

Baseline Wildlife Studies in Atlantic Waters Offshore of Maryland (2013-2014)

Final Report to the Maryland
Department of Natural Resources and the
Maryland Energy Administration

October 2015



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Working Partners:

Biodiversity Research Institute, 276 Canco Rd., Portland, Maine 04103. www.briloon.org, 207-839-7600

College of Staten Island (City University of New York) Department of Biology, 2800 Victory Blvd., Staten Island, NY 10314

North Carolina State University Department of Forestry and Environmental Resources, 2200 Hillsborough, Raleigh, NC 27695

Duke University Marine Laboratory, 135 Pivers Island Road, Beaufort, NC 28516-9721

Oregon State University Marine Mammal Institute, Hatfield Marine Science Center, 2030 SE Marine Science Drive, Newport, Oregon 97365



Project webpage: www.briloon.org/mabs

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Executive Summary

Kathryn A. Williams, Iain J. Stenhouse, Sarah M. Johnson, and Emily E. Connelly
Biodiversity Research Institute, Portland, ME

In 2013, the Maryland Department of Natural Resources and the Maryland Energy Administration funded a study to develop baseline data on wildlife distribution and abundance offshore of Maryland, in state and federal marine waters. This study was intended to complement existing survey efforts in the region (see below), and provide detailed information on animal distributions in relation to future offshore wind energy development off Maryland's Atlantic coast.

The pre-existing Mid-Atlantic Baseline Studies (MABS) Project was a collaborative research effort to study bird, sea turtle, and marine mammal distributions, densities, and movements on the Mid-Atlantic Outer Continental Shelf between 2012 and 2014 (Williams et al. 2015a). This effort was led by the Biodiversity Research Institute (BRI) and funded by the U.S. Department of Energy (DOE) and other entities, and included collaborators from a wide variety of academic institutions, non-governmental organizations, federal agencies, foundations, and private companies. The study goal was to provide regulators, developers, and other stakeholders with comprehensive baseline ecological data and analyses that could help address environmental permitting requirements for current and future projects, and would serve as a starting point for more site-specific studies. In particular, we produced information that could be used to identify: 1) important wildlife areas, 2) data gaps, and 3) approaches for collecting and incorporating natural resource data into decision making. The specific study area in the Mid-Atlantic was chosen because it was viewed as a likely location for future wind energy development offshore of Delaware, Maryland, and Virginia, including three federally designated Wind Energy Areas (WEAs). The study included a variety of research efforts, such as boat-based and aerial surveys in the Mid-Atlantic Outer Continental Shelf, individual tracking of several bird species, hierarchical modeling of data, and dissemination of project results to stakeholders and interested parties (Williams et al. 2015a).

In 2013, the Maryland Department of Natural Resources and the Maryland Energy Administration recognized an opportunity to significantly increase the MABS data collection effort. During the second year of the MABS study, the State provided funding to expand the existing surveys to cover a greater extent of Maryland's state and federal waters (the Maryland Project; Figure 1). This expansion included three major components: the extension of existing boat surveys into Maryland state waters; the extension of high resolution digital video aerial surveys into areas west and south of the Maryland WEA (providing much greater survey coverage in these areas than was occurring previously); and the addition of an eighth annual aerial survey for Maryland waters, conducted in August 2013 (including both the WEA and the extension areas). Unless noted otherwise, data from the MABS Project and the Maryland Project were fully integrated, and survey data presented throughout this report include both the

Maryland Project transects and data from the broader MABS Project (see “Maryland study area,” outlined in Figure I).

Project activities included standardized surveys to quantify bird, marine mammal, and sea turtle densities seasonally and annually throughout the study region in order to identify important habitat use or aggregation areas and examine temporal variation in these patterns. The project team also developed statistical models to help understand the drivers of these patterns and predict the combinations of environmental conditions likely to support large densities of birds, marine mammals, and turtles in the future (or in areas not included in our surveys). Such efforts have helped us to identify species that are likely to be exposed to offshore wind energy development activities in the Mid-Atlantic study area, and may also help with siting, permitting, and mitigating the effects to wildlife from these development activities.

Offshore wind and wildlife

Offshore wind energy development has progressed rapidly in Europe since the first facility became operational in 1991 (Breton and Moe 2009), and it is now being pursued in the U.S. as well. This renewable resource has the potential to reduce global carbon emissions, and thus to positively affect many species, but offshore wind energy developments may also affect local wildlife more directly. Researchers are still learning about how offshore wind energy facilities affect marine ecosystems, but it seems clear that effects vary during different development phases, and that species respond in a variety of ways (Fox et al. 2006). Some species are negatively affected, while others show no net effect, or may even be affected positively (Bergström et al. 2014). Possible effects to fish, marine mammals, sea turtles, birds, and bats include: mortality or injury from collisions with turbines or vessels; displacement from, or attraction to, habitat use areas; avoidance of facilities during migration or daily movements, which may necessitate increased energetic expenditures; and changes to habitat or prey populations, including artificial reef effects (Fox et al. 2006, Kunz et al. 2007, Boehlert and Gill 2010, Langston 2013, Bailey et al. 2014, Bergström et al. 2014). The scale of development is likely to be important in determining the significance of these effects. Overall, the cumulative effects to wildlife will be dependent on the size and number of wind facilities that are built, as well as local topography, climate, species ranges, and other oceanographic and biological factors (Langston 2013). Effects from offshore wind may also be combined with other natural and anthropogenic stressors (Fox et al. 2006). As a result, ecological context is essential for understanding and minimizing effects of offshore development on wildlife.

Project components

The chapters in this report represent a broad range of study efforts and goals. Some chapters are purely methodological in nature, while others present a variety of analyses and results (Figure II). This report consists of four parts:

1. *Project overview*, which includes the executive summary (this section), a background chapter on the study area and methods (Chapter 1), a synthesis of study results, including the identification of large-scale patterns and trends (Chapter 2);

2. *Examining wildlife distributions and relative abundance from a digital video aerial survey platform* (Chapters 3-5);
3. *Examining wildlife distributions and abundance using boat-based surveys* (Chapters 6-9); and
4. *Integrating data across survey platforms* (Chapters 10-14), which incorporates data from boat and aerial survey efforts to gain a more comprehensive view of wildlife populations in the environment offshore of Maryland.

Project overview

The Mid-Atlantic region is used by a broad suite of wide-ranging marine wildlife species across the annual cycle. This, along with the high levels of productivity in the region, mean that it is essential to understand the dynamics of this ecosystem in order to manage it effectively, particularly with regard to anthropogenic stressors such as offshore development. In Chapter 1, we briefly discuss the ecosystem of the Mid-Atlantic Bight and describe the methods employed in the Mid-Atlantic Baseline Studies Project and Maryland Project. We discuss the relative strengths of digital video aerial surveys and other methods used in this study, with a particular focus on comparing boat-based surveys and digital video aerial surveys. We also briefly discuss the various approaches used to present results in this report.

In Chapter 2, we summarize persistent and seasonal patterns in wildlife distributions that were observed during the two years of this study. We also present a series of case studies to examine in detail the abundance and distributions of potentially vulnerable taxa. Observed community composition, distribution patterns, phenology, and behaviors in this study all varied somewhat from other recent baseline studies along the eastern seaboard, as might be expected based on these studies' different latitudes, bathymetry, and other characteristics. However, at a broad scale, geographic and temporal patterns in the Mid-Atlantic were consistent with findings from other recent baseline studies in that overall abundance and species diversity were driven in large part by bathymetry, and tended to be highest in shallow water areas (which in many cases were coincident with areas closer to shore, though not always; Geo-Marine Inc. 2010; Paton et al. 2010). In several cases, results from these previous studies have been used to identify areas of high biodiversity and priorities for conservation, ultimately influencing the choice of lease sites for offshore wind development (Rhode Island Coastal Resources Management Council 2013)¹.

Examining wildlife distributions and relative abundance from a digital aerial survey platform

Fifteen aerial surveys were conducted over two years by HiDef Aerial Surveying, Ltd., using high resolution digital video. Digital aerial survey approaches have largely replaced visual aerial surveys in Europe for monitoring wildlife in relation to offshore wind energy, as their higher flight speeds and much higher flight altitudes make them safer to conduct than visual aerial surveys, and also reduce or eliminate disturbance to wildlife compared to visual aerial or boat-based survey approaches. Digital approaches also produce archivable data, which allow for a robust quality assurance and audit process. There are still limitations to the digital video aerial survey method, however, including difficulties identifying some species. Digital aerial surveys avoid the distance bias common to visual methods, but to date, other forms of detection bias have not been addressed for digital aerial surveys.

¹ www.boem.gov/BOEM-Newsroom/Press-Releases/2012/press05302012.aspx

This study includes the first application of this technology on a large spatial scale in the United States. Surveys were conducted along transects with a dense spatial coverage (20% ground coverage) within WEAs and in an area west and south of the Maryland WEA, as well as a broader sawtooth transect throughout the MABS study area (Figure I). Four belly-mounted cameras recorded video footage during surveys, which was later analyzed to locate and identify animals (Chapter 3). Detailed video data analysis and management protocols were developed by BRI, in consultation with HiDef, including the Quality Assurance and Quality Control (QA/QC) protocol used to audit survey results (Chapter 4). Twenty percent of all video was included in blind re-reviews to ensure consistency in locating and identifying objects.

Completed analysis provided data on the number of target organisms in the video, the species or other identification category of organisms, the approximate flight height for flying birds and bats (Hatch et al., 2013, Chapter 5), and geospatial data for all objects that were used in modeling efforts (Chapter 5). Over 25,000 animals were observed within the Maryland study area over two years of digital video aerial surveys, including over 7,000 birds and 18,000 aquatic animals. The greatest numbers of animals were observed in July and September. Large groups of fishes and rays were observed in the data; if they were not individually distinguishable, they were counted as groups (e.g., shoals of fish or fevers of rays; Chapter 5), but otherwise, all animals were individually recorded and identified. The most common individually counted animals within the Maryland study area were rays, primarily Cownose Rays (*Rhinoptera bonasus*). Digital video aerial surveys proved to be particularly good at observing aquatic animals located near the water's surface, such as sea turtles and large migratory schools of rays. The most common avian group identified in video footage from the Maryland study area was gulls and terns (Laridae). Identification of animals to species proved difficult for some taxa, such as terns, alcids, and loons, due to variations in image quality and other factors (Chapter 5). Newer generations of camera systems currently used in Europe have greatly improved upon the identification rates obtained in this study (HiDef Aerial Surveying, Ltd. unpubl. data). Species observed during aerial surveys within the Maryland study area that are listed as rare, threatened, or endangered in the state of Maryland included one Common Tern (*Sterna hirundo*), two Bald Eagles (*Haliaeetus leucocephalus*), 22 Loggerhead Sea Turtles (*Caretta caretta*), 16 Leatherback Sea Turtles (*Dermochelys coriacea*), eight Kemp's Ridley Sea Turtles (*Lepidochelys kempii*), five Green Sea Turtles (*Chelonia mydas*), one Hawksbill Sea Turtle (*Eretmochelys imbricata*), and one Humpback Whale (*Megaptera novaeangliae*; Chapter 5).

Roughly 56% of flying animals observed in the study area were estimated to be in the lowest flight altitude category (0-20 m above the water's surface); another 40% were estimated to be at altitude ranges between 20 and 200 m, which are at or near the potential rotor-sweep zone for future offshore wind energy development along the Eastern Seaboard (depending on the size and type of turbines; Chapter 5, Willmott et al., 2013).

Examining wildlife distributions and abundance using boat surveys

To accompany data from digital aerial surveys, 16 boat surveys were conducted over two years (Figure I). Standardized boat-based surveys with distance estimation are a widely used method of obtaining density data for birds, marine mammals, and sea turtles (Chapter 6); the study design was particularly optimized for avian species, and detected a wide variety of seabird species as well as raptors, passerines, and other taxa (Chapter 7). Over 10,000 animals were observed during surveys in the

Maryland study area, including over 9,700 birds and 300 aquatic animals, with the greatest numbers observed in February, October, and November, when large flocks of wintering birds were present in the study area (Chapter 7).

The most common species group identified during surveys in the Maryland study area was gulls and terns. Avian species observed within the Maryland study area that are listed as rare, threatened, or endangered in the state of Maryland included 235 Common Terns, 148 Royal Terns (*Thalasseus maximus*), 11 Forster's Terns (*Sterna forsteri*), eight Least Terns (*Sternula antillarum*), two Roseate Terns (*Sterna dougallii*, which are also federally endangered), one Northern Harrier (*Circus cyaneus*), and one Bald Eagle (Chapter 7). Non-avian state-listed species observed during boat surveys included 15 Loggerhead Sea Turtles, three Leatherback Sea Turtles, and one Humpback Whale (Chapter 7). While conducting surveys, we also collected environmental covariate data in order to assess fine-scale patterns of these environmental variables in relation to wildlife densities. In particular, fisheries sonar (a scientific echo sounder) was used to estimate relative prey biomass in the same areas as boat survey observations (Chapter 8).

Boat-based survey data were used to develop statistical models of seabird distributions, which also incorporated estimates of detectability and environmental covariates. Hierarchical Bayesian statistical approaches are useful for situations where distribution patterns or resource use vary with scale, and where species of interest are highly mobile and may be periodically unavailable for detection (Mordecai et al. 2011). For example, distance bias (in which observers are less likely to see animals located farther from the survey vessel) and other survey biases are well known for boat-based survey data (Buckland et al. 1993, 2001), and can be addressed within a hierarchical modeling context. These modeling methods allow distribution models to be chosen to fit the observed data (Gardner et al. 2008, Zipkin et al. 2010), and incorporate distance estimation and environmental covariates into the model structure in order to predict animal distributions and abundance on a broad geographic scale. Project collaborators first focused on the development of a community distance sampling (CDS) model for seabirds, using data from the first boat survey in April 2012 (Sollmann et al. 2015). This novel multi-species approach explicitly estimated seabird detection as well as abundance parameters (Sollmann et al. 2015). By sharing information across species, this community model allowed us to make inferences about abundance, distribution, and response to environmental variables of rare species for which there would not be enough data to run individual models.

Building on the CDS model, Chapter 9 examined survey data from 15 boat surveys and incorporated remotely collected environmental covariate data into the hierarchical modeling structure. This approach accounted for imperfect detection to estimate "true" abundance, and predicted seabird distributions by season to help identify important habitat use areas and patterns. Seabird distributions were spatially, seasonally, and taxonomically variable. Within the Maryland study area, species with the highest predicted abundances included wintering Northern Gannets (*Morus bassanus*), Common Loons (*Gavia immer*), Razorbills (*Alca torda*), and scoters (*Melanitta* spp.), as well as Laughing Gulls (*Leucophaeus atricilla*) in fall. Overall avian abundance within the Maryland study area was predicted to be highest in winter and lowest in summer. High species density and diversity was also predicted to occur in spring

and fall, suggesting that migratory and overwintering species dominated the region's species composition. Distributions for some species, such as Common Terns and Red-throated Loons (*Gavia stellata*), were concentrated farther offshore in spring (during the pre-breeding migratory period).

While summer was the period of lowest overall predicted abundance, several federally- and state-listed species were present in the region during that time of year, including Roseate Terns, Least Terns, Common Terns, Forster's Terns, and Royal Terns. The CDS model enabled us to accommodate these relatively rare species and estimate their relationships with habitat features, improving our understanding of their distributions. This study demonstrated the importance of quantifying detection and determining the ecological drivers of a community's distribution and abundance in order to reliably predict potential exposure to offshore development activities (Chapter 9).

Integrating data across survey methods

Part IV of this report is focused on the comparison and integration of data from boat-based surveys and high resolution digital video aerial surveys. Chapter 10 contrasts results from boat-based and digital video aerial survey approaches. For some taxa, data from one survey approach were used independently to analyze wildlife distributions and relative abundance (Chapters 11-12). In other cases, digital video aerial survey data and boat survey data were used jointly (Chapters 11, 13-14) to describe distributions and abundance of animals across the study area.

In order to test the utility of high resolution digital video aerial surveys in U.S. waters and to examine how best to integrate new aerial survey data with historical data, we compared the digital video aerial data to boat-based surveys using experimentally controlled methods (Williams et al. 2015b), as well as using a more *ad hoc* approach (Chapter 10). These comparisons indicated largely complementary strengths of the two survey approaches, though they also highlighted their respective weaknesses (namely, the need for additional analytical development for digital survey data, and the issue of disturbance to wildlife populations caused by the vessel during boat-based surveys). Species identification rates, as well as detection rates, varied considerably between methods for some taxa (Chapter 10). In the Maryland study area, more birds per unit effort and more bird species were observed in the boat surveys, and birds made up a higher proportion of boat observations (97%) compared to digital video aerial surveys (27%). In contrast, much higher counts and species diversity of sea turtles and other aquatic animals (rays, fish, sharks, etc.), were detected on the aerial surveys than on the boat surveys (Chapter 10). Gulls and terns were the most abundant avian group observed in both boat (33% of birds) and digital video aerial surveys (20% of birds) in the Maryland study area, with anatids (ducks and geese) the next most abundant group (25% boat and 19% aerial). This differed from the pattern seen in the broader MABS study area, where scoters comprised the highest percentage of birds observed.

These differences complicated the combined analysis of the two survey datasets, but also provided an opportunity to create higher-quality end products by incorporating complementary data streams. On a small scale, this led to the publication of a scientific paper on Eastern Red Bat (*Lasiurus borealis*) migration in the offshore environment of the Mid-Atlantic (Hatch et al., 2013, Chapter 11). The bat observations from this study provided new evidence of bat movements offshore, and offered insight

into their flight heights above sea level and the times of day at which such migrations may occur. Collaborators also used boat-based and aerial datasets to identify temporal and spatial patterns of species presence and relative abundance in the study area, including the identification of “hotspots,” or geographic areas with consistently high numbers of animals through time (Chapter 11), which likely provided important habitat for foraging, roosting, or other activities (Santora and Veit 2013). The presence and relative abundance of different species varied widely by time of year, but for many taxa, hotspots were most consistently observed in areas within 30-40 km from shore, particularly offshore of the mouths of Chesapeake Bay and Delaware Bay (Chapter 11). These areas consistently showed high species diversity and abundance of animals across all taxa observed in this study, and may have been attractive to many animals due to environmental gradients in salinity, water temperature, and other factors that created reliable foraging habitat in these locations. Areas offshore of Maryland’s northern Atlantic coast also showed high diversity and abundance, although this may have been partially due to the high survey effort in nearshore waters in this region. Species that were consistently observed farther offshore on the Outer Continental Shelf included sea turtles, Common Dolphins (*Delphinus delphis*), Common Loons, and alcids.

The incorporation of environmental covariates into modeling efforts allowed for the prediction of relative densities across the study area for several taxa (Chapters 12 and 13), with one or the other survey dataset used to describe each population of interest. In some cases, one survey method was significantly better than the other for surveying a particular taxon. For example, sea turtles were much more frequently observed in digital aerial surveys than in boat surveys, likely in large part because the turtles could be detected even when they were fully submerged. Because of these high detection rates, we used only the aerial survey results to develop predictive models of sea turtle distributions (Chapter 12). Sea turtles were most abundant from May to October, and their densities were correlated with warmer water temperatures and greater distances from shore. There was substantial overlap between sea turtle distributions and WEAs, particularly in the southern part of the MABS study area. Bottlenose Dolphin (*Tursiops truncatus*) distributions were modeled using boat data, and they were predicted to use primarily more nearshore areas with high levels of primary productivity and higher sea surface temperatures in spring, summer, and fall. There were few observations of the species during cooler months.

In several cases, boat-based and digital aerial survey datasets could be combined using recently developed integrated modeling frameworks. Common Loons and Red-throated Loons, which proved difficult to distinguish in aerial video, provided a test case for using boat-based species identifications to inform aerial models and develop spatially explicit species-specific estimates of relative abundance (Hostetter et al., 2015, Chapter 11). In a preliminary analysis of data for four seabird groups (terns, gannets, loons, and alcids), boat and aerial models with remotely collected environmental covariate data were compared to determine if the two sampling methods detected similar patterns in seabird abundance, with the goal of determining how best to combine boat and digital aerial survey data for an integrated analysis (Chapter 13). Accounting for imperfect detection resulted in higher abundance for the boat-based than the aerial models. Similar species-habitat relationships were estimated between the two survey types for gannets, terns, and loons, but alcids were less consistent between the survey types and years. These

results suggested that a model combining both data types could be powerful for understanding seabird distributions, but that caution may be required for species like alcids where different patterns were observed between surveys, possibly due to temporal variation or differences in the sampling domain or detectability.

In Chapter 14, project collaborators built off of this model comparison to develop an integrated modeling approach in which predictions of marine bird abundance and distribution were jointly informed by aerial surveys (which encompassed a large geographic area), and boat surveys (which allowed for estimation of detection probability). Integrated models were developed for the same four taxa examined in Chapter 13. The combined predictions of this chapter generally supported the conclusions of Chapters 9, 11, and 13, which found that the distribution of marine birds was often patchy, species- and survey-specific, and correlated with habitat covariates. The integrated models had noticeable improvements in predicting local hotspots and marine bird distributions relative to models that only included boat-based data. The greater spatial span of aerial surveys may have assisted in the detection of latitudinal gradients and hotspots, especially those occurring outside of areas surveyed by the boat. The integrated models, however, often had lower predictive power than boat-only models for describing observations from other surveys conducted in the same season, which was likely a consequence of dynamic relationships between boat and aerial surveys and changing habitat covariates (Winiarski et al. 2013, 2014). While additional exploration and model development is needed, these results indicate that joint modeling approaches may be a fruitful avenue of continued research.

Synthesis: Advancements in the state of our knowledge

The Mid-Atlantic ecosystem

The Mid-Atlantic region is used by a broad range of marine wildlife species across the entire annual cycle, due in part to a relatively high level of productivity, as compared to many other areas in the western North Atlantic (Yoder et al. 2001). The importance of the region to wildlife is also partially due to the region's central location on the eastern edge of the continent (a major migratory corridor for many species). As a result, the Mid-Atlantic supports large populations of marine wildlife during breeding, nonbreeding, and migratory periods, which leads to a complex ecosystem where the community composition is shifting regularly, and temporal and geographic patterns are highly variable.

The Mid-Atlantic Baseline Studies Project and Maryland Project have filled a significant information gap for wildlife in a large swath of the Mid-Atlantic region between New Jersey and North Carolina. In part, this area was a focus due to its ecological significance and relative lack of data on wildlife distributions. Additionally, this region has great economic importance, including commercial fisheries, shipping, and the potential for offshore renewable energy development. To minimize the effects of such anthropogenic activities on wildlife populations, the complexities of this ecosystem require that a range of study methods be used to obtain a comprehensive view of ecosystem structure and configuration.

Study methods and comparisons

Field study methods have a substantial influence on the resulting analysis and presentation of wildlife distribution data. The methods that we used to examine marine wildlife distributions in the Mid-Atlantic

each had inherent strengths and weaknesses. Our evaluation of the utility of each survey method in documenting different types of data is necessarily subjective in many cases, and is dependent upon the specific study design implemented for this project (i.e., the study area, available technology, sample size, and other factors).

Boat and aerial surveys provided relatively comprehensive information on wildlife populations in the offshore environment (Chapter 1). Each showed distinct benefits in detecting different taxa. High resolution digital video aerial surveys provided better detection rates for aquatic animals, likely due to a combination of reduced disturbance, reduced glare, and a unique field of view compared to boat-based and visual aerial surveys, which allowed for submerged animals to more easily be detected in the upper reaches of the water column (Chapters 5 and 10; Normandeau Associates Inc., 2012). Boat surveys provided better detection rates for many birds, however, which is probably due to a combination of availability bias, detection bias, and identification issues in digital video aerial surveys (Chapters 7 and 10). Digital aerial surveys have the advantage of being auditable and archivable, and include an extensive quality assurance process, which may lead to a greater degree of reliability in species identifications. The safety and speed with which digital aerial surveys can be conducted also make this approach attractive in the offshore environment, and the capabilities of digital aerial surveys will likely continue to improve with technological advances in the field. Boat-based surveys can provide detailed behavioral data, however, and had generally better rates of identification of animals to species. The analytical approaches for boat survey data are also well established, while additional technological advances and analytical developments for digital aerial surveys would strengthen this approach for understanding wildlife distributions in the offshore environment of North America.

Patterns of wildlife distribution and abundance

Primary productivity forms the base of the pelagic food chain on which nearly all species observed during this study rely. In general, primary productivity in the Mid-Atlantic was higher in nearshore areas, although patterns varied seasonally. Schools of forage fishes were most commonly observed in nearshore waters, particularly offshore of northern Delaware and Maryland, around the mouth of Delaware Bay (Chapters 5, 8, and 11). In turn, despite seasonal variation in habitat characteristics, areas within about 30-40 km of shore appeared to provide important foraging habitat for a wide range of species year-round. In particular, analyses of survey data indicated that areas near the mouths of the Chesapeake Bay and Delaware Bay were consistent hotspots of species diversity and abundance during this study (Chapter 11). These areas were likely attractive to a wide variety of high trophic-level species, such as seabirds and marine mammals, due to foraging opportunities arising from gradients in salinity, water temperature, and other factors offshore of the mouths of the bays, and the consistently higher primary productivity relative to the broader study area. Areas off of Maryland's northern Atlantic coast, within roughly 20-30 km of shore, were also consistent hotspots for biodiversity and abundance for many taxa, although this may have been partially driven by the more inshore study design implemented in this location as compared to the remainder of the study area. High numbers of some species may have been consistently present in other nearshore areas of the Mid-Atlantic as well, but similar surveys were not conducted in state waters elsewhere during this study.

Avian taxa with persistent hotspots in the Maryland study area included Red-throated Loons, primarily to the west of the Maryland WEA; Common Loons, in areas between roughly 10 and 40 km from shore (both inside and outside the WEA); storm-petrels (Hydrobatidae), both inside and outside of the WEA; Northern Gannets, with persistent hotspots throughout the Maryland study area; alcids, primarily in offshore areas south of the WEA; and gulls and terns, particularly in nearshore areas in the western part of the Maryland study area (Chapter 11). Persistent hotspots of ray aggregations and delphinids occurred throughout the Maryland study area, and particularly to the west and south of the Maryland WEA (Chapter 11); the pattern of Bottlenose Dolphin distributions predicted in Chapter 12 remained fairly consistent in spring, summer, and fall, with higher densities in the western half of the study area. Hotspots of turtle persistence occurred in offshore sections of the Maryland study area, but were less consistent than hotspots in the southern half of the MABS study area, offshore of Virginia (Chapter 11).

Seasonal Variations

There were strong seasonal variations in community composition and wildlife distributions (Chapters 9, 11, and 12). Important environmental factors influencing species distributions included distance to shore, sea surface temperature, primary productivity levels (i.e., chlorophyll *a*), salinity, seafloor slope, and sediment type, though wildlife responses to these factors varied widely by species and time of year (Chapters 9 and 12). The breadth of the region was used during spring and fall migration by seabirds, landbirds, sea turtles, cetaceans, rays, and other taxa. Many of these taxa were also part-time or year-round residents of the study area, using it for foraging during the breeding season, or for foraging, roosting, and other activities during non-breeding periods.

During the spring (March-May), high species diversity was observed, suggesting that migratory and overwintering species dominate the region's species composition (Chapter 9). During this time, wintering seabirds departed the region to begin their migrations towards breeding grounds inland or to the north. Additionally, songbirds and shorebirds migrated through the region both along the coast and over open waters, (Chapter 11). Summer resident seabirds, such as terns, shearwaters (Procellariidae), and storm-petrels, arrived after migrating from wintering grounds in the south or breeding grounds in the Southern Hemisphere (Chapters 5, 7, and 11). Spring also marked the arrival of Bottlenose Dolphins and a variety of sea turtle species, which were predicted to occur in highest densities offshore of Virginia (Chapter 12).

During summer (June-August), hydroacoustic surveys generally observed higher levels of aquatic biomass in nearshore areas (Chapter 8). Seabirds were also generally more associated with nearshore habitat in the summer than in the spring (Chapter 9). Breeding seabirds, including several species of terns, were predicted to be associated with nearshore habitat and were found foraging near the shore and near the mouths of the bays (Chapters 9, 11, and 13-14). Non-breeding species from the southern hemisphere, such as Great Shearwaters (*Puffinus gravis*) and Wilson's Storm-Petrels (*Oceanites oceanicus*), generally occupied a wider swath of the continental shelf (Chapter 11). In early summer, large numbers of Cownose Rays migrated through the regional study area on their way to feeding grounds in Chesapeake Bay and Delaware Bay (Chapter 5; Blaylock 1993). Sea turtles and Bottlenose Dolphins were most abundant across the regional study area in the summer, with distributions influenced by sea surface temperatures and primary productivity. Bottlenose Dolphins were predicted

to occur primarily in nearshore areas (possibly because most of the individuals observed in this study were residents from coastal stocks; Kenney, 1990), while sea turtles were still predicted to occur primarily in the southern parts of the regional study area (Chapter 12).

In the fall (September-November), Cownose Rays moved out of the bays and aggregated in dense groups in the Maryland study area as they migrated south (Chapter 5). Seabird species composition changed over the course of the fall, as summer residents migrated south and winter residents migrated into the region from breeding grounds farther north or inland (Chapter 11). Landbirds, shorebirds, and bats were recorded flying over open waters as they migrated through the regional study area (Chapter 11; Adams et al., 2015; Hatch et al., 2013). Alcids moved into the study region in the fall (Chapter 11). Large schools of forage fish were also observed in the regional study area, particularly nearshore and on the Maryland Project transects (Chapters 8 and 11). Sea turtles were widespread across the regional study area and offshore of Maryland through October (Chapter 12), and were most abundant in the Maryland study area during this season. Bottlenose Dolphins remained until late fall, while Common Dolphins largely arrived in the regional study area in November (Chapters 11 and 12).

During winter (December-February), seabirds occupied habitat throughout the region, though there was variation in distribution patterns among species (Chapters 9, 11, and 14) and individuals. Northern Gannets were the most ubiquitous seabird in the regional study area during this period, and were often observed in the bays as well as relatively far out on the shelf (Chapters 9 and 11). Scoters were observed in large aggregations at the mouths of Chesapeake Bay and Delaware Bay (Chapter 11). Common Loons, in contrast, were most often observed individually and were widely dispersed throughout the regional study area, generally more associated with lower sea surface temperatures (Chapter 11; Hostetter et al., 2015). Many Bonaparte's Gulls (*Chroicocephalus philadelphia*) were observed in the region in winter (Chapters 5, 7, and 11). Alcids were predicted to occur in small numbers throughout the regional study area (Chapter 14). Baleen whales were most commonly observed during this season; of the 51 large whales observed within the regional study area during surveys (2012-2014), 31 were observed between December and February (Chapters 11 and 12). Common Dolphins occupied habitat throughout the regional study area during the winter, predominantly in offshore areas (Chapters 11 and 12).

Next steps

All data generated from this project will be made publically available in late 2015 via the Northwest Atlantic Seabird Catalog (formerly known as the Compendium of Avian Information), a relational database hosted by the U.S. Fish and Wildlife Service that contains decades of survey data on seabirds, marine mammals, sea turtles, and other wildlife across a broad spatial scale in the northwest Atlantic (O'Connell et al. 2009). Data are also hosted and available for download on the project web page (www.briloon.org/MABS), and certain analytical products are expected to be incorporated into other public databases, such as the Mid-Atlantic Regional Ocean Council's (MARCO) Data Portal².

Effects to wildlife from offshore development can be thought of as a combination of exposure to development and operation activities; hazards posed to individuals that are exposed; and the

² <http://midatlanticocean.org/data-portal/>

implications of individual-level impacts for population vulnerability (Crichton 1999, Fox et al. 2006). In this baseline study of wildlife distributions, we focused on developing a better understanding of wildlife distributions and potential exposure to future offshore development in the Mid-Atlantic. While exposure to offshore development does not necessarily indicate that exposed animals will suffer deleterious effects, or that any impacts that do occur will translate to population-level impacts, this study is an important first step towards understanding the implications of offshore wind energy development for bird, marine mammal, and sea turtle populations in the Mid-Atlantic United States. These baseline data may be used to inform future development or other proposed ocean activities. These results may also help to address environmental permitting requirements and inform mitigation efforts aimed at minimizing effects to wildlife. As planning and development move forward, however, it will be important to take steps beyond this baseline assessment in order to focus on species most likely to be impacted due to their conservation status or other factors.

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Figures

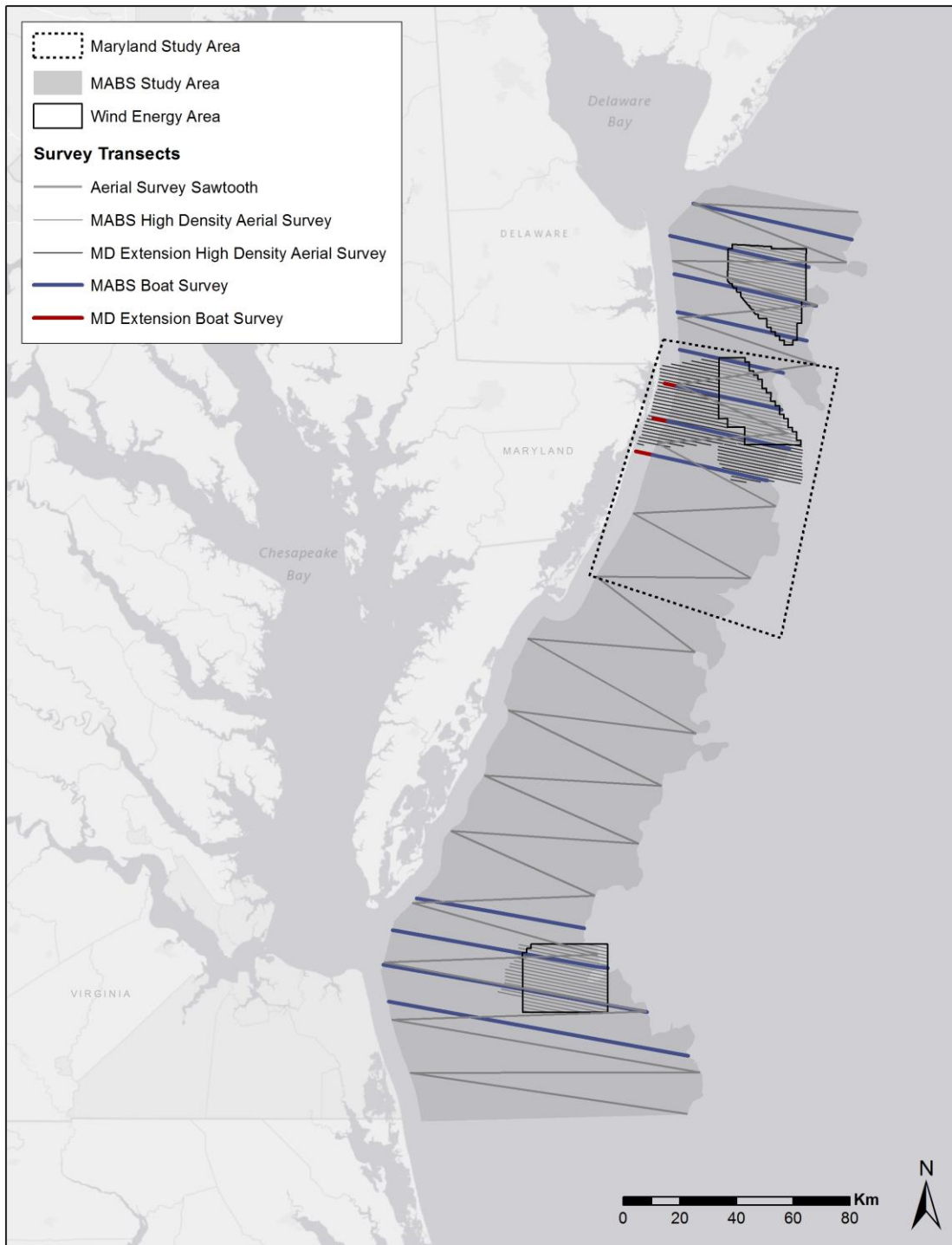


Figure I. Map of aerial and boat survey transects for the Mid-Atlantic Baseline Studies (MABS) and Maryland Projects. High resolution digital video aerial survey transects are shown in gray (MABS) and black (Maryland); boat based survey transects are shown in blue (MABS) and red (Maryland). The “Maryland Study Area,” for which data are presented throughout much of this report, includes data collected under both projects.

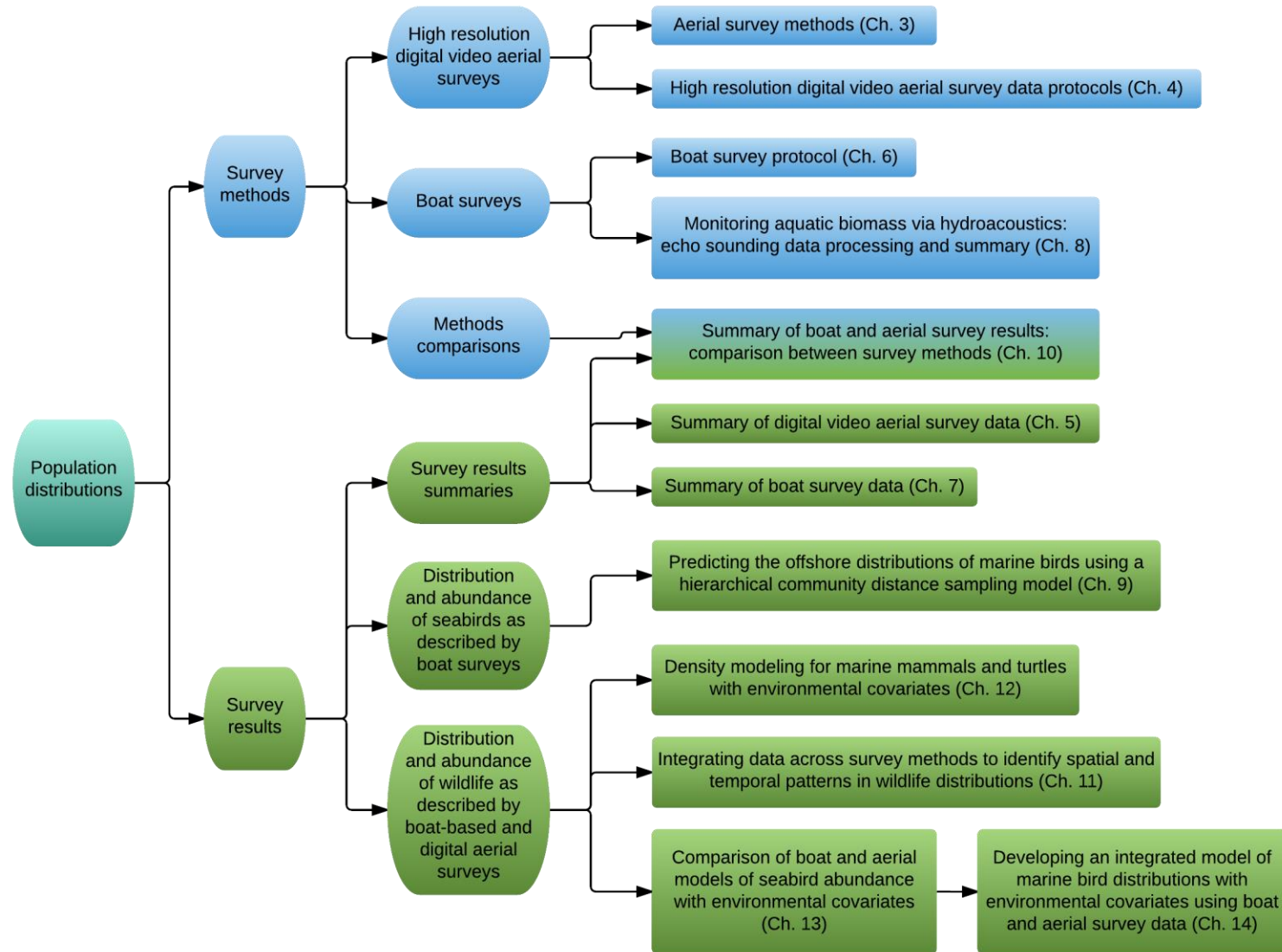


Figure II. Organization of chapters within this final report.