Chapter 5: Summary of digital video aerial survey data

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Chapter 5 Highlights

Results from high resolution digital video aerial survey data collected in the Maryland study area and the Mid-Atlantic Baseline Studies (MABS) study area.

Context[1]

High resolution digital video aerial surveys are a recently developed method to collect animal distribution and abundance data, and our study was the first to use this method on a broad scale in the U.S. Chapters 3 and 4 focus on the methods used to collect the digital video aerial survey data. Chapter 5 reviews the results of these surveys for the Maryland study area and the MABS study area, including data on observed counts and species identification rates for birds, marine mammals, sea turtles, and other wildlife. Flight heights for flying animals were also estimated from the video footage, allowing for analysis of animal altitude in relation to potential wind turbine heights.

Building off of this summary chapter, Chapter 10 examines the differences between the boat-based and digital video aerial survey datasets, with a focus on the Maryland study area. Subsequent chapters in Part IV of this report (Chapters 11-14) focus on integrating the two survey methods to better understand the distribution and abundance of wildlife in the Mid-Atlantic United States.

Study goal/objectives addressed in this chapter

Summarize animal distribution and abundance data that were collected using a novel survey method in the Maryland and MABS study areas.

Highlights for the Maryland study area

- Over 25,000 animals were observed in the fifteen surveys of the Maryland study area, less than expected given the percent of the MABS area covered offshore of Maryland.
- Over 7,000 birds and 18,000 non-avian animals were observed (including cetaceans, sea turtles, rays, sharks, and fish).
- The most abundant animals observed in aerial video were rays (Batoidea), making up 61% of the study data. The most commonly observed birds were Gulls and Terns (Laridae, 5% of the data).
- Scoters, loons, and Northern Gannets were also observed in large numbers.
- Notable animal sightings included many sea turtles and several species of baleen whales.
- Most of the animals with calculated flight heights were observed at altitudes below the predicted lower end of the rotor swept zone (~20 m).

Implications

Digital aerial surveys appear to have certain advantages for obtaining information on the distributions of animals within the marine environment, particularly for aquatic species such as sea turtles and rays. However, there are certain taxa that can more readily be identified than others using this technology.

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[1] For more detailed context for this chapter, please see the introduction to Part II of this report.

Abstract

High resolution digital video aerial surveys are a relatively novel method for collecting information on marine wildlife distributions and abundances, and this study is the first to use these methods on a broad scale in the United States. Our study focused on collecting marine bird, mammal, and turtle data within the Maryland study area as well as the broader Mid-Atlantic Baseline Studies project area, though we also documented the movements of rays and sharks, noted large schools of forage fish, and captured the migration of terrestrial species in the marine environment. We observed over 25,000 animals within the study area, including over 7,000 birds and 18,000 non-avian animals. The most abundant birds observed were gulls and terns (Laridae), and were primarily Bonaparte's Gulls (*Choicocephalus philadelphia*) seen in the winter. The most abundant animals overall were rays, making up 61% of the data; the Cownose Ray (*Rhinoptera bonasus*) was the most abundant species, which was primarily observed in the study area in the spring through early fall. Other abundant species included scoters, especially Black Scoters (*Melanitta americana*), Common Loons (*Gavia immer*), and Northern Gannets (*Morus bassanus*); less abundant but notable animals include several species of sea turtles and baleen whales, as well as diurnal migrations of Eastern Red Bats (*Lasiurus borealis*) through the offshore study area in the fall. Rates of identification to species in video aerial surveys varied widely based on the quality of the footage, as well as the taxonomic group in question. Identification rates of small alcids were low, while scoters were more easily identifiable. Flight heights were estimable for 80% of flying animals, and showed that 56% of these animals were flying below the likely rotor swept zone for current offshore wind turbines (<20 meters). More detailed analyses of these data can be found in Part IV of this report.

Introduction

The Mid-Atlantic region is an important area for a broad range of marine wildlife species throughout the year. Some breed in the area, such as coastal birds and sea turtles, while others visit from the southern hemisphere in their non-breeding season, such as shearwaters. In the fall, many summer residents migrate south to breed or winter in warmer climes, and they are replaced by species that have travelled south from their northern breeding grounds to winter in the Mid-Atlantic. Additionally, many pelagic, coastal, and terrestrial species make annual migrations up and down the eastern seaboard and travel directly through the region in spring and fall. Thus, many species use or funnel through the Mid-Atlantic region each year, resulting in a complex ecosystem where the community composition is constantly shifting, and the temporal and geographic patterns are highly variable

In our study, we aimed to produce baseline data to inform siting and permitting processes for offshore wind energy development in the Mid-Atlantic. We collected information on bird, sea turtle, and marine mammal abundances and movements over a two-year period (2012-2014) using a variety of technologies and methods to examine spatial patterns and trends. One of these methods included the first application of a new technology in the United States, high resolution digital video aerial surveys (hereafter, digital video aerial surveys). Digital video aerial surveys are a relatively new method for collecting distribution and abundance data on animals in the marine ecosystem (Thaxter and Burton, 2009). Although digital video aerial surveys have become common practice for offshore wind energy planning and monitoring in Europe, this Department of Energy (DOE)-funded Mid-Atlantic Baseline

Studies Project (MABS) and state-funded Maryland Project are the first projects to use these methods on a large scale in the United States. We also conducted boat surveys for wildlife within the study area on the continental shelf, to accompany and compare with the data from the digital video aerial surveys. For details on boat survey approaches, and for comparisons between boat and aerial data, see Parts III and IV of this report, respectively. Here, we examine the digital video aerial survey results in detail, including discussion of observation rates, species identification rates, and flight height estimates for flying animals.

The broader MABS study area encompasses the coastal area from Delaware to Virginia, extending from 3 nautical miles from the coastline (the boundary between state and federal waters) out to the 30 m isobath or the eastern extent of the Wind Energy Areas (WEAs). The Maryland Project extended the original Department of Energy-funded aerial and boat survey transects west and south to include more of Maryland's state waters (Figure 5-1). The "Maryland study area," as referenced throughout this report, includes all transect lines that fall within the extended state boundaries for Maryland, including those funded by the DOE (Figure 5-1).

We discuss the results for the Cownose Ray (*Rhinoptera bonasus*) in particular detail to highlight the utility of offshore digital video aerial surveys for aquatic taxa. This species is found along the coast of the western Atlantic Ocean from the northeastern U.S. to Brazil, and migrates seasonally, likely prompted by changes in water temperatures (Goodman et al., 2011). There are limited studies on Cownose Ray migration, but the Mid-Atlantic may be an important area for migrating rays (Blaylock, 1993; Goodman et al., 2011). Their movements are of interest to fisheries regulators as they are commonly thought to depredate bivalve aquaculture beds (Myers et al., 2007), though little evidence of this has been documented (Fisher, 2010). An unregulated Cownose Ray fishery exists in Virginia (the only targeted ray fishery in the northwest Atlantic), and there are also high bycatch and discard rates of rays within other fisheries; population declines are predicted as a result (Barker, 2006; Goodwin, 2012). They are listed by the IUCN as "Near Threatened" globally largely due to heavy and unregulated fishing pressure in Central and South America (Barker, 2006). Aerial surveys have been used to study the species in the Chesapeake Bay (Blaylock, 1993; Goodman et al., 2011), but rarely cover migration in the open ocean, and this is the first example of digital video aerial surveys being used to monitor their distributions and relative abundance.

Methods

Between March 2012 and May 2014, HiDef Aerial Surveying, Ltd. conducted fifteen large-scale surveys using super high-definition video on an aerial platform (Figure 5-1). For fourteen surveys, transects were flown at high densities within the federally-designated WEAs off of Delaware, Maryland, and Virginia, while the remainder of the study area was surveyed on an efficient 'sawtooth' transect path to provide broad-scale context (Chapter 3). In the second year of surveys (March 2013-May 2014), additional high density transects were added to the west and south of the Maryland WEA (Figure 5-1 inset), and the fifteenth survey was conducted in just the Maryland WEA and adjacent high-density extension areas (Table 5-1). Both MABS and Maryland survey data are presented in this report. Early surveys included video footage at 2 cm Ground Spatial Resolution (GSR) for transects within the WEAs, and 3 cm GSR for the broader sawtooth survey; beginning in September 2012, all transects were surveyed at 2 cm GSR.

Final geoprocessing of the data was completed in January 2015. The project team identified wildlife locations, taxonomic identities, behaviors, and flight heights from the video footage. Detailed data collection, analysis, and data management protocols can be found in Chapters 3 and 4 of this report.

This chapter presents summaries of raw count data from the digital video aerial surveys on a monthly, seasonal, and annual basis with a focus on the Maryland study area. We also discuss identification rates for the most common species groups. We compared results for the Maryland study area to the findings within the larger MABS project area, and compare the actual and "expected" numbers observed within different animal groups. To calculate "expected" values, we took the number of animals observed in the combined MABS and Maryland study areas, and multiplied it by 32%, the percentage of the surveyed transect area (linear transect length multiplied by strip width) that was located within the Maryland study area. For these summaries, all identifications in the aerial data were taken at face value (e.g., an identified "possible Black Scoter [*Melanitta americana*]" was considered to be a Black Scoter, rather than an "Unidentified Scoter"; see Chapter 4 for additional information on certainty levels and identification criteria). Ray (Batoidea) densities were examined across the study area using counts of rays per Bureau of Ocean Energy Management (BOEM) 4.8 x 4.8 km lease block, corrected for survey effort within the lease blocks (km^2). All rays were included in the analysis, and the four survey periods with highest ray abundances were mapped using ArcGIS 10.1 (ESRI, Redlands, CA).

Flight heights were examined for different avian species groups to compare to the rotor-swept zone of offshore wind turbines. Flight heights were estimated using a proprietary estimation method, based on the principle of parallax, developed by HiDef Aerial Surveying, Ltd., which uses measurements of "parallax", or the apparent motion of an elevated object against a distant background due to the movement of the observer (Hatch et al., 2013). Flight heights of flying animals could not be estimated when the animal was flying directly parallel to the plane, rendering calculations of displacement impossible, or the animal was present in an unusually small number of frames (Hatch et al., 2013). Flight heights were estimated in altitude bands (0-20, 20-50, 50-100, 100-200, and 200+ m).

Part IV of this report presents additional information comparing digital aerial and boat survey results, and integrating data from both survey types into in-depth analyses of wildlife distributions and relative abundance.

Results

A total of 15,698 km^2 were surveyed in the Maryland Study area, comprising approximately 32% of the entire MABS area (49,577 km^2). A total of 25,115 animals were observed in the fifteen surveys of the Maryland study area, less than expected given the percent of the MABS area covered within Maryland (35,008). Over 7,000 birds and 18,000 non-avian animals were observed (including cetaceans, sea turtles, rays, sharks, and fish; see Appendix 5A). At least 30 species of birds and 15 species of non-avian animals were represented. Overall, 43% of the animals observed in the study were identified to species level, close to the identification rate for the broader MABS data. The greatest numbers of animals were observed in July and September (Table 5-2). There were variations in data quality throughout the project, with low light in winter causing difficulty for identifications. It should be noted that data collected between the two years (as shown in Table 5-2 and Appendix 5A) are not entirely comparable across the duration of the study, as the study area was significantly expanded beginning in March of 2013. Additionally, the exact timing of surveys can have a huge effect on species counts, particularly during migration periods when large numbers of wintering birds could be moving in or out of the study area; a week's difference in survey dates could have a significant effect on observed overall abundance.

Quality assurance and quality control (QA/QC) protocols for analysis of the video data are presented in Chapter 4. An audit was not conducted for the first (March 2012) survey, as object identifications for those data were performed collectively among BRI biologists to develop a common identification process and pool their existing expertise. For all other surveys, object identifications were independently conducted by BRI biologists, and random audits (e.g., blind re-reviews of 20% of all objects, and 100% of object identified as state- or federally- listed threatened and endangered species) were conducted for all identifications. Early adjustments to the Ground Spatial Resolution (GSR) for surveys are discussed in Chapter 3; all Maryland Project surveys were conducted at 2 cm GSR. Audits for 2013-2014 surveys were conducted jointly for DOE-funded and Maryland-funded data from each survey period; agreement rates for the random audit varied from 87-98% between 2013-2014 surveys with DOE and Maryland funding (Connelly et al., 2015); when agreement was less than 90% (for random audit objects) or less than 100% (for threatened and endangered species) in a survey, then partial re-review of survey data and/or arbitration of disagreements among reviewers occurred (as described in detail in Chapter 4).

Relative abundance of counts

Birds

Gulls and terns were the most abundant avian species observed in the Maryland aerial surveys, making up 5.6% of the observations within Maryland, very close to the expected amount given the proportion of the MABS area included in Maryland (Figure 5-3). Gulls and terns were most commonly observed in the summer and fall surveys (Figure 5-7). Of those identified to the species level, Bonaparte's Gulls were the most common (*Choicocephalus Philadelphia*, 0.41%), and they were predominantly observed in winter. Great Black-backed Gulls (*Larus marinus*; 0.39%) were the next most abundant, and were seen throughout the year, mostly in the fall. Laughing Gulls (*L. atricilla*; 0.22%) were seen predominantly in the summer of 2013. The most abundant tern species seen was Black Tern (*Chlidonias niger*; 0.12%) followed by Caspian Tern (*Hydroprogne caspia*; 0.02%). There were an additional 4.2% of observations classified to higher taxonomic levels within the *Laridae* family (see Table 5-2 for details).

Scoters (*Melanitta* spp.) were the next most abundant avian group observed in the aerial surveys, making up 5.3% of MD observations, which is less than expected for the Maryland study area based on its size relative to the MABS area, and the numbers of scoters observed within the MABS area (Figure 5-3). Most were classified as *Melanitta* sp. (Black Scoter [*M. americana*], Surf Scoter [*M. perspicillata]*, or White-winged Scoter [*M. fusca*]), but could not be identified to the species level. Scoters were present in the winter and early spring (Figure 5-7). The most abundant species observed were the Black Scoter (1.49%) and Surf Scoter (0.53%).

Loons were the next most abundant avian family (5.05%), with most categorized as *Gaviidae* sp. (4.3%); this is also slightly fewer than would be expected based on the size of the Maryland study area (Figure 5-3), and most were observed in the winter (Figure 5-7). Identified loons were either Common Loons (0.56%) or Red-throated Loons (0.16%). Northern Gannets (*Morus bassanus*) made up 4.8% of the observations, fewer than expected (Figure 5-3). Alcids were observed at 0.31% of the Maryland study area data, and were mostly unidentified (0.25%). Of those identified, most were Dovekies (*Alle alle*; 0.03%).

Non-avian animals
Large numbers of animals were observed in aerial surveys at or below the surface of the water (Figure 5-4). There were major seasonal differences for aquatic animal abundance, most notably with very large numbers of rays observed in summer and fall surveys (Figure 5-8). Rays were the most common animal group observed in the Maryland study area (44%), and the number of rays observed very closely matched the expected quantity (Figure 5-5). Fish were the next most commonly observed non-avian animals; individually recognizable larger fish (>1 m in length) were counted as individual fish even if they were located within a school, and these are the only data presented in figures in this chapter. However, most fish observed in video footage were groups of small forage fish, or "bait balls," of varying size, which were observed mostly between May and September, primarily inshore. The majority of bait balls within the entire MABS study area were seen on the September 2013 survey (4,142 schools of fish), and 7,514 schools were observed in all (61% were observed in the Maryland Project transects). Some schools were less than a m^2, while some extended across all four cameras and spanned many frames of footage (school size was not quantified during video analysis). Additional discussion of bait ball geographic patterns may be found in Chapter 11.

Dolphins were the most commonly observed marine mammals in the Maryland digital video aerial surveys (4.6% overall, Figure 5-4). Dolphins were seen throughout the study period, but Bottlenose Dolphins (*Tursiops truncatus*, the most commonly identified species; Appendix 5A) were most abundant in the spring and summer. Large cetaceans were also observed in Maryland surveys: one Humpback Whale (*Megaptera novaeangliae*) and one Minke Whale (*Balaenoptera acutorostrata)*, in February and May of 2014.

A notable number of sea turtles were observed (1.46% of observations), primarily in the spring, summer, and autumn. Most of the turtles were not identified to species (Figure 5-10). Loggerhead Turtles (*Caretta caretta*) and Leatherback Turtles (*Dermochelys coriacea*) were the two most commonly identified, with some observations of the rarer species (Kemp's Ridley Turtle [*Lepidochelys kempii*], Green Turtle [*Chelonia mydas*], and Hawksbill Turtle [*Eretmochelys imbricate*]; Appendix 5A).

Identification rates
Identification rates varied by survey and season. June surveys had the highest rate of birds identified to species (55%), closely followed by October and December (54%); the lowest identification rates were in August and September (11% and 10%, respectively). Image quality, observer bias, and other factors, however, could also have varied through time and influenced identification rates.

Identification rates for Anatidae (geese, swans, and ducks) were strong relative to the rates for other avian groups (Figure 5-9), with 38% of anatids identified to species. This rate is lower than the identification rate for the broader MABS project area (53%, Figure 5-11). Gulls and terns were identified to species 24% of the time, less than the identification rate for the broader study area (35%, Figure 5-11). Only 14% of loons were identified, as the video footage was not always clear enough to distinguish the subtleties of winter plumage coloration between Red-throated Loons and Common Loons, and there is also a significant overlap in size between the two species in the Mid-Atlantic study area (Gray et al., 2014). This rate was the same between the Maryland and MABS areas (Figure 5-11). Small birds, like auks and terns, were seldom identified to species (Figure 5-9), but the rate was slightly higher in Maryland compared to the overall study area (11% MD, 6% MABS; Figure 5-11), often due to difficulty in picking out fine details in plumage variation.

Few individual fish were identified to species, as this taxon was not a focus of the current study, but video data will remain archived in case additional analysis of species identities or forage fish school sizes is warranted. Cownose Rays were the most commonly identified fish or shark species in this study (Figure 5-10). While most sea turtles were not identified to species (85%; Figure 5-10), all species observed in the area are federally endangered. Most non-Leatherback Turtles remained unidentifiable at the species level because of inconclusive carapace length measurements and/or insufficient detail visible on the carapace (often due to the animal being too deeply submerged in the water column to allow for detailed observation). Of all toothed whales (Odontoceti), 67% were not identified to species level, again in part due to animals being submerged to varying depths in the water column. These identification rates are similar to those observed in the broader MABS area.

Flight heights

Flight heights were estimated for 80% of flying animals (or 1,559 observations in the Maryland study area). Of all birds with estimable flight heights in the study area, 56% were estimated to be flying within 0-20 meters of the water's surface. Forty percent of observations occurred between 20 and 200 m in altitude (623 observations), a range that was used in one recent study to cover a variety of possible turbine types, foundations, and variations in tidal heights (Willmott et al., 2013). We observed nearly every avian taxonomic group flying within this zone, though the proportions of individuals in this latitude band varied by taxon. Within this range, 18% of birds were flying from 20-50 m, 14% were flying from 50-100 m, and 8% were flying from 100-200 m. An additional 8% of birds were flying above 200 m.

Of all the birds with estimated flight heights, the five most commonly observed avian families were all marine birds that forage in the study area and spend some time on the surface of the water, and were by far most commonly observed in the lowest 0-20 m altitude band (Figure 5-13).Gulls and terns were the most commonly observed species aloft, followed by Northern Gannets (Figure 5-12 and Figure 5-13). Gulls and terns were observed flying at the 20-50m flight band 19% of the time, 50-100m 15% of the time, and 100-200 m 6% of the time. Gannets had a similar distribution, and were observed flying at 20-50 m 17% of the time, 50-100 m 19% of the time, and 100-200 m 9% of the time. Scoters, ducks, and geese were generally observed flying lower, at 20-50 m 29% of the time, 50-100 m 2% of the time, and 100-200 m 1% of the time. Loons were also flying lower, in the 20-50 m altitude band 26% of the time, 50-100 m 0% of the time, and 100-200 m 3% of the time (for more details see Figure 5-13). Species groups that were less commonly observed in aerial surveys also had a more varied altitudinal distribution (Figure 5-14). While the majority of birds were observed flying below the rotor-swept zone, 40% of observations occurred between 20 and 200m in altitude (623 observations), and nearly every avian taxonomic group occurred within this zone. Gannets, gulls and terns, and loons all had high proportions of birds observed within this higher risk area (Figure 5-13). Flight height distributions were similar between the Maryland and MABS areas.

Fifteen Eastern Red Bats (*Lasiurus borealis*) were detected by observers in the September 2012 and 2013 MABS aerial surveys (Appendix 5A; Hatch et al. 2013). Fourteen of the bats were observed in one survey day in September of 2012, while an additional possible bat was seen on the September 2013 survey within the Maryland study area, and it was flying above 200 m. The bat observations were notable as they provided new evidence of offshore migrations of Eastern Red Bats, how high they fly while on migration, and the time of day that migrations may occur. Additional information may be found in Hatch et al. (2013).

Rays

Rays (Batoidea) represented over 61% of all observations from the Maryland aerial surveys (Table 5-2), a higher proportion than that found in the overall MABS area (44%). Cownose Rays were the most common ray species observed (47% of all rays, and almost 100% of all rays identified to species; Figure 5-10). Rays were not identified to species unless they were individually identifiable and their characteristic snouts were clearly visible, so many of the rays present in Cownose Ray schools (though they were not identifiable as Cownose Rays themselves) were likely also of the same species; the overwhelming majority of rays in video footage are thought to have been Cownose Rays. Some schools of rays were so densely packed and submerged that individuals could not be discerned, and these were identified as schools rather than as individuals (31 schools). These schools were primarily found in September (16 schools) when rays migrate through the study area (Goodman et al., 2011).

Rays were primarily observed during the summer and fall surveys (Figure 5-8), though there was a high level of variation between the two survey years: many more rays were observed in 2013 compared to 2012 (Table 5-2). The differences in observations between the two years, while partly attributable to the differences in survey coverage, may also reflect variation in water temperatures, timing of migration movements relative to our survey dates, or differences in migration behaviors. Rays additionally showed distinct monthly variation in abundance and distribution. Rays were distributed more broadly in the early summer surveys, June 2012 and July 2013 (Figure 5-15). More rays were seen in the July 2013 survey, and they were predominantly found further north along the coast of Virginia and Maryland compared to June 2012, when they were mostly found off the coast of Virginia and Chesapeake Bay. Rays in the September surveys were much more densely packed in pockets throughout the study area, but the 2013 survey had densities up to fifteen times those of the 2012 survey (Figure 5-15). High densities of rays were found in the Maryland Project study area during the September 2013 survey, a portion not surveyed in 2012, but other areas within the MABS study area showed high ray densities as well, particularly at the mouths of the Chesapeake Bay and Delaware Bay.

Discussion

Digital video aerial surveys and aquatic taxa

Digital aerial surveys have been noted to have less glare compared to visual aerial and boat surveys, and have an advantageous field of view for looking down on the water, both factors which increase visibility for aquatic animals such as sea turtles (Normandeau Associates, Inc. 2013), and we saw similar results in our study (Chapter 10). The high altitude of digital aerial survey aircraft also reduces disturbance compared to low-flying visual observation planes or survey vessels, which may play a role in increased detections (Normandeau Associates Inc. 2013). We discuss these differences in more detail in Chapter 10, where we directly compare the results of the two survey approaches.

We examine ray distributions and abundances in some detail in this chapter, as they were the most abundant animal in aerial surveys, and provided a good example of the use of digital video aerial surveys to monitor aquatic animals. Our study was the first to use digital video aerial surveys to monitor ray distributions and densities. Our findings not only illustrate the utility of the digital video aerial surveys for documenting the distributions of Cownose Rays, and aquatic animals in general, but add to the limited knowledge of Cownose Ray migratory movements in the Mid-Atlantic (Blaylock, 1993; Goodman et al., 2011). There is a continued risk of overfishing Cownose Rays, and a need to establish a baseline population assessment and develop an effective conservation and management plan (Goodwin, 2012). Additionally, rays could be affected by the formation of artificial reefs, as turbine foundations provide new habitats for benthic organisms, which could include species that they prey upon) (Andersson, 2011; Zucco et al., 2006). However, it is not clear whether Cownose Rays forage offshore during migration (e.g., in locations where turbines would be placed), so the potential for indirect effects to this taxon from such ecological changes is likewise unclear.

Many elasmobranchs are both magnetosensitive and electrosensitive, senses which are though tot be used to locate prey, predators, or conspecifics, as well as for navigation(Normandeau Associates Inc. et al., 2011). As a result, elasmobranchs can detect electromagnetic fields (EMF) produced by power transmission cables in the marine environment, including cables associated with offshore wind development (Gill et al., 2009; Normandeau Associates Inc. et al., 2011). It has been hypothesized that EMF could affect the navigation or foraging behaviors of these species, possibly causing disruption of migratory routes or influencing foraging patterns, although evidence of such effects is limited, and the results of the limited experimental studies on rays have been mixed (Boehlert and Gill, 2010; Gill, 2005; Gill et al., 2009). Experiments using EMF of similar types and intensities to those emitted by sub-sea cables showed some response by the EM-sensitive benthic Thornback Ray (*Raja clavata*), with some individuals showing increased searching effort for prey in the presence of EMF (presumably because the EMF were similar to those emitted by prey), but the response was not predictable (Gill et al., 2009). Cownose Rays do use electroreception to detect their prey, but their ability to detect and tendency to react to EMFs from sub-sea cables has not yet been determined (Boehlert and Gill, 2010; Smith and Merriner, 1985). In addition, the species could only be affected by EMF if they are at or near the ocean floor, within range of the fields (Boehlert and Gill, 2010). While the species is known to forage for mollusks on the seafloor in coastal bays during the summer breeding season (Smith and Merriner, 1985), it is unknown whether they behave similarly during migration, as we were only able to observe rays in the upper few meters of the water column.

Distribution and relative abundance patterns

Gulls and terns were the most abundant bird group observed in the aerial data in the Maryland study area, with scoters, ducks, and geese, gannets, and loons also observed in large numbers. This pattern was similar to that found in the broader MABS area, though scoters were the most abundant avian group in the MABS area, and most avian groups had fewer than the expected numbers of birds given the proportional spatial coverage of the Maryland study area compared to the MABS area. This pattern was also similar to that found in the boat-based surveys (Chapter 7), though much higher numbers of birds were found in the boat surveys (Chapter 10). Gulls and terns were the most abundant in the summer and fall, when several species were breeding onshore and foraging in the study area, though Bonaparte's Gulls were most abundant in the winter (Nisbet et al., 2013). Maryland and the Mid-Atlantic region are important wintering grounds for gannets, scoters, and loons (Barr et al., 2000; Bordage and Savard, 2011; Mowbray, 2002; Savard et al., 1998), and in this study, all three of these species groups were most commonly found in the study area in the winter and spring. Fewer aquatic animals were seen in the Maryland study area in the winter, but many fish were observed in spring, and rays were extremely abundant in the spring, summer, and fall. Toothed whales were observed in highest numbers in the spring; in general, Bottlenose Dolphins were present in the warmer months, and Common Dolphins (*Delphinus delphis*) more abundant in the cooler months (Chapter 12).

Other notable observations include many observations of sea turtles, including all five species present in the study area. There was also a sighting of an Eastern Red Bat in the Maryland study area, as well as over a dozen other red bat observations in the MABS study area in the fall, providing evidence for offshore migration in this species. Two large whales were seen migrating through the Maryland study area in cooler months. Some passerines were observed migrating through the study area as well, though they were not identified to species; more passerines were observed from the boat platform than in aerial video. Most passerines migrate at night, however, when surveys do not occur (Adams et al., 2015a, 2015b).

Flight heights and collision risk

Flight height data is often used alongside information on avoidance behaviors, turbine specifications, and other data in models that attempt to estimate avian collision risk for offshore wind energy projects in Europe (e.g., Band 2012), although there is still debate in the European literature regarding the factors that best predict this risk (e.g., Cook et al. 2012, Douglas et al. 2012, Langston 2013, Furness et al. 2013). Flight heights are suspected to vary in relation to weather and time of day, for example, so collision risk is likely to be highest at night, and in particular on nights with poor visibility (Dirksen et al., 2000; Hüppop et al., 2006). Our surveys were limited to daytime hours and periods of clear weather, when cameras had adequate visibility for observing and identifying animals (Chapter 3), which may limit the applicability of these flight height data for estimating collision risk.

In our study, we compared the estimated flight heights of birds and bats in relation to the potential rotor-swept zones (RSZ) of offshore wind turbines. The RSZ depends on the turbine type; for example, the RSZ for Siemens 3.6 MW offshore turbines is about 28-132 m, while the RSZ for Siemens 6 MW turbines is about 27-177 m, though specific altitudes will vary by site[2]. Larger turbines are also possible, and prototypes have already been deployed in some locations in Europe[3]. While the majority of birds were observed flying below 20 meters, and thus below the expected RSZ, 40% of observations occurred between 20 and 200 m in altitude (623 observations), and nearly every avian taxonomic group was observed within this zone at some point in our study. Gannets, gulls and terns, loons, and scoters, ducks, and geese all had high proportions of birds within this altitude range (Figure 5-13).

Species identifications

Identification rates for some animal groups were low in this study. In future, it is likely that many of the issues related to identification rates and lower-confidence observations that occurred in this study will be addressed through technical improvements to the camera systems, but analytical approaches can also help address this issue. The development and use of a metric for image quality, which could be applied to all video data, would be helpful for assessing identification rates relative to changing atmospheric conditions (Duron et al., 2015). Inter-observer and inter-survey bias in species identifications could also be examined using a double observer approach during video analysis. This approach would be relatively straightforward to incorporate into existing audit protocols for object location and species identification.

Early digital video aerial surveys were conducted at 2 cm GSR in some areas, and 3 cm GSR in others. Initial review of these video data indicated that, despite the high number of easily identifiable scoters in early surveys, the clarity of the 3 cm video was not sufficient to identify many taxa to species (Duron et al., 2015). The study design was adjusted beginning in September 2012 to conduct all survey flights at 2 cm GSR. While this reduced the sampled area for the sawtooth transects from roughly 3.2% of the study area to 2.1% (since a higher GSR necessitates a narrower transect strip), project collaborators felt it was necessary to improve video clarity and species identification rates. Newer generations of these camera systems, currently in operation in Europe, have a wider strip width and better clarity and color rendition, thus rendering this tradeoff largely unnecessary (A. Webb pers. comm.).

Other analyses of digital video aerial survey data

Chapters in Part IV of this report further analyze digital video aerial data, either separately or alongside boat survey data. Two chapters focus on contrasting boat and digital video aerial survey approaches (Chapters 10 and 13). In other cases, digital video aerial survey data and boat survey data are used jointly to describe distributions and abundance of animals across the study area (Chapters 11-12, 14).

[2] http://www.energy.siemens.com/hq/en/renewable-energy/wind-power/platforms/
[3] http://www.windpowermonthly.com/10-biggest-turbines

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Figures and tables

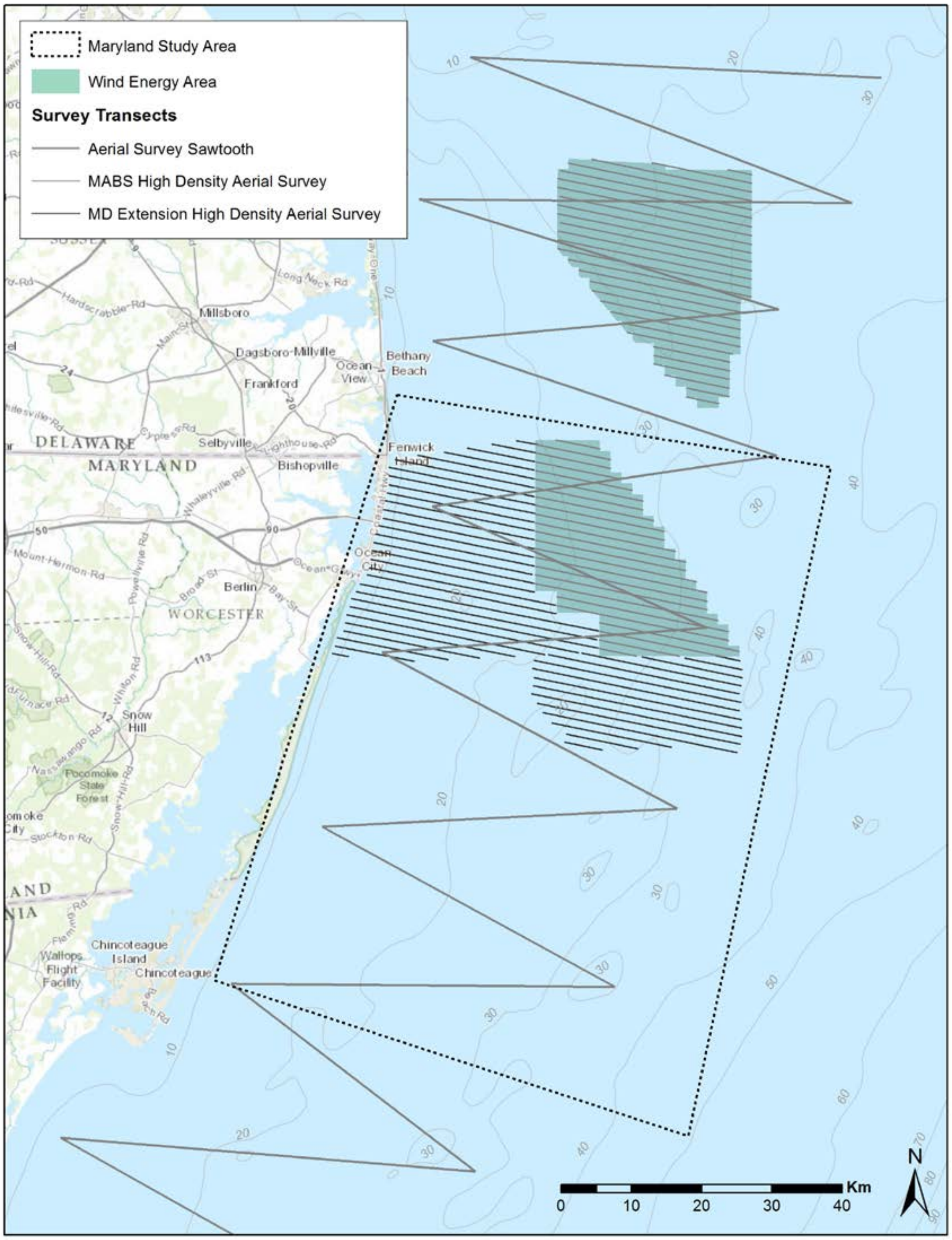

Figure 5-1. Map of aerial survey transects for the Maryland Project. The northern part of the MABS study area is also shown. The Maryland study area (black box) includes all boat and aerial survey transects in waters offshore of Maryland (both DOE and Maryland-funded surveys, 2012-2014). The Maryland Project surveys are a subset of the surveys within the Maryland study area that were specifically funded by the state of Maryland in 2013-2014 (shown in darker gray).

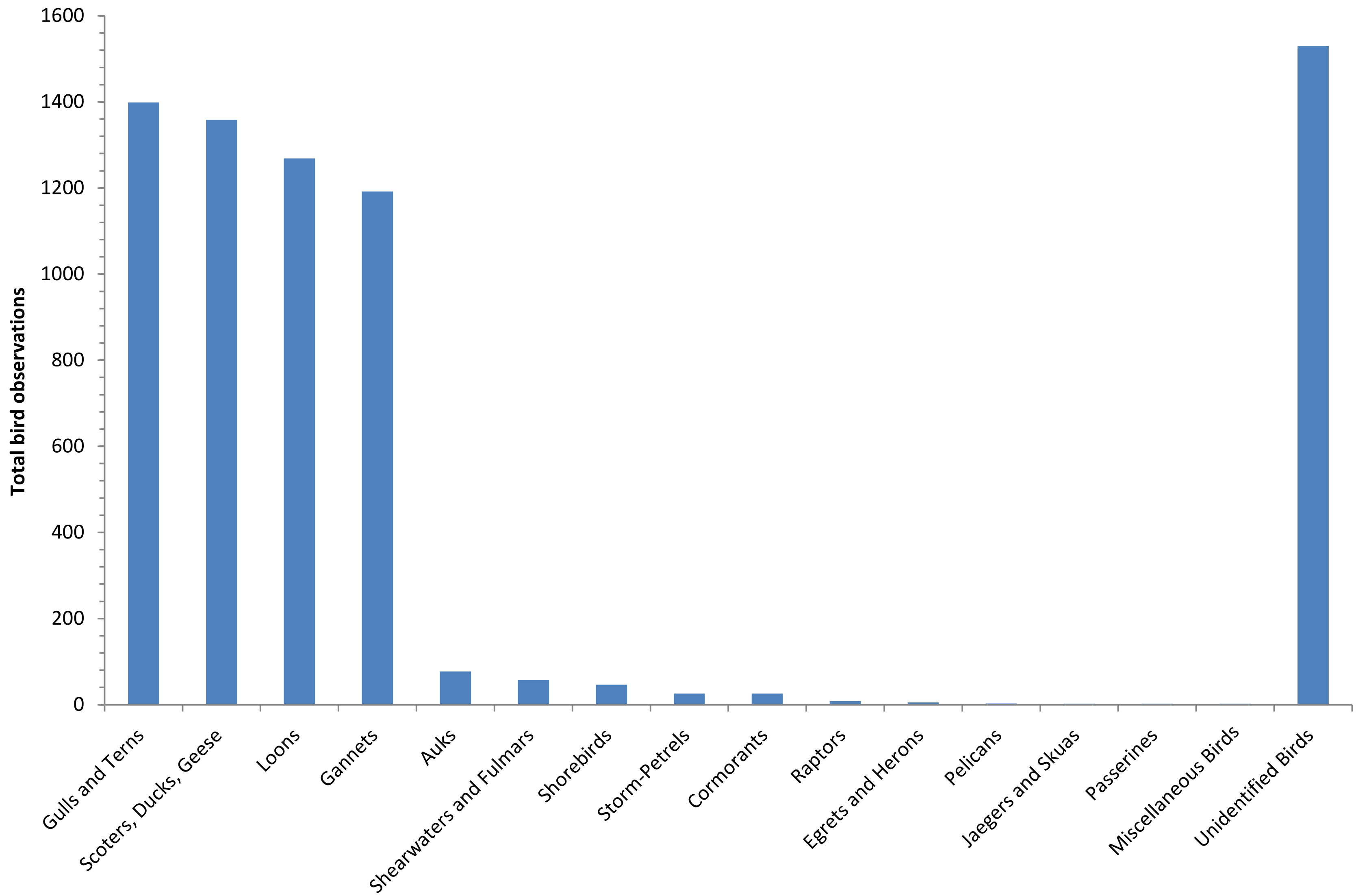

Figure 5-2. Avian observations from the Maryland study area digital video aerial surveys by family (March 2012 - May2014). Unidentified birds are all birds not identified to species or to any higher level taxonomic groups. Birds from all levels of identification are taken at face value (e.g., possible Northern Gannet is counted as Northern Gannet).

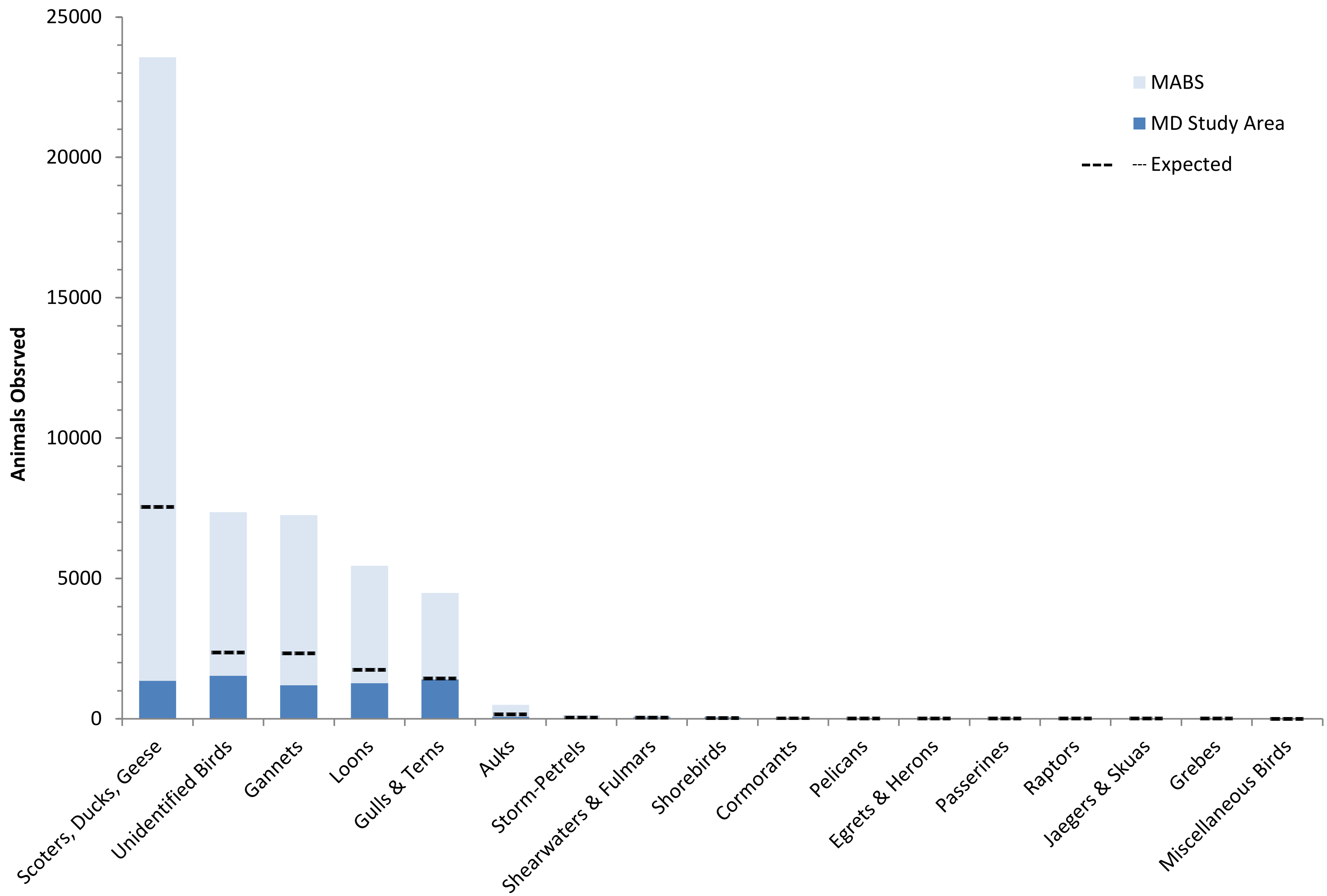

Figure 5-3. Birds observed in the Maryland study area and the Mid-Atlantic Baseline Studies project area (Figure 5-1). The expected number of animals given the proportion of the study area covered in the Maryland project area (32%) is shown for each bird group using a dashed line.

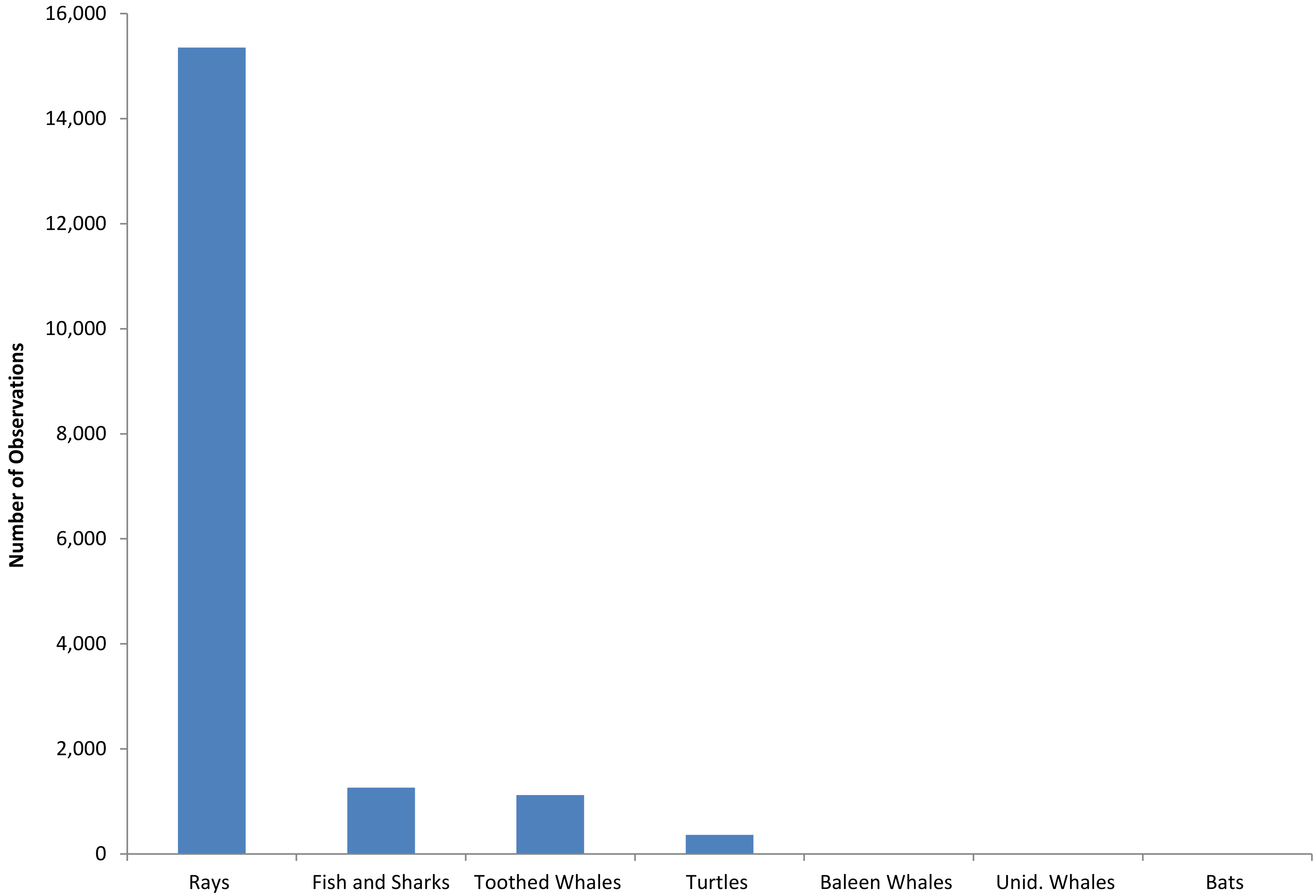

Figure 5-4. Observations from the Maryland digital video aerial surveys of other non-avian animals by family group (March 2012 – May 2014). Note that the numbers presented here do not include schools of rays or fish, so these data are an underestimate of the total counts of these animals.

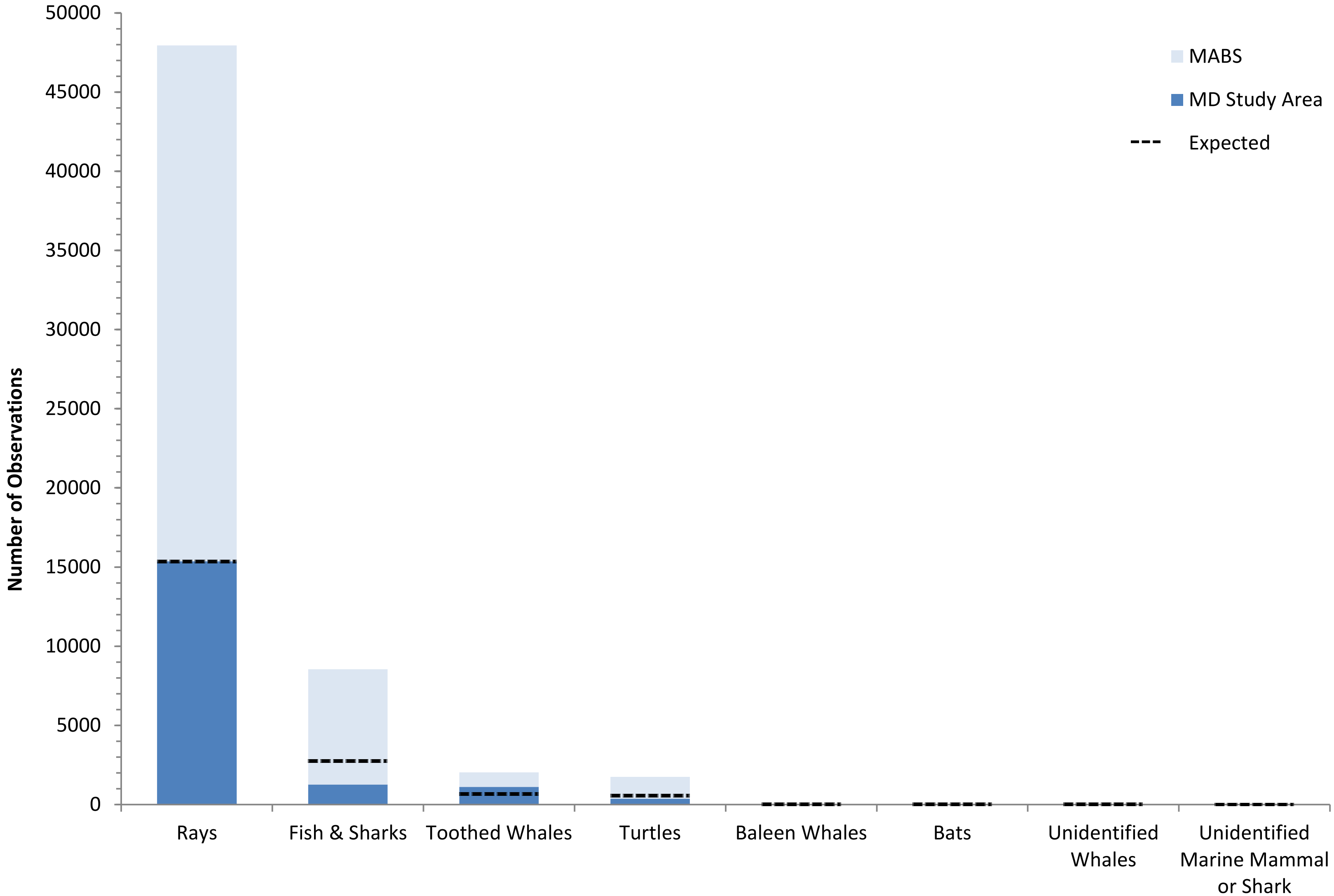

Figure 5-5. Aquatic animals observed in the Maryland study area and the Mid-Atlantic Baseline Studies project area (Figure 5-1). The expected number of animals given the proportion of the study area covered in the Maryland project area (32%) is shown for each group using a dashed line.

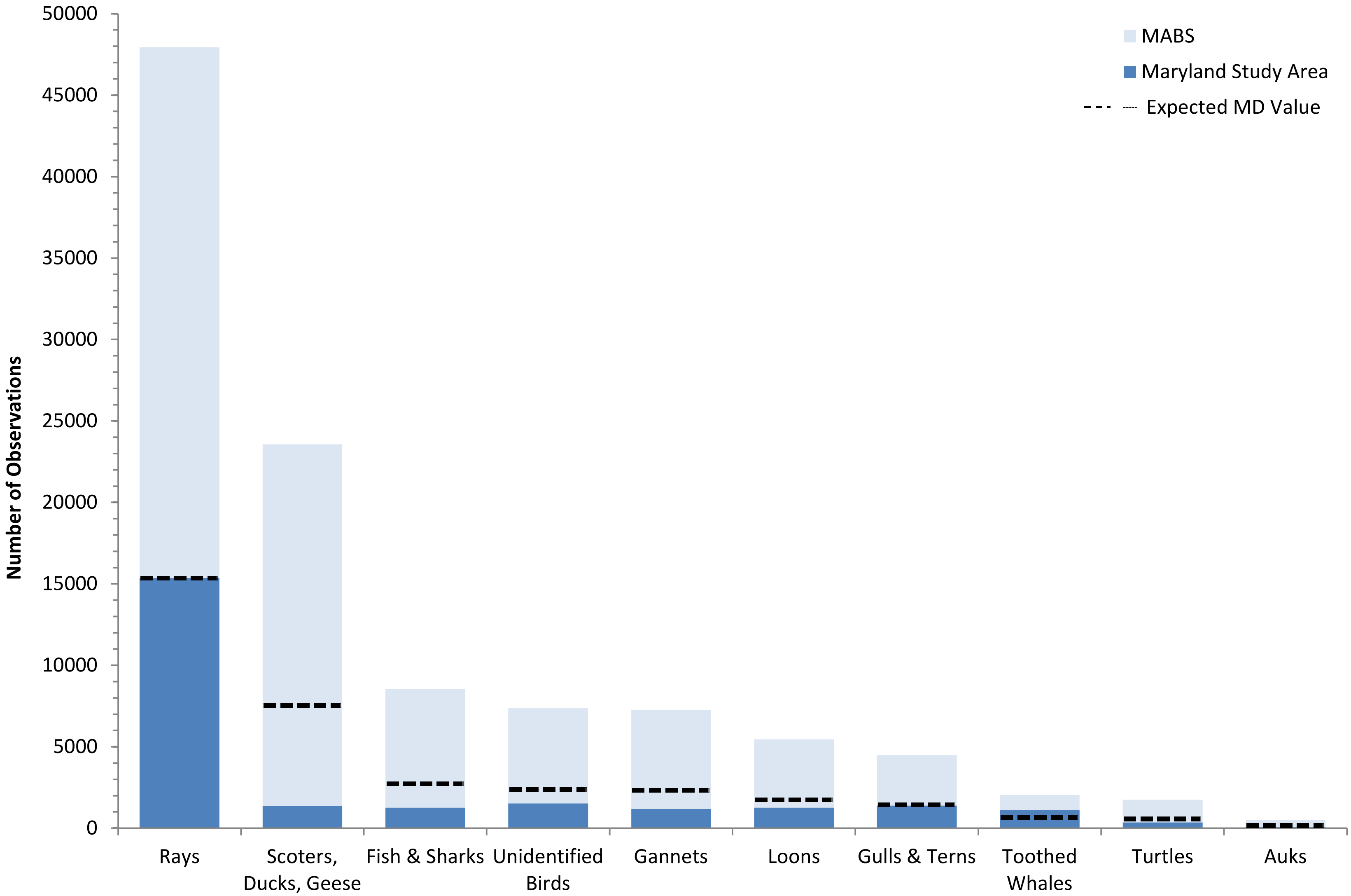

Figure 5-6. Observations of the most abundant animal groups from Maryland study area and the Mid-Atlantic Baseline Studies project area (Figure 5-1). The dashed line represents the expected number of animals given the proportion of the overall study area that includes Maryland (32%).

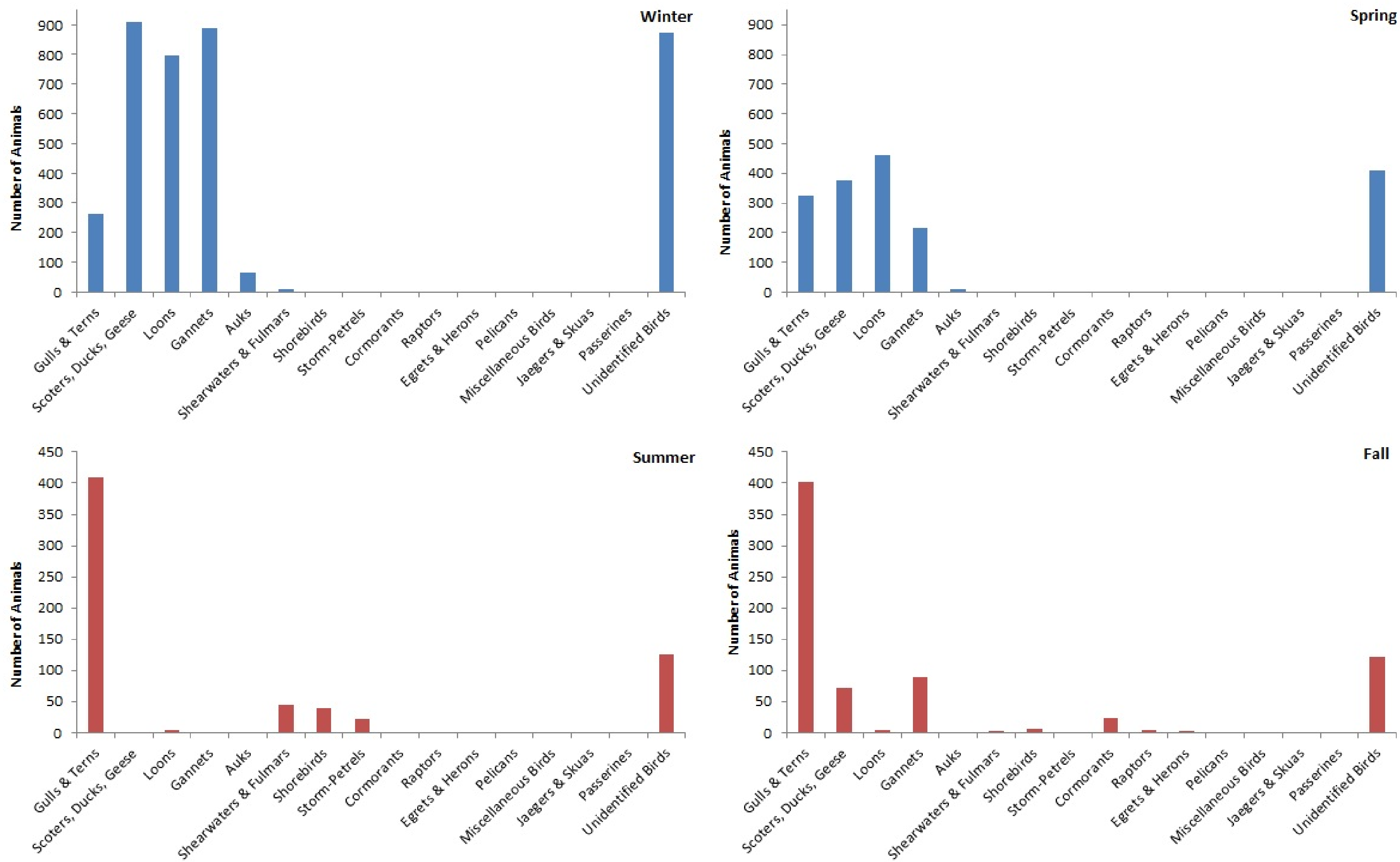

Figure 5-7. Abundance of birds by family or group in winter (December through February), spring (March and May), summer (June, July, August), and fall (September and October). Note different y-axis between top and bottom graphs. X-axes are in order of overall abundance by family or group across all surveys.

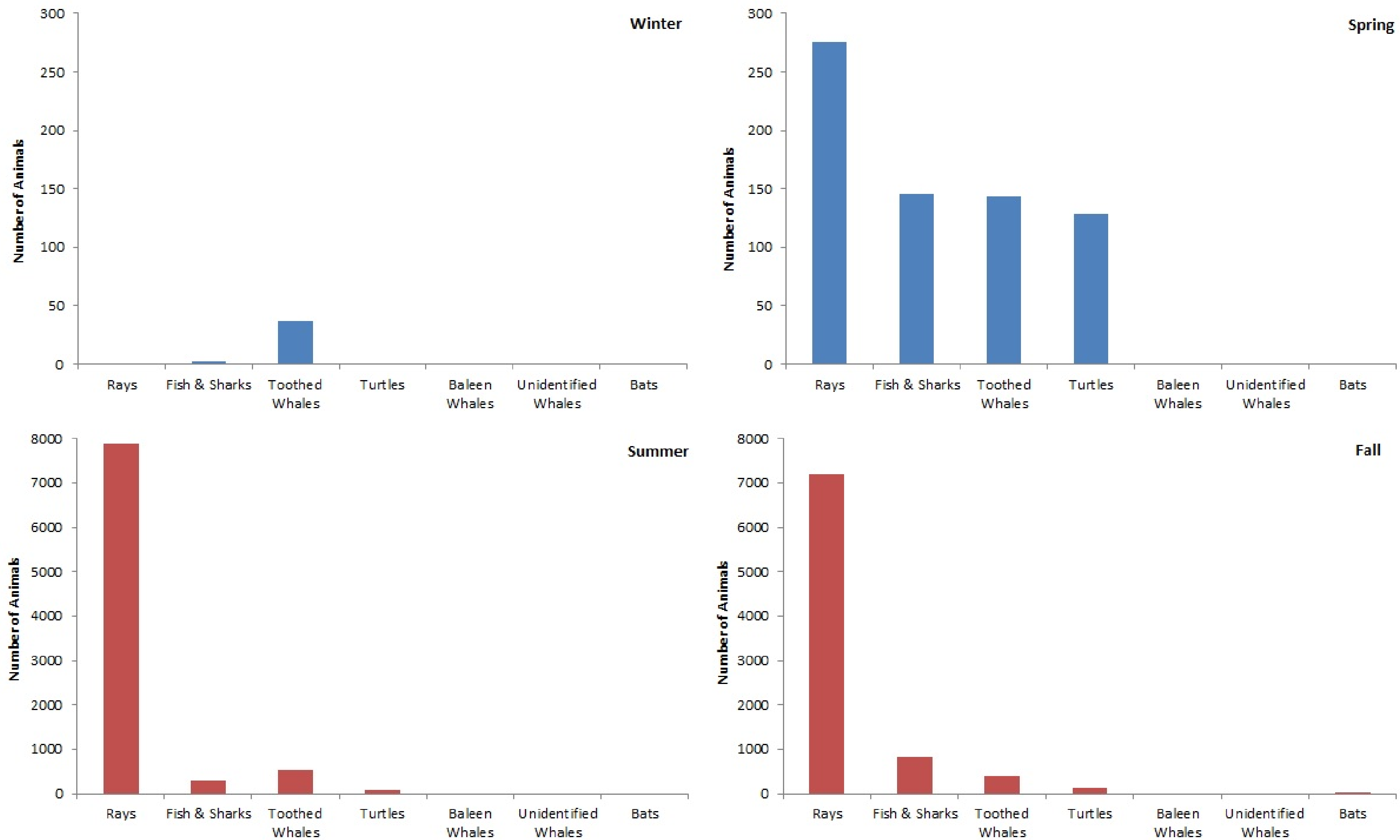

Figure 5-8. Abundance of non-avian animals by group in winter (December to February), spring (March and May), summer (June, July, August), and fall (September and October). Note different y-axis between the top and the bottom graphs. X-axes are in order of overall abundance by family or group across all surveys.

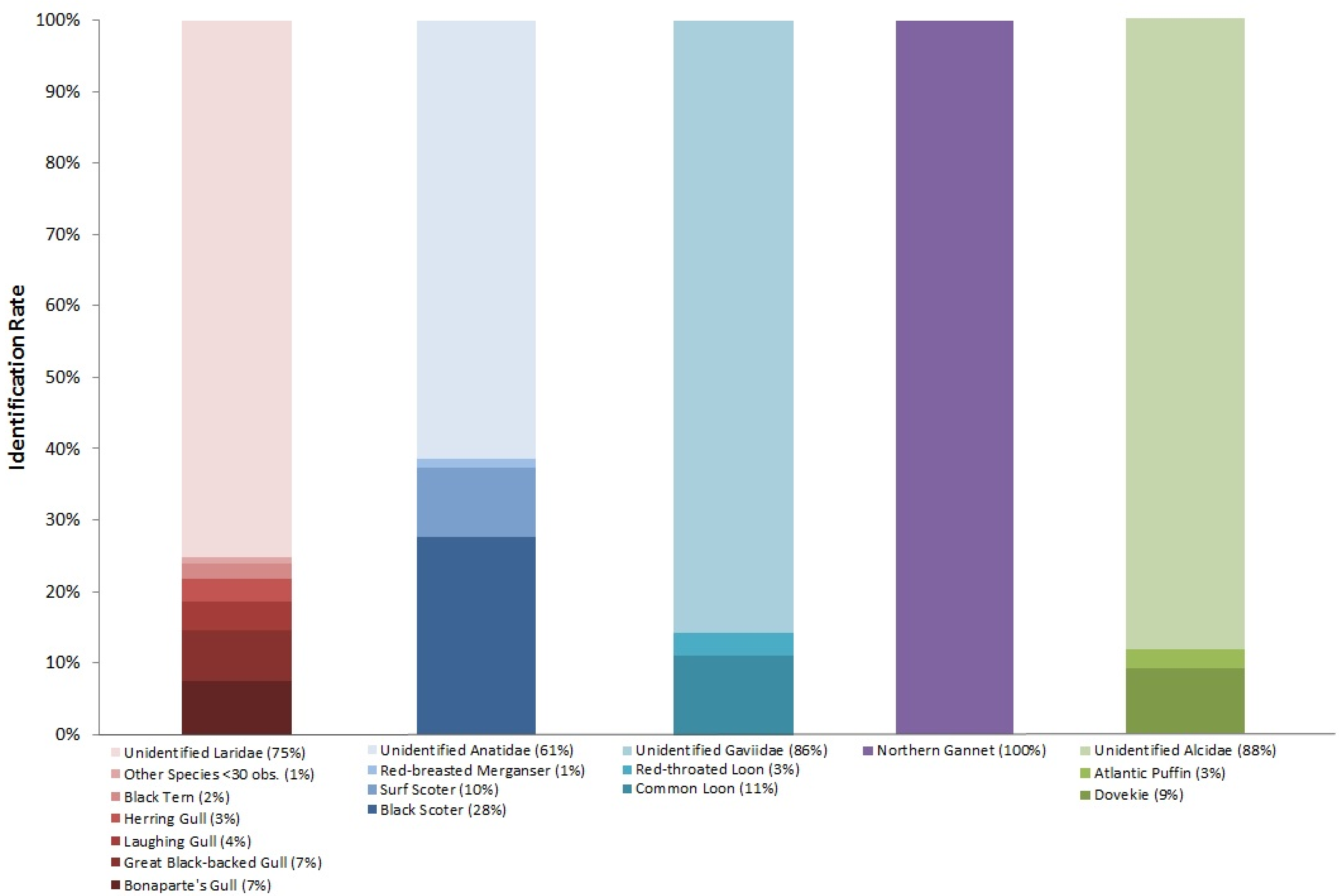

Figure 5-9. Rates of species-level identifications of most abundant avian families from the Maryland study area digital aerial surveys. "Other Species" in the Laridae (red, n=1399) column can be found in Appendix 5A. Sample sizes for Anatidae, Gaviidae, Sulidae, and Alcidae are 1358, 1269, 1192, and 77, respectively. Birds from all levels of identification are taken at face value (e.g., possible Black Scoter is counted as Black Scoter).

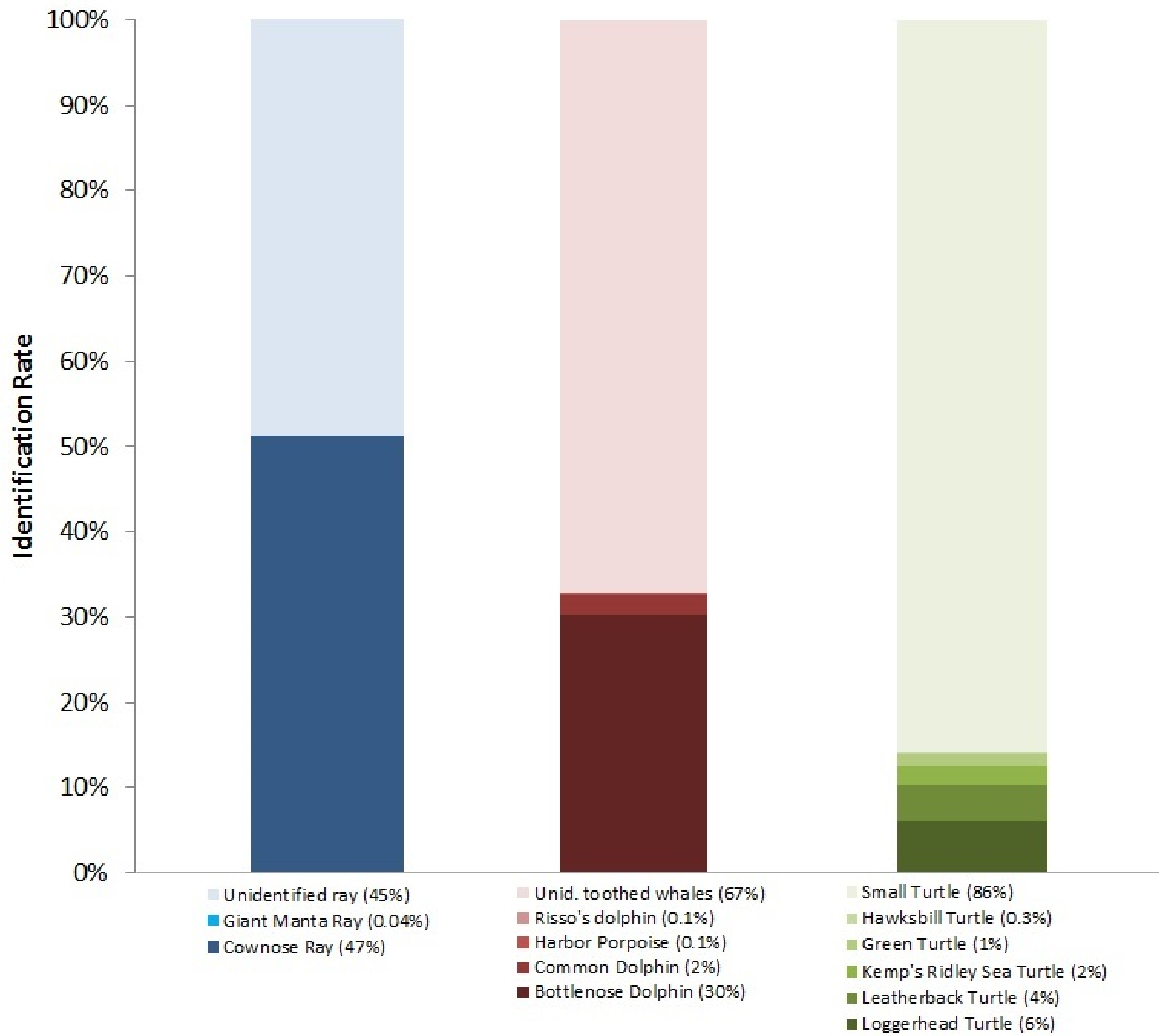

Figure 5-10. Rates of species-level identifications of aquatic animal groups from the Maryland study area digital video aerial surveys. Sample sizes for rays, dolphins, and turtles are 15357, 1121, and 366, respectively.

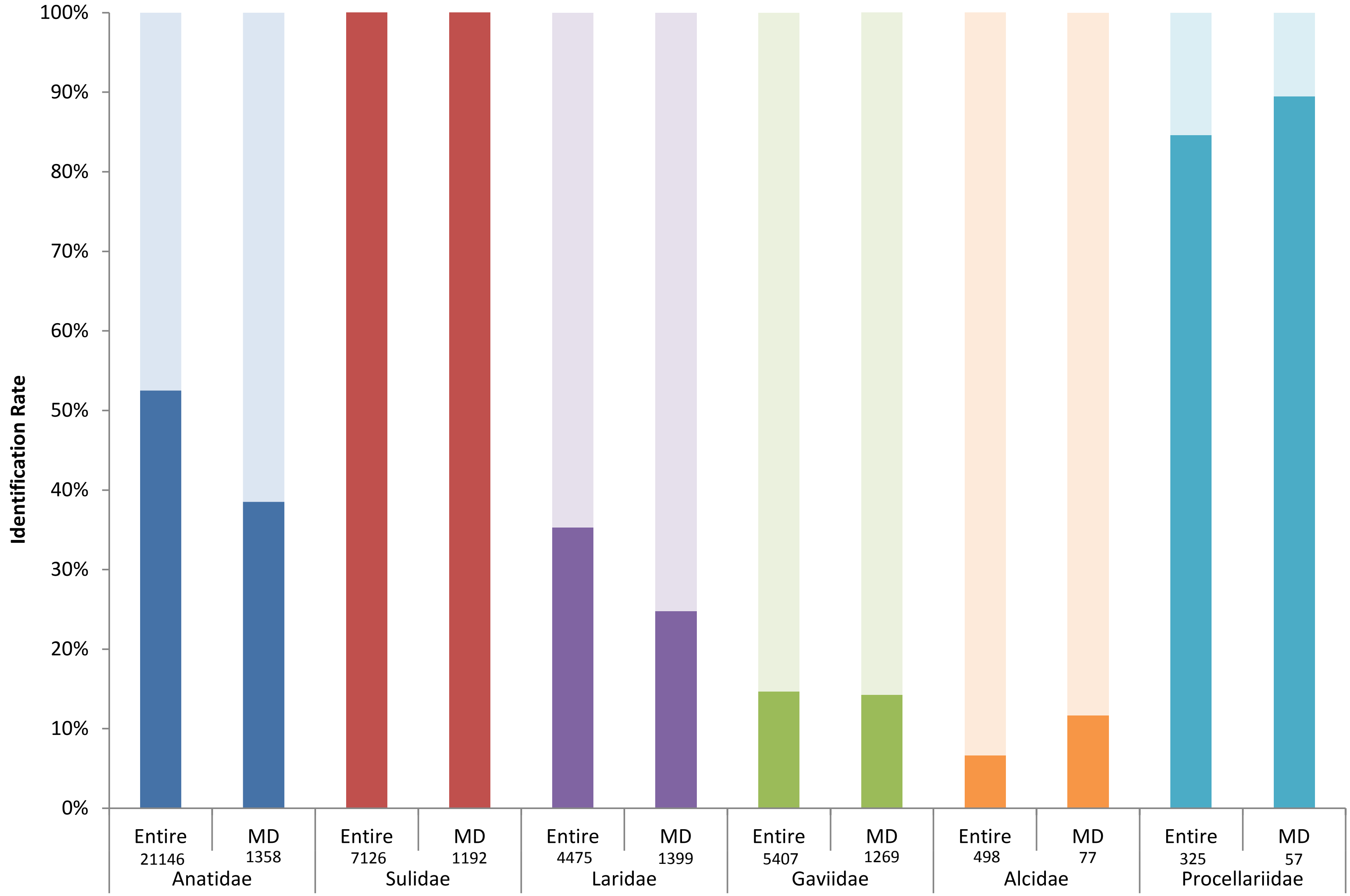

Figure 5-11. Rates of species-level identifications for the five most abundant avian groups from the Mid-Atlantic Baseline Studies and Maryland Projects (Entire) and the Maryland Study Area specifically (MD). Within each taxonomic group, birds that were identified to the species level are shown in dark colors, and those identified to a higher taxonomic level are shown in lighter colors. The total number of birds in each category is given below the bar.

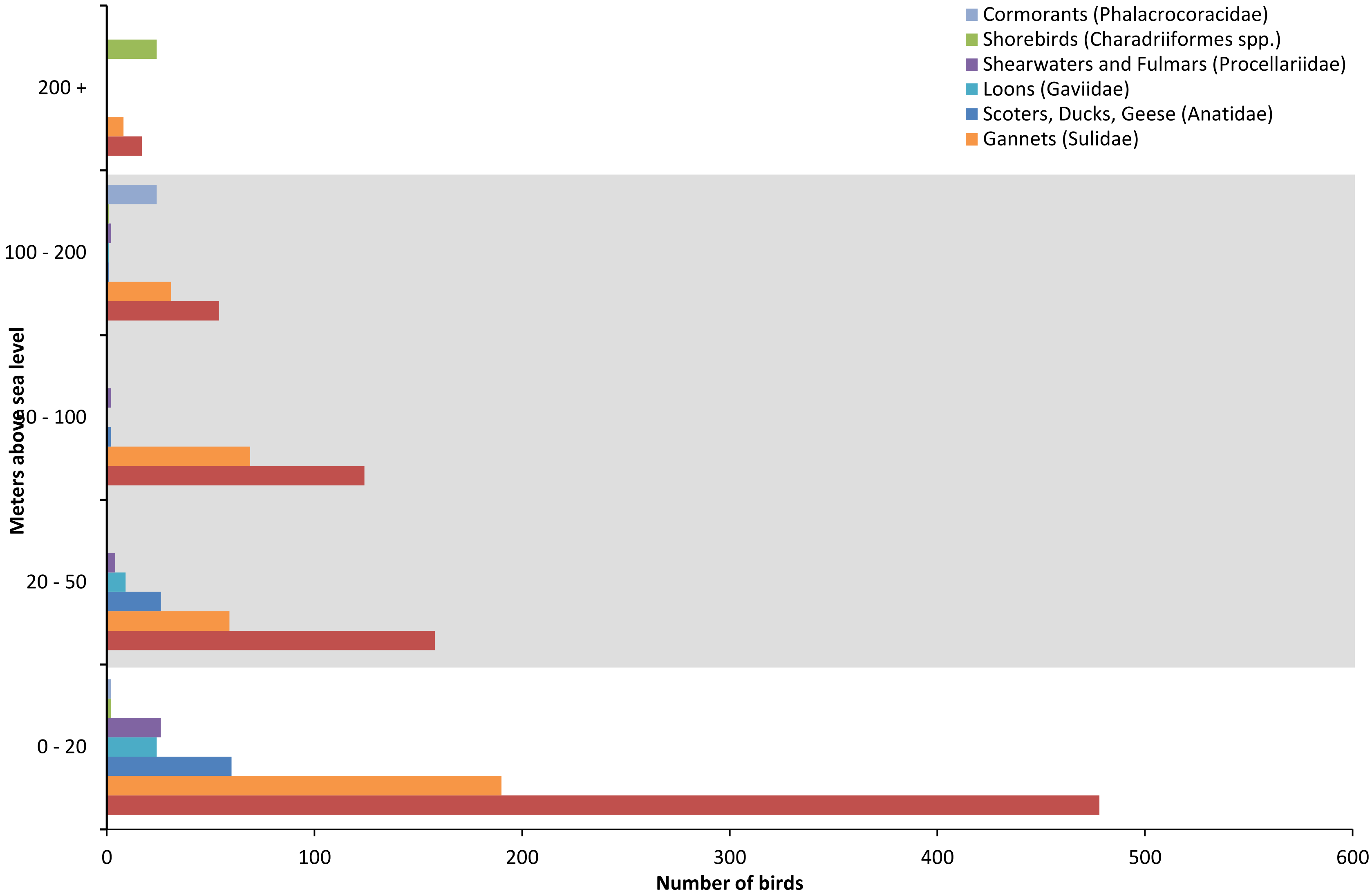

Figure 5-12. Flight height above sea level (meters) of the most abundant bird families from digital video aerial surveys in the Maryland study area. Data are presented as number of animals observed at the given height range. All confidence levels are included for this figure. Grey hatch marks indicate a possible range of altitudes for the rotor-swept zone for offshore wind turbines.

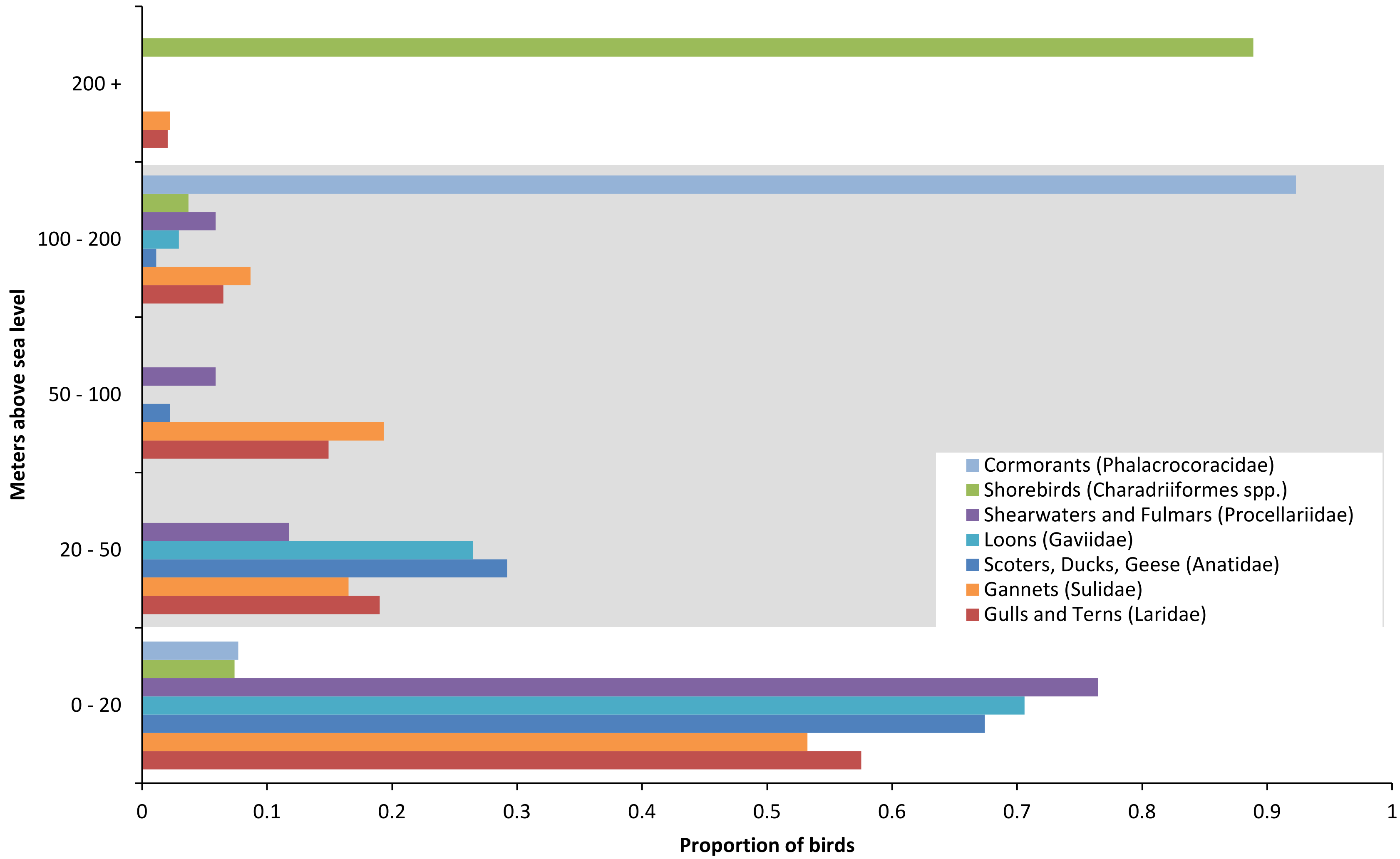

Figure 5-13. Flight height above sea level (meters) of the most abundant bird families from digital video aerial surveys in the Maryland study area. Data are presented as the proportion of each species group observed at the given height range. All confidence levels are included for this figure. Grey hatch marks indicate a possible range of altitudes for the rotor-swept zone for offshore wind turbines.

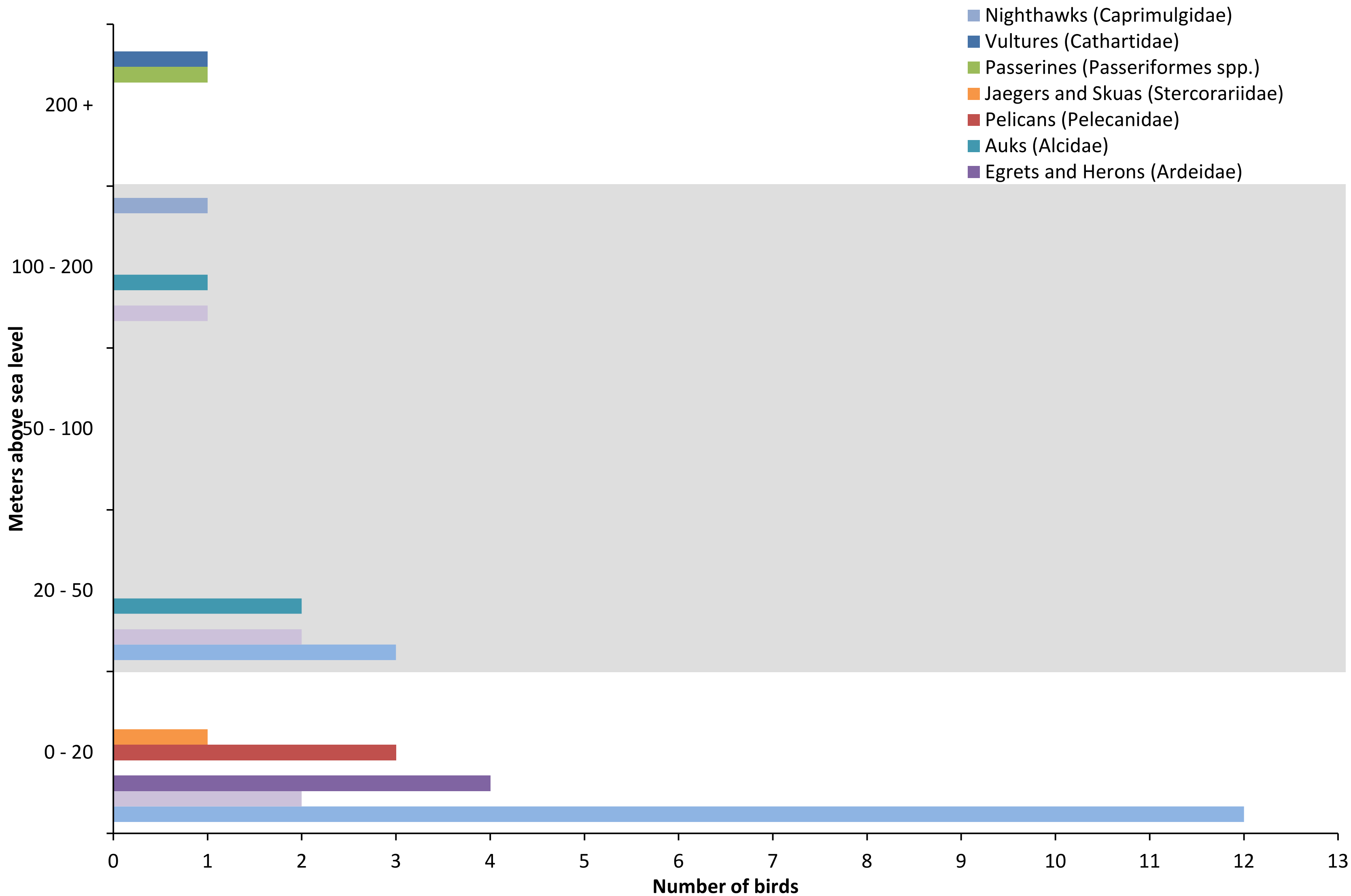

Figure 5-14. Flight height above sea level (meters) for eight less abundant bird families or groups from digital video aerial surveys in the Maryland study area. In several cases, less common families have been combined into broader taxonomic categories (e.g., Passerines). Data are presented as number of animals observed at the given height range. All confidence levels are included for this figure. Grey hatch marks indicate a possible range of altitudes for the rotor-swept zone for offshore wind turbines.

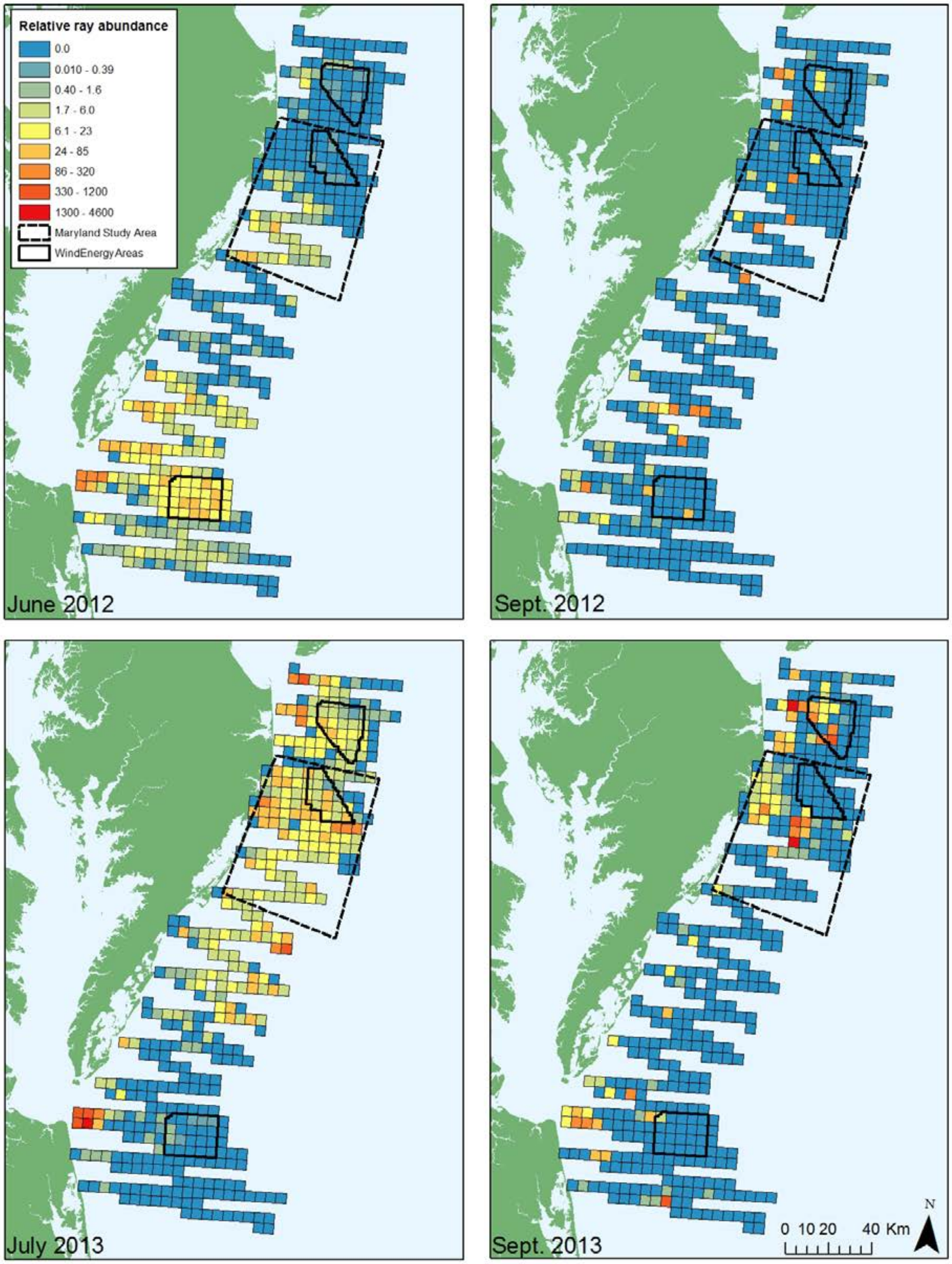

Figure 5-15. Effort-corrected ray counts within lease blocks for the four surveys when they were the most abundant. Count data were corrected by area surveyed within each lease block. Values have not been corrected for detection bias and should be considered as relative estimates of density, not as estimates of actual ray densities. The Wind Energy Areas and Maryland study area are indicated in black.

Table 5-1 Weeks in which digital aerial video surveys were completed during the Mid-Atlantic Baseline Studies Project. Each survey took from one to eleven survey days to complete, depending upon weather, plane availability, and other factors. Surveys colored in gray only included Mid-Atlantic Baseline Studies transects; surveys in blue included Maryland Project transects as well. The survey noted in pale blue (August 2013) included only Maryland Project transects and coverage of the Maryland WEA.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
2012												
2013												
2014												

Table 5-2. Summary data for the Maryland aerial surveys (by species group). Data include the Maryland Project surveys, the Maryland MABS WEA surveys, and the DOE Sawtooth surveys that fall within Maryland waters (**Figure 5-1**). Data are presented in order of abundance based on the total count from all surveys. Counts include definite, probable, and possible identifications (see text). Grey survey headings and totals include only the MABS surveys; darker blue surveys include the Maryland Project in addition to the MABS WEA and sawtooth surveys; and the light blue survey included only the Maryland Project and the Maryland WEA.

Animal Group	Mar. 2012	May. 2012	Jun. 2012	Sep. 2012	Oct. 2012	Dec. 2012	Feb. 2013	Mar. 2013	Jul. 2013	Aug. 2013	Sep. 2013	Oct. 2013	Dec. 2013	Feb. 2014	May. 2014	Grand Total	Percent
Unidentified Birds (Aves spp.)	17	36	24	11	15	51	199	221	19	83	52	44	330	326	102	1530	6.09%
Gulls and Terns (Laridae)	37	109	25	16	55	31	14	31	122	262	197	134	205	15	146	1399	5.57%
Scoters, Ducks, Geese (Anatidae)	1	0	0	0	0	14	328	229	0	0	0	73	185	383	145	1358	5.41%
Loons (Gaviidae)	16	90	2	0	3	64	240	234	1	2	1	1	248	268	99	1269	5.05%
Gannets (Sulidae)	31	4	0	0	16	66	267	168	1	0	1	72	413	151	2	1192	4.75%
Auks (Alcidae)	0	0	0	0	0	31	8	6	0	0	0	1	21	10	0	77	0.31%
Shearwaters and Fulmars (Procellariidae)	0	0	46	0	1	0	0	0	0	0	0	2	1	6	1	57	0.23%
Shorebirds (Charadriiformes spp.)	0	0	0	7	0	0	0	0	32	7	0	0	0	0	0	46	0.18%
Storm-Petrels (Hydrobatidae)	0	0	10	0	0	0	0	0	8	5	0	1	0	0	2	26	0.10%
Cormorants (Phalacrocoracidae)	0	0	0	0	24	0	0	0	0	0	0	0	0	0	2	26	0.10%
Raptors (Accipitridae and Pandionidae)	0	0	0	0	0	0	0	0	0	0	2	4	0	0	2	8	0.03%
Egrets and Herons (Ardeidae)	0	0	0	0	4	0	0	0	0	1	0	0	0	0	0	5	0.02%
Pelicans (Pelecanidae)	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	3	0.01%
Miscellaneous Birds	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	2	0.01%
Jaegers and Skuas	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0.01%

Animal Group	Mar. 2012	May. 2012	Jun. 2012	Sep. 2012	Oct. 2012	Dec. 2012	Feb. 2013	Mar. 2013	Jul. 2013	Aug. 2013	Sep. 2013	Oct. 2013	Dec. 2013	Feb. 2014	May. 2014	Grand Total	Percent
(Stercorariidae)																	
Passerines (Passeriformes spp.)	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0.01%
Total Birds	**102**	**240**	**109**	**34**	**118**	**257**	**1056**	**890**	**184**	**361**	**255**	**333**	**1403**	**1159**	**501**	**7002**	**27.88%**
Rays (Batoidea)	0	0	298	593	121	1	0	0	7224	374	6463	7	0	0	276	15357	61.15%
Fish and Sharks	1	65	15	126	88	2	0	1	177	96	610	4	0	1	79	1265	5.04%
Toothed Whales (Odontoceti)	2	37	41	98	1	21	11	8	203	284	311	2	0	5	97	1121	4.46%
Turtles (Testudines)	0	24	20	27	59	0	0	0	46	25	43	17	0	0	105	366	1.46%
Baleen Whales (Mysticeti)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	0.01%
Unidentified Whale (Cetacea)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0.00%
Bats (Chiroptera)	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0.00%
Non-Avian Total	**3**	**126**	**374**	**844**	**269**	**24**	**11**	**9**	**7650**	**779**	**7428**	**30**	**0**	**8**	**558**	**18113**	**72.12%**
Total	**105**	**366**	**483**	**878**	**387**	**281**	**1067**	**899**	**7834**	**1140**	**7683**	**363**	**1403**	**1167**	**1059**	**25115**	**100.00%**

Supplementary material

Appendix 5A. Summary of animals observed in Maryland during aerial surveys

Table 5A-1 Summary of animals observed in Maryland during 14 aerial surveys in 2012-2014. Data include the Maryland Project surveys, the Maryland DOE WEA surveys, and the DOE Sawtooth surveys that fall within Maryland waters (**Figure 5-1**). Data are presented in order of abundance by family, based on the total count from all surveys. Note the August 2013 survey included only the Maryland WEA and Maryland Project study area. Grey survey headings and totals include only the MABS surveys; darker blue surveys include the Maryland Project in addition to the MABS WEA and sawtooth surveys; and the light blue survey included only the Maryland Project and the Maryland WEA.

Common Name	Mar. 2012	May. 2012	Jun. 2012	Sep. 2012	Oct. 2012	Dec. 2012	Feb. 2013	Mar. 2013	Jul. 2013	Aug. 2013	Sep. 2013	Oct. 2013	Dec. 2013	Feb. 2014	May. 2014	Grand Total	Percent
Unidentified Bird	17	36	24	11	15	51	199	221	19	83	52	44	330	326	102	1530	6.09%
Unidentified Birds (Aves spp.) Total	**17**	**36**	**24**	**11**	**15**	**51**	**199**	**221**	**19**	**83**	**52**	**44**	**330**	**326**	**102**	**1530**	**6.09%**
Unidentified Gull	5	7	1	1	15	4	9	22	26	89	60	44	69	9	34	395	1.57%
Unidentified Tern	0	18	4	9	6	0	0	0	46	75	47	22	0	0	57	284	1.13%
Tern/Small or Medium Gull	12	29	3	1	7	1	1	1	3	14	7	4	43	3	36	165	0.66%
Bonaparte's Gull	13	0	0	0	0	12	1	1	0	0	0	0	76	1	0	104	0.41%
Great Black-backed Gull	0	3	0	0	10	13	1	3	2	3	10	40	9	1	4	99	0.39%
Unidentified Large Gull	0	2	3	1	10	0	2	0	4	16	48	7	2	0	0	95	0.38%
Laughing Gull	0	0	2	0	0	0	0	1	31	7	4	5	0	0	6	56	0.22%
Herring Gull	3	2	3	0	4	1	0	3	0	3	5	10	6	1	5	46	0.18%
Medium Tern: 32-45 cm	0	42	2	1	0	0	0	0	0	0	0	0	0	0	0	45	0.18%
Black Tern	0	0	0	0	0	0	0	0	0	26	4	0	0	0	0	30	0.12%
Unidentified small Tern	0	0	0	1	0	0	0	0	2	14	4	0	0	0	0	21	0.08%
Unidentified large Tern	1	3	3	0	0	0	0	0	3	1	5	0	0	0	4	20	0.08%
Unidentified small gull	3	0	0	0	0	0	0	0	3	13	0	0	0	0	0	19	0.08%
Medium Gull: 38-53 cm	0	3	2	1	2	0	0	0	0	0	0	0	0	0	0	8	0.03%
Sabine's Gull	0	0	0	0	0	0	0	0	0	1	1	2	0	0	0	4	0.02%
Caspian Tern	0	0	1	1	0	0	0	0	2	0	0	0	0	0	0	4	0.02%
Lesser Black-backed Gull	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	3	0.01%
Common Tern	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.00%
Gulls and Terns (Laridae) Total	**37**	**109**	**25**	**16**	**55**	**31**	**14**	**31**	**122**	**262**	**197**	**134**	**205**	**15**	**146**	**1399**	**5.57%**

Common Name	Mar. 2012	May. 2012	Jun. 2012	Sep. 2012	Oct. 2012	Dec. 2012	Feb. 2013	Mar. 2013	Jul. 2013	Aug. 2013	Sep. 2013	Oct. 2013	Dec. 2013	Feb. 2014	May. 2014	Grand Total	Percent
Unidentified Scoter	0	0	0	0	0	1	186	103	0	0	0	24	43	330	144	831	3.31%
Black Scoter	1	0	0	0	0	13	123	82	0	0	0	45	100	10	1	375	1.49%
Surf Scoter	0	0	0	0	0	0	19	36	0	0	0	2	34	42	0	133	0.53%
Red-breasted Merganser	0	0	0	0	0	0	0	6	0	0	0	0	8	1	0	15	0.06%
Unidentified Duck	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	4	0.02%
Scoters, Ducks, Geese (Anatidae) Total	**1**	**0**	**0**	**0**	**0**	**14**	**328**	**229**	**0**	**0**	**0**	**73**	**185**	**383**	**145**	**1358**	**5.41%**
Unidentified Loon	16	30	1	0	2	51	172	224	0	2	1	1	232	261	95	1088	4.33%
Common Loon	0	52	1	0	1	10	44	6	1	0	0	0	16	7	3	141	0.56%
Red-throated Loon	0	8	0	0	0	3	24	4	0	0	0	0	0	0	1	40	0.16%
Loons (Gaviidae) Total	**16**	**90**	**2**	**0**	**3**	**64**	**240**	**234**	**1**	**2**	**1**	**1**	**248**	**268**	**99**	**1269**	**5.05%**
Northern Gannet	31	4	0	0	16	66	267	168	1	0	1	72	413	151	2	1192	4.75%
Gannets (Sulidae) Total	**31**	**4**	**0**	**0**	**16**	**66**	**267**	**168**	**1**	**0**	**1**	**72**	**413**	**151**	**2**	**1192**	**4.75%**
Unidentified Alcid	0	0	0	0	0	11	7	6	0	0	0	0	20	7	0	51	0.20%
Unidentified large alcid (Razorbill or Murre)	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	13	0.05%
Dovekie	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	7	0.03%
Unidentified small alcid (Puffin/Dovekie)	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0	4	0.02%
Atlantic Puffin	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0.01%
Auks (Alcidae) Total	**0**	**0**	**0**	**0**	**0**	**31**	**8**	**6**	**0**	**0**	**0**	**1**	**21**	**10**	**0**	**77**	**0.31%**
Greater Shearwater	0	0	32	0	0	0	0	0	0	0	0	0	0	0	0	32	0.13%
Cory's Shearwater	0	0	6	0	1	0	0	0	0	0	0	2	0	0	0	9	0.04%
Northern Fulmar	0	0	1	0	0	0	0	0	0	0	0	0	1	6	0	8	0.03%
Unidentified Shearwater	0	0	5	0	0	0	0	0	0	0	0	0	0	0	1	6	0.02%
Sooty Shearwater	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0.01%
Shearwaters and Fulmars (Procellariidae) Total	**0**	**0**	**46**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**1**	**6**	**1**	**57**	**0.23%**
Dowitcher spp.	0	0	0	0	0	0	0	0	32	0	0	0	0	0	0	32	0.13%
Unidentified Phalarope	0	0	0	6	0	0	0	0	0	3	0	0	0	0	0	9	0.04%
Small Shorebird sp.	0	0	0	1	0	0	0	0	0	4	0	0	0	0	0	5	0.02%

Common Name	Mar. 2012	May. 2012	Jun. 2012	Sep. 2012	Oct. 2012	Dec. 2012	Feb. 2013	Mar. 2013	Jul. 2013	Aug. 2013	Sep. 2013	Oct. 2013	Dec. 2013	Feb. 2014	May. 2014	Grand Total	Percent
Shorebirds (Charadriiformes spp.) Total	**0**	**0**	**0**	**7**	**0**	**0**	**0**	**0**	**32**	**7**	**0**	**0**	**0**	**0**	**0**	**46**	**0.18%**
Wilson's Storm-Petrel	0	0	10	0	0	0	0	0	2	0	0	0	0	0	2	14	0.06%
Unidentified Storm-petrel	0	0	0	0	0	0	0	0	6	5	0	1	0	0	0	12	0.05%
Storm-Petrels (Hydrobatidae) Total	**0**	**0**	**10**	**0**	**0**	**0**	**0**	**0**	**8**	**5**	**0**	**1**	**0**	**0**	**2**	**26**	**0.10%**
Double-crested Cormorant	0	0	0	0	24	0	0	0	0	0	0	0	0	0	2	26	0.10%
Cormorants (Phalacrocoracidae) Total	**0**	**0**	**0**	**0**	**24**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**26**	**0.10%**
Osprey	0	0	0	0	0	0	0	0	0	0	2	2	0	0	2	6	0.02%
Bald Eagle	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0.01%
Raptors (Accipitridae and Pandionidae) Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**4**	**0**	**0**	**2**	**8**	**0.03%**
Great Blue Heron	0	0	0	0	3	0	0	0	0	1	0	0	0	0	0	4	0.02%
American Bittern	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0.00%
Egrets and Herons (Ardeidae) Total	**0**	**0**	**0**	**0**	**4**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**5**	**0.02%**
Brown Pelican	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	3	0.01%
Pelicans (Pelecanidae) Total	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**3**	**0.01%**
Common Nighthawk	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0.00%
Black Vulture	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.00%
Miscellaneous Birds Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**2**	**0.01%**
Unidentified Jaeger	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0.01%
Jaegers and Skuas (Stercorariidae) Total	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0.01%**
Unidentified Passerine	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0.01%
Passerines (Passeriformes spp.) Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**2**	**0.01%**
Avian Total	**102**	**240**	**109**	**34**	**118**	**257**	**1056**	**890**	**184**	**361**	**255**	**333**	**1403**	**1159**	**501**	**7002**	**27.88%**
Cownose Ray	0	0	38	438	38	0	0	0	4130	97	2981	0	0	0	143	7865	31.32%
Unidentified ray	0	0	260	155	83	1	0	0	3094	277	3475	7	0	0	133	7485	29.80%
Giant Manta Ray	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	7	0.03%
Rays (Batoidea) Total	**0**	**0**	**298**	**593**	**121**	**1**	**0**	**0**	**7224**	**374**	**6463**	**7**	**0**	**0**	**276**	**15357**	**61.15%**

Common Name	Mar. 2012	May. 2012	Jun. 2012	Sep. 2012	Oct. 2012	Dec. 2012	Feb. 2013	Mar. 2013	Jul. 2013	Aug. 2013	Sep. 2013	Oct. 2013	Dec. 2013	Feb. 2014	May. 2014	Grand Total	Percent
Unidentified fish	1	54	8	108	70	2	0	1	133	58	479	0	0	1	64	979	3.90%
Unidentified shark	0	2	6	16	0	0	0	0	34	33	115	0	0	0	1	207	0.82%
Ocean Sunfish (Mola)	0	9	1	2	18	0	0	0	0	1	2	4	0	0	9	46	0.18%
Hammerhead shark	0	0	0	0	0	0	0	0	5	3	13	0	0	0	0	21	0.08%
Thresher Shark	0	0	0	0	0	0	0	0	5	1	1	0	0	0	5	12	0.05%
Fish and Sharks Total	**1**	**65**	**15**	**126**	**88**	**2**	**0**	**1**	**177**	**96**	**610**	**4**	**0**	**1**	**79**	**1265**	**5.04%**
Small beaked Cetacean to 3 m	0	22	10	57	0	7	1	4	98	213	178	1	0	0	53	644	2.56%
Bottlenose Dolphin	0	15	31	41	1	0	0	1	95	39	74	0	0	0	43	340	1.35%
Unidentified Dolphin	2	0	0	0	0	0	4	2	3	32	58	0	0	0	1	102	0.41%
Common Dolphin	0	0	0	0	0	14	5	0	7	0	1	0	0	0	0	27	0.11%
Unidentified Toothed Whales	0	0	0	0	0	0	1	0	0	0	0	0	0	5	0	6	0.02%
Harbor Porpoise	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.00%
Risso's dolphin	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0.00%
Toothed Whales (Odontoceti) Total	**2**	**37**	**41**	**98**	**1**	**21**	**11**	**8**	**203**	**284**	**311**	**2**	**0**	**5**	**97**	**1121**	**4.46%**
Small turtle	0	21	18	12	42	0	0	0	42	24	38	15	0	0	102	314	1.25%
Loggerhead Turtle	0	2	2	6	7	0	0	0	1	1	2	1	0	0	0	22	0.09%
Leatherback Turtle	0	0	0	5	4	0	0	0	3	0	2	1	0	0	1	16	0.06%
Kemp's Ridley Sea Turtle	0	0	0	2	3	0	0	0	0	0	1	0	0	0	2	8	0.03%
Green Turtle	0	1	0	2	2	0	0	0	0	0	0	0	0	0	0	5	0.02%
Hawksbill Turtle	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0.00%
Turtles (Testudines) Total	**0**	**24**	**20**	**27**	**59**	**0**	**0**	**0**	**46**	**25**	**43**	**17**	**0**	**0**	**105**	**366**	**1.46%**
Minke Whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0.00%
Humpback Whale	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0.00%
Baleen Whales (Mysticeti) Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**2**	**0.01%**
Unidentified Medium Whale	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0.00%
Unidentified Whale (Cetacea) Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0.00%**
Red Bat	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0.00%
Bats (Chiroptera) Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**0.00%**

Common Name	Mar. 2012	May. 2012	Jun. 2012	Sep. 2012	Oct. 2012	Dec. 2012	Feb. 2013	Mar. 2013	Jul. 2013	Aug. 2013	Sep. 2013	Oct. 2013	Dec. 2013	Feb. 2014	May. 2014	Grand Total	Percent
Non-Avian Total	**3**	**126**	**374**	**844**	**269**	**24**	**11**	**9**	**7650**	**779**	**7428**	**30**	**0**	**8**	**558**	**18113**	**72.12%**
Grand Total	**105**	**366**	**483**	**878**	**387**	**281**	**1067**	**899**	**7834**	**1140**	**7683**	**363**	**1403**	**1167**	**1059**	**25115**	**100.00%**