Chapter 10: Summary of boat and aerial datasets: comparison between survey methods

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Chapter 10 Highlights

Examining differences in observations and species identifications between the boat-based and digital video aerial survey datasets.

Context[1]

Digital video aerial surveys and boat surveys were both used to collect data on marine animal abundances and distributions in the Maryland Project and Mid-Atlantic Baseline Studies project areas, and the results from each survey method provide complimentary information about the ecology of the region. Digital video aerial surveys are described in detail in Part II, with information on the methods used to collect and analyze the survey data (Chapters 3 - 4), and the results of the surveys (Chapter 5). Part III describes the boat surveys, with methods outlined in the protocol (Chapter 6), and a summary of the results (Chapter 7). Chapter 9 analyzes the boat survey data in greater detail using statistical models.

Part IV of this report examines ways to integrate the two survey datasets, using a variety of methods. This chapter compares the overall results of the boat and digital video aerial study methods across the two years of surveys to increase our understanding of how each of the methods can best be used to examine the marine environment. Subsequent chapters in Part IV use the two datasets together to develop more integrated views of wildlife distributions and abundance (Chapters 11-14).

Study goal/objectives addressed in this chapter

Examine the differences between data collected during two years (2012-2014) of boat-based and digital video aerial surveys conducted offshore of Maryland and elsewhere in the mid-Atlantic.

Highlights for the Maryland study area

- More birds and more bird species were observed in the boat surveys, and birds made up a higher proportion of boat observations (97%) compared to digital video aerial surveys (27%).
- Gulls and terns were the most abundant avian group observed using both study methods.
- Rays were the most abundant animal observed in the digital video aerial surveys, but were rarely observed in the boat study.
- More sea turtles were observed in the digital video aerial surveys, with more species observed; in both methods, turtles were most abundant in warmer months (spring through fall).

Implications

Both survey methods have distinct strengths and weaknesses, though they showed similar overall patterns for avian species. Digital video aerial surveys appear to be particularly good for observing sea turtles and other aquatic animals, while boat surveys generally had higher rates of species identification.

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

Abstract
High resolution digital video aerial surveys are a relatively novel method for collecting information on marine wildlife distributions and abundances, particularly in North America. In contrast, standardized boat based surveys are widely used to collect information on marine animals, and biases inherent to this survey approach are well understood. Our study focused on using both methodologies to collect marine bird, mammal, and sea turtle data within the Maryland Project and Mid-Atlantic Baseline Studies project areas in 2012-2014. More birds, and more species of birds, were observed in the boat surveys, while much higher numbers of aquatic animals were observed in the digital video aerial surveys; birds made up a much higher proportion of the animals observed in boat surveys as compared to digital video aerial surveys. Similar avian species were found to be abundant in the study area according to both methods, but digital video aerial surveys observed more rays and turtles than the boat surveys, where the most abundant aquatic animals were toothed whales. Identification rates were notably different between study methods, with higher rates of animals identified to species on the boat surveys. Sea turtles provided an interesting case study for comparing the study methods. Taken together, the two methodologies provide complementary information on marine animal abundances and distributions offshore of Maryland.

Introduction
The Mid-Atlantic region is an extremely important area for a broad range of marine wildlife species throughout the year. This is largely due to a relatively high level of productivity as compared with the rest of the western North Atlantic, and to the region's geographic location on the eastern edge of the continent (Chapter 1). The Mid-Atlantic area supports large populations of marine wildlife in the summer; some breed along the coastline west of the project study area, including some tern species, while others visit from the southern hemisphere in their non-breeding season, such as shearwaters. In the fall, many of the summer residents migrate south and are replaced by species that have travelled 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 this study, we aimed to produce the data that will 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, 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 or digital 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 aerial surveys have become common practice for offshore wind energy planning and monitoring in Europe, these baseline wildlife studies in the Mid-Atlantic (funded by the Department of Energy and the state of Maryland) 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

Outer Continental Shelf to accompany and compare with the data from the digital aerial surveys. Standardized boat-based surveys are a widely used method of obtaining density data for birds, sea turtles, and marine mammals (Camphuysen et al., 2004; Gjerdrum et al., 2012; Tasker et al., 1984). A focused comparison study of the two methods was conducted in March of 2013 (Williams et al., 2015), but we present a more general examination of the full datasets here, to provide details on a broader range of animals observed by boat and digital aerial surveys throughout the Maryland Project and Mid-Atlantic study areas over the two-year survey period. While the experimental comparison study was focused on comparing the results of the two survey methodologies from the same location and time period, the diversity and number of animals observed during this experimental comparison was limited, and comparing the two full datasets can provide further insight into the relative utility and strengths of the two survey methodologies.

The broader Mid-Atlantic Baseline Studies (MABS) study area encompasses the continental shelf from Delaware to Virginia, extending from 3 nautical miles from the coastline (the boundary between state and federal waters) out to either the 30 m isobath or the eastern extent of the Wind Energy Areas (WEAs; Figure 10-1). In 2013, the state of Maryland funded an expansion of this survey effort, extending the original Department of Energy-funded aerial and boat survey transects west and south to include more of the state and federal waters offshore of Maryland (Figure 10-2). For this report, we consider data from both the MABS and Maryland Projects.

We examine the differences in observations and identification rates between the two study methods, with a particular focus on sea turtles. All five species of sea turtle present in the Mid-Atlantic study area are listed as threatened or endangered under the Endangered Species Act. Fisheries bycatch affects Loggerhead Sea Turtles (*Caretta caretta*) and Leatherback Sea Turtles (*Dermochelys coriacea*) in the Mid-Atlantic and directly negatively impacts their populations' survival (Murray and Orphanides, 2013). Turtles are also vulnerable to vessel collisions, particularly at higher ship speeds (Hazel et al., 2007). Relatively little is known about sea turtle hearing capabilities, or the effects of noise on these species, but the hearing range of the Leatherback overlaps with all noise-generating activities conducted during offshore wind development (Dow Piniak et al., 2012), and the noise generated during offshore wind construction is thought to be a potential concern for this taxon (Michel, 2013).

Methods

Data collection

Details on data collection methods used in both the aerial and the boat surveys can be found in Chapters 3, 4, and 6. Between March 2012 and May 2014, 15 digital video aerial surveys and 16 boat surveys were conducted in the Mid-Atlantic study area (Figure 10-1). In the second year of surveys (March 2013 – May 2014), funding from the state of Maryland led to the addition of 747 km of high density aerial survey transects to the west and south of the Maryland WEA in the aerial surveys, and a total of approximately 12.5 km of additional boat survey transect at the western edges of three existing transect lines off of Maryland (Figure 10-2). Seven of the aerial surveys encompassed the MABS area (March 2012-February 2013), seven included the MABS area and the Maryland Project (March 2013-May 2014), and one survey (August 2013) included only the Maryland Project and the Maryland WEA (see Chapter 5 for information on specific flight timing). Analyses below include either the entire dataset from both studies, or data specifically for the Maryland study area (shown in Figure 10-2), which includes transects funded by the DOE as well as the state of Maryland.

Aerial observers indicated a degree of certainty for each object identified (Chapter 3). For the summaries below, all aerial identifications 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).

Observation rates

Digital aerial survey data were easily effort-corrected to present observations per square kilometer surveyed, as aerial transects had a defined strip width (Chapter 3). For purposes of comparison with boat survey data, aerial count data were taken at face value, and were not corrected for distance bias or other potential biasing factors, apart from variation in survey effort (Buckland et al., 2012; Williams et al., 2015). Boat surveys were designed to have a strip width of at least 300 m, but the *effective* strip width varied by taxon (Chapter 7). Detection of objects in boat surveys is known to vary with distance from the observer (Thomas et al., 2010), and thus species that were readily detected large distances away from the boat had a larger surveyed area, or effective strip width, than species that were generally only detectable near the boat. We calculated effective strip half widths for the entire MABS/Maryland dataset for the four avian taxa where data were sufficient to parameterize a null distance model in package ‘unmarked’ in the R Statistical Computing Environment (R Core Team, 2014). These groups included Sulidae (gannets), Laridae (gulls and terns), Gaviidae (loons), and Anatidae (scoters, ducks, and geese; Figure 10-3). Effective strip width was calculated in ‘unmarked’ by applying distance-based detection functions (half-normal distributions) to species groups during distance modeling, and integrating the area underneath the distance curve. Because of specific properties of distance detection curves, this number is equal to the distance at which there is a 50% chance of detecting an object (Royle et al., 2004). Because we surveyed on both sides of the ship, this effective strip half-width was multiplied by two to obtain the full effective strip width for each species group. This value was multiplied by the total linear distance of the survey to estimate the effective boat survey area for each species group. For species groups with insufficient boat observations to fit a distance curve, we used the median observation distance as a proxy for the effective half strip width, as the two values appeared to be comparable for the species where we could calculate both values.

Identification rates

We used the naïve counts from each of the Maryland study area surveys to calculate identification rates for the data collected on the two survey platforms. Within each of the most commonly observed family groups, including Anatidae, Sulidae, Laridae, Gaviidae, Alcidae (alcids, including puffins, murres, and others), Procellariidae (shearwaters and fulmars), Odontoceti (toothed whales, including dolphins and porpoises); Testudines (sea turtles); and Mysticeti and Cetacea (baleen and other large unidentified whales), the proportion of observations in which animals were identified to the species level vs. the group level (e.g., Common Tern, *Sterna hirundo,* vs. “Unidentified Tern”) was compared between survey methods.

Results

Our assessments of the boat-based and aerial survey data indicated that the two methods differed in their abilities to detect and identify certain taxa. We discuss these results in detail below.

Observation rates

Within the combined MABS and Maryland Project datasets, boat survey observers detected larger numbers of birds per unit effort and more species of birds than the digital video aerial survey observers (Figure 10-4), while the digital aerial surveys appeared to be better at detecting certain aquatic animals (Figure 10-5, Table 10-1). In the Maryland study area alone, birds made up a very large proportion of the animals observed on the boat survey (97%) compared to the digital video aerial survey (27%). Gulls and terns were the most abundant avian group observed in both boat (33% of birds) and digital video aerial surveys (20% of birds) in the Maryland study area, with anatids the next most abundant group in each (25% boat and 19% aerial, Figure 10-6). This is different from the pattern seen in the broader MABS area, where scoters comprised the highest percentage of birds observed. A similar percentage of gannets were observed in the Maryland boat data (18%) compared to the Maryland aerial data (17%), while loons made a larger percentage of the digital video aerial data than the boat data, in both Maryland and the MABS areas (Figure 10-6).

Digital aerial surveys detected many aquatic animals compared to boat surveys, including turtles, sharks, fish, and rays; the same patterns were observed offshore of Maryland and the broader MABS area (Figure 10-7, Table 10-1). The aerial surveys provided an excellent platform for detecting and identifying animals within the upper reaches of the water column. In particular, higher counts and species diversity of sea turtles and mammals were detected on the aerial surveys (Figure 10-5; Chapter 4) than from the boat. Of the non-avian digital video aerial observations, the bulk of detections were rays (61% of the Maryland study area data), with many fish (7%), toothed whales (6%), and some turtles (2%) observed as well; in contrast, the most commonly observed aquatic species group in the boat data (both in the Maryland study area and overall) was toothed whales (dolphins and porpoises; Figure 10-7). Major migrations of Cownose rays (*Rhinoptera bonasus*) were observed in the aerial study but went undetected in the boat surveys; almost 48,000 rays were observed in aerial surveys in all, and 200 times as many rays were observed from the aerial surveys as from the boat surveys (Figure 10-8; Chapter 4). Many schools of baitfish were observed in the aerial data, some spanning hundreds of meters, with peak observations occurring in July-September 2013. Schools of small fish were not measured nor individuals enumerated, but in the MABS area a total of 7,501 schools of fish of varying sizes were observed on the aerial surveys, while 50 were counted on the boat surveys. Baitfish schools were observed primarily in nearshore areas, and many were observed in the high-density transect extension offshore of Maryland in the second year of surveys, as well as in western extents of the sawtooth transects; the bulk of the baitfish observations occurred within the Maryland study area (74%, Figure 10-8).

Identification rates

There appeared to be differences in observers' ability to identify animals between the aerial and boat-based surveys in some cases, and the patterns observed in the Maryland study area were similar to those seen in the entire MABS area (Figure 10-9; see Connelly et al., 2015 for MABS identification rates). Twice as many bird species were definitively identified in the Maryland study area boat surveys than from the air (Table 10-1), with many more digital video aerial observations limited to the family or genus level of identifications. Gulls and terns, loons, and alcids all had much higher identification rates to the species level from the boat surveys than from the aerial surveys (Figure 10-9). Aerial observers were slightly better at identifying scoters, ducks, and geese (Anatidae) to species, which was likely due to boat observers having difficulty differentiating large flocks of Black Scoters (*Melanitta nigra*) and Surf Scoters (*M. perspicillata*) at a distance (Figure 10-9; see Williams et al., 2015 for a more detailed discussion). Observers from both survey types had similarly high identification rates of shearwaters (Procellariidae).

As fish were not a focal taxon for research in this study, neither platform identified fish to species, aside from Ocean Sunfish (*Mola mola*); in the Maryland study area, the aerial observers detected 46 sunfish, while the boat observers did not detect any. Identification rates of toothed whales (Odontoceti) were higher on boat surveys, but baleen whales (Mysticeti) had higher rates of identification from aerial surveys (Figure 10-10), and each method observed a few species that were missed by the other (Chapters 5 and 7).

Case study: sea turtles

Much higher counts and species diversity of sea turtles were detected on the aerial surveys than on the boat surveys in the MABS area (Figure 10-11) and in the Maryland study area (Chapters 4 and 7). While there were higher identification rates of turtles on the boat survey (Figure 10-10), only two species of turtles were identified (Loggerhead and Leatherback Sea Turtles) were identified from the boat. Despite difficulties with differentiating some subsurface turtles in the aerial footage, video observers were able to identify three additional species of turtles (Kemp's Ridley, *Lepidochelys kempii*; Hawksbill, *Eretmochelys imbricata*; and Green, *Chelonia mydas*) in both the Maryland and MABS areas.

Turtle distributions shift according to temperature, as they are poikilotherms and are limited to certain water temperature ranges (Gardner et al., 2008). There were times of year when turtles were far less abundant in the study area; as shown in Chapter 12 and the figures below, sea turtles had highest abundances from May through October. Overall, turtles were more abundant in the southerly survey transects, especially near the Virginia WEA (Figure 10-12 - Figure 10-14). Seasonal distributions varied between species groups, however. In the spring, Loggerhead Sea Turtles were found predominantly off the coast of Virginia, with a few individuals observed on the sawtooth transects further up the coast (Figure 10-12). One Leatherback and a few Green Sea Turtles were seen in Virginia and Maryland further offshore, and Kemp's Ridley Sea Turtles were seen mostly in the south (Figure 10-12). More Leatherbacks were observed in the summer compared to the other seasons, and while observations occurred mostly in the south, some were seen as far north as Delaware (Figure 10-13). Loggerheads were found further north in the summer as well, but all Kemp's Ridley and Green Sea Turtle observations were made off of Virginia (Figure 10-13). Turtles were much more evenly distributed up the coast in the fall than during earlier seasons; all five species were observed in the Virginia and Maryland WEAs during fall surveys. The only sightings of Hawksbill Sea Turtles occurred in the fall, in the Virginia and Maryland WEAs (Figure 10-14). There were only two turtle sightings in winter, one Kemp's Ridley and one unidentified to the species level, both located off of Virginia. All species of turtle were observed in the Maryland study area, with the highest number of observations and highest diversity in fall. Turtles were relatively evenly distributed in spring in the Maryland study area, with a more offshore distribution in summer and fall, unlike many other taxa observed in this study (Chapter 11).

Discussion

Overall, there were substantial similarities between the species groups detected via the two study methods offshore of Maryland. Gulls and terns were the most abundant bird group detected in both studies, with anatids observed in high numbers from both platforms as well. Both platforms detected similar species within these broader taxonomic groups. Chapters 13-14 continue to explore these similarities, with the goal of developing an integrated model that uses data from both survey platforms to yield more information about the study area than would have been possible through the use of either survey method alone.

However, there were notable differences in observation and identification rates between the two survey methods as well, which point towards differing strengths and weaknesses of the two methods (Figure 10-15). For example, there were more birds and more species of birds observed in the boat surveys, while aerial surveys detected many more aquatic animals. A similar efficiency in detecting and identifying sea turtles and marine mammals from high resolution digital aerial platforms (as compared to visual aerial or boat surveys) has also been observed elsewhere (Normandeau Associates Inc., 2013). Some of the discrepancies in observations point towards potential differences in detectability between the two survey types; for example, Northern Gannets (*Morus bassanus*) and larger gulls were visible at great distances from the boat survey, as observers could look from the vessel all the way to the horizon. Reviewers of aerial survey data, in contrast, could only see animals present in the narrow strip of the transect onscreen, and aerial survey speed was roughly 13.5 times that of the boat, potentially limiting onscreen appearances by highly mobile animals (Williams et al., 2015). Boat surveys are also known to affect animal behavior, and possibly detections as a result. Gulls are often attracted to boats as potential sources of food, while scoters are sensitive to disturbance by boats (Schwemmer et al., 2014), which we found to be the case in the focused comparison of the boat and aerial methods in the MABS study (Williams et al., 2015). Marine mammals are known to be attracted to or disturbed by boats (Mattson et al., 2005), and our boat survey counts of these species were potentially biased by the influence of the vessel's presence.

Differences in identification abilities between survey methods may have also played a role in explaining lower detections for many avian taxa. Low rates of aerial species identification were not altogether surprising for alcids and terns, given their small size and subtle differences between species. However, higher identification rates had been expected for loons based on results from European studies. Aerial video reviewers faced difficulties in differentiating the two loon species that use the Mid-Atlantic during the non-breeding season, due to the high degree of suspected size overlap (particularly for birds sitting at the water's surface) in this time period and region of the U.S. (Gray et al., 2014).

Additionally, the aerial results were analyzed using defined confidence level criteria, and were audited following an exhaustive quality assurance protocol. Both of these processes increase the amount of scrutiny given to identifications, which could result in lower identification rates. In contrast, boat observations are generally unverifiable and unable to be audited. The quality assurance and quality control protocol followed during analysis of digital video aerial survey data recognizes the inherent uncertainty in the identification process, which is generally under-recognized in visual surveys, as it is difficult to measure. At the same time, some of the lower identification rates in aerial surveys were, in the opinion of reviewers, clearly due to image quality, and this issue limits the utility of the digital video aerial surveys for describing the distributions of some taxa. Within the Maryland study area, a large percentage of digital video aerial observations of birds were recorded as Unidentified Bird due to poor image quality (6% overall, 21% of birds; Figure 10-6; Chapter 5). The next generation of cameras being used in Europe have higher resolution and color rendition than the cameras used in this study, however, with increased identification rates as a result (A. Webb pers. comm.), so technological advances in the field may largely ameliorate this issue.

We examined sea turtles more closely to compare observers' abilities to detect and identify aquatic animals using the two study methods, and found the digital video aerial surveys to be particularly good for observing and identifying sea turtles in the Mid-Atlantic. High resolution digital aerial survey platforms have previously been shown to be particularly efficient means to detect sea turtles as compared to visual aerial or boat survey platforms (Normandeau Associates Inc., 2013). Looking directly down on the surface of the water likely allows for clearer views of submerged or partially submerged animals, and video capture allows for in-depth examination of the animals for key characteristics. The animals are also not disturbed in the same way that they would be by a boat or a low-flying airplane (Hazel et al., 2007; Normandeau Associates Inc., 2013). Given that all species of sea turtle in Maryland and the Mid-Atlantic are federally listed and are of conservation concern, more accurate counts and distribution data for these species (even if many of the observations are recorded as simply non-Leatherback "unidentified turtles"), are still extremely useful for resource managers. As mentioned above, cameras used in this study have already been replaced by better models in Europe, and continued technological improvements are likely to dramatically increase identification rates for this key taxon.

Given the seasonal distribution patterns found for sea turtles, it is clear that there is overlap between these species' observed distributions and the locations of planned offshore wind energy development (WEAs), in part because sea turtles in the mid-Atlantic display a generally more offshore distribution pattern (thus placing them in areas of potential exposure to development activities in federal waters; Chapter 12). Offshore wind construction is the development period with the most risk to sea turtles, due to noise from pile driving and other activities, as sea turtles can detect and react to low-frequency sounds of the same frequencies as those emitted by seismic airguns, offshore drilling, sonar, pile driving, ships, and operational wind turbines (Chapter 12; Dow Piniak et al., 2012; Lenhardt et al., 1983; Read, 2013) Sea turtles are also vulnerable to collisions with ships, particularly those moving at higher speeds (Hazel et al., 2007). Turtles can be displaced from operating offshore wind facilities due to turbine or vessel noise, or artificial reef effects could lead to turtles aggregating around turbine foundations (Read, 2013). It may be possible to minimize potential effects of offshore wind energy development on sea turtles in the mid-Atlantic by planning offshore wind energy construction activities for periods in which turtles are not present (e.g., winter), though conducting construction activities during winter can be difficult or impossible. Since it is likely that turtle presence and construction will overlap, the development of techniques to avoid or reduce interactions between sea turtles and development activities should be a priority (Chapter 12). Restricting vessel speeds within areas and times of year when turtles are present could also help prevent negative impacts and/or mortalities of sea turtles (Hazel et al., 2007). Aerial video surveys appear to be an effective means to document sea turtle distributions, and we would suggest that future studies of sea turtles strongly consider digital aerial survey methodologies in order to obtain the best possible data for conservation and mitigation purposes.

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Figures and tables

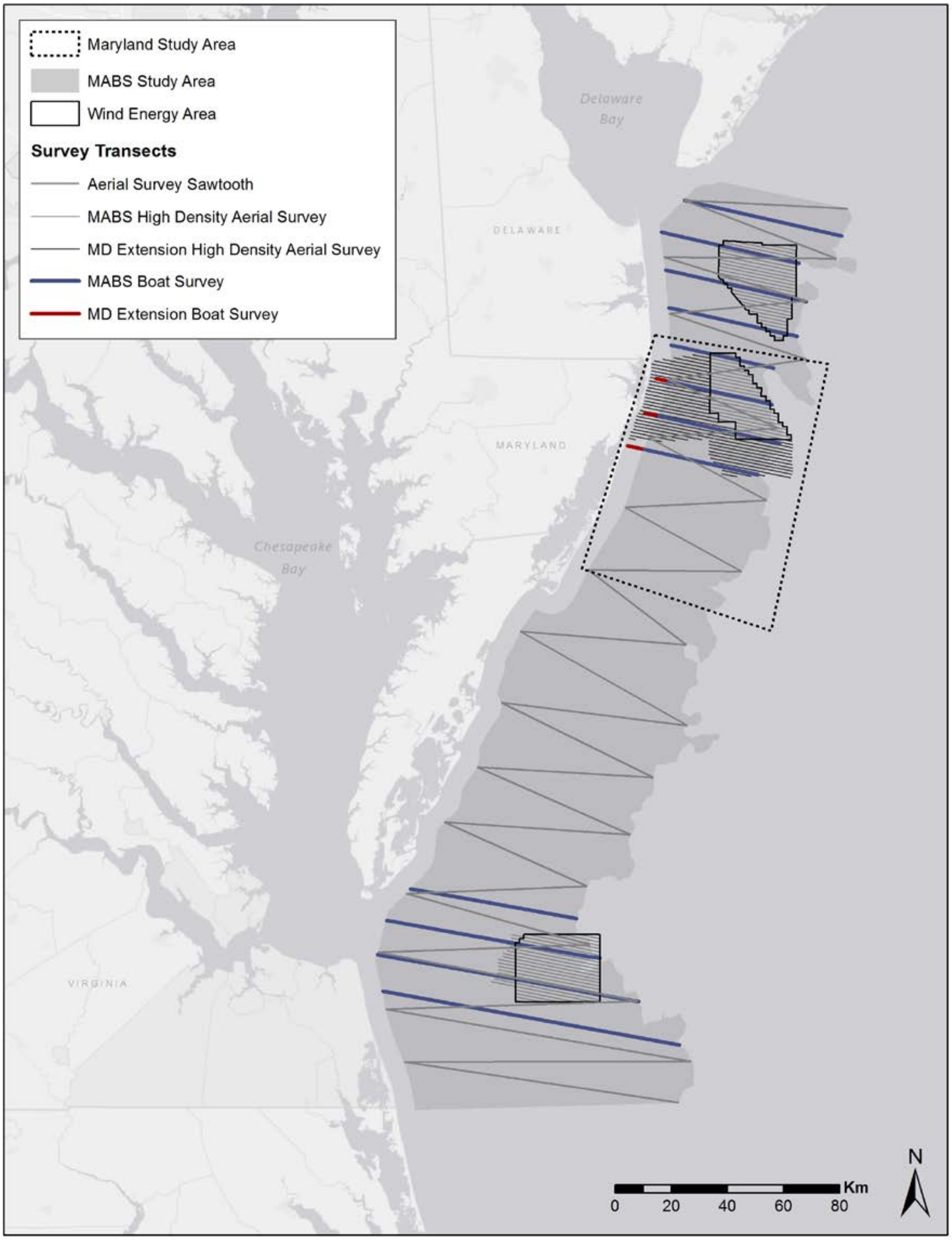

Figure 10-1. Map of digital video aerial survey transects and boat survey transects for the Maryland-funded Maryland Project (2013-2014) and the DOE-funded Mid-Atlantic Baseline Studies Project (2012-2014). MABS boat transects are shown in dark blue and Maryland Project boat transects are shown in red. MABS aerial transects are shown in light grey and Maryland Project aerial transects are shown in dark grey.

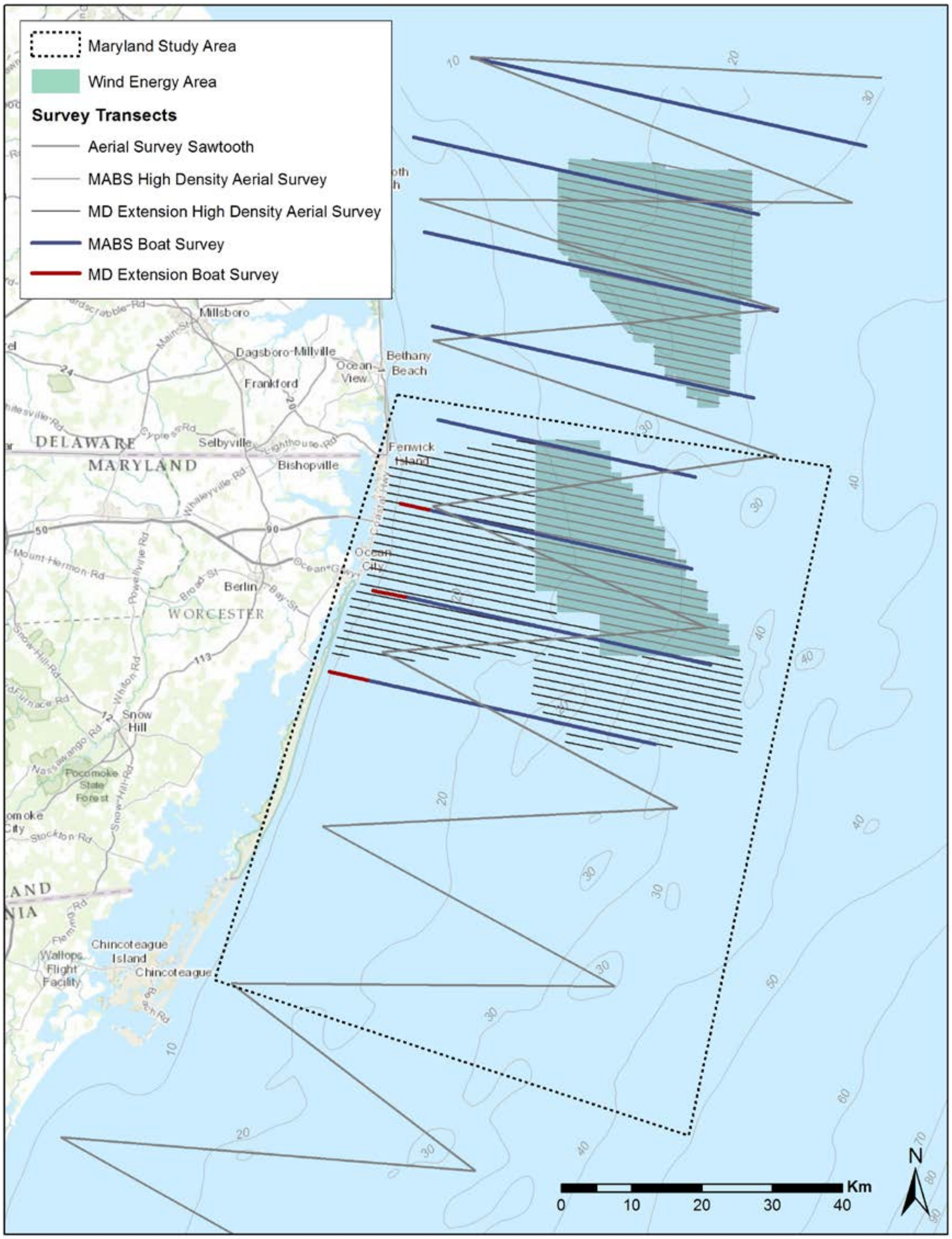

Figure 10-2. Detailed map of aerial survey transects focused on the digital video aerial surveys and boat surveys for the Maryland-funded Maryland Project (2013-2014) along with the adjacent DOE-funded Mid-Atlantic Baseline Studies Project (2012-2014). The "Maryland Study Area" includes all boat and aerial survey transects in waters offshore of Maryland (both DOE and Maryland-funded surveys) 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. These extension surveys included boat survey extensions into state waters (red bars), aerial survey high-density transect extensions west and south of MD WEA (dark grey lines), and a 15th aerial survey of the Maryland WEA and Maryland Project high-density transects in 2013. Surrounding transect lines for the MABS study are also shown.

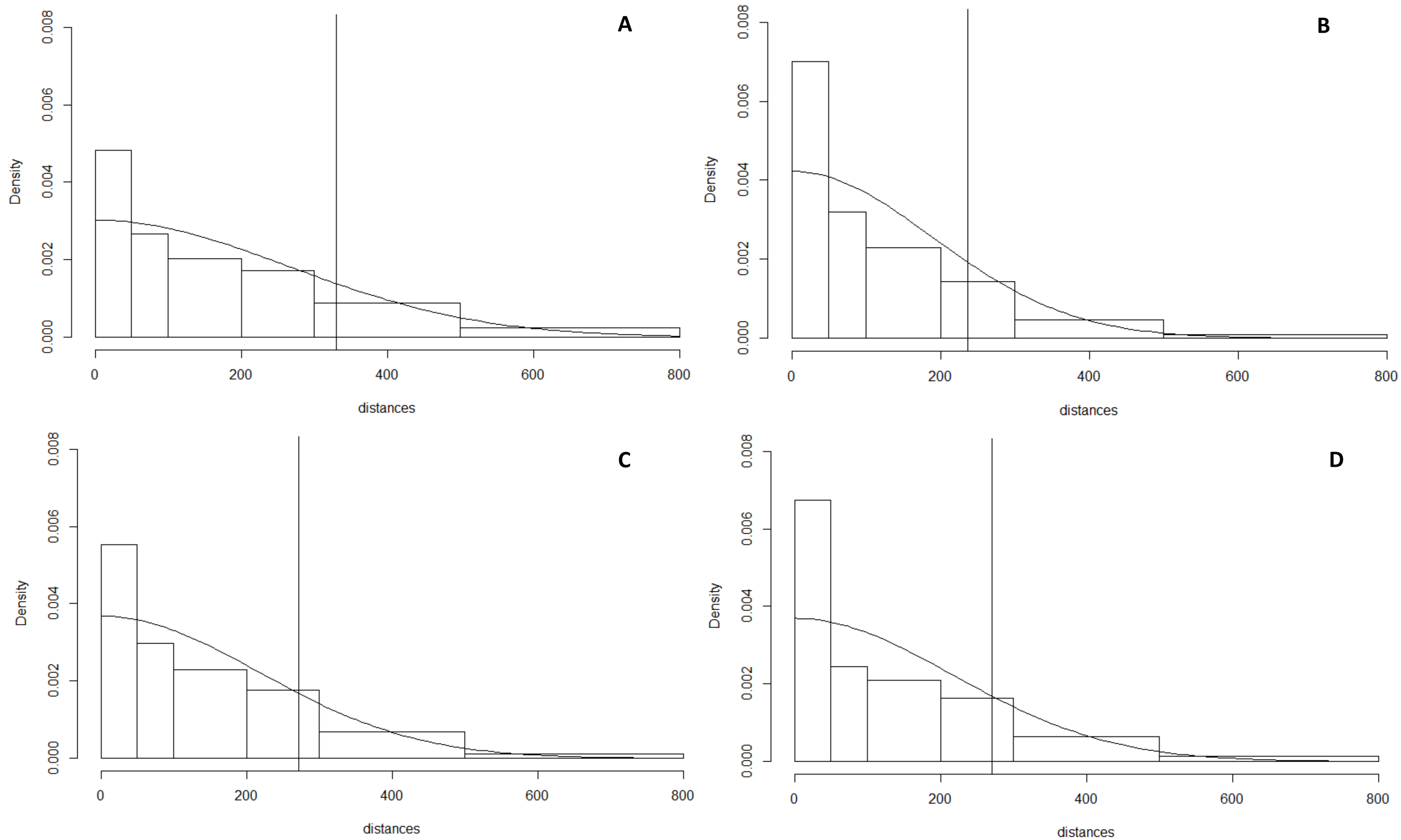

Figure 10-3. Distance functions for a) Sulidae, b) Laridae, c) Gaviidae, and D) Anatidae from the combined MABS and Maryland Project boat survey data. Effective strip half-widths, or the distance from the boat at which there is average detection probability, are indicated by the vertical line in each chart (330m for Sulidae, 236m for Laridae, 272m for Gaviidae, and 271m for Anatidae).

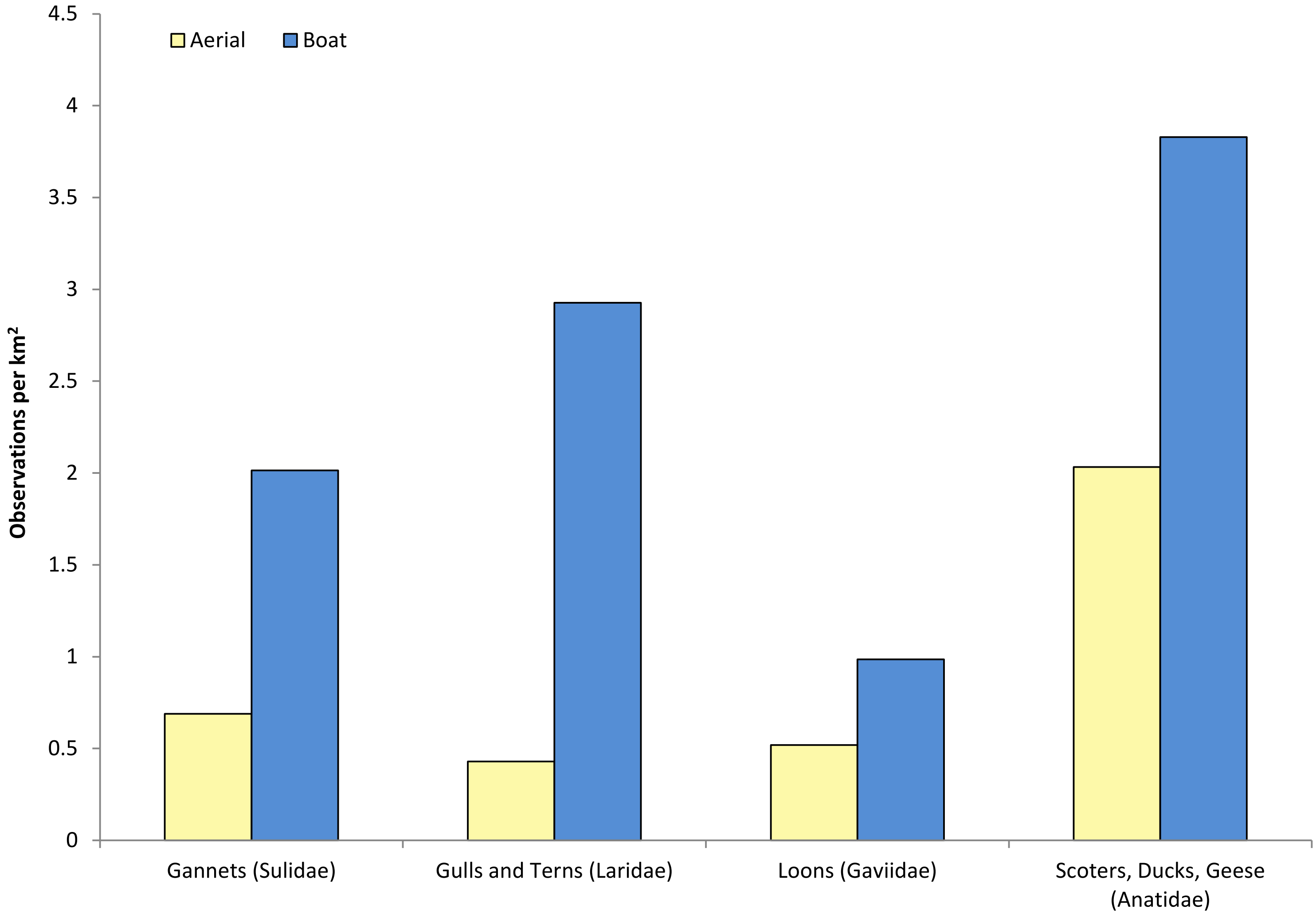

Figure 10-4. Comparison of total effort-corrected boat and aerial survey counts by taxon for the combined MABS and Maryland Project study area. Densities are calculated by the total number of counts divided by the total surveyed area. Aerial data have transect widths of either 200 or 300 meters (Chapter 3). Effective boat transect strip widths were calculated for each group based on the effective half strip width (see Figure 10-3).

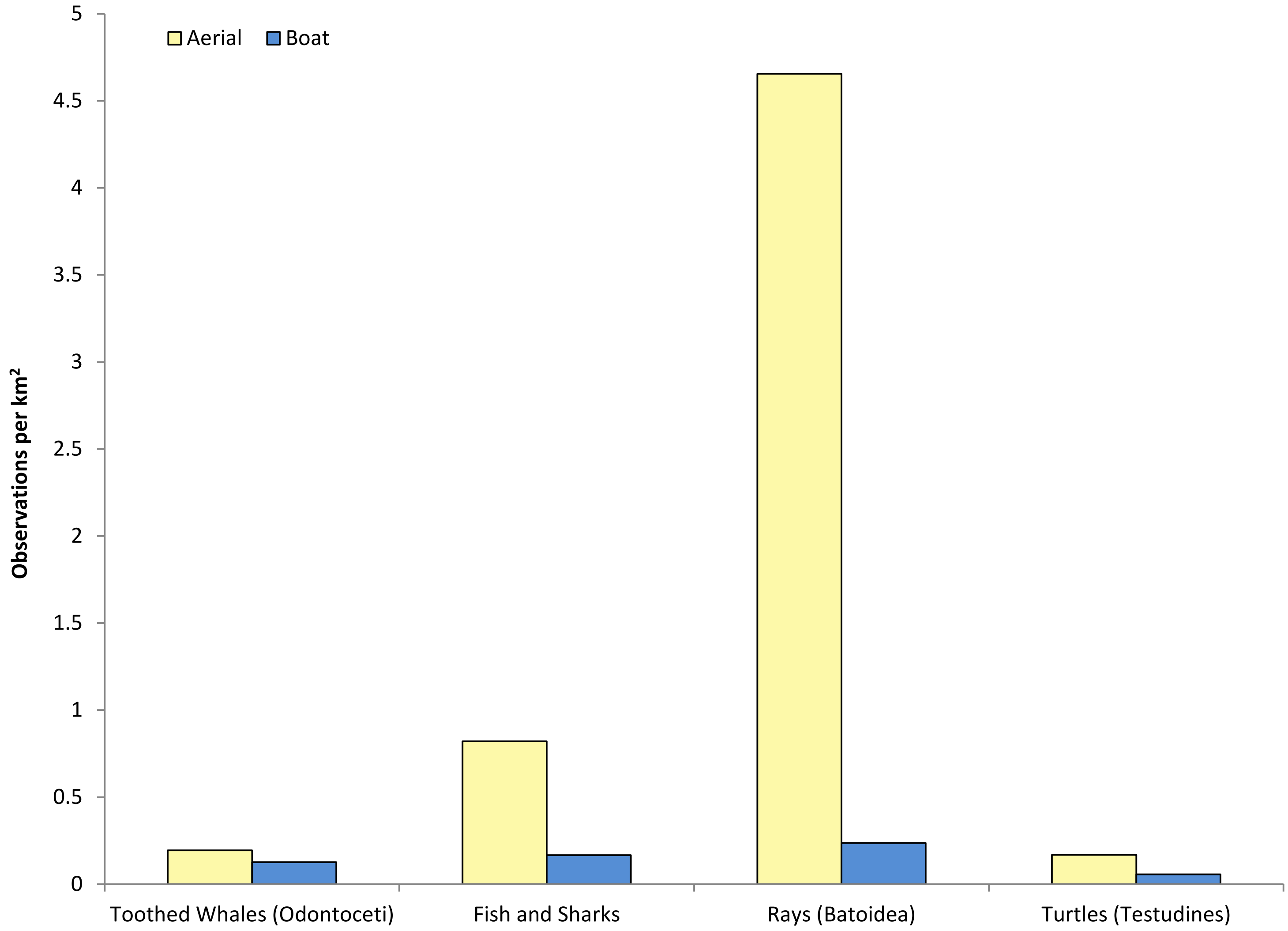

Figure 10-5. Comparison of total effort-corrected boat and aerial survey counts by taxon for the combined MABS and Maryland Project study area. Densities are calculated by the total number of counts divided by the total survey area. Aerial data have transect widths of 200 or 300 meters (see Chapter 3). Boat data transect widths were based on the median distance of observations from the boat, in meters (Odontoceti, 300 m; Fish/Sharks, 50 m; Batoidea, 7.5 m; Testudines, 100 m). Observations of groups that were not individually counted or identified (e.g., bait balls, ray schools) are excluded from this figure (see Chapter 5 for more information).

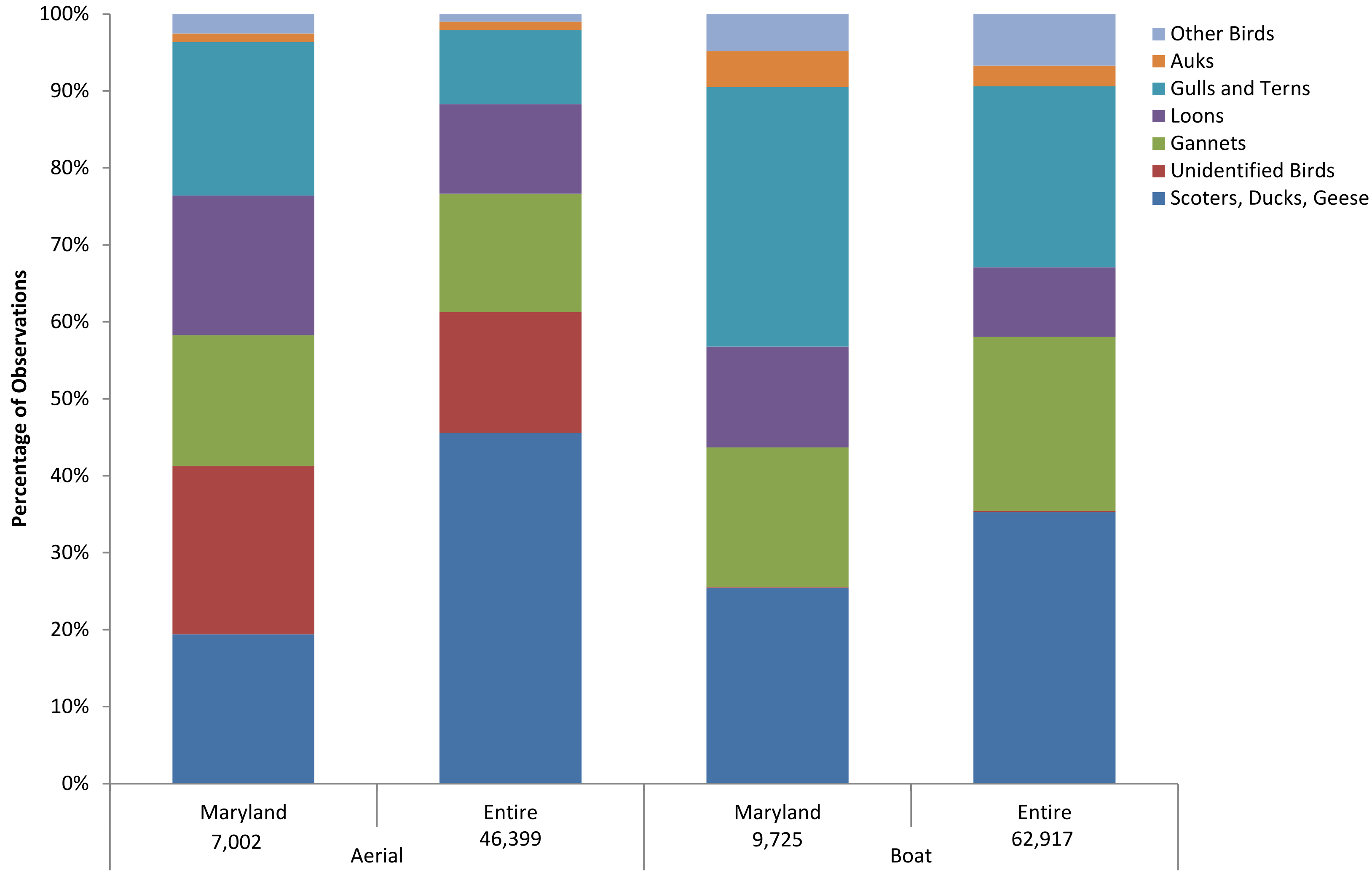

Figure 10-6. Bird groups observed in the digital video aerial and boat surveys in the Maryland study area (Maryland) and the combined MABS area and Maryland Project study area (Entire). The sample size for each group is given in the x-axis. Animals shown are scoters, ducks, and geese (Anatidae); unidentified birds (birds not identified to lower taxonomic levels); Northern Gannets (Sulidae); loons (Gaviidae); gulls and terns (Laridae); auks (Alcidae); and other birds (additional less common animal groups, see Chapters 5 and 7 for animals observed).

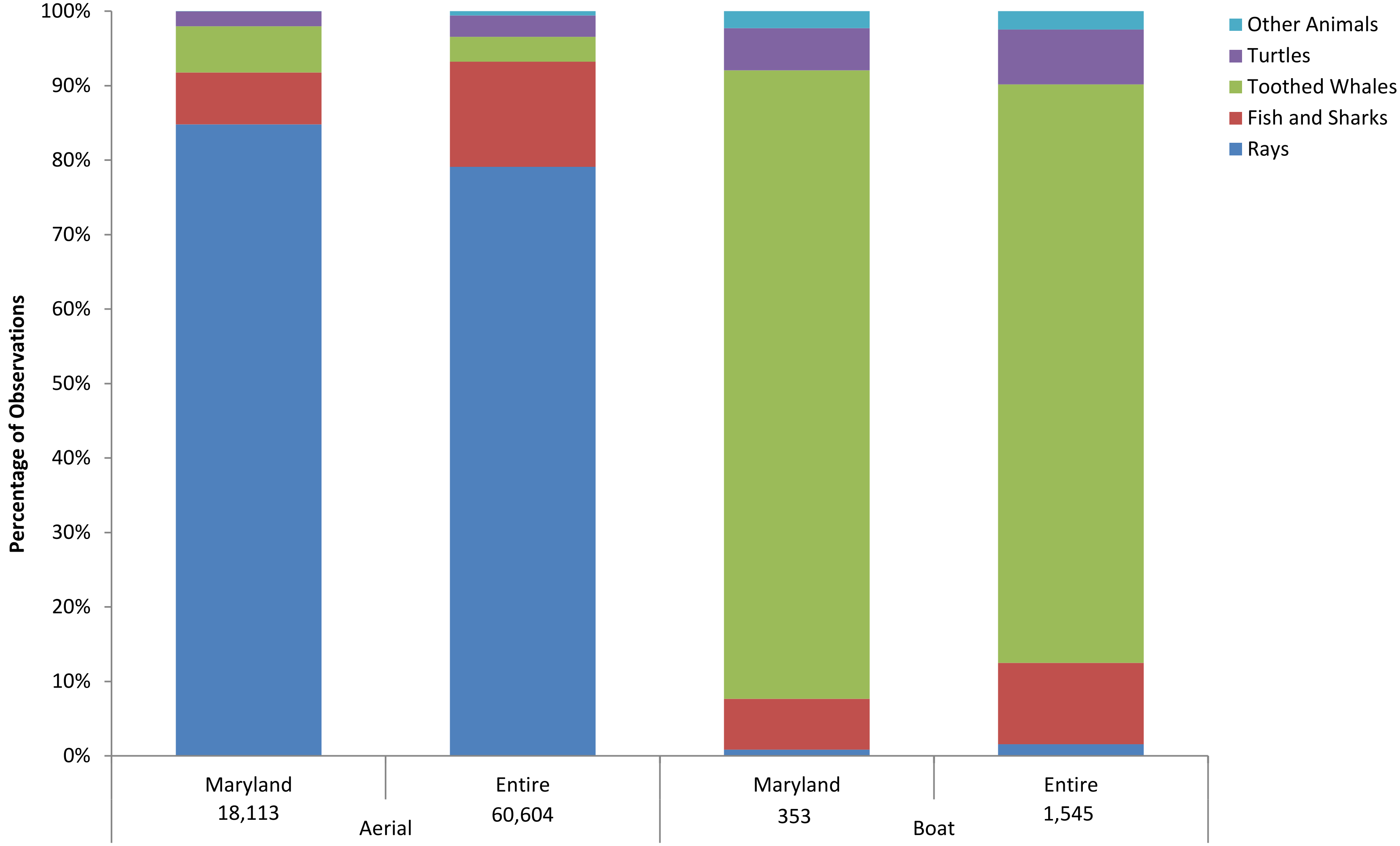

Figure 10-7. Non-avian animals observed in the digital video aerial and boat surveys in the Maryland study area (Maryland) and the combined MABS area and Maryland Project study area (Entire). The sample size for each group is given in the x-axis. Animals shown are rays (Batoidea); fish and sharks (Chordata); toothed whales (Odontoceti, including dolphins and porpoises); turtles (Testudines); and other animals (additional less common animal groups, see Chapters 5 and 7 for animals observed).

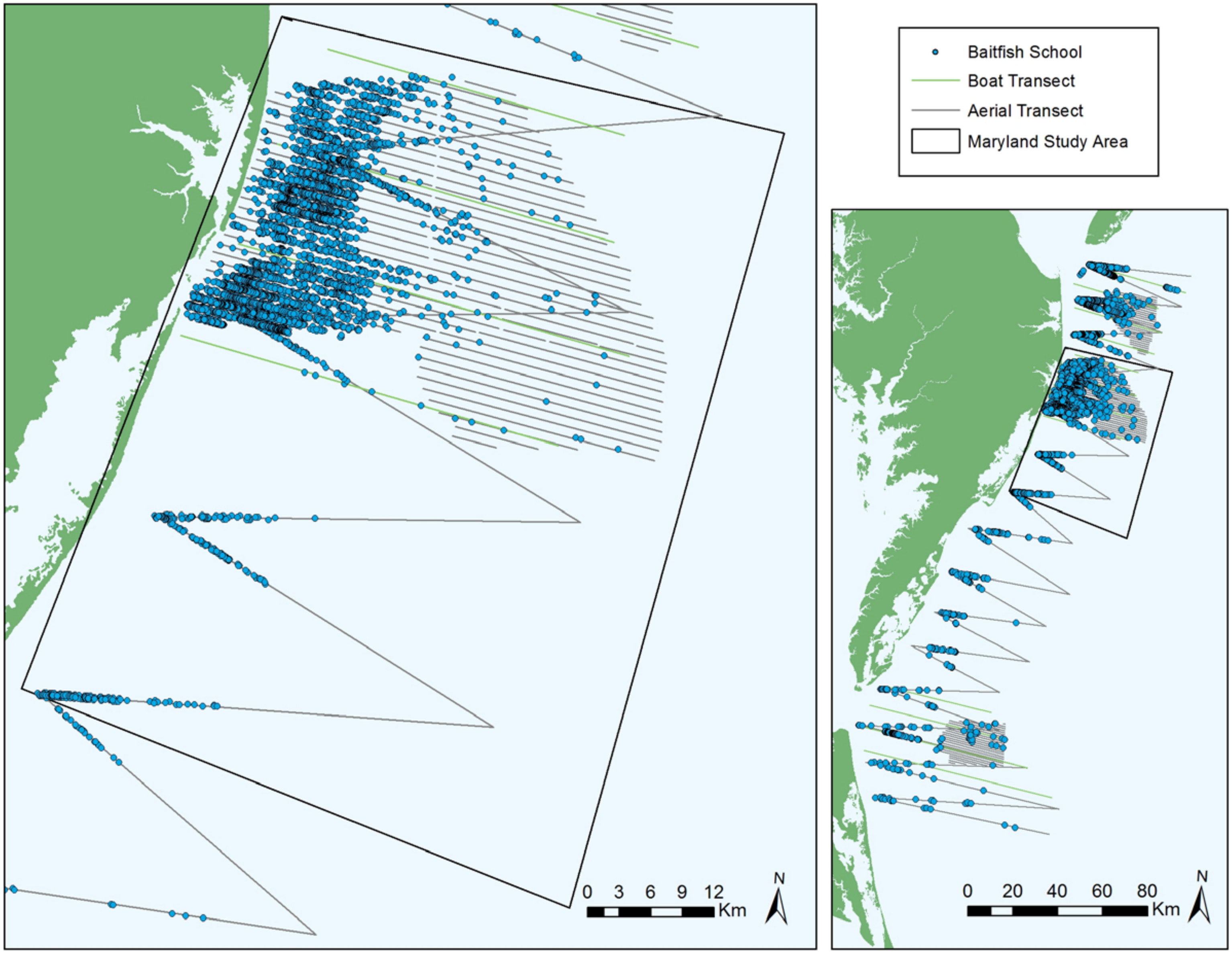

Figure 10-8. Schools of baitfish (forage fish) observed in Maryland boat and digital video aerial surveys. The inset map shows the broader project area.

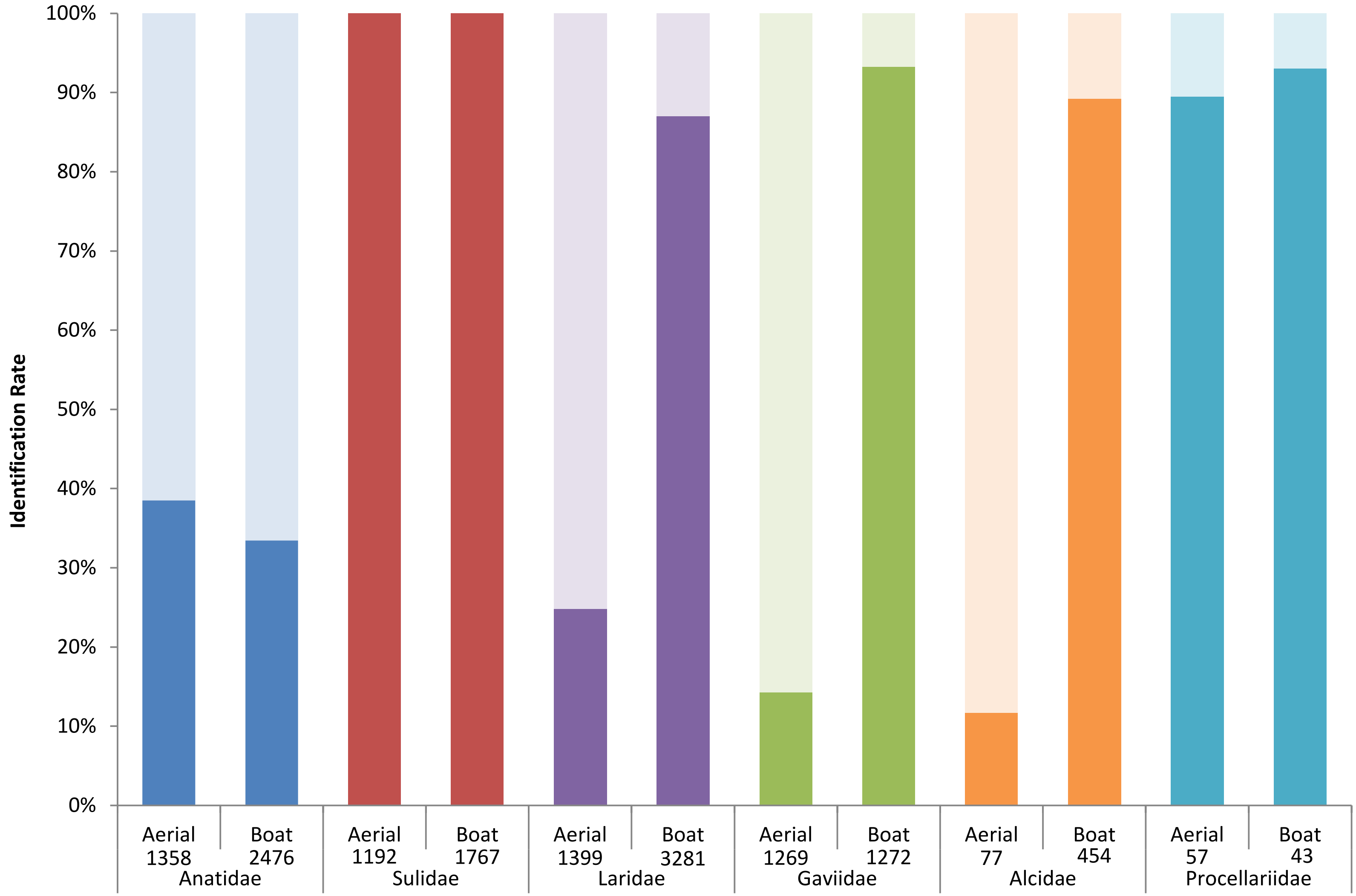

Figure 10-9. Identification rates for common bird taxa observed during boat-based and digital video aerial surveys in the Maryland study area, in order of abundance. Darker colors indicate animals identified to species, and lighter colors indicate animals identified to higher taxonomic levels. Sample sizes are noted in the x-axis. Details on species sighted within each taxonomic group can be found in Chapters 5 and 7. The most common avian families observed in surveys were scoters, ducks, and geese (Anatidae); Northern Gannets (Sulidae); gulls and terns (Laridae); loons (Gaviidae); auks (Alcidae); and fulmars and shearwaters (Procellariidae).

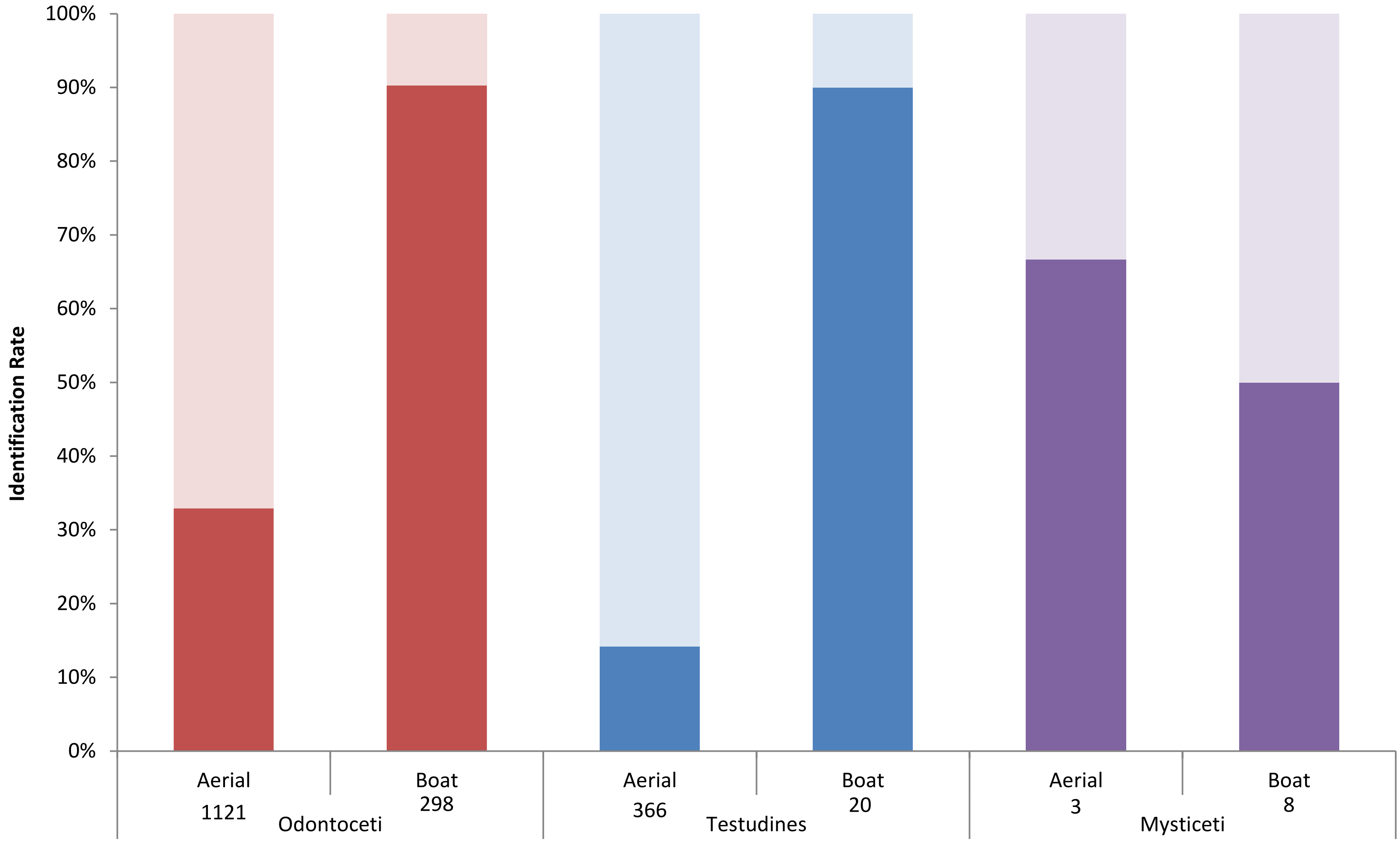

Figure 10-10. Identification rates of mammals and turtles observed on during boat-based and digital video aerial surveys in the Maryland study area. Darker colors indicate animals identified to species, and lighter colors indicate animals identified to higher taxonomic levels. Sample sizes are noted in the x-axis. Details on species included within each taxonomic group can be found in Chapters 5 and 7. Groups are toothed whales (Odontoceti, including dolphins and porpoises); sea turtles (Testudines); and baleen whales (Mysticeti).

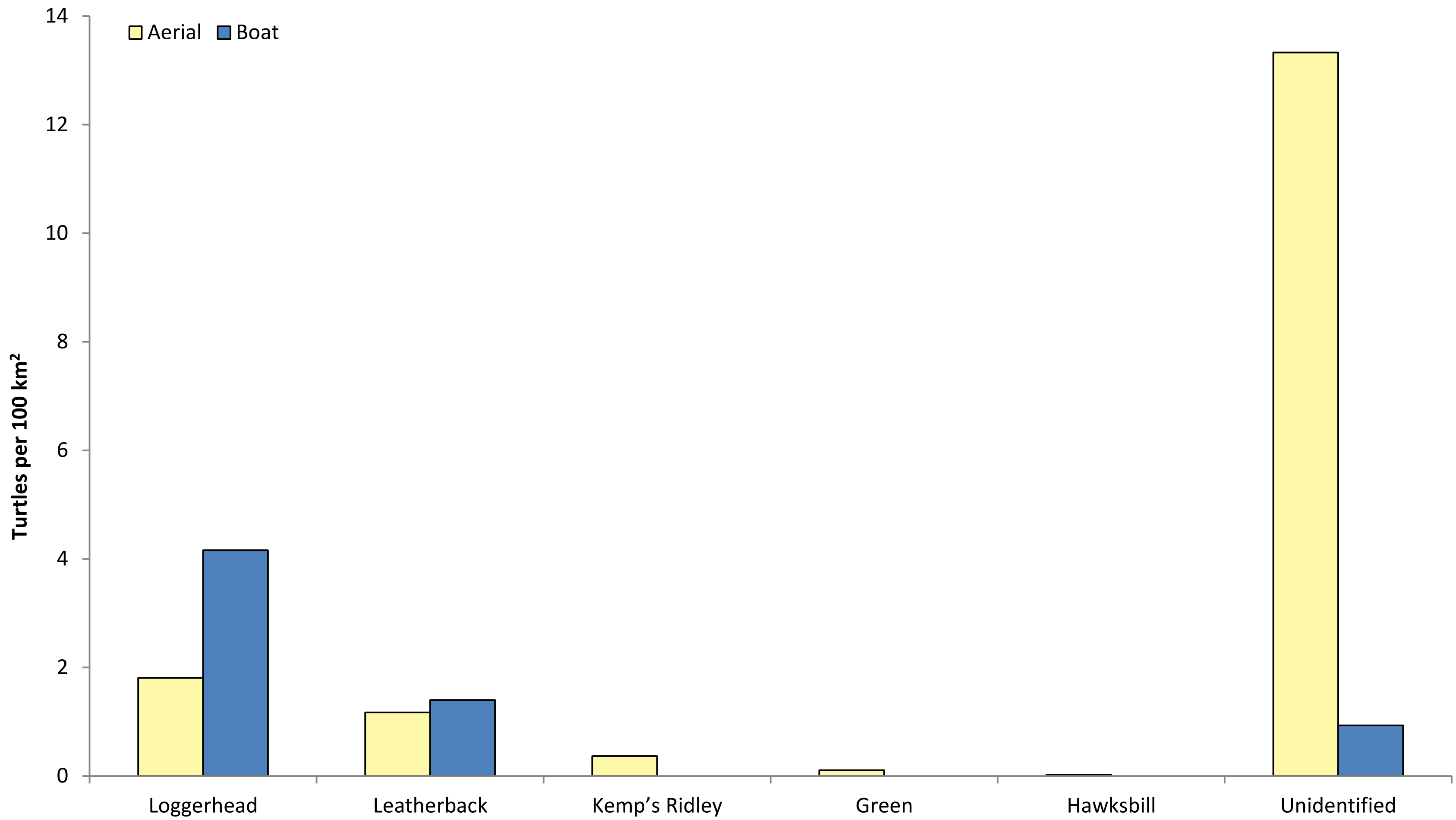

Figure 10-11. Comparison of total effort-corrected boat and aerial survey counts of sea turtles for the combined MABS and Maryland Project study areas. Densities were calculated by the total number of counts divided by the total survey area across all surveys, and standardized to 100 square km. Aerial surveys had transect strip widths of 200 or 300 m (Chapter 3). Boat transect strip widths were based on the median distance of observations from the boat, in meters (Loggerhead 100, Leatherback 50, Unidentified 50 m), and multiplied by two to account for observations made on both sides of the boat.

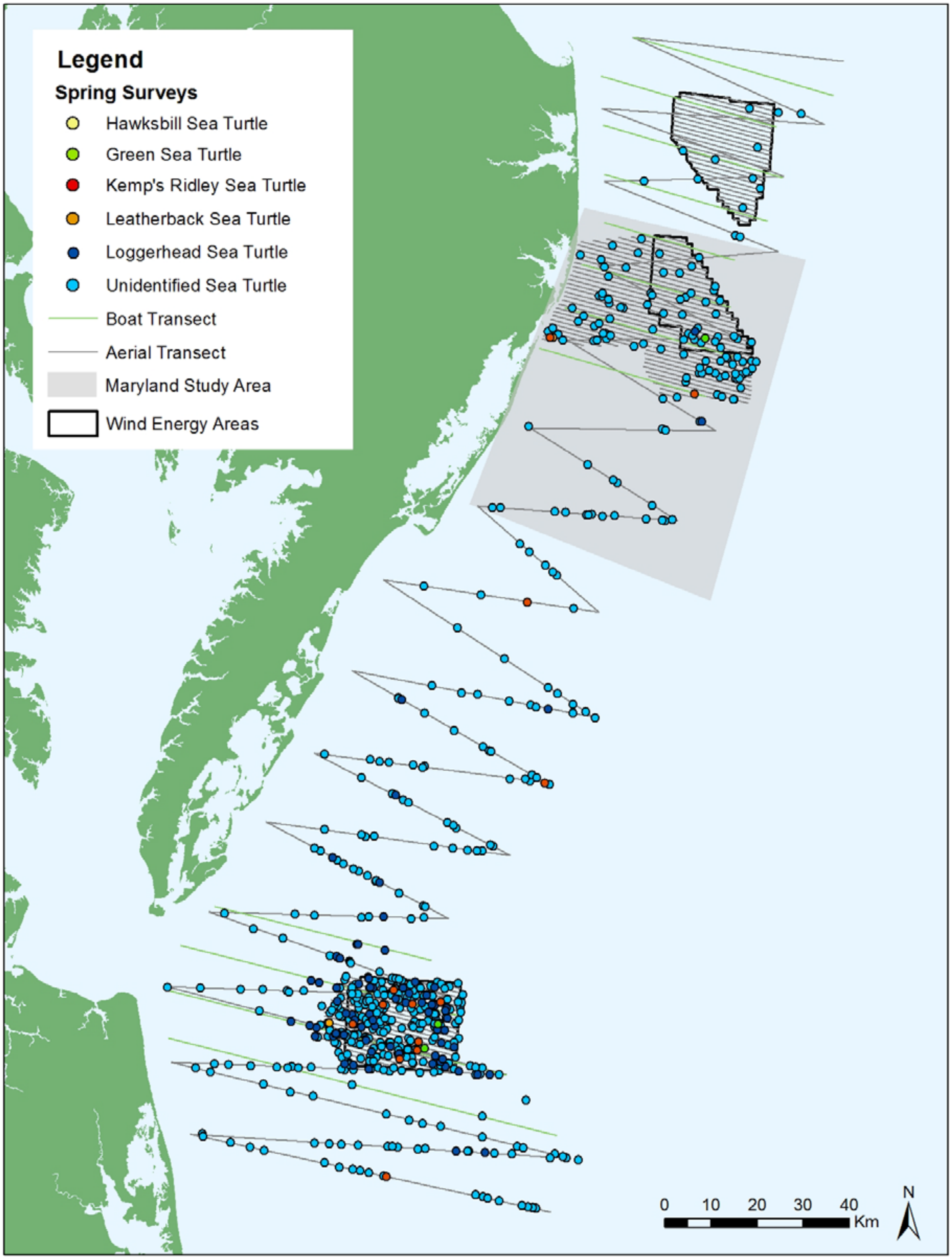

Figure 10-12. Turtles observed in the spring (Mar-May 2012-2014) in boat and high resolution video aerial surveys. Unidentified sea turtles are any turtles not identified to species, and could represent any of the four smaller turtle species present in the study area (excluding Leatherback Sea Turtles).

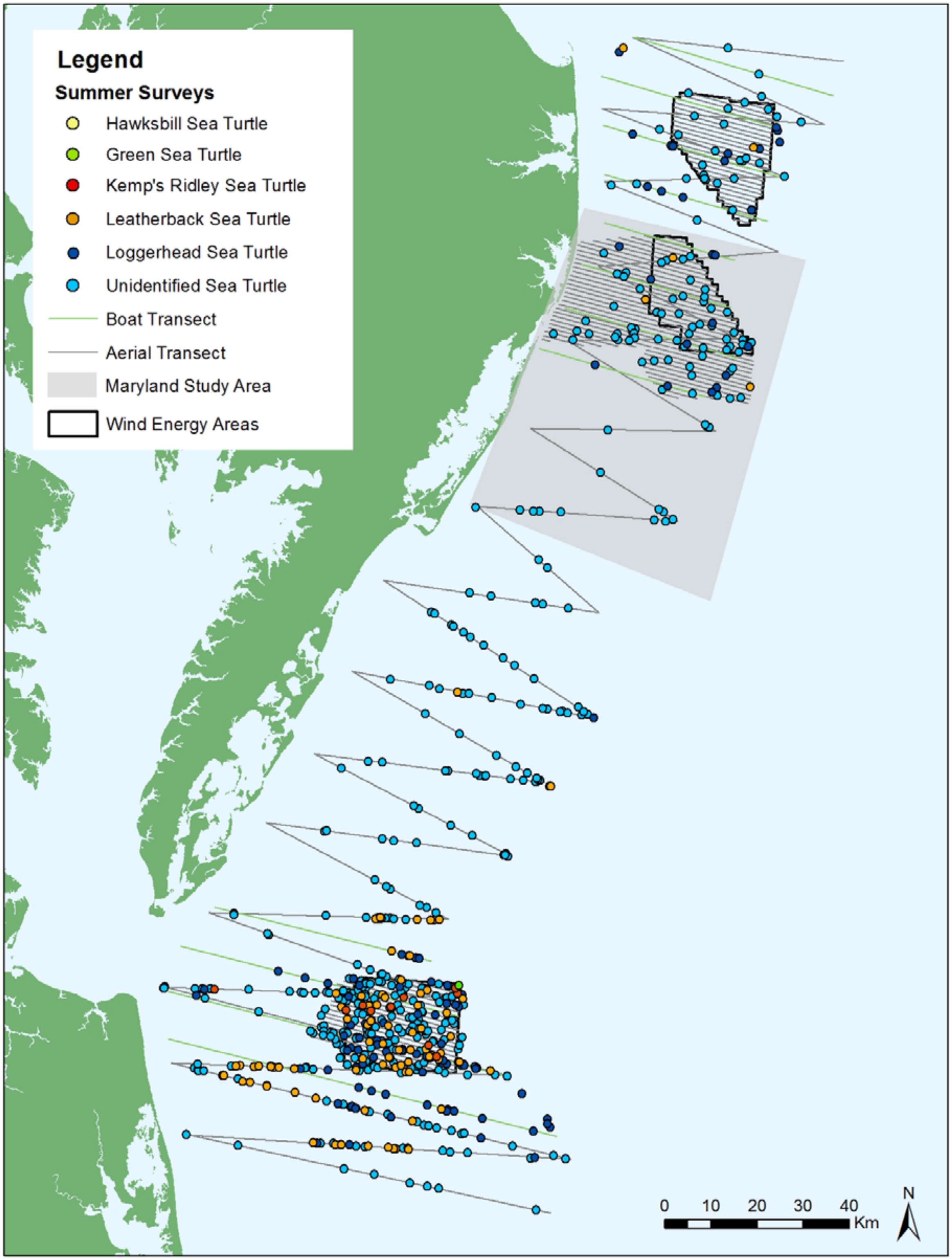

Figure 10-13. Turtles observed in the summer (Jun.-Aug. 2012-2013) in boat and high resolution video aerial surveys. Unidentified sea turtles are any turtles not identified to species, and could represent any of the four smaller turtle species present in the study area (excluding Leatherback Sea Turtles).

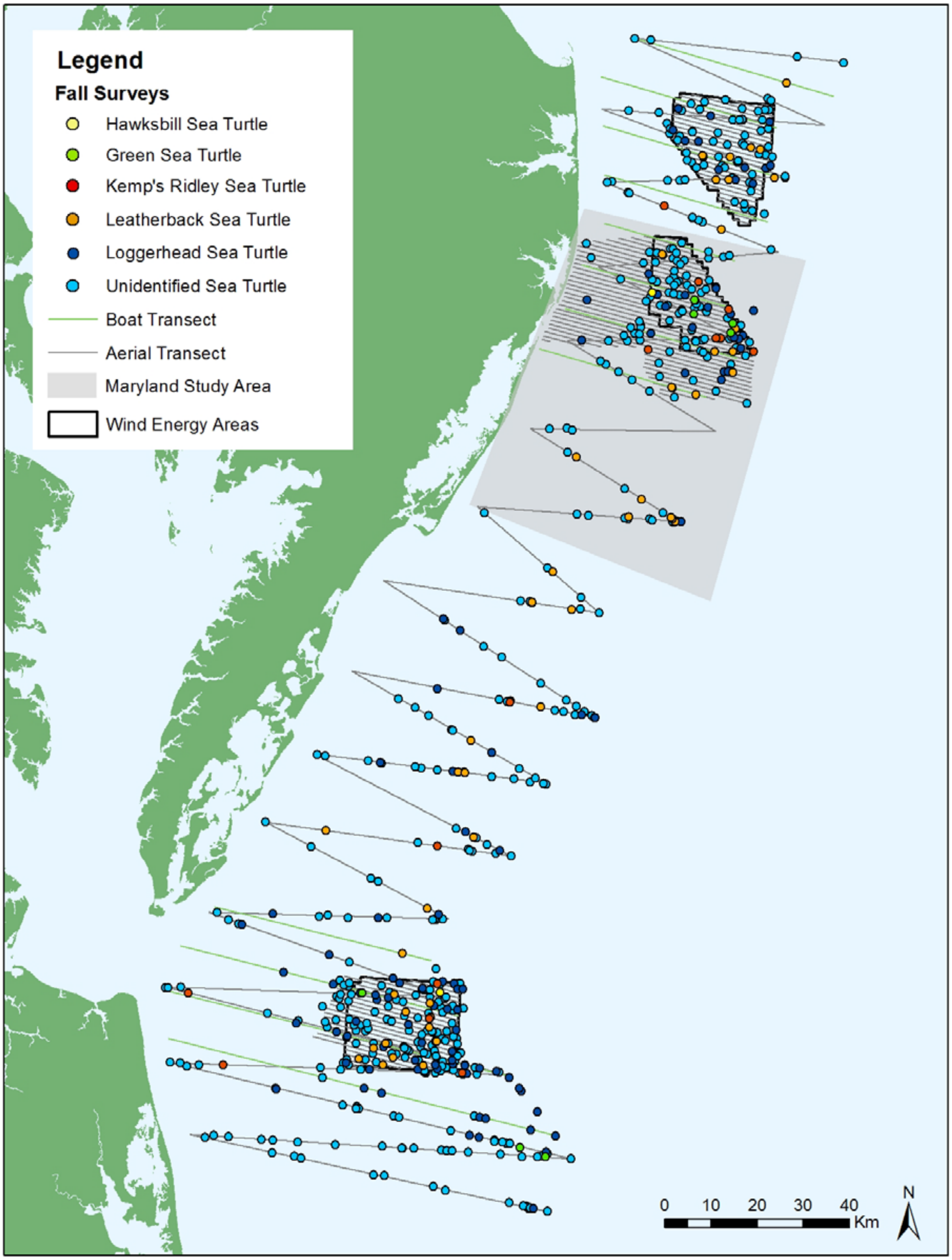

Figure 10-14. Turtles observed in the fall (Sep.-Nov. 2012-2013) in boat and high resolution video aerial surveys. Unidentified sea turtles are any turtles not identified to species, and could represent any of the four smaller turtle species present in the study area (excluding Leatherback Sea Turtles).

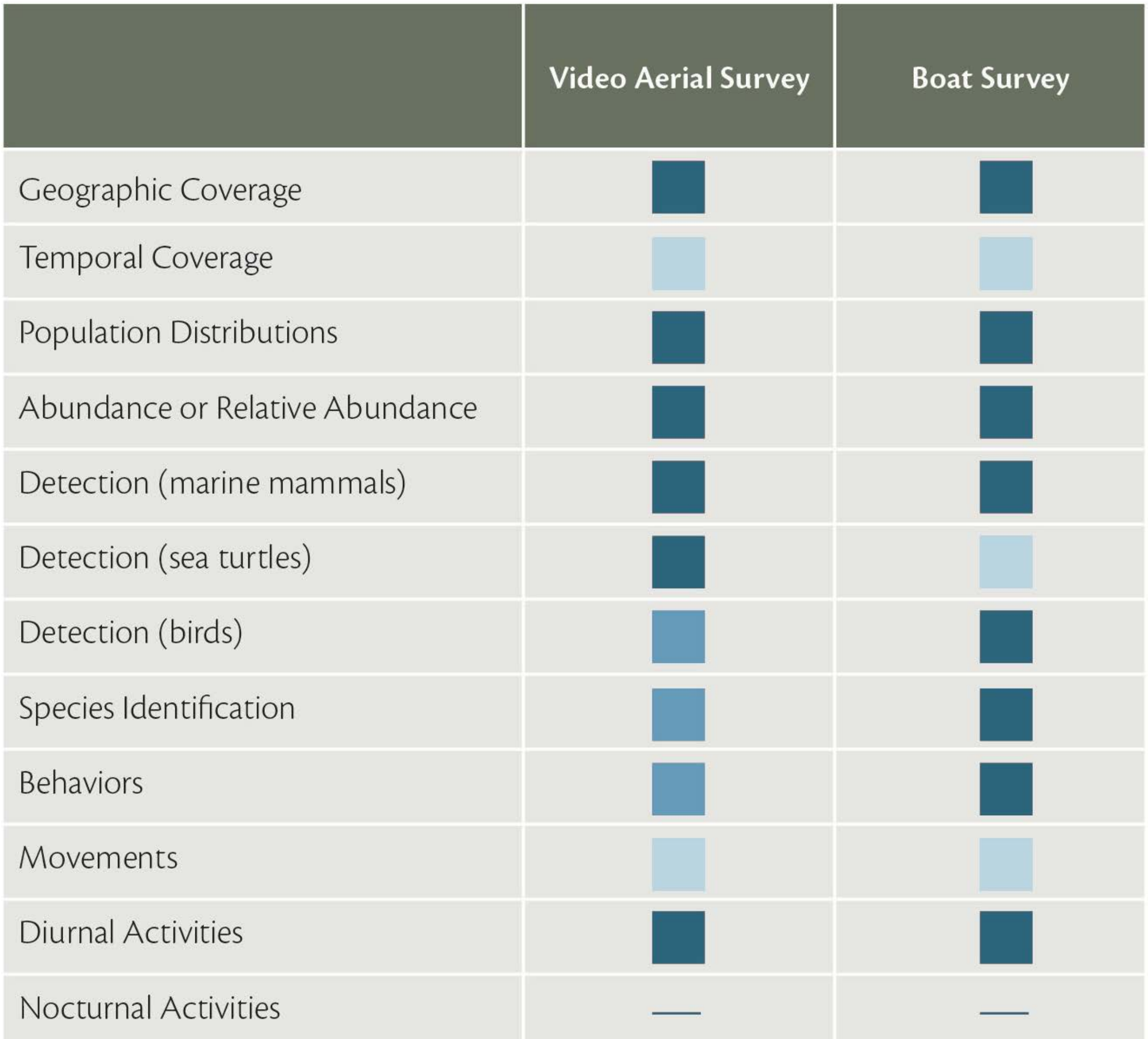

Figure 10-15. Methods for surveying offshore wildlife in this study. Relative strengths and weaknesses of video aerial and boat surveys in this study are indicated by depth of color (dark blue = good, medium blue = fair, light blue = poor). A dash indicates that data are not available from this survey method. Values are subjective; for example, while detection bias was not quantified for aerial surveys, detection of avian species in our boat surveys appeared to be better than digital video aerial surveys in many cases, at least after correction for distance bias in boat data. Thus, boat surveys were categorized as "good" for this type of data, while digital video aerial surveys were considered "fair".

Table 10-1. Total number of individuals observed, species observed, and survey effort for the boat-based and high resolution digital video aerial surveys for the entire study area (MABS and the Maryland Project transects) and the Maryland study area (2012-2014, Figure 10-1). Aerial transect width was 200 meters, with the partial exception of the first three surveys (when the sawtooth transect width was 300 meters). Boat data were collected at varying distances from the transect line depending on the taxon, but the effective transect width for the survey likely fell between 300 and 500 meters for most taxa (and these two numbers are used to present an approximate range of total area covered by the boat surveys in the table below. See Chapters 2 and 6 for more details on data collection methods.

Survey	**Study Area**	**Avian Animals**		**Non-Avian Animals**		**Effort**	
		Number observed	Species	Number observed	Species	Linear km	Area (km^2)
Aerial	Entire	46,399	47	60,604	19	49,576	10,403
	MD	7,002	30	18,113	15	15,698	3,223
Boat	Entire	59,336	94	1,439	12	10,698	3,209 - 5,349
	MD	9,725	61	353	6	2,606	782 - 1,303