Chapter 5: Summary of high resolution digital video aerial survey data

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Chapter 5 Highlights

Results from high resolution digital video aerial survey data collected in the mid-Atlantic 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 3-4 focus on the methods used to collect the digital video aerial survey data, and Chapter 6 includes recommendations for future work using this technology. Chapter 5 reviews the results of these surveys for the mid-Atlantic 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 13 discusses an experimental survey conducted to directly compare boat and aerial survey methodologies, while Chapter 14 examines the differences between the overall boat and aerial datasets. Subsequent chapters in Part IV of this report (Chapters 15-19) focus on integrating the two survey methods using a variety of techniques to better understand the distribution and abundance of wildlife within the mid-Atlantic study area.

Study goal/objectives

Summarize animal distribution and abundance data that were collected using a novel surveying method in the mid-Atlantic study area.

Highlights

- Over 100,000 animals were observed within the study area over two years of surveys, including over 46,000 birds and 60,000 aquatic animals.
- The most abundant animals observed in aerial video were rays (Batoidea), making up 44% of the study data. The most commonly observed birds were scoters (*Melanitta* spp., 19% of the data), primarily Black Scoters.
- Northern Gannets and Bonaparte's Gulls were also observed in large numbers.
- Notable animal sightings included many sea turtles, several species of baleen whales, and migrating Eastern Red Bats.
- Most of the animals with calculated flight heights flew 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.

[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 mid-Atlantic region, 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 100,000 animals within the study area, including over 46,000 birds and 60,000 aquatic animals. The most abundant birds observed were scoters (*Melanitta* spp.), making up 19% of the data collected, and most of those observed were Black Scoters in the winter (*M. americana*). The most abundant animals overall were rays, making up 44% 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 Northern Gannets (*Morus bassanus*) and Bonaparte's Gulls (*Chroicocephalus philadelphia*); 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*, n = 15) through the offshore study area in the fall. Identification rates for the 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 75% of flying animals, and showed that 59% 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 and whales. In the fall, many summer residents migrate south to breed or winter in warmer climes, and they are replaced by species that have traveled 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 mid-Atlantic 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 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 time period (2012-2014) using a variety of technologies and methods to examine spatial patterns and trends, while simultaneously testing a new technology for the first time 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 volant taxa.

We discuss 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 predate 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, 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 Chesapeake Bay (Blaylock, 1993; Goodman et al., 2011), but rarely cover migration in the open ocean, and this is the first instance of using digital video aerial surveys 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 digital video on an aerial platform (Table 5-1). For fourteen surveys, transects were flown at high densities within the federally-designated Wind Energy Areas (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), and the fifteenth survey was conducted in just the Maryland WEA and adjacent high-density Maryland survey areas (Table 5-1). Both MABS and Maryland Project 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 3-4 of this report.

This chapter presents summaries of raw count data from the digital video aerial surveys on a monthly, seasonal, and annual basis. We also discuss identification rates for the most common species groups. 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 flight height estimation method 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 107,003 animals were observed in the fifteen surveys of the MABS and Maryland Project study areas, including over 46,000 birds and 60,000 aquatic animals (including cetaceans, sea turtles, rays, sharks, and fish; see Appendix 5A). At least 48 species of birds and 19 species of non-avian animals were represented. Overall, 45% of the animals observed in the study were identified to species level. The greatest numbers of animals were observed in March, 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 in each survey (as shown in Table 5-2 and Table 5A-1) 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 objects identified as state- or federally-listed threatened and endangered species) were conducted for all identifications (Table 5-3). Species identifications were problematic for 3 cm footage in early surveys, due to poorer image clarity and color rendition, and this issue was addressed by project collaborators by discontinuing all use of 3 cm GSR for surveys beginning in September 2012 (Chapter 6, Table 6-2). Agreement rates for the random audit varied from 80-98% between surveys (Table 5-3); 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

Scoters (*Melanitta* spp.) were the most abundant avian species observed in the digital video aerial surveys, making up over 19% of all observations (Figure 5-2 and Table 5-2). Black Scoters represented 9% of the total dataset and were the most commonly represented avian species. Another 9% of the data were classified as *Melanitta* sp. (either Black Scoter; Surf Scoter, *M. perspicillata;* or White-winged Scoter, *M. fusca*), but could not be identified to the species level. Scoters were generally present in the region in the winter and early spring months (Figure 5-4), and were often observed in large flocks spanning across multiple video frames and between cameras. Numbers of scoters observed varied from year to year, with the highest numbers of scoters observed in the first survey in late March of 2012 (Table 5-2, Figure 5-4).

Gannets (all identified to a single species, the Northern Gannet, or *Morus bassanus*) were the next most commonly observed avian family (6.7% of the total dataset), followed by loons (Gaviidae; 5%), with both groups predominantly observed in winter and spring (Table 5-2, Figure 5-4). Gannets were most abundant during the aerial survey in February of 2013, but the numbers of loon observations did not vary greatly from year to year (Table 5-2).

A variety of gull and tern species were observed throughout the year (Appendix 5A). Bonaparte's Gulls (*Chroicocephalus philadelphia*) were the most common (1%) and were predominantly seen in the winter and fall, while Herring Gulls (*Larus smithsonianus*, 0.09%) and Great Black-backed Gulls (*L. marinus*, 0.22%) were seen in lower numbers throughout the year (Appendix 5A) Few auks (Alcidae) were observed overall (Figure 5-2, Table 5-2).

Non-avian animals

Large numbers of animals were observed in digital video aerial surveys at or below the surface of the water (Figure 5-3). There were major seasonal differences for aquatic animal abundance, most notably with very large numbers of rays observed in summer and fall surveys (Figure 5-5). Rays were the most common species group observed in the digital video aerial surveys. 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 footage were in groups of small forage fish, or "bait balls," of varying sizes, which were observed mostly between May and September, primarily inshore. The majority of bait balls 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 smaller than a square meter while others 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 17.

Dolphins were the most commonly observed marine mammals in the aerial video. 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 observed as well, with eight endangered North Atlantic Right Whales (*Eubalaena glacialis*) observed in February and March of 2012-2014. One instance provided still images of high enough quality to identify a known female, named “Blackheart”, with her calf on their migration north to the Gulf of Maine (Figure 5-6). Three Minke Whales (*Balaenoptera acutorostrata*), two Humpback Whales (*Megaptera novaeangliae*), and one Fin Whale (*B. physalus*) were also observed. Whales were observed predominantly in the autumn, winter, and early spring (Table 5-2).

A notable number of sea turtles were observed (1.63% of total survey observations), primarily in the spring, summer, and autumn. Loggerhead Turtles (*Caretta caretta*) and Leatherback Turtles (*Dermochelys coriacea*) were the two most commonly identified to species, with some observations of rarer species (Kemp’s Ridley Turtle, *Lepidochelys kempii*; Green Turtle, *Chelonia mydas;* and Hawksbill Turtle, *Eretmochelys imbricata*; Appendix 5A).

Identification rates

Identification rates varied by survey and season. March surveys had the highest rate of birds identified to species due to the number of highly identifiable Black Scoters observed. However, image quality, observer bias, and other factors 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 5-7), with 53% of anatids identified to species. Only 15% of loons were identified as either Red-throated Loon (*Gavia stellata*) or Common Loon (*G. immer,* Appendix 5A), as the video footage was not always clear enough to distinguish plumage coloration, and there is significant size overlap between Red-throated Loons and Common Loons in the mid-Atlantic study area (Gray et al., 2014). Gulls and terns were identified to species 35% of the time, with Bonaparte’s Gulls the most common of identified gull species (1% of total observed animals). Small birds like auks and terns were seldom identified to species (6%, Figure 5-7), 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 baitfish school sizes is warranted. 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). While most turtles were not identified to species (79%, Figure 5-8), all species observed in the area are federally endangered. Of all toothed whales (Odontoceti), including dolphins, 51% were not identified to species level, again in part due to animals being submerged to varying depths in the water column.

Flight heights

Flight heights were estimated for 75% of flying animals (or 5,299 animals). Of all birds with estimable flight heights, 59% were estimated to be flying within 0-20 meters of the water's surface. Thirty eight percent of observations occurred between 20 and 200 m in altitude (1,990 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 proportion of individuals in this latitude band varied by taxon. Within this range, 19% of birds were flying from 20-50 m, 12% were flying from 50-100 m, and 6% were flying from 100-200 m. An additional 3% of birds were flying above 200 m.

Of the birds with estimated flight heights, the seven 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 5-9, Figure 5-10). Gulls and terns were the most commonly observed species aloft, followed by Northern Gannets. Gulls and terns were observed flying at the 20-50m flight band 19% of the time, 50-100 m 12% of the time, and 100-200 m 7% of the time. Gannets had a similar distribution, and were observed flying at 20-50 m 22% of the time, 50-100 m 15% of the time, and 100-200 m 6% of the time. Scoters, ducks, and geese were generally observed flying lower, at 20-50 m 12% of the time, 50-100 m 3% of the time, and 100-200 m 3% of the time. Loons were also flying lower, in the 20-50 m altitude band 22% of the time, 50-100 m 4% of the time, and 100-200 m 1% of the time (for more details see Figure 5-10). Species groups that were less commonly observed in digital video aerial surveys had a more varied altitudinal distribution (Figure 5-11); cormorants and shorebirds both showed a split distribution between the lowest 0-20 meter band and the >100 meter bands. Passerines were observed at all height bands, but most were observed at 200+ meters, as were most shorebirds, egrets and herons (Figure 5-11).

Fifteen Eastern Red Bats (*Lasiurus borealis*) were detected by observers in the September 2012 and 2013 digital video 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 bat was seen on the September 2013 survey. Flight heights were estimated for seven of the 15 bats observed, and all fell into the >200 m flight height category, meaning that all bats with calculated flight heights were flying higher than the likely rotor-swept zone for offshore wind turbines. Bats were observed between 16.9 and 44 km offshore of Delaware, Maryland, and Virginia. These observations were notable as they provided new evidence of offshore migrations of red bats, how high they fly while on migration, and the time of day the migrations may occur. Additional information may be found in Hatch et al. (2013).

Rays

Rays (Batoidea) represented over 44% of all observations from the digital video aerial surveys (Table 5-2). Cownose Rays were the most common ray species observed (54% of all rays, and almost 100% of all rays identified to species; Figure 5-8). Rays were not identified to species unless they were individually identifiable and their characteristic noses 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 (78 schools). These schools were primarily found in September (53 schools) when rays migrate through the study area (Goodman et al., 2011).

Rays were primarily observed during the summer and fall surveys (Figure 5-5), though there was a high level of variation between the two survey years: many more rays were observed in 2013 compared to 2012, with nine times as many rays observed in September 2013 than September of 2012 (Table 5-2). The differences in observations between the two years may 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 5-12). More rays were seen in the July 2013 survey, and they were predominantly found further north up 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 high density pockets throughout the study area, but the 2013 survey had densities up to fifteen times those of the 2012 survey (Figure 5-12).

Discussion

Digital video aerial surveys and aquatic taxa

Aerial surveys, and particularly digital video aerial surveys, have been noted to reduce glare and increase visibility for aquatic animals such as sea turtles when compared to boat-based surveys (Normandeau Associates Inc. 2013), and we saw similar results in our study (Chapter 14). The high altitude of digital aerial survey aircraft also reduces disturbance compared to low-flying observation planes or survey vessels (Chapter 13), which may play a role in increased detections of aquatic animals (Normandeau Associates Inc. 2013). We discuss these differences in more detail in Chapters 13-14, 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 (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 thought to 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). The strength of the electric and magnetic fields emitted by a cable, and thus the distance from the cable at which the fields are detectable, depends on a variety of factors, including the type of cable (e.g., AC vs. DC) and whether it is buried or sheathed (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 have not yet been determined. 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

Scoters were the most abundant bird group observed in the aerial data, with gannets and loons also observed in large numbers. This pattern was similar to that found in the boat-based surveys (Chapter 8), though much higher numbers of birds were found in boat surveys (Chapter 14). The mid-Atlantic region is an important wintering ground for these species (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. The timing of seasonal variations in abundance of scoters, gannets, and loons was similar to that of migratory movements indicated by individual tracking of Surf Scoters, Northern Gannets, and Red-throated Loons (Chapters 20-23). Gulls and terns were the most abundant bird group 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). Fewer aquatic animals were seen in the study area in the winter, but many fish were observed in spring, and rays were extremely abundant in the summer and fall. Toothed whales were observed in similar numbers throughout the year, though the species composition changed over the course of each year, with Bottlenose Dolphins present in the warmer months, and Common Dolphins (*Delphinus delphis*) more abundant in the cooler months (Chapter 15).

A few large whales were seen in the study area, mostly in cooler months, including several observations of endangered North Atlantic Right Whales. Though a large number of documented mortalities have occurred in the mid-Atlantic region (Firestone et al., 2008), and North Atlantic Right Whales are known to use the study area as a migration corridor, little is known of their movements in the region, and even the few observations made in this study provide useful new information about a period in their life cycle that is not well understood. Some passerines were observed migrating through the study area as well, more commonly from the boat platform than in aerial video. Most passerines migrate at night, however, when surveys did not occur (Chapters 26-27).

Bats

Other notable observations included Eastern Red Bats, which were seen migrating in the daytime through the study area during the fall, providing evidence for offshore migration of this species. While the number of bats observed was small overall (n = 15), most of those sightings occurred on one survey day, likely because it was flown during a peak migration time for Eastern Red Bats. Little is known about the migration routes of migratory tree bats in the U.S., but Eastern Red Bats are the most frequently encountered bat species off the east coast during fall migration; autumnal sightings at sea have been recorded dating back to 1890, usually as individuals but sometimes in large flocks (Hatch et al., 2013). Bats likely prefer to migrate at night, and most of the previous offshore observations took place at night, but there have been previous daytime fall migration sightings as well.

Marine surveys are poorly designed to detect bats and other small migrants aloft, due to their size (and thus low detectability, particularly if they are flying more than a few tens of meters above sea level), as well their primarily nocturnal migration behaviors. The flight heights at which bats were observed in our surveys was unexpected, given the limited data available on bat movements in the offshore environment (Ahlen et al., 2009), and suggests that some bats migrating offshore may fly at altitudes that prevent visual detection and identification under most circumstances. The altitude at which our surveys were flown, in combination with our ability to zoom in on small high-flying organisms for identifications, may have allowed for higher detection rates than other survey methods (Hatch et al., 2013).

Bat fatalities have been documented at offshore wind facilities in Europe (European Environmental Agency, 2009). Eastern Red Bats migrate over land in large numbers, where they make up the greatest proportion of bats killed at terrestrial commercial-scale wind facilities (Arnett et al., 2008), and they are also the species most often observed at sea in the eastern U.S. While the proportion of the population that migrates offshore remains unknown, Eastern Red Bats are probably the bat species most likely to interact with future offshore wind developments in the mid-Atlantic (Hatch et al., 2013).

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; Hill et al., 2014; 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. Despite these limitations, the suspected importance of flight height data in predicting collision risk means that these data are used in assessments of relative vulnerability of various taxa to offshore wind energy development (e.g., Furness et al., 2013; Garthe and Hüppop, 2004; Willmott et al., 2013).

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 and may be specific to each project; 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[2], though specific altitudes will vary based on site-specific attributes. 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, 38% of observations occurred between 20 and 200 m in altitude (1,990 observations), and nearly every avian taxonomic group was observed within this zone at some point in our study. Gannets, gulls and terns, and loons all had high proportions of birds within this altitude range (Figure 5-10). Most passerines that were detected were flying above 200 meters.

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. The newer generation of cameras currently used in Europe have a greatly improved identification rate as compared to those used in this study (HiDef Aerial Surveying Ltd. unpubl. data).

Analytical approaches can also help address this issue. Chapter 16 uses boat data and environmental covariates to develop species-specific estimates of distribution and abundance from the digital video aerial dataset. Additionally, 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 (see recommendations in Chapter 6). 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 (Table 5-3; also see Chapter 6, Table 6-2). 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),

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

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. Several chapters focus on contrasting boat and digital video aerial survey approaches (Chapters 13-14 and 18). In other cases, digital video aerial survey data and boat survey data are used jointly (Chapters 15-17 and 19) to describe distributions and abundance of animals across the study area.

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Figures and tables

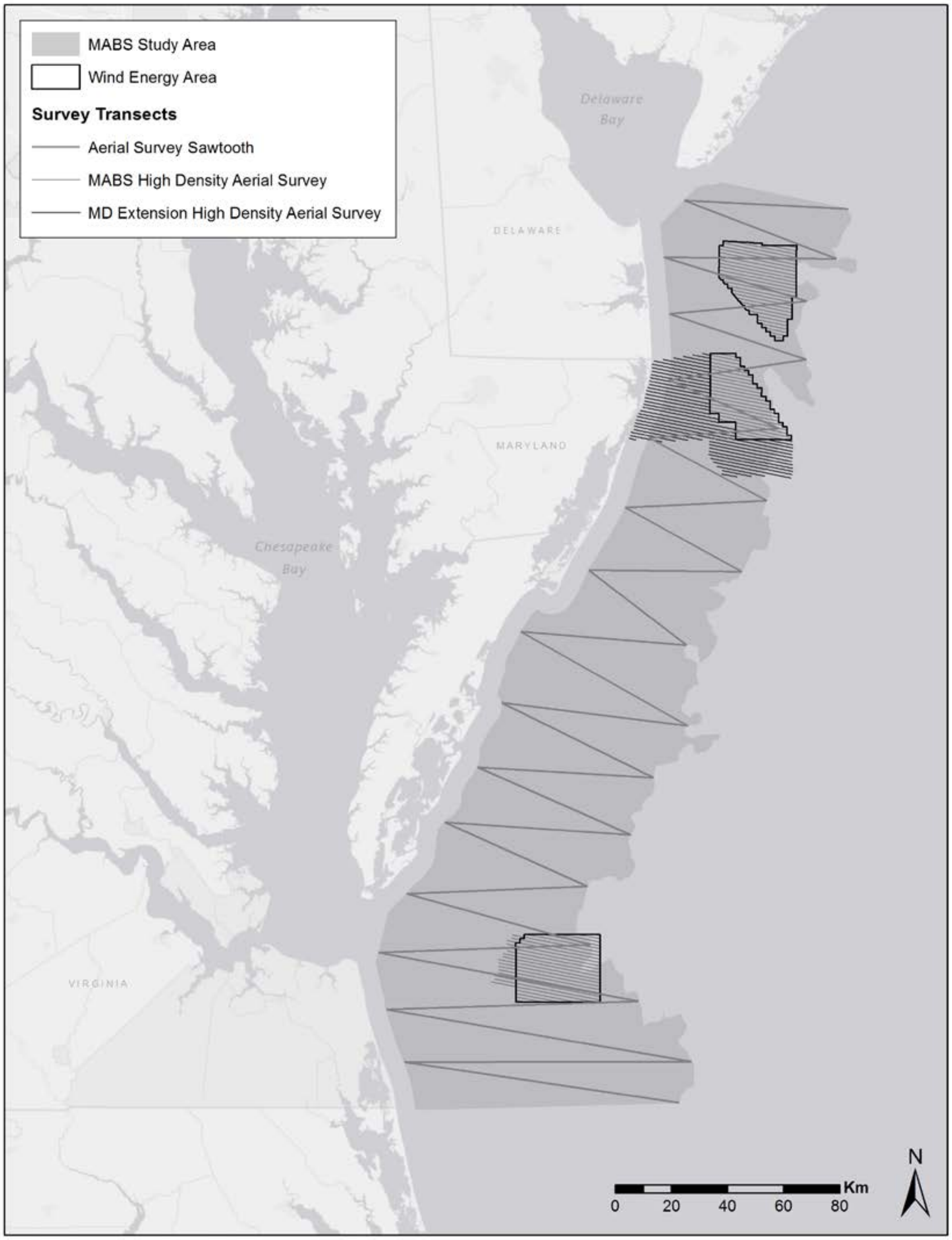

Figure 5-1. Aerial survey transects for the Mid-Atlantic Baseline Studies and Maryland projects (2012-2014). Light grey transects are part of the Mid-Atlantic Baseline Studies; darker grey transects off the coast of Maryland are part of the Maryland Project (surveys conducted in March 2013-May 2014).

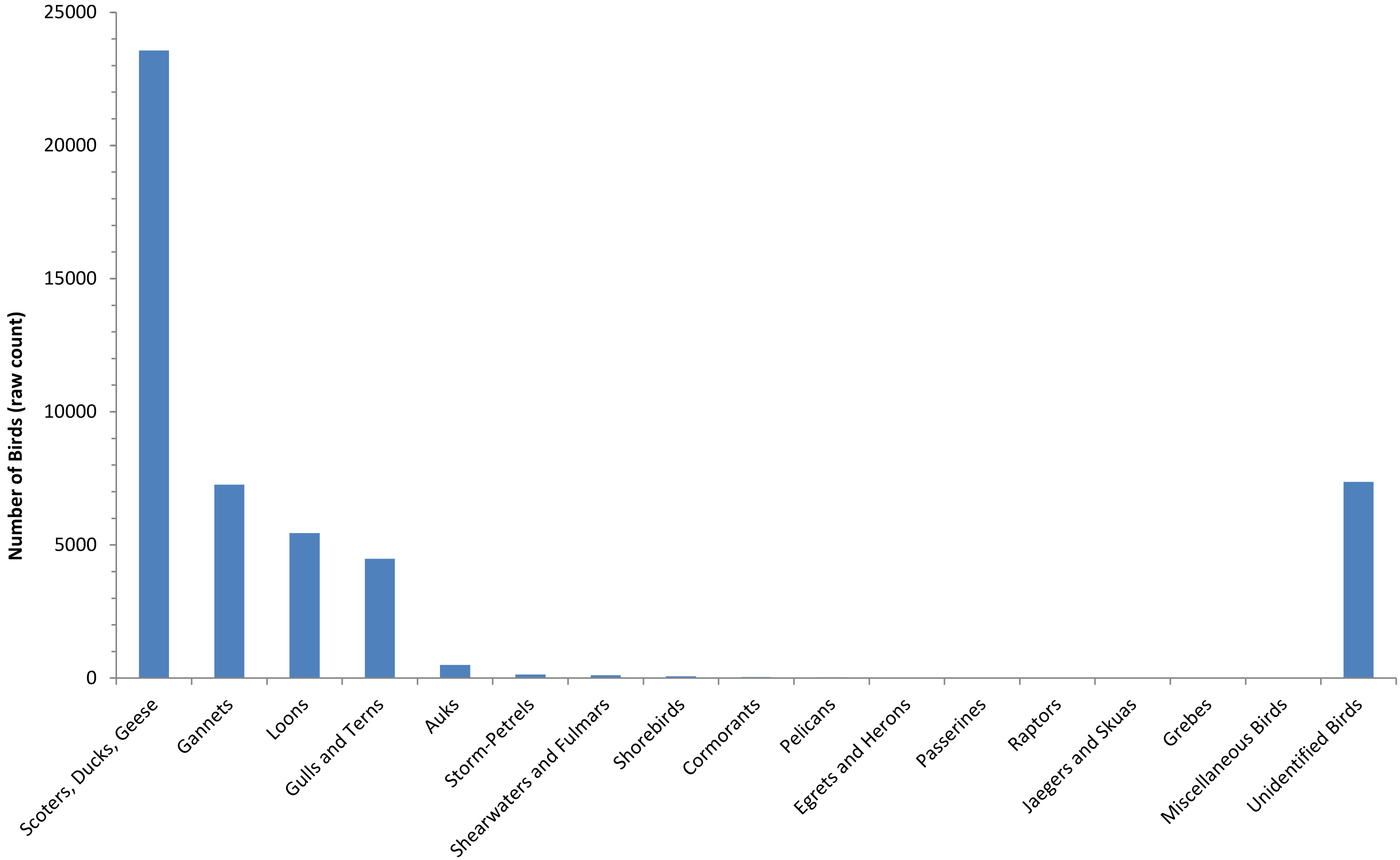

Figure 5-2. Avian observations (raw counts) from the digital video aerial surveys, by family (March 2012 – May 2014). Unidentified birds are all birds not identified to species or to any higher level taxonomic group. Birds from all levels of identification are taken at face value (e.g., a "possible" Northern Gannet is counted as a Northern Gannet; see Chapters 3-4).

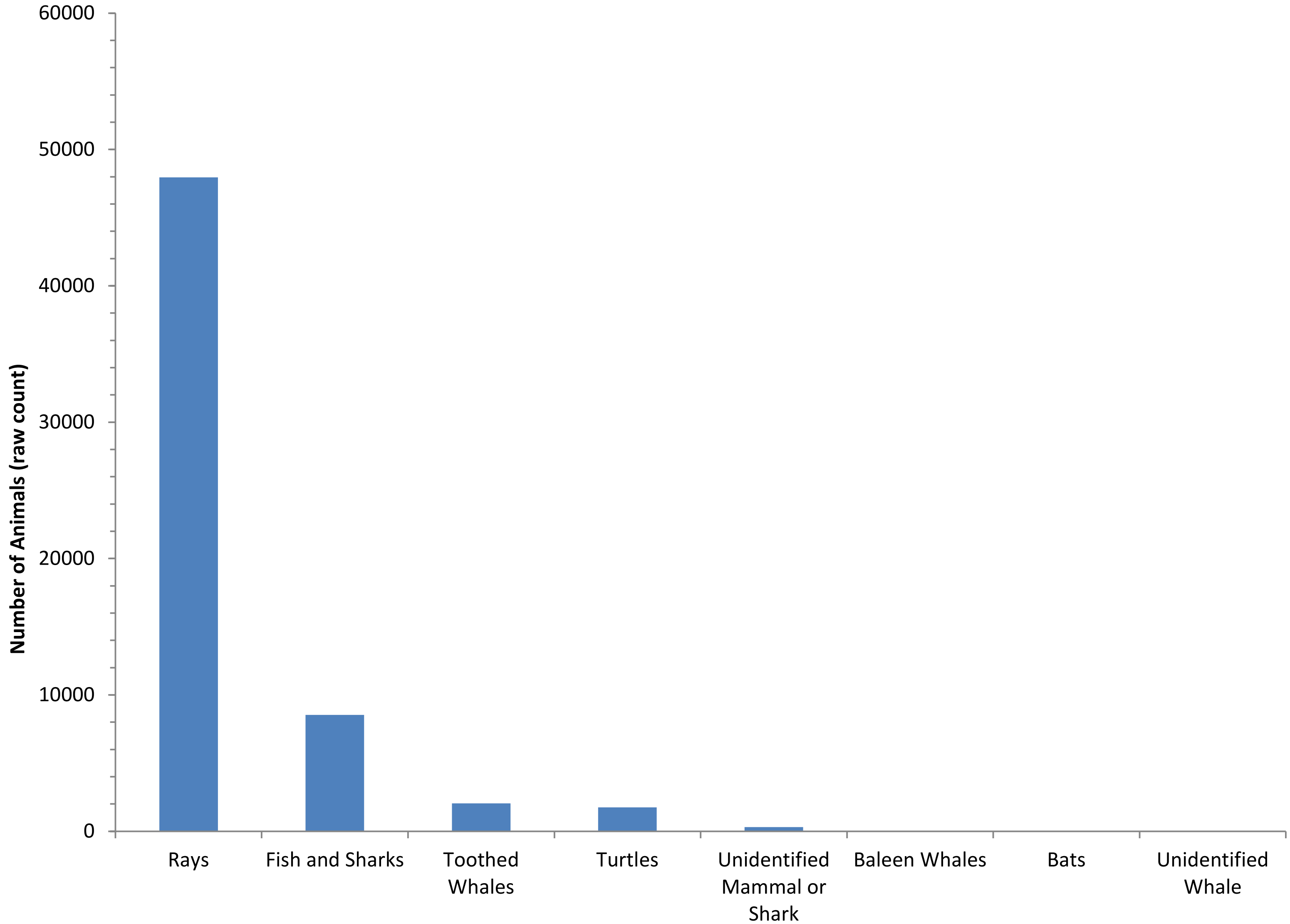

Figure 5-3. Observations from the digital video aerial surveys of other non-avian animals by family group (March 2012 – May 2014). Numbers do not include schools of rays or fishes, so these data are an underestimate of the total counts for these animals.

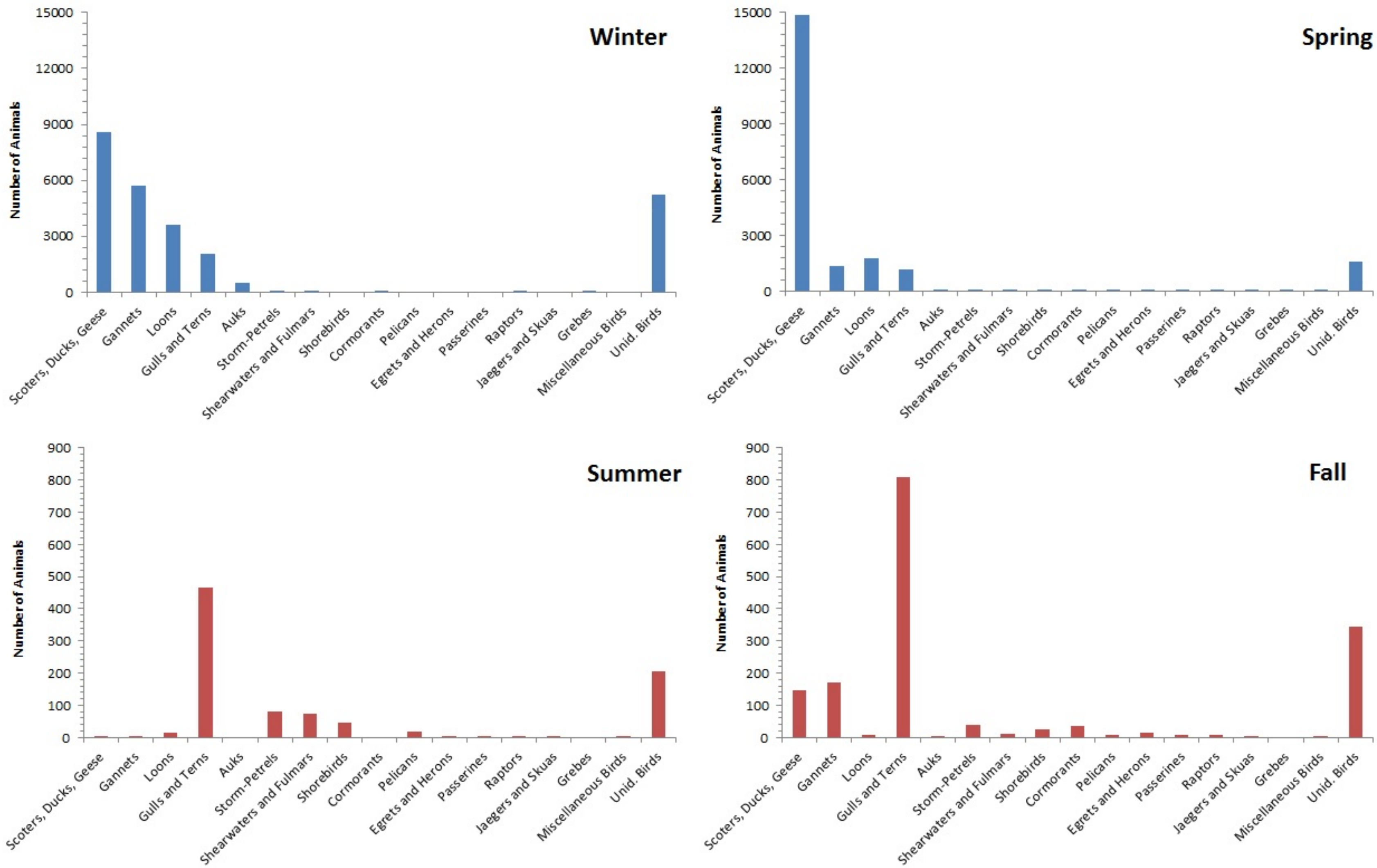

Figure 5-4. Abundance of birds by family or group in winter (December to February), spring (March and May), summer (June, July, August), and fall (September and October). Note different y-axes between the top and bottom graphs. X-axes are in order of overall abundance by family or group across all surveys.

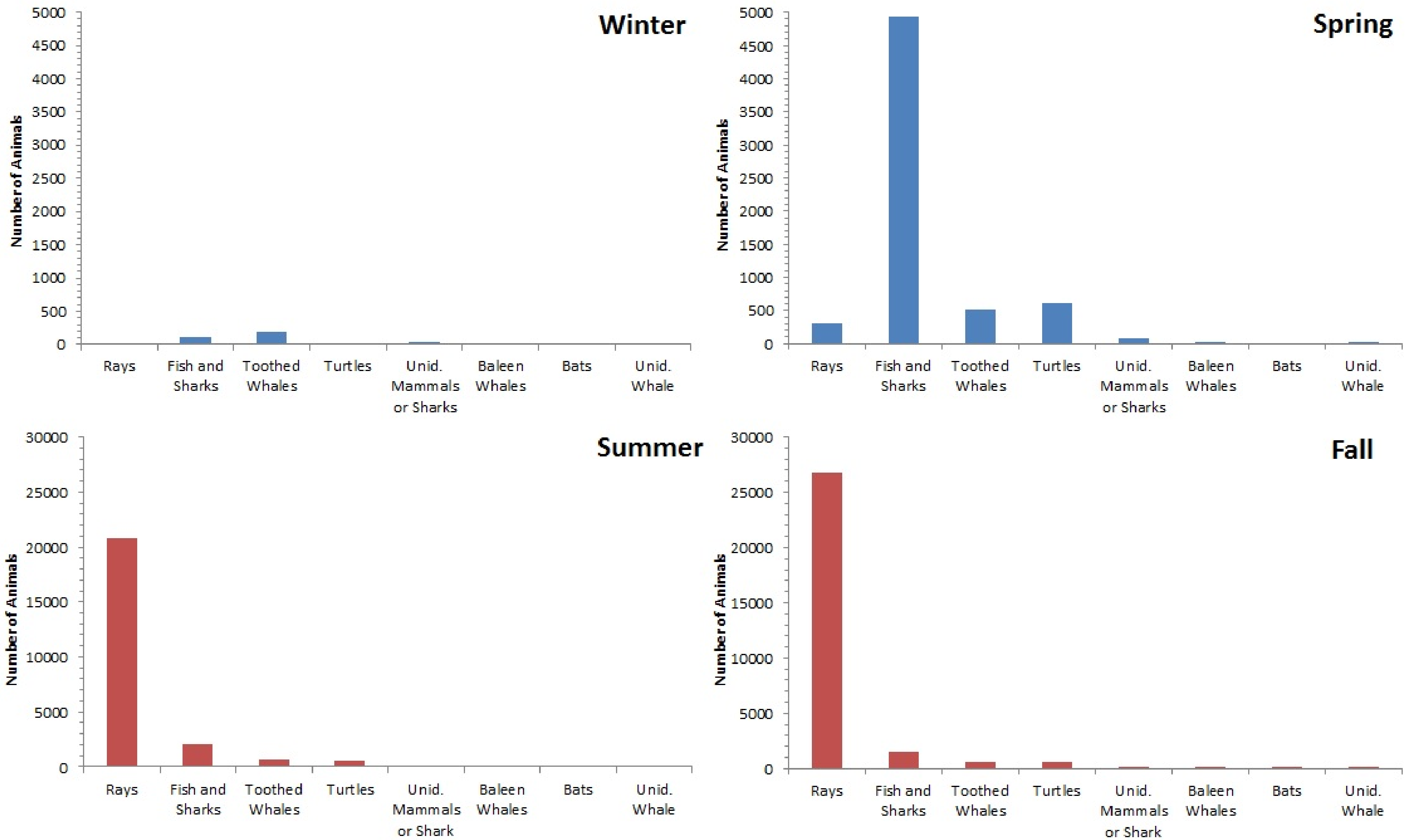

Figure 5-5. Abundance of non-avian animals by group in winter (December to February), spring (March and May), summer (June to August), and fall (September and October). Note different y-axes between top and bottom graphs. X-axes are in order of overall abundance by family or group across all surveys.

Figure 5-6. Two of the eight North Atlantic Right Whales (*Eubalaena glacialis*) observed in the aerial footage. Blackheart (#3390) and her calf were observed on February 16, 2013, 56 kilometers offshore of Virginia. All recorded footage of Right Whales was passed on to the North Atlantic Right Whale Consortium (NOAA) and the New England Aquarium.

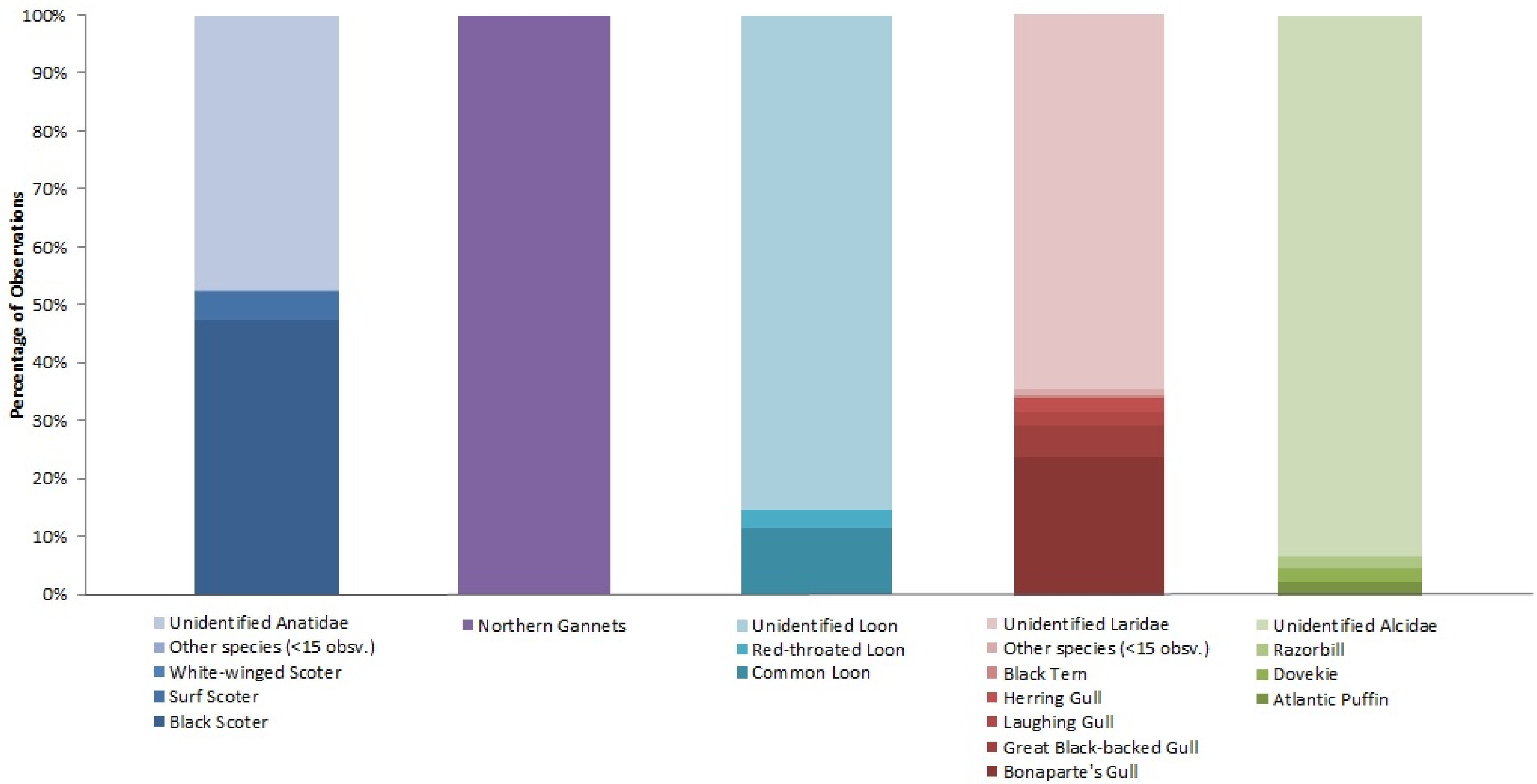

Figure 5-7. Identification rates for the most abundant avian families in the digital video aerial surveys. Identifications to species level are shown in darker colors. "Other Species" in the Laridae (red, n = 4475) and Anatidae (dark blue, n=21,146) columns can be found in Appendix 5A. Sample sizes for gannets, loons, and auks are 7,126, 5,407, and 495 respectively. Birds from all levels of identification are taken at face value (see Chapters 3-4).

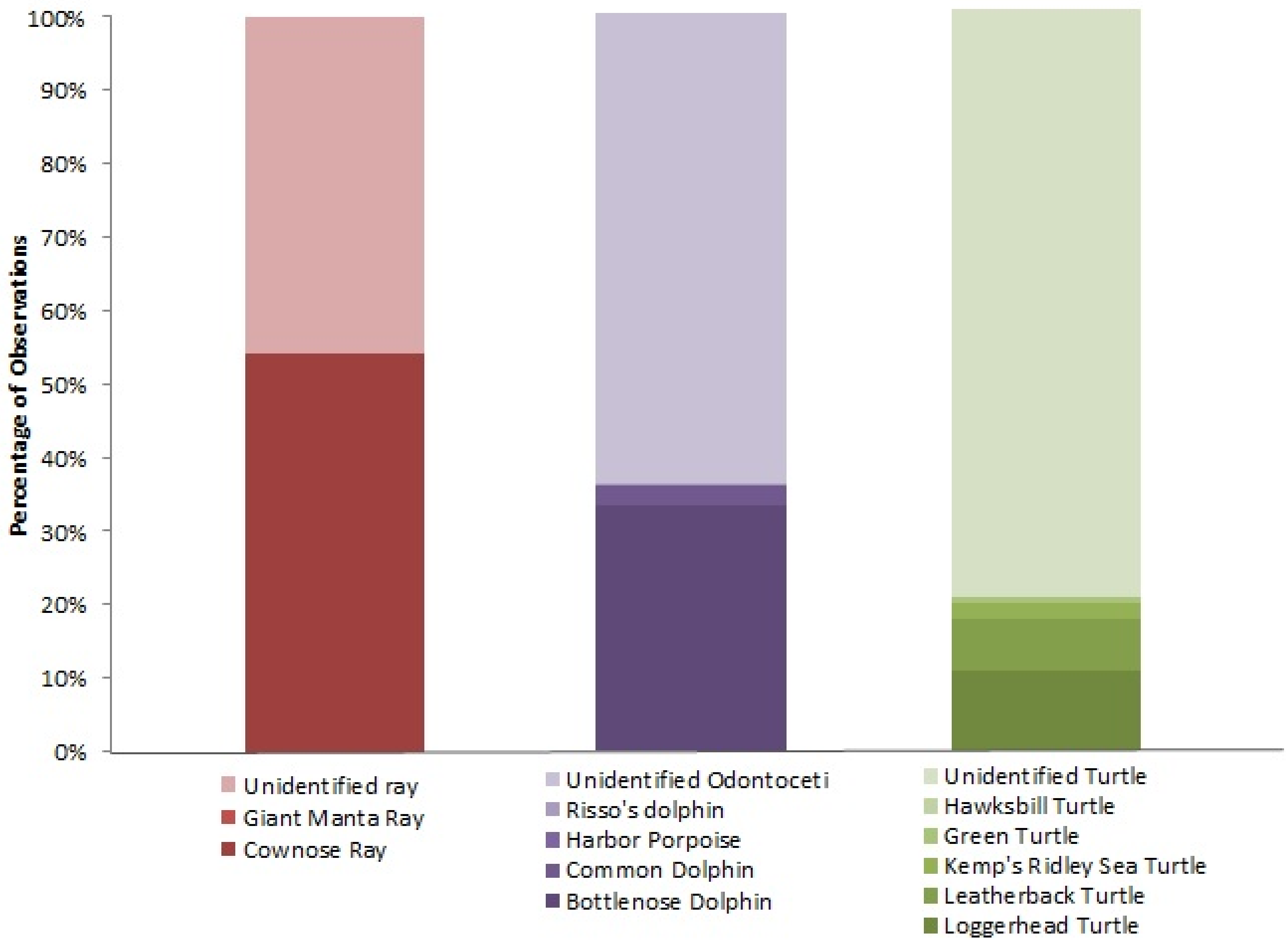

Figure 5-8. Identification rates for common aquatic animal groups in the digital video aerial surveys. Identifications to species level are shown in darker colors. Sample sizes are 47,945 for rays (red), 2,028 for Odontoceti (purple), and 1,748 for turtles (green).

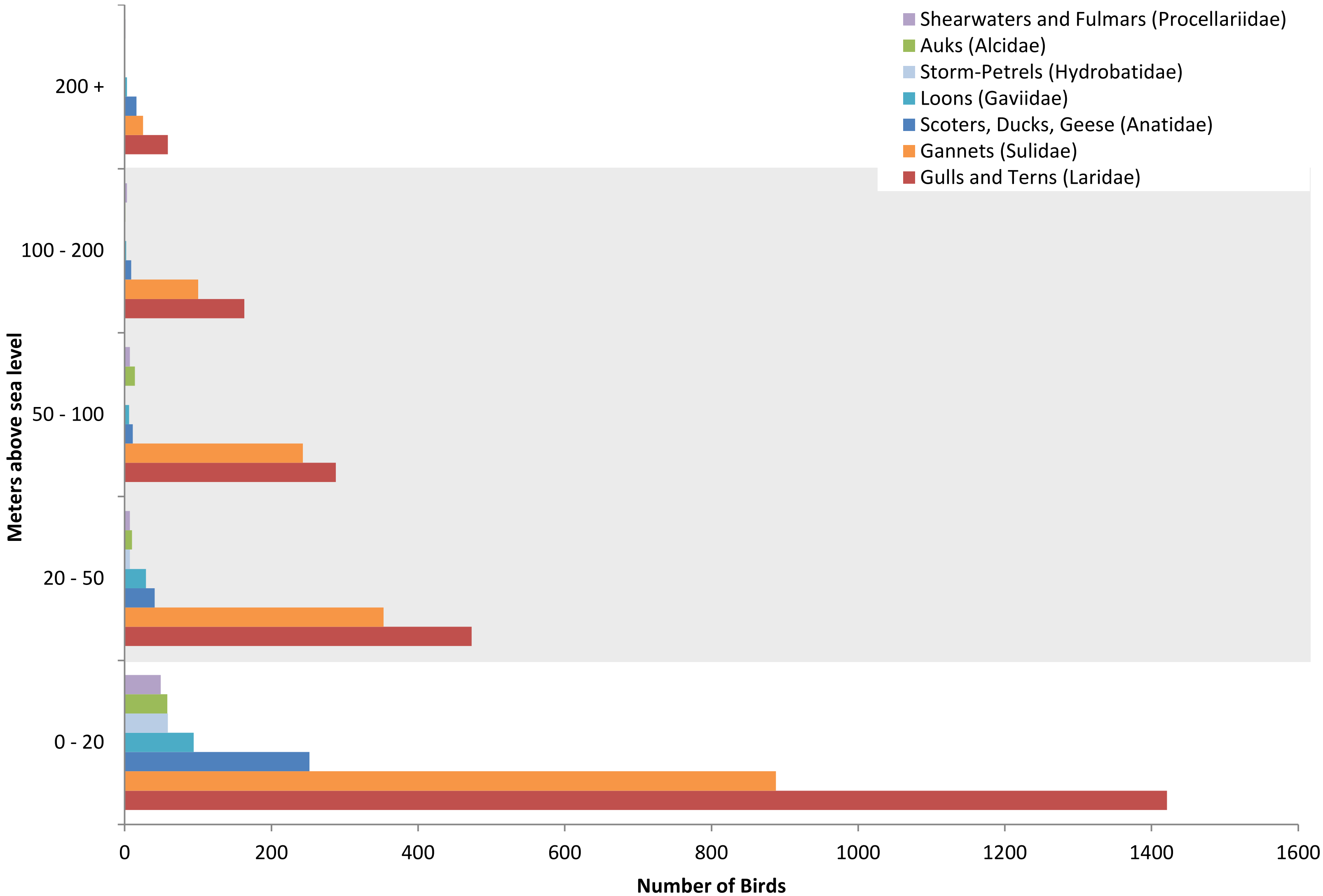

Figure 5-9. Flight height above sea level (meters) of the most abundant bird families from the digital video aerial surveys, presented as raw counts. Data are presented as number of animals observed at the given height range. All confidence levels of animal identifications and flight height estimates are included for this figure. Grey hatch marks indicate an approximate range of altitudes for the rotor-swept zone for offshore wind turbines (see text).

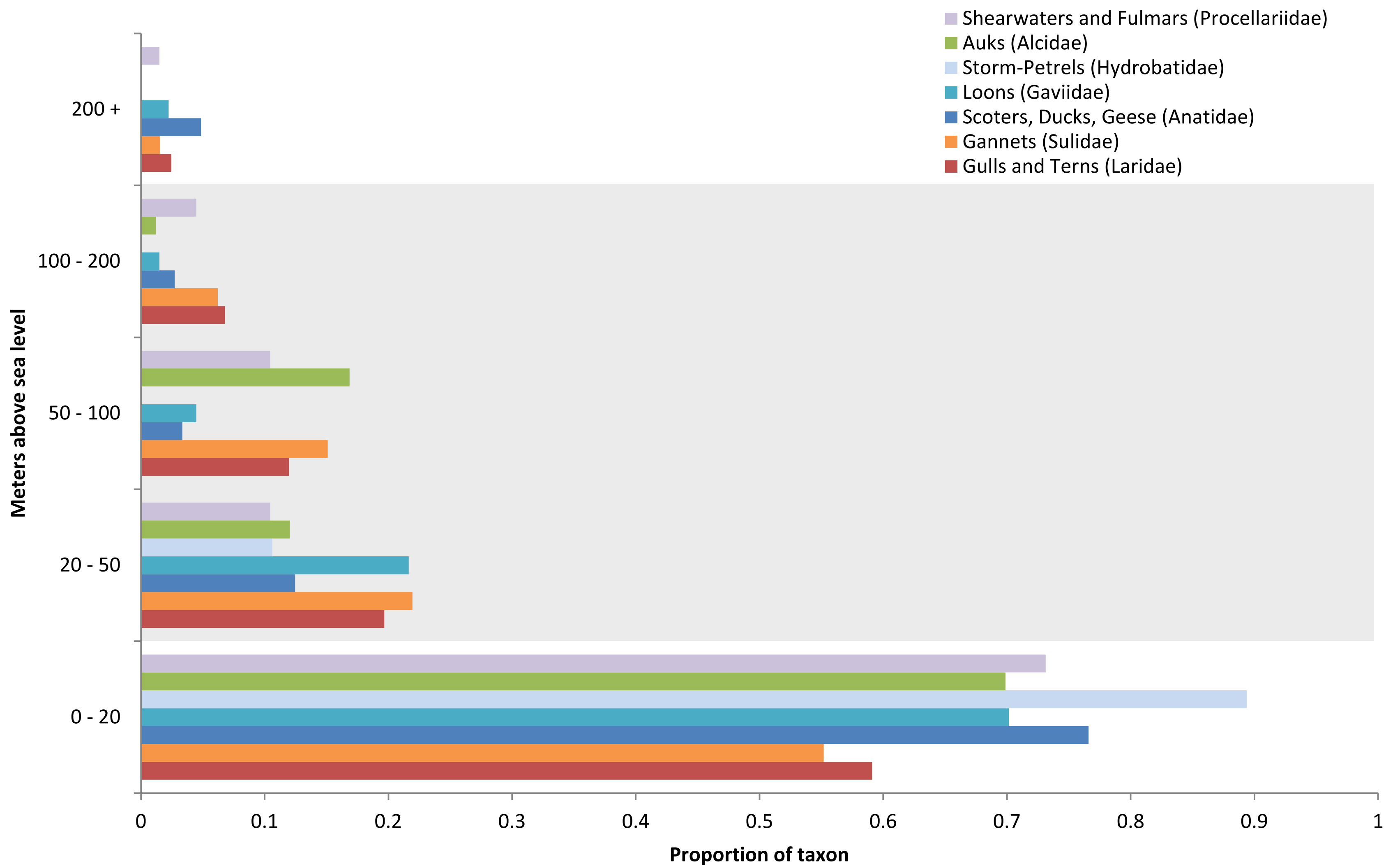

Figure 5-10. Flight height above sea level (meters) of the most abundant bird families from the digital video aerial surveys, presented as proportions of each taxon. Data are presented as the proportion of each species group observed at the given height range. All confidence levels of animal identifications and flight height estimates are included for this figure. Grey hatch marks indicate an approximate range of altitudes for the rotor-swept zone for offshore wind turbines (see text).

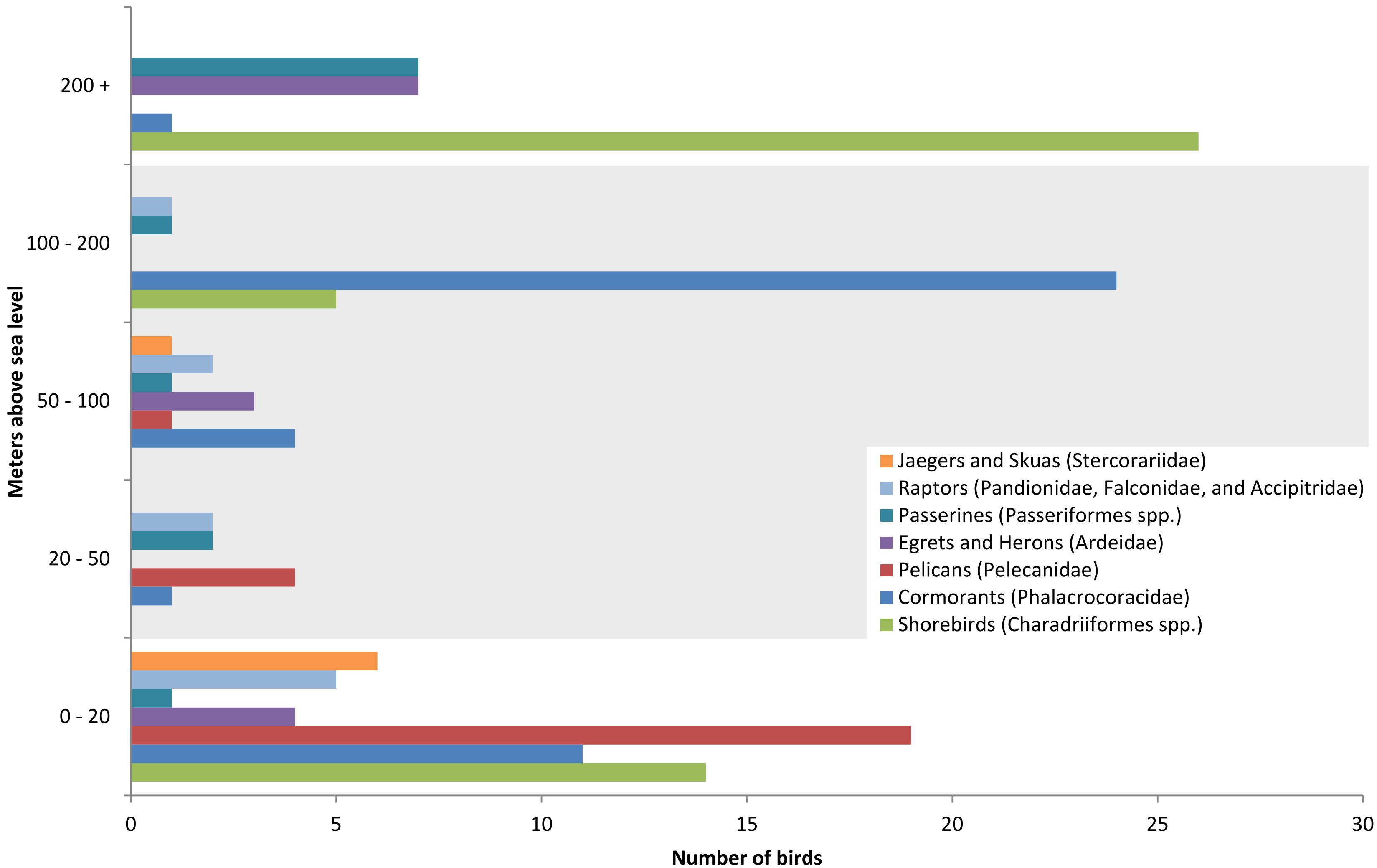

Figure 5-11. Flight height above sea level (meters) for seven less abundant bird families or groups from the digital video aerial surveys, presented as raw counts. In several cases, less common families have been combined into broader taxonomic categories (e.g., "passerines"). Data are presented as number of animals observed at the given height range. All confidence levels of animal identifications and flight height estimates are included for this figure. Grey hatch marks indicate an approximate range of altitudes for the rotor-swept zone for offshore wind turbines (see text).

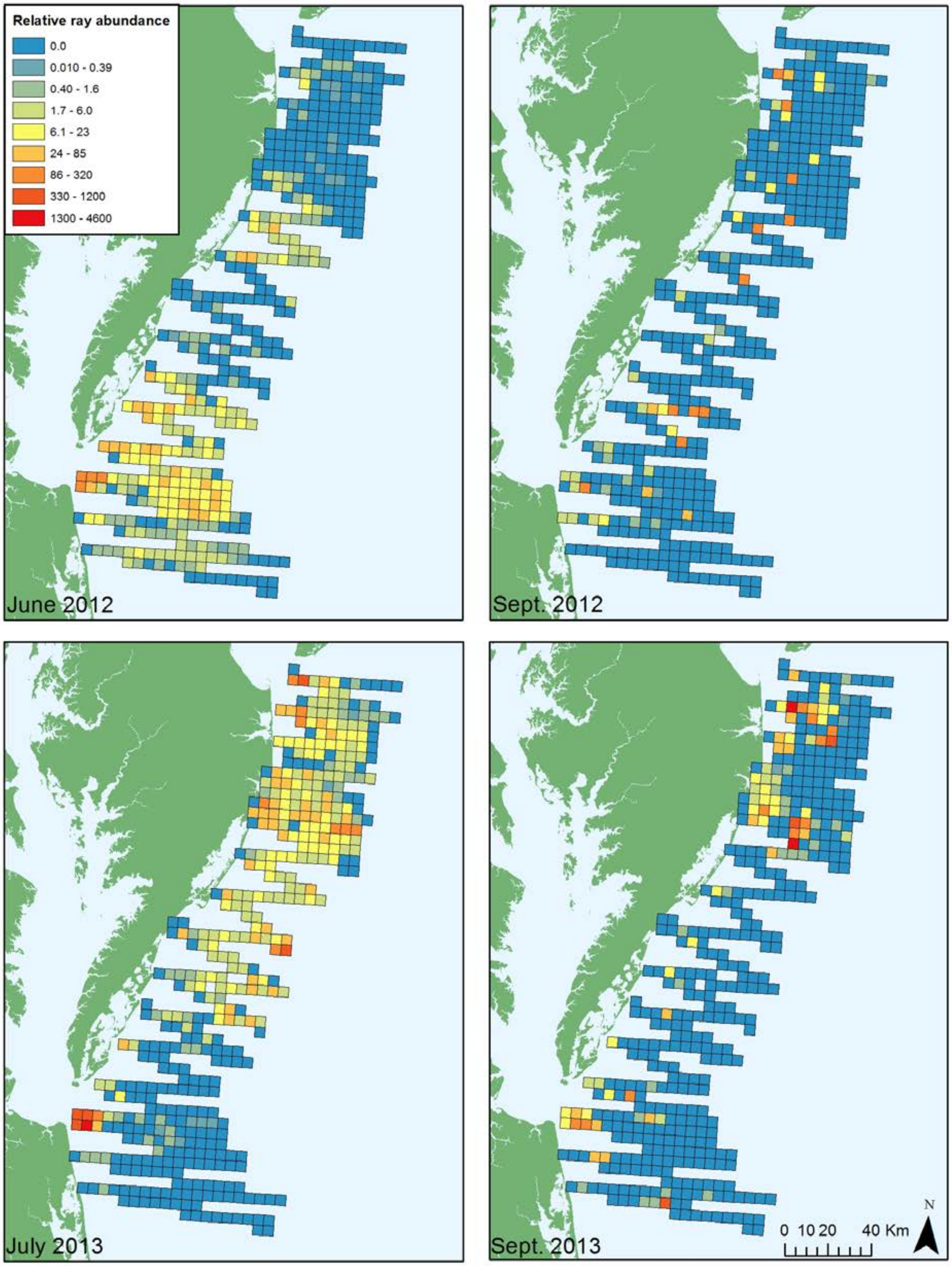

Figure 5-12. Effort-corrected counts of rays (Batoidea) within Bureau of Ocean Energy Management (BOEM) lease blocks (4.8 x 4.8 km), for the four surveys when they were the most abundant. Count data were corrected by area surveyed (km^2) within each lease block. Values have not been corrected for detection bias, and should be considered as relative estimates of density, not as estimates of actual ray densities.

Table 5-1 Weeks in which digital video aerial 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.

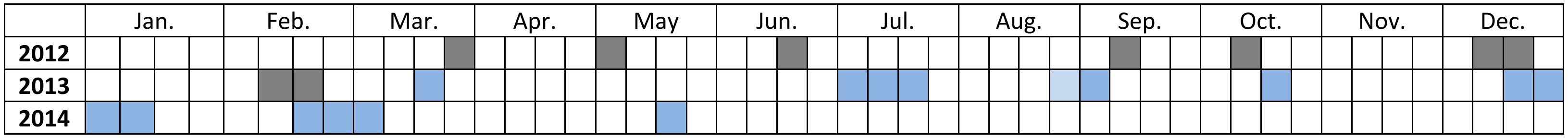

Table 5-2. Summary data for the digital video aerial surveys (by species group). Data from the aerial-boat comparison study (Chapter 13) are not presented. Data are presented in order of abundance based on the total count from all surveys. Counts include definite, probable, and possible identifications (Chapters 3-4). Surveys from March 2013 onwards included an additional ~21% ground coverage from Maryland Project transects (surveys noted in blue); the August 2013 survey included only the Maryland WEA and Maryland Project transects, but excluded the remainder of transects offshore of Delaware and Virginia (as well as the sawtooth transects throughout the study area) conducted in the remainder of surveys.

Animal Group	Mar. 2012	May 2012	Jun. 2012	Sept. 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	% of Total*
Scoters, Ducks, Geese (Anatidae)	9408	1	1	0	0	487	1691	2876	0	0	0	147	4653	1737	145	21146	19.76%
Unidentified Birds (Aves spp.)	545	218	81	120	48	736	1852	538	41	83	99	78	1667	972	209	7287	6.81%
Gannets (Sulidae)	337	72	0	0	52	421	3730	821	1	0	1	119	728	839	5	7126	6.66%
Loons (Gaviidae)	614	460	8	0	3	719	967	496	3	2	1	2	907	1047	178	5407	5.05%
Gulls and Terns (Laridae)	552	332	73	120	178	737	118	69	172	222	302	210	1148	60	182	4475	4.18%
Auks (Alcidae)	0	0	0	0	0	154	193	13	0	0	0	1	78	59	0	498	0.47%
Storm-Petrels (Hydrobatidae)	1	0	53	38	0	12	0	0	21	5	0	1	0	0	5	136	0.13%
Shearwaters and Fulmars (Procellariidae)	0	0	74	5	2	14	4	0	0	0	1	3	2	6	1	112	0.10%
Shorebirds (Charadriiformes spp.)	2	0	0	20	0	0	0	0	39	7	4	2	0	0	0	74	0.07%
Cormorants (Phalacrocoracidae)	0	0	0	1	25	1	0	0	0	0	0	8	1	0	6	42	0.04%
Pelicans (Pelecanidae)	0	2	2	3	1	0	0	0	17	0	2	2	0	0	1	30	0.03%
Egrets and Herons (Ardeidae)	0	2	0	7	7	0	0	0	0	1	0	0	0	0	0	17	0.02%
Passerines (Passeriformes spp.)	0	0	1	2	4	0	0	0	0	0	2	1	0	0	7	17	0.02%
Raptors (Pandionidae, Falconidae, and Accipitridae)	0	1	1	0	0	1	0	0	1	0	2	6	0	0	2	14	0.01%

Animal Group	Mar. 2012	May 2012	Jun. 2012	Sept. 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	% of Total*
Jaegers and Skuas (Stercorariidae)	0	4	3	0	1	0	0	0	0	0	0	0	0	0	0	8	0.01%
Grebes (Podicipedidae)	4	0	0	0	0	2	1	0	0	0	0	0	0	0	0	7	0.01%
Nighthawks	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3	0.00%
Kingfishers	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0.00%
Vultures	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0.00%
Avian Total	**11463**	**1092**	**297**	**316**	**322**	**3284**	**8556**	**4814**	**295**	**321**	**414**	**580**	**9184**	**4720**	**741**	**46399**	**43.36%**
Rays (Batoidea)	0	1	5562	2663	428	16	0	0	14903	374	23292	404	0	1	301	47945	44.81%
Fish and Sharks	2527	205	389	346	168	10	4	3	1526	96	945	31	86	2	2206	8544	7.98%
Toothed Whales (Odontoceti)	39	196	61	117	136	75	77	38	347	284	361	21	12	27	237	2028	1.90%
Turtles (Testudines)	29	282	192	151	184	1	0	0	360	25	183	50	0	1	290	1748	1.63%
Unidentified Marine Mammal or Shark	4	24	13	4	8	7	20	32	48	16	107	2	4	0	5	294	0.27%
Baleen Whales (Mysticeti)	0	0	0	0	1	1	4	4	0	0	0	0	1	3	1	15	0.01%
Bats (Chiroptera)	0	0	0	14	0	0	0	0	0	0	1	0	0	0	0	15	0.01%
Jellyfish (Cnidaria)	0	1	3	1	1	0	1	0	1	0	1	0	0	0	0	9	0.01%
Unidentified Whale (Cetacea)	0	2	0	2	0	0	0	0	1	0	0	0	0	1	0	6	0.01%
Non-Avian Total	**2599**	**711**	**6220**	**3298**	**926**	**110**	**106**	**77**	**17186**	**795**	**24890**	**508**	**103**	**35**	**3040**	**60604**	**56.64%**

Table 5-3. Audit results for digital video aerial surveys. Audits consist of 20% of eligible biota, as well as objects with a Threatened and Endangered (T&E) status that are not part of the random audit (see text). All T&E observations—whether part of the random 20% or added afterwards—were held to a 100% agreement criterion, while the remainder of the audits were required to be in ≥ 90% agreement. If these percentages were not met, then there were associated consequences (1 = audit was passed, no additional processes required; 2 = refinement of ID criteria for taxon that represented the majority of mismatches, complete re-review of that taxon, and then 20% audit of re-reviewed objects that were not included in first audit; 3 = all objects in disagreement went to arbitration to develop final identifications; see Chapter 4 for more information). An audit was not conducted for the March 2012 survey, as object identifications were performed collectively to develop a common identification process among reviewers. The first three surveys were flown with the sawtooth transects at 3 cm ground spatial resolution (GSR). Difficulties with identifications resulted in changing all transects to 2 cm GSR from September 2012 onwards.

Survey	Ground Spatial Resolution (GSR)	Audit	No. of objects	% agreement	Consequences
Mar. 2012	2 cm (WEAs); 3 cm (sawtooth)	20% Audit	0	N/A	N/A
		T&E Audit	0	N/A	N/A
May 2012	2 cm (WEAs); 3 cm (sawtooth)	20%	376	80%	2
		T&E	251	94%	3
Jun. 2012	2 cm (WEAs); 3 cm (sawtooth)	20%	1,506	93%	1
		T&E	209	88%	3
Sep. 2012	2 cm (all transects)	20%	868	96%	1
		T&E	177	86%	3
Oct. 2012	2 cm (all transects)	20%	335	88%	3
		T&E	210	93%	3
Dec. 2012	2 cm (all transects)	20%	861	86%	3
		T&E	4	25%	1
Feb. 2013	2 cm (all transects)	20%	2,228	85%	3
		T&E	4	100%	1
Mar. 2013 (comparison)	2 cm (all transects)	20%	559	96%	1
		T&E	0	N/A	N/A
Mar. 2013	2 cm (all transects)	20%	1,186	92%	1
		T&E	4	100%	1
Jul. 2013	2 cm (all transects)	20%	3,910	95%	1
		T&E	370	95%	3
Aug. 2013	2 cm (all transects)	20%	586	94%	1
		T&E	26	96%	3
Sep. 2013	2 cm (all transects)	20%	6,248	98%	1
		T&E	188	97%	3
Oct. 2013	2 cm (all transects)	20%	297	88%	3
		T&E	52	96%	3
Dec. 2013	2 cm (all transects)	20%	1,226	87%	3
		T&E	2	50%	3
Feb. 2014	2 cm (all transects)	20%	1,934	94%	1
		T&E	4	75%	3
May 2014	2 cm (all transects)	20%	878	91%	1
		T&E	280	98%	3

Supplementary material

Appendix 5A.

Table 5A-1. Summary of animals observed during 15 digital video aerial surveys in 2012-2014. Data are presented in order of abundance by family, based on the total count from all surveys. Surveys in blue include Maryland Project surveys. Note the August 2013 survey included only the Maryland WEA and Maryland extension area (Figure 5-1).

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	% Total
Black Scoter	8272	1	0	0	0	284	537	374	0	0	0	67	277	176	1	9989	9.34%
Unidentified Scoter	607	0	0	0	0	121	928	2362	0	0	0	30	4312	1458	144	9962	9.31%
Surf Scoter	526	0	0	0	0	59	226	129	0	0	0	2	50	79	0	1071	1.00%
Unidentified Duck	0	0	0	0	0	6	0	2	0	0	0	48	3	21	0	80	0.07%
White-winged Scoter	3	0	0	0	0	15	0	3	0	0	0	0	2	0	0	23	0.02%
Red-breasted Merganser	0	0	0	0	0	0	0	6	0	0	0	0	8	1	0	15	0.01%
Brant	0	0	0	0	0	1	0	0	0	0	0	0	1	2	0	4	0.00%
Greater Snow Goose	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.00%
Long-tailed Duck	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0.00%
Scoters, Ducks, Geese (Anatidae) Total	**9408**	**1**	**1**	**0**	**0**	**487**	**1691**	**2876**	**0**	**0**	**0**	**147**	**4653**	**1737**	**145**	**21146**	**19.76%**
Unidentified Bird	545	218	81	120	48	735	1852	538	41	83	99	78	1667	971	209	7285	6.81%
Auk or Shearwater	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0.00%
Fulmar or Medium Gull	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0.00%
Unidentified Birds (Aves spp.) Total	**545**	**218**	**81**	**120**	**48**	**736**	**1852**	**538**	**41**	**83**	**99**	**78**	**1667**	**972**	**209**	**7287**	**6.81%**
Northern Gannet	337	72	0	0	52	421	3730	821	1	0	1	119	728	839	5	7126	6.66%
Gannets (Sulidae) Total	**337**	**72**	**0**	**0**	**52**	**421**	**3730**	**821**	**1**	**0**	**1**	**119**	**728**	**839**	**5**	**7126**	**6.66%**
Unidentified Loon	551	170	3	0	2	568	824	481	2	2	1	2	836	1004	167	4613	4.31%
Common Loon	53	245	4	0	1	87	89	10	1	0	0	0	71	43	10	614	0.57%
Red-throated Loon	10	45	1	0	0	64	54	5	0	0	0	0	0	0	1	180	0.17%
Loons (Gaviidae) Total	**614**	**460**	**8**	**0**	**3**	**719**	**967**	**496**	**3**	**2**	**1**	**2**	**907**	**1047**	**178**	**5407**	**5.05%**
Bonaparte's Gull	116	0	0	0	0	497	14	10	0	0	0	0	418	11	0	1066	1.00%
Tern/Small or Medium Gull	218	64	15	10	20	124	40	1	3	14	10	4	448	10	49	1030	0.96%
Unidentified Gull	107	82	5	16	42	32	40	48	31	50	93	74	201	26	41	888	0.83%
Unidentified Tern	1	38	12	63	34	3	0	0	55	75	89	34	4	0	71	479	0.45%
Great Black-backed Gull	2	16	4	2	31	45	11	5	4	2	13	54	37	9	5	240	0.22%
Unidentified Large Gull	6	26	5	3	19	13	5	0	7	16	59	18	23	1	0	201	0.19%
Laughing Gull	0	1	5	3	9	1	0	1	52	7	11	7	0	0	7	104	0.10%
Herring Gull	18	5	4	2	12	9	1	3	0	3	7	15	14	3	5	101	0.09%
Medium Tern: 32-45 cm	7	76	12	5	1	0	0	0	0	0	0	0	0	0	0	101	0.09%

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	% Total
Unidentified large Tern	36	9	3	1	1	0	1	0	3	1	7	0	0	0	4	66	0.06%
Unidentified small gull	27	2	0	0	1	0	0	0	11	13	0	0	3	0	0	57	0.05%
Medium Gull: 38-53 cm	8	6	2	4	3	11	5	0	0	0	0	0	0	0	0	39	0.04%
Unidentified small Tern	0	7	1	4	0	0	0	0	4	14	4	0	0	0	0	34	0.03%
Black Tern	0	0	0	1	0	0	0	0	0	26	6	0	0	0	0	33	0.03%
Caspian Tern	0	0	2	5	4	0	0	0	2	0	0	0	0	0	0	13	0.01%
Lesser Black-backed Gull	2	0	2	0	1	1	1	0	0	0	2	2	0	0	0	11	0.01%
Royal Tern	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	4	0.00%
Sabine's Gull	0	0	0	0	0	0	0	0	0	1	1	2	0	0	0	4	0.00%
Ring-billed Gull	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	3	0.00%
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	**552**	**332**	**73**	**120**	**178**	**737**	**118**	**69**	**172**	**222**	**302**	**210**	**1148**	**60**	**182**	**4475**	**4.18%**
Unidentified Alcid	0	0	0	0	0	102	127	11	0	0	0	0	33	14	0	287	0.27%
Unidentified small alcid (Puffin/Dovekie)	0	0	0	0	0	7	47	2	0	0	0	0	44	44	0	144	0.13%
Unidentified large alcid (Razorbill or Murre)	0	0	0	0	0	27	7	0	0	0	0	0	0	0	0	34	0.03%
Atlantic Puffin	0	0	0	0	0	9	0	0	0	0	0	1	1	1	0	12	0.01%
Dovekie	0	0	0	0	0	8	3	0	0	0	0	0	0	0	0	11	0.01%
Razorbill	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	10	0.01%
Auks (Alcidae) Total	**0**	**0**	**0**	**0**	**0**	**154**	**193**	**13**	**0**	**0**	**0**	**1**	**78**	**59**	**0**	**498**	**0.47%**
Wilson's Storm-Petrel	0	0	51	35	0	0	0	0	2	0	0	0	0	0	5	93	0.09%
Unidentified Storm-petrel	1	0	2	3	0	12	0	0	19	5	0	1	0	0	0	43	0.04%
Storm-Petrels (Hydrobatidae) Total	**1**	**0**	**53**	**38**	**0**	**12**	**0**	**0**	**21**	**5**	**0**	**1**	**0**	**0**	**5**	**136**	**0.13%**
Greater Shearwater	0	0	57	0	0	3	0	0	0	0	0	0	0	0	0	60	0.06%
Unidentified Shearwater	0	0	6	3	0	9	1	0	0	0	0	0	0	0	1	20	0.02%
Cory's Shearwater	0	0	8	2	2	0	0	0	0	0	1	3	0	0	0	16	0.01%
Northern Fulmar	0	0	1	0	0	0	1	0	0	0	0	0	2	6	0	10	0.01%
Great Shearwater or Black-capped Petrel (flying)	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0.00%
Manx Shearwater	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2	0.00%
Sooty Shearwater	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0.00%
Shearwaters and Fulmars (Procellariidae) Total	**0**	**0**	**74**	**5**	**2**	**14**	**4**	**0**	**0**	**0**	**1**	**3**	**2**	**6**	**1**	**112**	**0.10%**
Dowitcher spp.	0	0	0	0	0	0	0	0	39	0	0	0	0	0	0	39	0.04%
Unidentified Phalarope	2	0	0	8	0	0	0	0	0	3	4	2	0	0	0	19	0.02%
Small Shorebird sp.	0	0	0	11	0	0	0	0	0	4	0	0	0	0	0	15	0.01%

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	% Total
Large Shorebird sp.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0.00%
Shorebirds (Charadriiformes spp.) Total	**2**	**0**	**0**	**20**	**0**	**0**	**0**	**0**	**39**	**7**	**4**	**2**	**0**	**0**	**0**	**74**	**0.07%**
Double-crested Cormorant	0	0	0	1	25	1	0	0	0	0	0	8	1	0	6	42	0.04%
Cormorants (Phalacrocoracidae) Total	**0**	**0**	**0**	**1**	**25**	**1**	**0**	**0**	**0**	**0**	**0**	**8**	**1**	**0**	**6**	**42**	**0.04%**
Brown Pelican	0	2	2	3	1	0	0	0	17	0	2	2	0	0	1	30	0.03%
Pelicans (Pelecanidae) Total	**0**	**2**	**2**	**3**	**1**	**0**	**0**	**0**	**17**	**0**	**2**	**2**	**0**	**0**	**1**	**30**	**0.03%**
Great Blue Heron	0	0	0	7	4	0	0	0	0	1	0	0	0	0	0	12	0.01%
American Bittern	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	3	0.00%
Snowy Egret	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0.00%
Egrets and Herons (Ardeidae) Total	**0**	**2**	**0**	**7**	**7**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**17**	**0.02%**
Cedar Waxwing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	7	0.01%
Unidentified Swallow	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	4	0.00%
Unidentified Passerine	0	0	0	1	0	0	0	0	0	0	2	1	0	0	0	4	0.00%
Baltimore Oriole	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0.00%
Barn Swallow	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.00%
Passerines (Passeriformes spp.) Total	**0**	**0**	**1**	**2**	**4**	**0**	**0**	**0**	**0**	**0**	**2**	**1**	**0**	**0**	**7**	**17**	**0.02%**
Osprey	0	0	1	0	0	1	0	0	1	0	2	4	0	0	2	11	0.01%
Bald Eagle	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	3	0.00%
Raptors (Pandionidae, Falconidae, and Accipitridae) Total	**0**	**1**	**1**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**2**	**6**	**0**	**0**	**2**	**14**	**0.01%**
Unidentified Jaeger	0	2	2	0	1	0	0	0	0	0	0	0	0	0	0	5	0.00%
Parasitic Jaeger	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0.00%
Pomarine Jaeger	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.00%
Jaegers and Skuas (Stercorariidae) Total	**0**	**4**	**3**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**8**	**0.01%**
Unidentified Grebe	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	4	0.00%
Horned Grebe	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0.00%
Red-necked Grebe	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0.00%
Grebes (Podicipedidae) Total	**4**	**0**	**0**	**0**	**0**	**2**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**7**	**0.01%**
Belted Kingfisher	0	0	0	0	1	0	0	0	0	0	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%
Common Nighthawk	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0.00%
Miscellaneous Birds Total	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**3**	**0.00%**
Avian Total	**11463**	**1092**	**297**	**316**	**322**	**3284**	**8556**	**4814**	**295**	**321**	**414**	**580**	**9184**	**4720**	**741**	**46399**	**43.36%**

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	% Total
Cownose Ray	0	0	3345	1699	78	0	0	0	9328	97	11005	268	0	0	143	25963	24.26%
Unidentified ray	0	1	2216	963	350	16	0	0	5574	277	12280	136	0	1	158	21972	20.53%
Giant Manta Ray	0	0	0	1	0	0	0	0	0	0	7	0	0	0	0	8	0.01%
Unidentified Manta Ray	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.00%
Roughtail or Southern Stingray	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0.00%
Rays (Batoidea) Total	**0**	**1**	**5562**	**2663**	**428**	**16**	**0**	**0**	**14903**	**374**	**23292**	**404**	**0**	**1**	**301**	**47945**	**44.81%**
Unidentified fish	2525	147	284	296	114	4	4	1	1435	58	706	7	85	2	2176	7844	7.33%
Unidentified shark	1	11	97	32	3	1	0	0	57	33	190	2	1	0	9	437	0.41%
Ocean Sunfish (Mola)	1	45	3	7	51	5	0	0	17	1	10	21	0	0	15	176	0.16%
Hammerhead shark	0	1	4	7	0	0	0	0	10	3	18	1	0	0	0	44	0.04%
Thresher Shark	0	1	0	3	0	0	0	0	7	1	20	0	0	0	6	38	0.04%
Scalloped Hammerhead	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	3	0.00%
Basking Shark	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0.00%
Fish and Sharks Total	**2527**	**205**	**389**	**346**	**168**	**10**	**4**	**3**	**1526**	**96**	**945**	**31**	**86**	**2**	**2206**	**8544**	**7.98%**
Small beaked Cetacean to 3m	7	91	13	65	90	25	16	25	153	213	204	2	0	14	126	1044	0.98%
Bottlenose Dolphin	12	104	48	51	36	10	0	2	178	39	84	5	0	0	108	677	0.63%
Unidentified Dolphin	20	0	0	1	1	1	52	7	9	32	59	2	5	0	1	188	0.18%
Unidentified Toothed Whales	0	0	0	0	9	18	1	3	0	0	10	11	3	6	2	63	0.06%
Common Dolphin	0	0	0	0	0	21	8	2	7	0	4	0	4	6	0	52	0.05%
Harbor Porpoise	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	3	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	**39**	**196**	**61**	**117**	**136**	**75**	**77**	**38**	**347**	**284**	**361**	**21**	**12**	**27**	**237**	**2028**	**1.90%**
Small turtle	22	216	138	71	137	0	0	0	276	24	174	43	0	1	285	1387	1.30%
Loggerhead Turtle	6	52	42	40	30	0	0	0	7	1	5	3	0	0	2	188	0.18%
Leatherback Turtle	0	1	2	31	6	0	0	0	76	0	2	3	0	0	1	122	0.11%
Kemp's Ridley Sea Turtle	0	11	9	7	5	1	0	0	1	0	2	0	0	0	2	38	0.04%
Green Turtle	1	2	1	2	4	0	0	0	0	0	0	1	0	0	0	11	0.01%
Hawksbill Turtle	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2	0.00%
Turtles (Testudines) Total	**29**	**282**	**192**	**151**	**184**	**1**	**0**	**0**	**360**	**25**	**183**	**50**	**0**	**1**	**290**	**1748**	**1.63%**
Cetacean/Seal/Shark	4	23	13	4	8	7	20	32	48	16	107	2	4	0	5	293	0.27%
Seal/Dolphin	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.00%
Unidentified Marine Mammal or Shark Total	**4**	**24**	**13**	**4**	**8**	**7**	**20**	**32**	**48**	**16**	**107**	**2**	**4**	**0**	**5**	**294**	**0.27%**
Right Whale	0	0	0	0	0	0	3	3	0	0	0	0	0	2	0	8	0.01%
Minke Whale	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	3	0.00%
Humpback Whale	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	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	% Total
Fin Whale	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0.00%
Unidentified Fin/Sei	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.00%
Baleen Whales (Mysticeti) Total	**0**	**0**	**0**	**0**	**1**	**1**	**4**	**4**	**0**	**0**	**0**	**0**	**1**	**3**	**1**	**15**	**0.01%**
Red Bat	0	0	0	14	0	0	0	0	0	0	1	0	0	0	0	15	0.01%
Bats (Chiroptera) Total	**0**	**0**	**0**	**14**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**15**	**0.01%**
Unidentified jellyfish	0	1	3	1	1	0	1	0	1	0	1	0	0	0	0	9	0.01%
Jellyfish (Cnidaria) Total	**0**	**1**	**3**	**1**	**1**	**0**	**1**	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**9**	**0.01%**
Unidentified Cetacean	0	2	0	2	0	0	0	0	1	0	0	0	0	0	0	5	0.00%
Unidentified Medium Whale	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0.00%
Unidentified Whale or Dolphin (Cetacea) Total	**0**	**2**	**0**	**2**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**6**	**0.01%**
Non-Avian Total	**2599**	**711**	**6220**	**3298**	**926**	**110**	**106**	**77**	**17186**	**795**	**24890**	**508**	**103**	**35**	**3040**	**60604**	**56.64%**
Grand Total	**14062**	**1803**	**6517**	**3614**	**1248**	**3394**	**8662**	**4891**	**17481**	**1116**	**25304**	**1088**	**9287**	**4755**	**3781**	**107003**	**100.00%**