site was on the coast or offshore*. Residuals were large in some cases but not overly influential since the largest residuals occurred in the middle of the range of predicted values. Estimated number of calls per night was greatest for coastal sites, although those estimates were heavily inflated by the large number of calls recorded at an individual coastal site (the Seguin Island light). Omitting Seguin from the analysis, the number of calls by all bats and by non-migratory bats remained greatest at coastal sites; in contrast, for migratory bats the estimated number of calls was actually greatest offshore and least inland, although there was broad overlap of the 95% confidence intervals.

Table 3-5

Estimated coefficients of negative binomial regression models of the number of calls per night at inland, coastal, and offshore sites for all bats (including unidentified calls), non-migratory bats, and migratory bats.

Data assembled from detectors at 33 sites (17 inland, 11 coastal, 5 offshore), 147 detectors (generally 1/ coastal/offshore site, median 6 detectors/site inland), for a total of 9,534 detector-nights. Due to the large numbers of calls recorded at Seguin Island, the coefficients are reported including and excluding those data (198 detector-nights). Numbers in parentheses are 95% confidence intervals estimated by likelihood profiling.

		Entire dataset		Without Seguin Island	
All calls	inland	20.5	(14.8, 28.6)	20.8	(15.0, 29.1)
	coastal	6098	(3977, 9493)	423.0	(234, 780)
	offshore	152	(83.8, 287)	159.0	(87.3, 300)
Non-migratory species	inland	2.26	(1.42, 3.66)	2.24	(1.41, 3.61)
	coastal	869	(522, 1479)	179.0	(103, 321)
	offshore	0.438	(0.0228, 2.61)	0.438	(0.0228, 2.61)
Migratory species	inland	11.8	(7.71, 19.3)	11.9	(7.94, 19.1)
	coastal	325	(190, 581)	17.4	(10.5, 30.4)
	offshore	29.5	(16.5, 55.7)	36.3	(20.7, 66.6)

3.3.1 Intensity of Bat Calls over 10-Night Periods

In view of the extreme nightly fluctuations in the number of bat calls recorded and the prevalence of zeros in nightly call intensity, we summed the number of calls recorded over 10-night periods. Periods were defined based on the first two digits of a date's day-of-the-year, e.g., July 20 is the 200th day of the year (in non-leap years), so July 20-29 were the 20th 10-night period of the year.

Considering all bat calls, the cumulative number of calls recorded by individual detectors over 10-night periods ranged from 0 to 8,190 (median 4, inter-quartile range 18-93). There were 67 10-night periods (out of a total of 878, i.e., 7.6%) with no calls; 57 of them were period 27 (28 September) or later.

As a response variable, the cumulative number of calls was amenable to log-transformation after adding a small constant; based on likelihood profiling (Venables and Ripley 1999), 0.25 was selected as the optimal constant, therefore the response variable was *y'* = log(calls-per-10-night-period + 0.25). That response variable was amenable to linear mixed effects modeling. We fit a set of candidate models to that response variable that was similar to those we had fit to the presence/absence data in the logistic regression framework, although we fit fewer candidates. The basic model had fixed effects of detector altitude and season (in this case represented by the 10-night period) and random effects of site, detector nested in site, and year; variations added fixed effects of coastal class and WNS impact and dropped the random effect of year. Among the candidate models, the best-supported was the fullest model, which included effects of coastal class and WNS impact, as well as all of the random effects (Table 3-6).

Table 3-6

Model selection for linear mixed effects models fit by maximum likelihood to cumulative number of bat calls over 10-night periods, all bats.

Data gathered from detectors at 33 sites (17 inland, 11 coastal, 5 offshore), 147 detectors (generally 1/ coastal/offshore site, median 6 detectors/site inland), for a total of 9,534 detector-nights. All models had fixed effects of detector altitude (low = 10 m or lower, high = higher than 10m) and season (10-night period), and all had random effects of site, detector nested in site, and year except where indicated. *k* = number of estimated parameters; -logL = negative log-likelihood; models ranked by AIC; *w* =Akaike weights.

Model	Additional terms	k	-logL	AIC	ΔAIC	W
4	Coastal class + WNS impact (pre-impact vs. post-impact)	19	1457	2953	0	0.9997
2	Coastal class (offshore, coastal, inland)	18	1467	2970	17.5	0.0002
3	Coastal class Dropping random effect of year	17	1469	2971	18.6	0.0001
1	None	16	1471	2974	21.1	0.0000

Residuals from the selected model were reasonably close to the normal distribution as judged by a normal probability plot (Venables and Ripley 1999). Seasonal activity peaked during periods 20-21 (July 20-August 18) and fell to a very low level by period 27 (end of September).

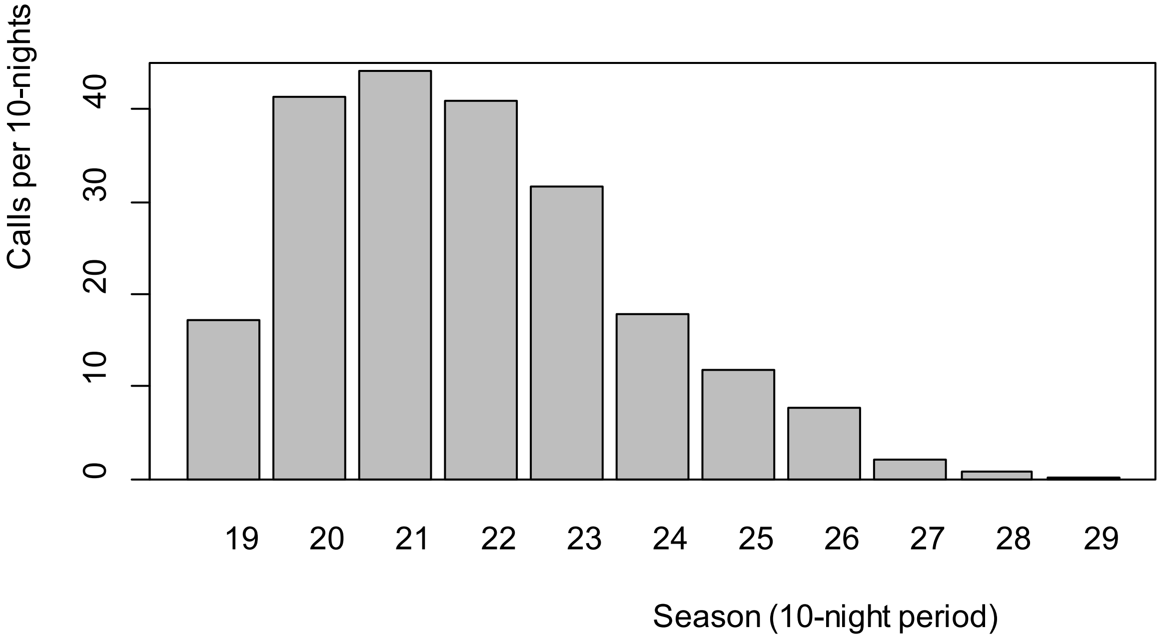


Figure 3-5 Model-based maximum likelihood estimates of the cumulative number of bat calls over 10-night periods. Period 19 = 10-19 July, period 29 = 18-27 October. Illustrated are estimates from a model with fixed effects of coastal class, altitude, and WNS impact (estimates are implicitly for a low detector at an inland site prior to WNS impact) with random effects as described in text. Data based on detectors at 33 sites (17 inland, 11 coastal, 5 offshore), 147 detectors (generally 1/ coastal/offshore site, median 6 detectors/site inland), for a total of 9,534 detector-nights.

Number of bat calls per 10-night period was estimated to be greater at coastal and offshore sites than inland (Figure 3-6, Table 3-7). That qualitative pattern held regardless of whether the impact of WNS was included in the model. For the data that we modeled, which did not include many sites or years after the arrival of WNS, WNS had a positive impact on the number of calls recorded.

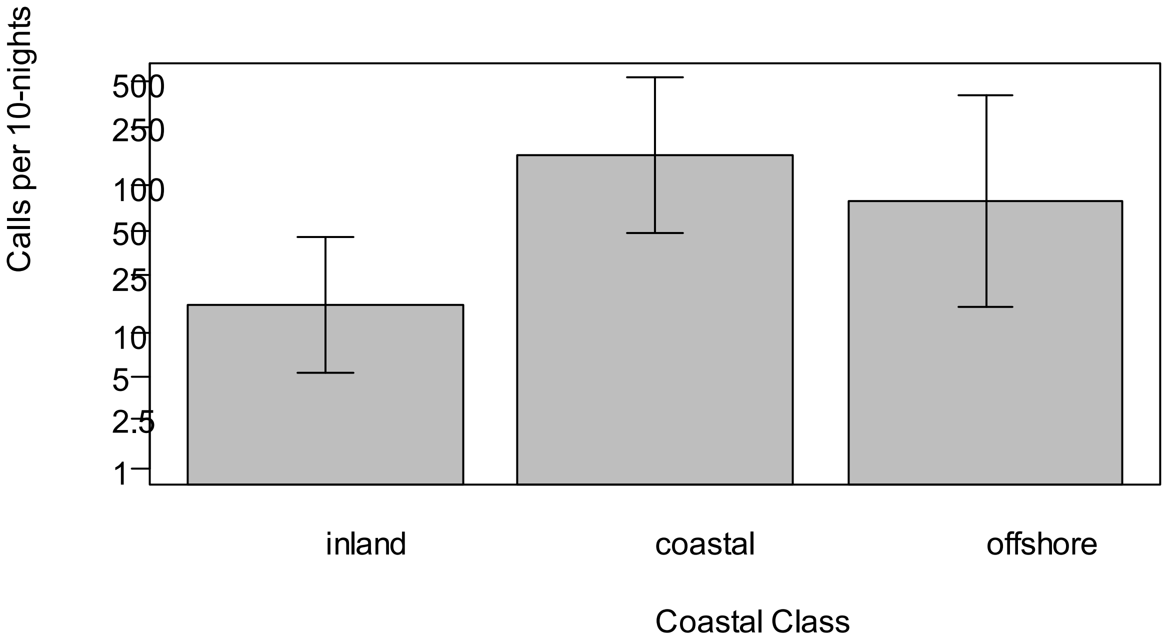


Figure 3-6 Model-based maximum likelihood estimates with 95% confidence intervals of the cumulative number of bat calls over 10-night periods by coastal class. Coefficients with 95% confidence limits: inland 15.8 (5.38-45.7); coastal 162 (48.3-540); offshore 78.3 (15.1-403). Illustrated are estimates from a model with fixed effects of season, altitude, and WNS impact (estimates are implicitly for period 19 (10-19 July), a low detector, and prior to WNS impact) with random effects as described in text. Data assembled from detectors at 33 sites (17 inland, 11 coastal, 5 offshore), 147 detectors (generally 1/ coastal/offshore site, median 6 detectors/site inland), for a total of 9,534 detector-nights.

Table 3-7

Maximum likelihood estimates, standard errors, and *t* ratios for differences in number of calls on the transformed scale [$y' = \log(y + 0.25)$] associated with coastal and offshore sites relative to inland sites.

Data assembled from detectors at 33 sites (17 inland, 11 coastal, 5 offshore), 147 detectors (generally 1/ coastal/offshore site, median 6 detectors/site inland), for a total of 9,534 detector-nights.

Parameter	Estimate	Std. Error	t ratio
Coastal	2.25	0.55	4.09
Offshore	1.50	0.77	1.95

The variance components estimated by the random effects in the model were approximately the same for site, detector nested within site, and residual variance with a minor but non-negligible component due to year (Table 3-8). Note that in contrast to the nightly occurrence data modeled above in the logistic regression framework, nightly variability was subsumed when the response variable modeled here was computed, therefore there is no variance component due to night (cf. Table 3-3).

When looking specifically at either non-migratory or migratory species, there remain too many zeros in the data even after accumulating counts over 10-night periods to model them in the linear mixed effects modeling framework.

Table 3-8

Variance components and proportions of total variance at various levels of random effects as well as residual variance.

Variance Component	Variance	Proportion
Site	1.06	30.6%
Detector (nested in Site)	1.14	32.9%
Year	0.100	2.90%
residual	1.16	33.6%

3.4 SPRING ACTIVITY AT OFFSHORE AND COASTAL SITES

Spring data were available for only two offshore/coastal sites: Mount Desert Rock and Great Duck Island. Bats were recorded during 6 of 61 spring nights (9.8%) at Mount Desert Rock and 1 of 61 spring nights (1.6%) at Great Duck Island. Every inland detector that operated during the same spring period (year 2011; $N = 18$) recorded bats on a greater proportion of nights ranging from 4 of 38 nights (10.5%) for a detector placed 30 m above the ground and 5 of 40 nights (12.5%) for a detector placed 8 m above the ground to 29 of 54 nights (53.7%) for a detector placed 10 m above the ground. Spring data were considered too sparse (no replication across years, poor representation across the coastal classification) to perform any inferential statistical analysis.

4.0 Discussion

At this time, acoustic surveys provide the best method for assessing bat activity, as researchers can adapt lessons learned from terrestrial deployments to the offshore environment. Acoustic data have been relied upon in terrestrial locations to inform environmental assessments at most proposed wind facilities, so it is a logical next step to collect and compare similar data from the offshore environment. Unfortunately, quantitative data on bat activity in the offshore environment are scarce as offshore acoustic data collection is in its infancy when compared to the relatively long history of terrestrial acoustic data collection. Additionally, data consistency is paramount when conducting the type of in-depth statistical analysis described here, and therefore data must be collected using similar methodologies.

A series of attempts were made to supplement our offshore data sets with data collected from outside sources. Twenty-one outside entities were contacted but only 3 were ultimately able to provide viable acoustic data from offshore/coastal sites. Datasets received from outside sources were either collected sporadically or followed different methods preventing direct comparison. As a result, data received from only one additional outside source could be included in our analysis. Similarly, only 25 percent of the data Stantec had collected (in terms of detector-nights) met the criteria for inclusion in this analysis.

We modeled bat acoustic activity in two different ways in order to look for differences in activity relative to the coastline and the offshore environment: (1) as a binary variable with bat presence indicated as having at least one call file recorded in a night (nightly occurrence), and (2) as a continuous variable calculated as the number of call files recorded per operational detector night (nightly intensity) or per 10-night period. Occurrence was modeled in the framework of mixed generalized linear models allowing for factors representing a random sampling from possible conditions (e.g., night within season and detector locations within sites) to contribute to variance. Nightly intensity data were highly over-dispersed requiring negative binomial regression models or zero-inflated models; implementing mixed effects in such models is a highly specialized practice area not accessible through widely available model-fitting routines. Therefore, we used ordinary generalized linear models, which modeled variability as residual variance with no random effects. However, by accumulating calls over 10-night periods intensity data were made amenable to being modeled in the general linear mixed models framework again allowing variance components due to random sampling.

When nightly occurrence was examined, bats were more likely to be observed in the coastal environment than at inland sites, and there was no detectable difference between offshore sites and either coastal or inland sites, which was partly due to great uncertainty about the estimate for offshore sites. Non-migratory bat species were most likely to be detected at coastal sites and least likely to be detected at offshore sites. Migratory bat species were more likely to be detected at both coastal and offshore sites than inland sites, but there was no difference between detectability at offshore and coastal sites. For the two more specific classes of bats, uncertainty, particularly for offshore sites, was even greater.

When we examined negative binomial model-based estimates of nightly intensity, the estimated number of calls per night for all bat species was greatest at coastal sites and next greatest at offshore sites. Even though there were some inland sites where deployed detectors recorded bats calling with great intensity, overall the model-based estimates were lowest inland. Intensity at coastal sites was inflated by one particularly active detector deployed on a lighthouse (Seguin Island Light) but the general pattern held even when those data were excluded. Similarly, non-migratory bats had the highest estimated number of calls per night at coastal sites, whereas the estimated number of calls per night for migratory bats was greatest offshore and was least inland[7].

Accumulated over 10-night periods, the number of recorded calls by all bat species was greater at coastal and offshore sites than inland. For specific classes of bats (e.g., migratory, non-migratory, *Myotis* spp.), there remained too many 10-night periods with no calls recorded for this approach to provide a satisfactory modeling framework. Nonetheless, the broad similarities between the logistic regression model of nightly call occurrence and the general linear model of call intensity accumulated over 10 nights—both in terms of fixed effects and variance components—lent credibility to viewing call occurrence as a suitable surrogate for bat activity.

We obtained similar results in both the nightly occurrence and nightly intensity analyses, generally indicating a higher amount of bat activity at coastal sites. Because data at inland sites were collected for the purposes of pre-construction surveys at proposed wind facilities, inland sites were generally located on high elevation forested ridgelines. While it is difficult to speak to "good bat habitat" for all species found in the Northeast overall, it is likely that warmer, lower elevation sites with access to nearby water sources and larger insect populations would be utilized by bats more often than high elevation ridgelines (Cryan et al. 2000; Grindal et al. 1999). Therefore, in comparing activity between our inland sites and coastal sites, an increase in occurrence and intensity along the warmer, lower elevation coastline could be explained in part by what may be considered preferred habitat located along the coast.

As we were limited to making statistical inferences during the post-breeding season into the fall, this trend of increased activity along the coast could also be a result of increased migratory activity at coastal sites during the fall. More data from the spring and breeding seasons at coastal and offshore sites would help to determine whether migration activity is having any effect on patterns of activity at different coastal classifications.

Although habitat and topography are very different between inland and offshore classes, an important conclusion is that both non-migratory and migratory bats were present in both types of sites. Both inland and offshore classes represent proposed areas for wind energy development, so it is appropriate to compare results of acoustic detector surveys between the two classes even though there may be different factors that contribute to the presence of bats in each class. Since we know that there is both acoustic presence and mortality at wind facilities located inland (Kunz et al. 2007a, 2007b), it is likely that acoustic presence in the offshore environment will lead to the potential for mortality offshore.

We could not detect a difference between probability of detection at offshore and inland sites. This indicates that patterns of nightly presence, at least in the post-breeding and fall migratory

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[7] It should be noted that the prevalence of zeros (i.e., zero call files recorded per detector night) results in model over-prediction of estimated number of calls per night at all coastal classes.

seasons, were indistinguishable between inland and offshore locations. The lack of significant difference between inland and offshore sites could also be due to the variability in acoustic data overshadowing what may be a small effect. We found that the inherent variability in bat acoustic data made it difficult to discern patterns among coastal classes. Bat activity recorded at individual detectors was more variable than bat activity recorded among different sites; bat activity recorded at a single detector was more variable on a night-to-night basis than bat activity recorded at the same detector site in different years. This striking result meant that there was a large amount of noise in the data that tended to obscure patterns that we were interested in observing. Therefore, we needed to take several steps to control this variability.

First, to accommodate the variability within detectors, sites, and nights, and to accommodate the prevalence of zeros in the dataset, we examined activity by half-month for the nightly occurrence analysis and by 10-night periods for the nightly intensity analysis. Using a mixed-effects logistic regression we were able to include site, detector, year, and night as random effects in the nightly occurrence analysis. Occurrence was summarized by half-month, so the probability of detecting at least one bat call in a night was allowed to vary freely among half-months. We could not account for the large sources of variability (detectors, sites, and nights) when modeling the intensity of calls as a negative binomial regression, although this exercise allowed us to account for highly over-dispersed data with a prevalence of zeros. However, when call intensity was summed over 10-night periods, we were able to model the data using a linear mixed effects model. As a result, we were able to estimate the cumulative number of bat calls recorded in a 10-night period while accounting for the random effects of site, detector, and year.

Second, to accommodate regional variability we included only inland sites in New England states (VT, NH, ME). The objective of this analysis was to compare acoustic activity patterns across coastal classes; as we only had coastal and offshore data from sites in the Gulf of Maine, we chose to limit our inland sites to those closest to this marine environment in order to have the best chance of discerning patterns. We assumed that broad differences in latitude between New England and other Mid-Atlantic states could lead to differences in climate patterns. These differences in turn likely led to slight differences in seasonal timing of migration, parturition, volancy, and even foraging, as insect activity timing and duration could vary among disparate regions (Bradshaw and Holzapfel 2008; Wolda 1988). Ultimately, nightly and seasonal timing of activity could be inherently different between Mid-Atlantic and New England regions, and it did not seem appropriate or useful to compare inland acoustic activity in New York, Pennsylvania, Maryland, or West Virginia with offshore activity hundreds of miles away in the Gulf of Maine.

Third, to accommodate seasonal variability we only examined data collected in the post-breeding season and into the fall. If we had sufficient replication of data among coastal classes we would have examined spring and summer as well. It is likely that we would have allowed interactions between season and other factors in order to account for differences in activity patterns due to differences in the annual cycle of bats: spring migration, summer residency and parturition, and fall dispersal and migration. However, we only had spring and breeding season data from two offshore/coastal sites, and so these seasons could not be examined statistically.

Fourth, since we only began deploying acoustic bat detectors at coastal and offshore sites in 2009 we only included data collected during and after 2009. WNS was first detected in New York in 2006 and spread across New England during the period represented by this database. However, WNS was not detected in ME until 2010, and may not have influenced coastal and offshore sites until 2012 or later. Because we were comparing inland sites with longer exposure to WNS to coastal and offshore sites with shorter exposure, WNS was also used as an explicit factor in the models. For both the nightly occurrence and nightly intensity analyses, WNS was included in the best supported models. Modeling the time elapsed since WNS appeared in an area resulted in a negative effect of the disease lowering the probability of occurrence, however that was not as well supported in the model selection process as representing WNS as a binary indicator (present or absent). As a binary indicator, WNS had an unexpected positive effect, increasing the probability of occurrence and increasing the predicted number of calls recorded.

It is likely that the WNS variable used in these models is not properly representing the intended effect of the variable (i.e., whether or not the site at which bat activity was recorded had been affected by WNS). In order to assign a year in which a site was affected by WNS, we were limited to locating the closest county which contained a hibernaculum, and assigning the year of WNS infection from that hibernaculum. However, activity data recorded at sites were recorded during the non-hibernation period (i.e., the active period of spring, summer, and fall). Not all individuals of WNS-affected species spend their annual cycle traveling back and forth between the same hibernaculum and summer roosting areas. In other words, not all individuals from a single summer maternity colony return to the same winter hibernacula, and conversely, not all individuals from a single hibernaculum travel to the same summer maternity colony (Kurta and Murray 2002). Further complicating this variable, individuals found at a given site in the active seasons have not necessarily arrived there from the closest hibernaculum. While it is straightforward to assess the winter in which WNS arrived at a given hibernaculum, this mixing of individuals on the landscape during the active period makes it very difficult to assess the year in which WNS would have arrived at a site and affected activity during the active period.

Alternatively, the WNS variable used in this model could properly represent the intended effect of WNS on bat activity, and either the effect cannot be observed until after one to two years or the effect is in fact to increase activity within the first one to two years after WNS is identified at nearby hibernacula. In this analysis, inland sites provided the only sources of data representing two or more years after WNS arrived. Further, about half of the inland data came from one to four years after the arrival of WNS, while almost all of the coastal and offshore data were collected before WNS was documented in the closest coastal counties. However, there is some evidence that hibernaculum counts may increase in the first years after WNS is detected in an area (Langwig et al. 2012), and that WNS either does not affect or serves to increase activity within the first years after WNS (Boyden et al. 2013). A lack of information gathered three to four years after the arrival of WNS in offshore and coastal sites may contribute to the positive effect that WNS has on detection or intensity of activity in these models.

At the outset of this analysis, we were aware the volume of data from offshore and coastal sites was limited. While we had anticipated obtaining more data from other organizations, we were able to include most detector-nights from our own offshore and coastal sampling sites, as well as from one National Wildlife Refuge. We ultimately included about the same number of offshore and coastal sites combined as inland sites. However, due to having deployed numerous detectors at inland sites, sampling inland was considerably more intense. Fewer than 20% of detector-nights were from offshore sites while about 40% of detector-nights were from coastal and inland sites. We might expect that with more data from offshore sites, better precision could have been attained, although for data as variable as these, more data may not have greatly improved precision.

Despite the caveats we have placed on interpreting our results, the overall message is clear. There are bats active offshore at least as far out as our most remote detectors were deployed, i.e., as far as 12 nm beyond the SLA boundary. Migratory bats were about equally likely to be recorded offshore as at coastal and inland sites. In contrast, non-migratory bats were substantially less likely to be recorded at offshore sites relative to observed levels of activity at coastal and inland sites. Offshore, the maximum-likelihood estimate of nightly occurrence for both migratory and non-migratory bats was about 0.2; in contrast, non-migratory bats had maximum likelihood occurrence of about 0.7-0.9. The observed level of activity offshore, however, was comparable between migratory and non-migratory species, so it would be incorrect to conclude that risk of collisions with wind turbines is limited to migratory bats.

5.0 References

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Exhibit 1

Exhibit 1, Table 1

List of sites in the analyzed database sorted by coastal classification and Dist SLA.

Project names were removed for inland sites and latitude-longitude rounded to nearest degree to maintain anonymity of proprietary data. Dist SLA refers to distance measured in nautical miles inside SLA boundary. By definition all US territorial land, including the smallest islands, is within the SLA boundary. Where bulging occurred along the SLA boundary we drew a straight line pinching off the bulge and measured the orthogonal distance from that straight line to the site; where a site was in a bubble of the SLA boundary, we measured the shortest orthogonal distance to the boundary around the mainland. Distances in or near the range -3 to 3 should not be construed literally nor should one expect values filling that range due to the fractal nature of the coastline. Proportion land [p(land)] was measured inside a 3 nautical mile circle around the site.

Site ID	Site	Lat	Lon	Region	Elevation (meters)	Dist SLA (nautical miles)	p(land)	Coastal Class	Island	Island Size	Year of WNS Impact
809	Matinicus Rock	43.78	-68.86	New England	27	-9.0	0.0066	offshore	rock	10.27	2010.5
805	Mt Desert Rock	43.96	-68.14	New England	23	-8.5	0.0001	offshore	rock	0.8	2011
815	Gloucester Buoy A	42.52	-70.56	New England	1	-2.2	0	offshore	buoy		unimpacted
816	Appledore Island	42.99	-70.62	New England	20	-1.8	0.0069	offshore	island	40	unimpacted

Exhibit 1, Table 1. List of sites in the analyzed database sorted by coastal classification and Dist SLA.

Site ID	Site	Lat	Lon	Region	Elevation (meters)	Dist SLA (nautical miles)	p(land)	Coastal Class	Island	Island Size	Year of WNS Impact
814	Halfway Rock	43.66	-70.04	New England	23	4.4	0.0069	offshore	rock	0.9	2010
801	Kent Island	44.58	-66.76	New England	5	-13	0.0245	Coastal	island	98.5	unimpacted
812	Monhegan Island	43.76	-69.32	New England	54	-2.6	0.0231	Coastal	island	207.6	2010.5
802	Petit Manan Island	44.37	-67.86	New England	37	3.1	0.0152	Coastal	rock	6.3	2011
807	Frenchboro	44.10	-68.37	New England	8	3.1	0.0774	Coastal	island	594.2	2011
806	Great Duck Island	44.14	-68.25	New England	20	3.1	0.0127	Coastal	island	85.8	2011
813	Seguin Island	43.71	-69.76	New England	57	3.2	0.0421	Coastal	island	25.6	2010
804	Schoodic Peninsula	44.34	-68.06	New England	24	3.4	0.185	Coastal	peninsula		2011

Exhibit 1, Table 1. List of sites in the analyzed database sorted by coastal classification and Dist SLA.

Site ID	Site	Lat	Lon	Region	Elevation (meters)	Dist SLA (nautical miles)	p(land)	Coastal Class	Island	Island Size	Year of WNS Impact
811	Metinic Island	43.88	-69.13	New England	5	3.7	0.0156	Coastal	island	139.8	2010.5
803	Petit Manan Point[8]	44.41	-67.90	New England	5	4.4	0.229	Coastal	peninsula		2011
808	Isle Au Haut	44.06	-68.65	New England	15	6.4	0.318	Coastal	island	2753	2011
810	Owls Head	44.09	-69.04	New England	14	8.4	0.191	Coastal	peninsula		2011
500		42	-78	New England	169	26	1	Inland	continent		2010
699		42	-79	New England	310	51	1	Inland	continent		2011

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[8] Stantec detector 2010, MCINWR 2011

Exhibit 1, Table 1. List of sites in the analyzed database sorted by coastal classification and Dist SLA.

Site ID	Site	Lat	Lon	Region	Elevation (meters)	Dist SLA (nautical miles)	p(land)	Coastal Class	Island	Island Size	Year of WNS Impact
694		45	-71	New England	450	52	1	Inland	continent		2008
689		44	-73	New England	530	57	1	Inland	continent		2008
522		42	-77	New England	266	59	1	Inland	continent		2011
532		39	-80	New England	659	63	1	Inland	continent		2008
299		42	-79	New England	610	63	1	Inland	continent		2008
492		45	-71	New England	256	64	1	Inland	continent		2011
539		45	-68	New England	462	76	1	Inland	continent		2010.5
385		42	-78	New England	670	82	1	Inland	continent		2010

Exhibit 1, Table 1. List of sites in the analyzed database sorted by coastal classification and Dist SLA.

Site ID	Site	Lat	Lon	Region	Elevation (meters)	Dist SLA (nautical miles)	p(land)	Coastal Class	Island	Island Size	Year of WNS Impact
624		44	-72	New England	786	95	1	Inland	continent		2009
685		44	-73	New England	896	99	1	Inland	continent		2007
495		39	-80	New England	931	104	1	Inland	continent		2010
482		43	-73	New England	908	106	1	Inland	continent		2010
365		45	-70	New England	629	110	1	Inland	continent		2007
67		43	-78	New England	561	114	1	Inland	continent		2007
I		45	-71	New England	756	122	1	Inland	continent		2009