Chapter 14: Summary of boat and aerial datasets: comparison between survey methods

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Chapter 14 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 mid-Atlantic study area, and the results of each study 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 and 4), and the results of the surveys (Chapter 5). Part III describes the boat surveys, with methods outlined in the protocol (Chapter 7), and a summary of the results (Chapter 8). Subsequent chapters in Part III analyze 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. Chapter 13 details an experimentally controlled comparison study completed in March 2013, where the boat and plane surveyed the same transect lines on the same day, allowing for a direct comparison of the two methods. The spatial and temporal coverage of this comparison were limited, however, as were the numbers of species observed, so this chapter compares the overall results of the two 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 15-19).

Study goal/objectives

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

Highlights

- More birds and more bird species were observed in the boat surveys, and birds made up a higher proportion of boat observations (98%) compared to digital video aerial surveys (43%).
- Scoters 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 identification rates.

[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, and this study is the first to use these methods on a broad scale in the United States. 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 collecting marine bird, mammal, and sea turtle data within the mid-Atlantic study area using both methodologies 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 level 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 in the mid-Atlantic study area.

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 required to inform siting and permitting processes for offshore wind energy development in the mid-Atlantic. We collected information on bird, sea turtle, and marine mammal abundances and movements over a two-year period (2012-2014) using a variety of technologies and methods to examine spatial patterns and trends, 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 video 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 and Garthe, 2004; Gjerdrum et al., 2012; Tasker et al., 1984). A focused comparison study of the two methods was conducted in March of 2013 (Chapter 13), 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 by digital aerial surveys throughout the study area over the two-year survey period. While the experimental comparison study in Chapter 13 was focused on comparing 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.

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, and they can detect and react to noises of the same frequencies as those emitted during offshore wind construction (Dow Piniak et al., 2012; Lenhardt et al., 1983; Read, 2013), 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 7. Between March 2012 and May 2014, 15 digital video aerial surveys and 16 boat surveys were conducted in the mid-Atlantic study area (Figure 14-1). 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 wind energy area (WEA), 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 14-1). Analyses below include data collected under both the Department of Energy-funded and Maryland-funded survey efforts.

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-based 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 (Chapter 13; Buckland et al., 2012). 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 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 14-2). 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 survey 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 (baleen 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

Boat survey observers detected larger numbers of birds per unit effort and more species of birds than the digital video aerial survey observers (Figure 14-3), while the digital video aerial surveys appeared to be better at detecting certain aquatic animals (Figure 14-4, Table 14-1). Birds made up a large proportion of the animals observed on the boat survey (98%) compared to the digital video aerial survey (43%; Figure 14-5). Scoters were the most abundant avian group identified during boat-based surveys

(35% of birds) and digital video aerial surveys (46% of birds; Figure 14-5). Gannets, loons, and gulls and terns were also commonly observed in both datasets, though the relative abundance of each taxon varied between the two survey methods (Figure 14-5).

Boat survey observers detected larger numbers of more species of birds than the aerial survey observers, while the digital aerial surveys appeared to be better at detecting certain aquatic animals (Figure 14-4, Table 14-1), including sharks, fish, and rays. While some of these animals were also observed in the boat survey, 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 (Chapter 5) than from the boat (Chapter 8).

Of the non-avian digital video aerial observations, the bulk of detections were rays, with many fish, toothed whales, and some turtles observed as well; in contrast, the most commonly observed aquatic species group in the boat data was toothed whales (dolphins and porpoises, Figure 14-5). Major migrations of Cownose rays (*Rhinoptera bonasus*) were observed in the aerial surveys 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 14-4, Chapter 5). Both surveys detected bats, specifically Eastern Red Bats (*Lasiurus borealis*), though more bats were detected in the aerial survey, and the bats observed from the aerial platform were flying higher than could be detected from the boat (Hatch et al., 2013). 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 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 extensions offshore of Maryland in the second year of surveys, as well as in western extents of the sawtooth transects (Figure 14-6).

Identification rates

There appeared to be differences in observers' ability to identify animals between the aerial and boat-based surveys in some cases (Figure 14-7). More than twice as many bird species were definitively detected in the boat surveys than from the air (Table 14-1), with many more 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 14-7). Aerial observers were better at identifying scoters, ducks, and geese to species, however, which is likely due to boat observers' difficulty in differentiating large flocks of Black Scoters and Surf Scoters (*M. perspicillata*) at a distance (Figure 14-7, see Chapter 13 for a more detailed discussion). Observers from both survey types had similarly high identification rates of shearwaters and fulmars (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*); the aerial observers detected 168 sunfish, while the boat observers detected three. Identification rates of toothed whales were higher on boat surveys, but baleen whales had higher rates of identification from aerial surveys (Figure 14-8), and each method observed a few species that were missed by the other (Chapters 5 and 8). While we saw more large (baleen and unknown) whales in the boat-based surveys (n =35) than in the digital video aerial surveys (n =16), for example, we saw eight North Atlantic Right Whales (*Eubalaena glacialis*) in the aerial surveys versus one in the boat surveys (Chapters 5 and 8).

Case study: sea turtles

Much higher counts and species diversity of sea turtles were detected on the aerial surveys than on the boat surveys (Figure 14-9). While there were higher identification rates of turtles on the boat survey (Figure 14-8), only two species of turtles were identified (Loggerhead and Leatherback Sea Turtles). 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 imbricate*; and Green, *Chelonia mydas*).

Turtle distributions shift according to temperature, as they are poikilotherms and are limited to certain water temperature ranges (Gardner et al., 2008; Chapter 15). There were times of year when turtles were far less abundant in the study area; as shown in Chapter 15 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 14-10 - Figure 14-12). 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 14-10). 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 14-10). 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 14-11). 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 14-11). 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 14-12). There were only two turtle sightings in winter, one Kemp's Ridley and one unidentified to the species level, both located off of Virginia.

Discussion

Overall, there were substantial similarities between the species groups detected via the two study methods. Scoters were the most abundant bird group detected in both studies, with gannets, loons, and gulls observed in high numbers from both platforms as well. Both platforms detected similar species of the different taxa observed. Chapters 18-19 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 14-13). 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 (Chapter 13). 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 (Buckland et al., 2012; Schwemmer et al., 2014), which we found to be the case in our comparison study (Chapter 13). Marine mammals are also known to be attracted to or disturbed by boats (Buckland et al., 2012; Mattson et al., 2005), and 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, as some aerial observations of birds were recorded as "Unidentified Bird" or "ID Impossible" due to poor image quality (Chapters 4-5).

Identification rates for birds observed in digital video aerial surveys were low compared to boat surveys. 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. 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.

Detailed examinations of the cost differences between the two survey methods are beyond the scope of this comparison, but the cost effectiveness of either method over the other would depend greatly on the specific study design. Relative costs would vary based on distance from shore, the size of the area to be studied, the taxa to be targeted in the study, and key questions to be addressed with the survey data. The greatly increased speed at which the aerial surveys can be conducted (13.5x faster than the boat) means that they become more cost effective relative to boat-based surveys in situations that require longer times on the water, for example, in areas that are further from shore and/or over larger survey areas (Chapter 13; Buckland et al., 2012).

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 platforms have previously been shown to be 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 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 15). 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 15; 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 15). 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

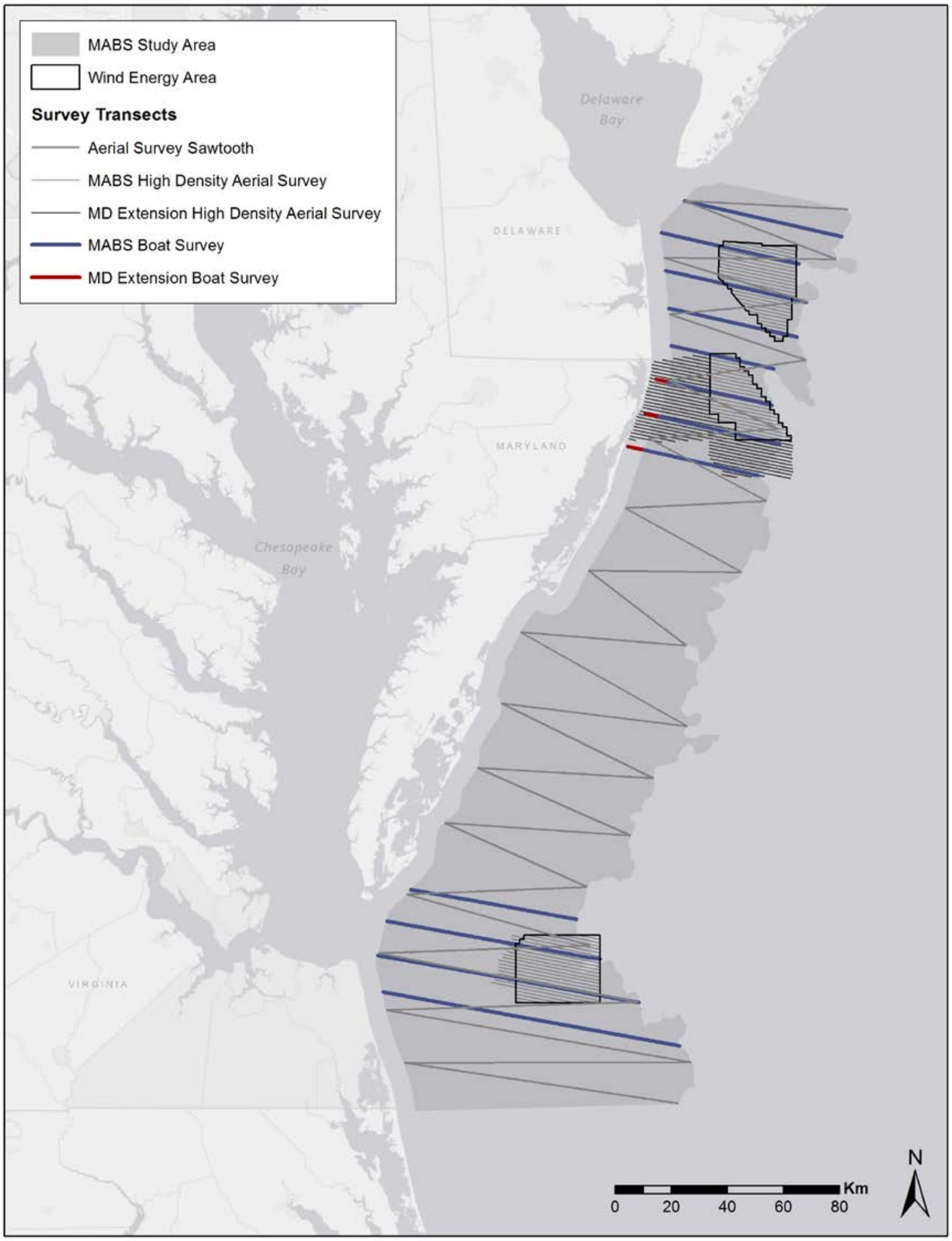

Figure 14-1. Map of transects for the digital video aerial surveys and the boat surveys for the Department of Energy (DOE)-funded Mid-Atlantic Baseline Studies Project (2012-2014) and the state of Maryland-funded Maryland Project (2013-2014). DOE-funded aerial transects are shown in light gray. High-density Maryland extension transects are shown in dark gray. DOE-funded boat surveys are shown in blue, and Maryland extension transects in state waters in red.

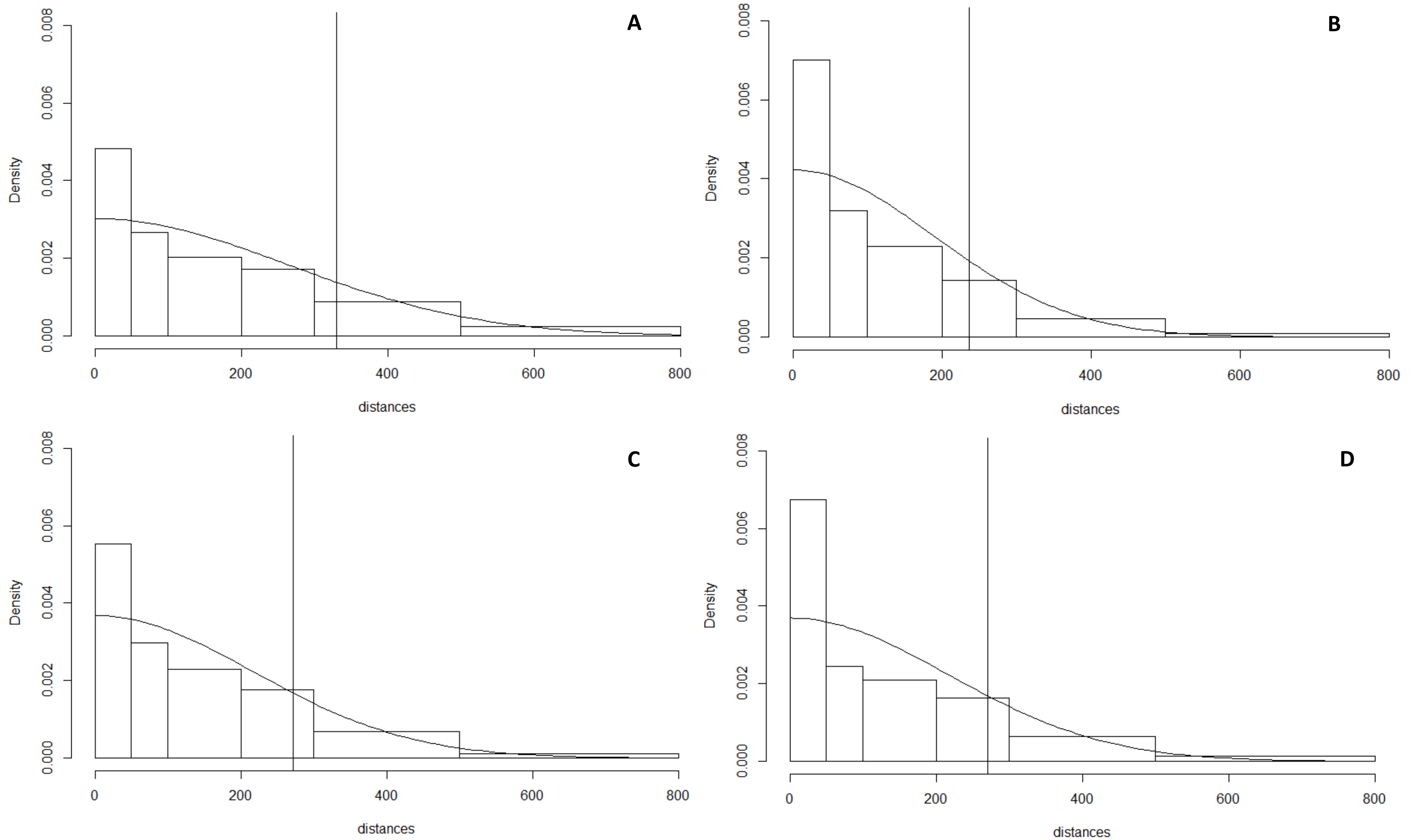

Figure 14-2. Distance functions for a) Sulidae, b) Laridae, c) Gavidae, and D) Anatidae from the boat survey data. Effective strip half-widths, or the distance from the boat at which there is average detection probability, are indicated by the vertical line in each chart (330m for Sulidae, 236m for Laridae, 272m for Gavidae, and 271m for Anatidae).

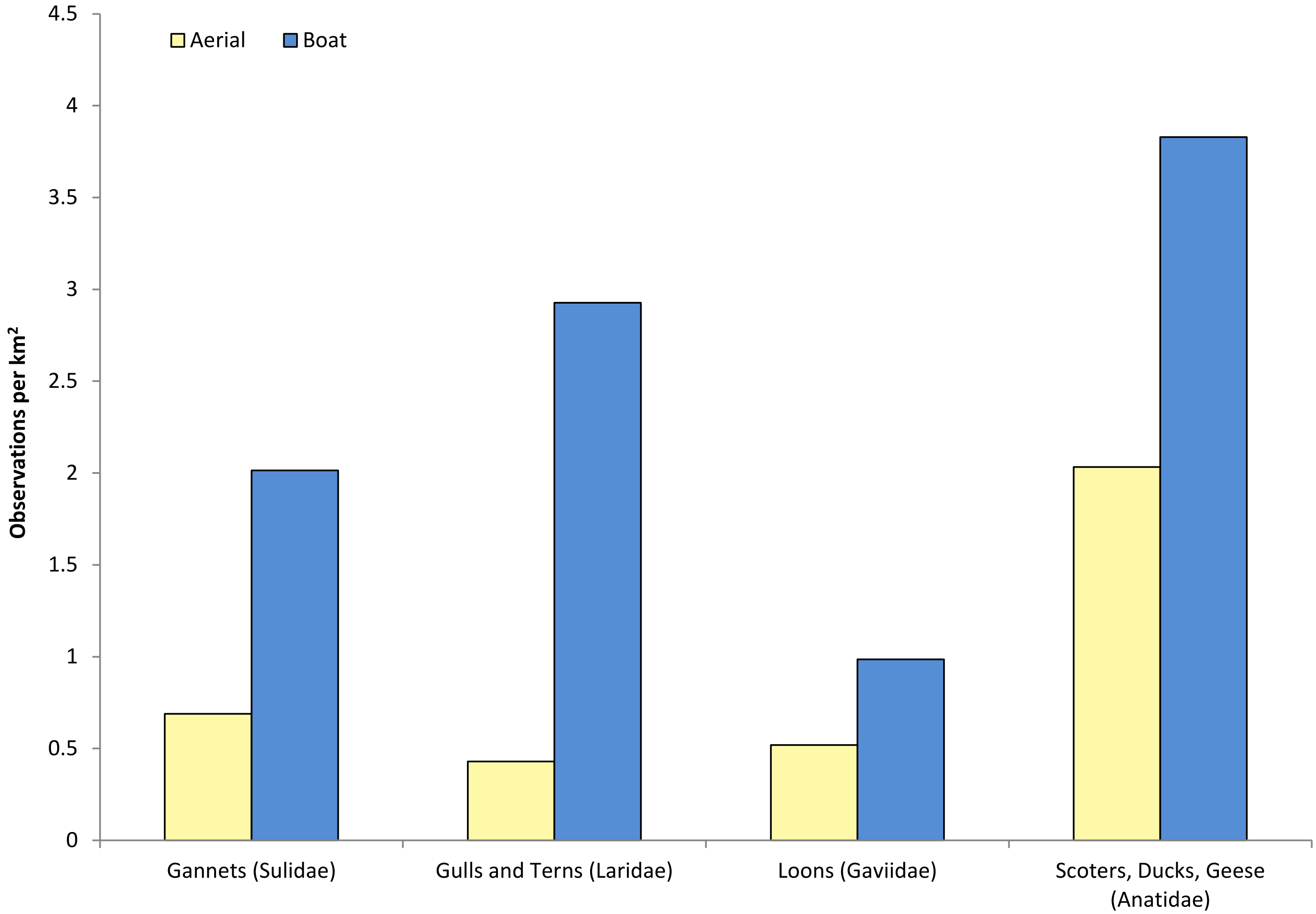

Figure 14-3. Comparison of total effort-corrected boat and aerial survey counts by taxon for all surveys. Densities are calculated by the total number of counts divided by the total survey area. Aerial data have transect widths of 200 or 300 meters (Chapter 2). Effective boat transect strip widths were calculated for each group based on the effective half strip width (see **Figure 14-2**).

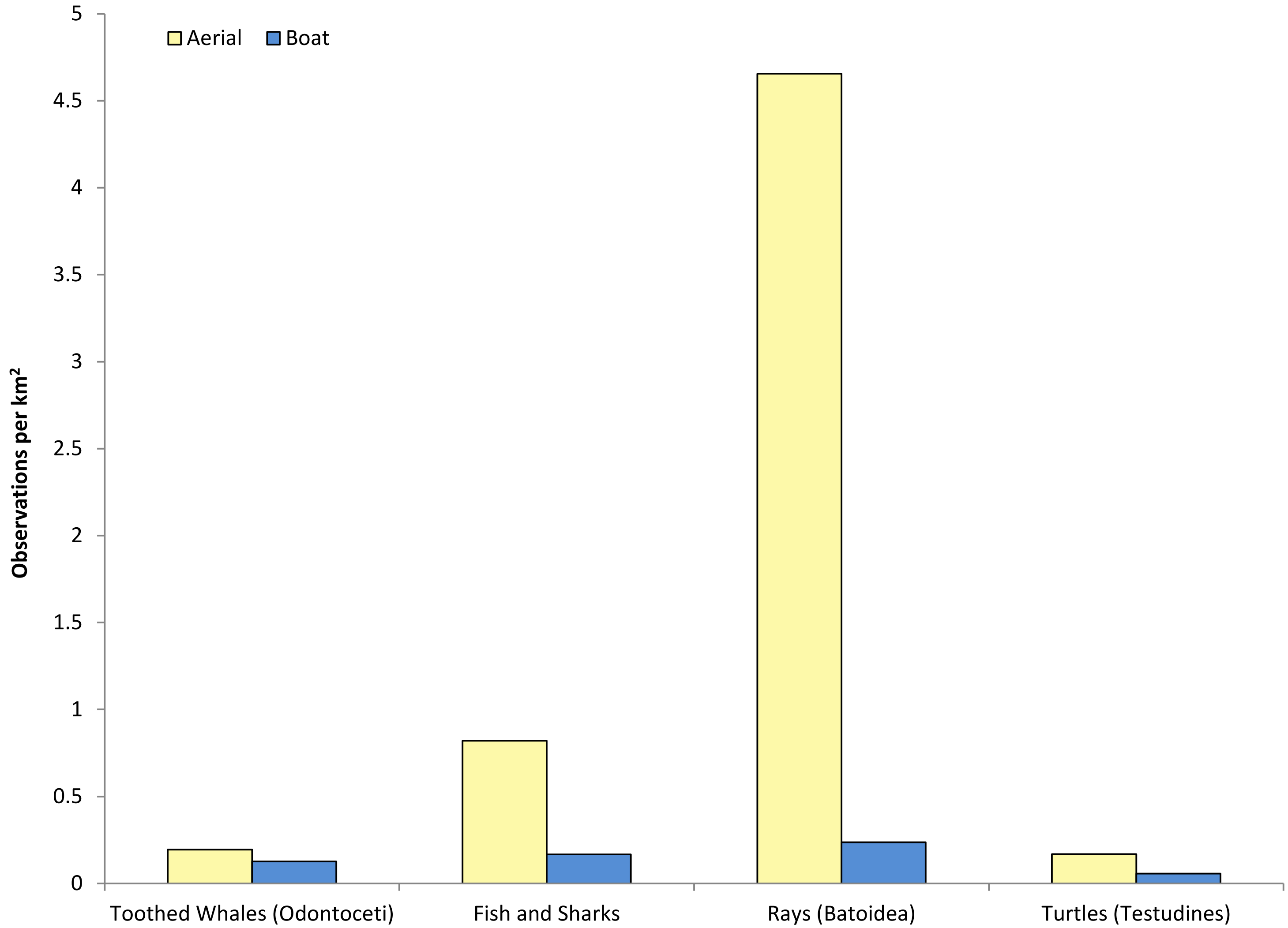

Figure 14-4. Comparison of total effort-corrected boat and aerial survey counts by taxon for all surveys. Densities are calculated by the total number of counts divided by the total survey area. Aerial data have transect widths of 200 or 300 meters (see Chapter 3). Boat data transect widths were based on the median distance of observations from the boat, in meters (Odontoceti, 300; Fish/Sharks, 50; Batoidea, 7.5; Testudines, 100 meters). 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).

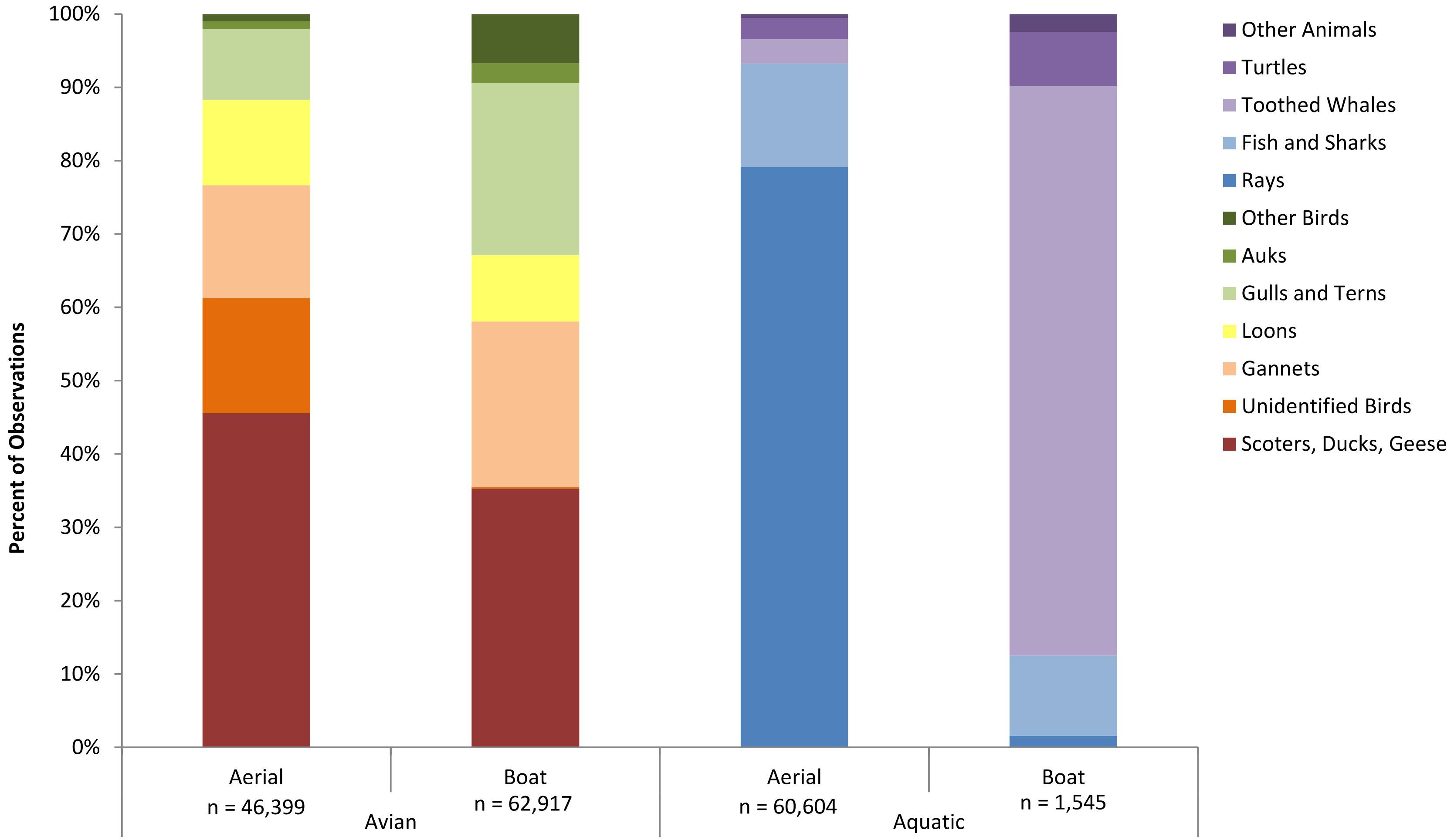

Figure 14-5. Avian (left) and aquatic (right) animals observed in the digital video aerial surveys and boat-based surveys. The sample size for each group is noted on the x-axis. Taxonomic categories shown for avian observations are scoters, ducks, and geese (Anatidae); unidentified birds (birds not identified to lower taxonomic levels); gannets (Sulidae); loons (Gaviidae); gulls and terns (Laridae); alcids (Alcidae); and other birds (additional less common bird groups, see Chapters 5 and 8 for animals observed). Aquatic taxa include rays (Batoidea); fish and sharks (Chordata); toothed whales (Odontoceti); turtles (Testudines); and other animals (additional less common animal groups, see Chapters 5 and 8 for animals observed).

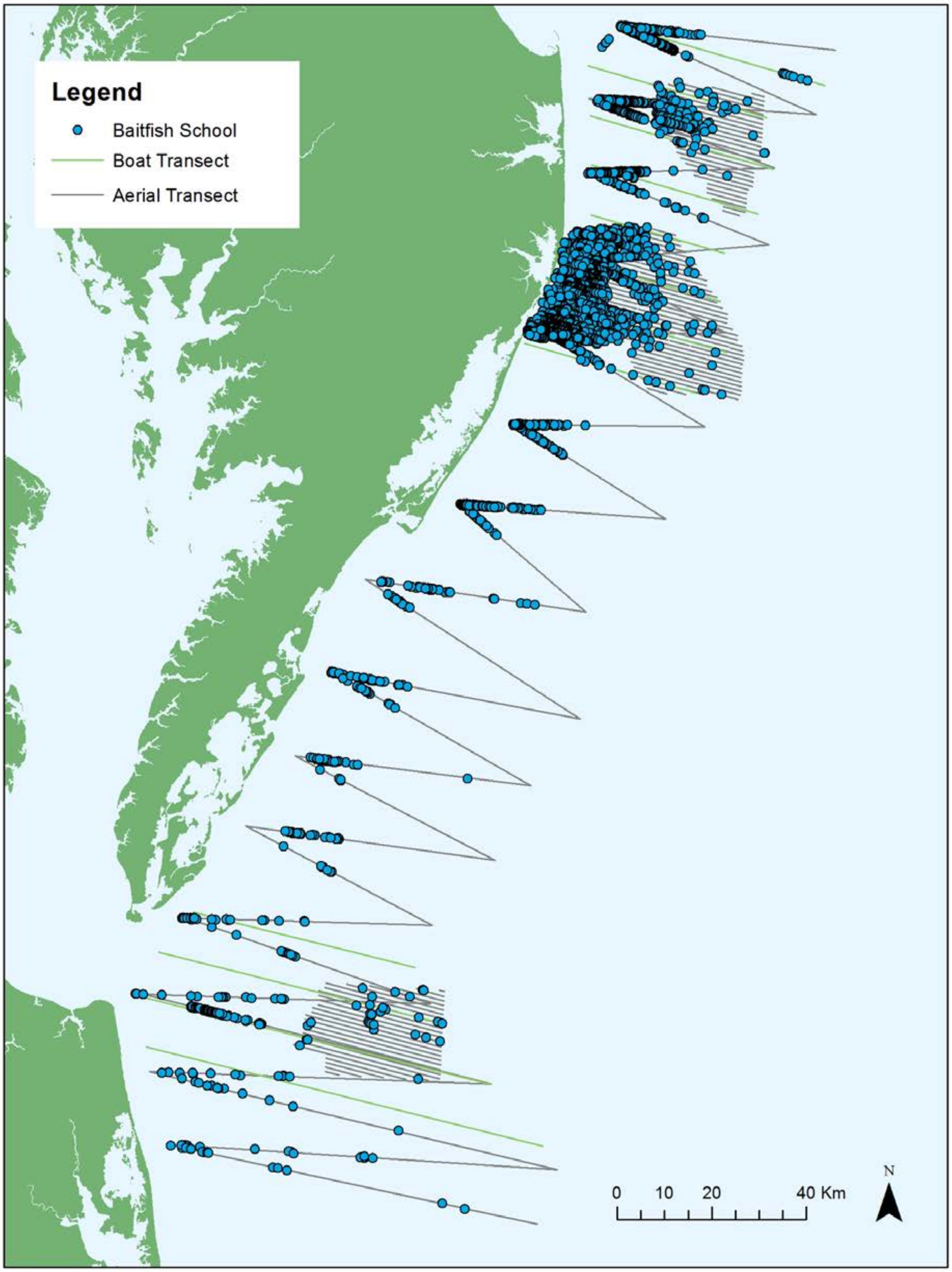

Figure 14-6. Schools of baitfish (forage fish) observed in boat and high resolution digital video aerial surveys.

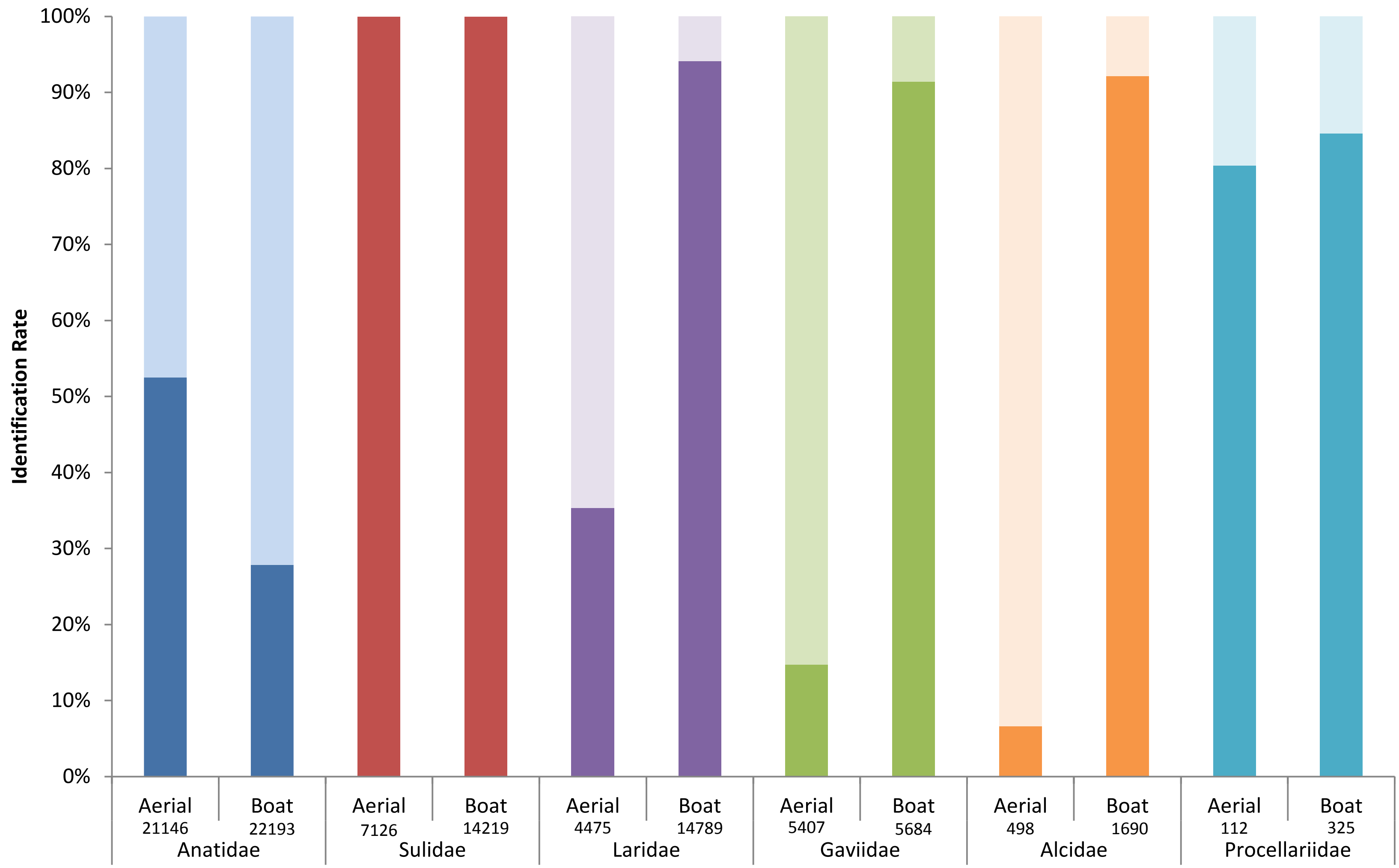

Figure 14-7. Identification rates for common bird taxa observed in boat and high resolution digital video aerial surveys, in order of abundance. Darker colors indicate animals identified to species, and lighter colors indicate animals identified to higher taxonomic levels. Sample sizes are noted in the x-axis. Details on species sighted within each taxonomic group can be found in Chapters 5 and 8. The most common avian families observed in surveys were scoters, ducks, and geese (Anatidae); gannets (Sulidae); gulls and terns (Laridae); loons (Gaviidae); alcids (Alcidae); and fulmars and shearwaters (Procellariidae).

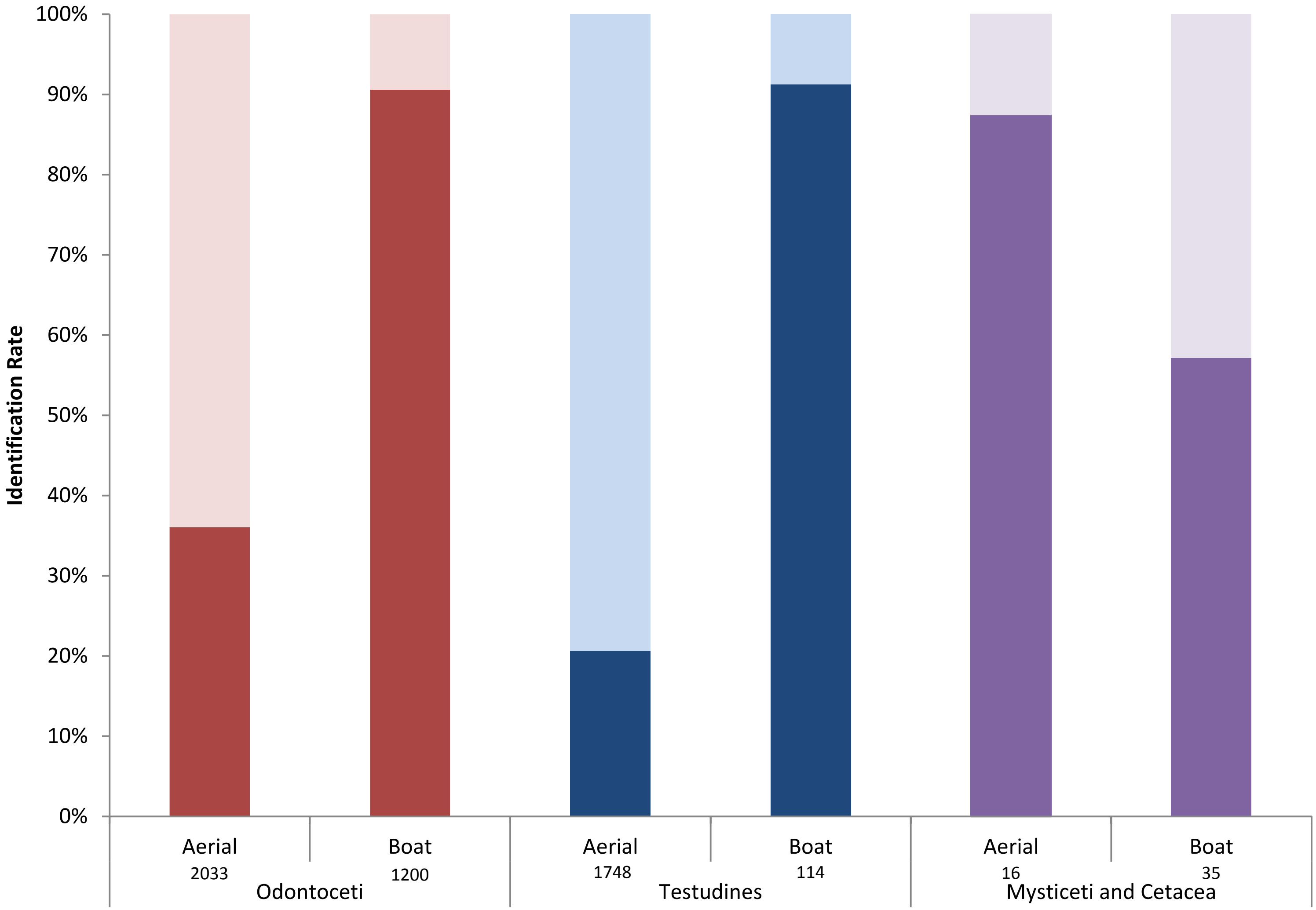

Figure 14-8. Identification rates of mammals and turtles observed during boat-based and high resolution digital video aerial surveys. Darker colors indicate animals identified to species, and lighter colors indicate animals identified to higher taxonomic levels. Sample sizes are noted in the x-axis. Details on species included in each taxonomic group can be found in Chapters 5 and 8. Groups are toothed whales (Odontoceti); sea turtles (Testudines); and large whales (Mysticeti and unidentified large Cetaceans).

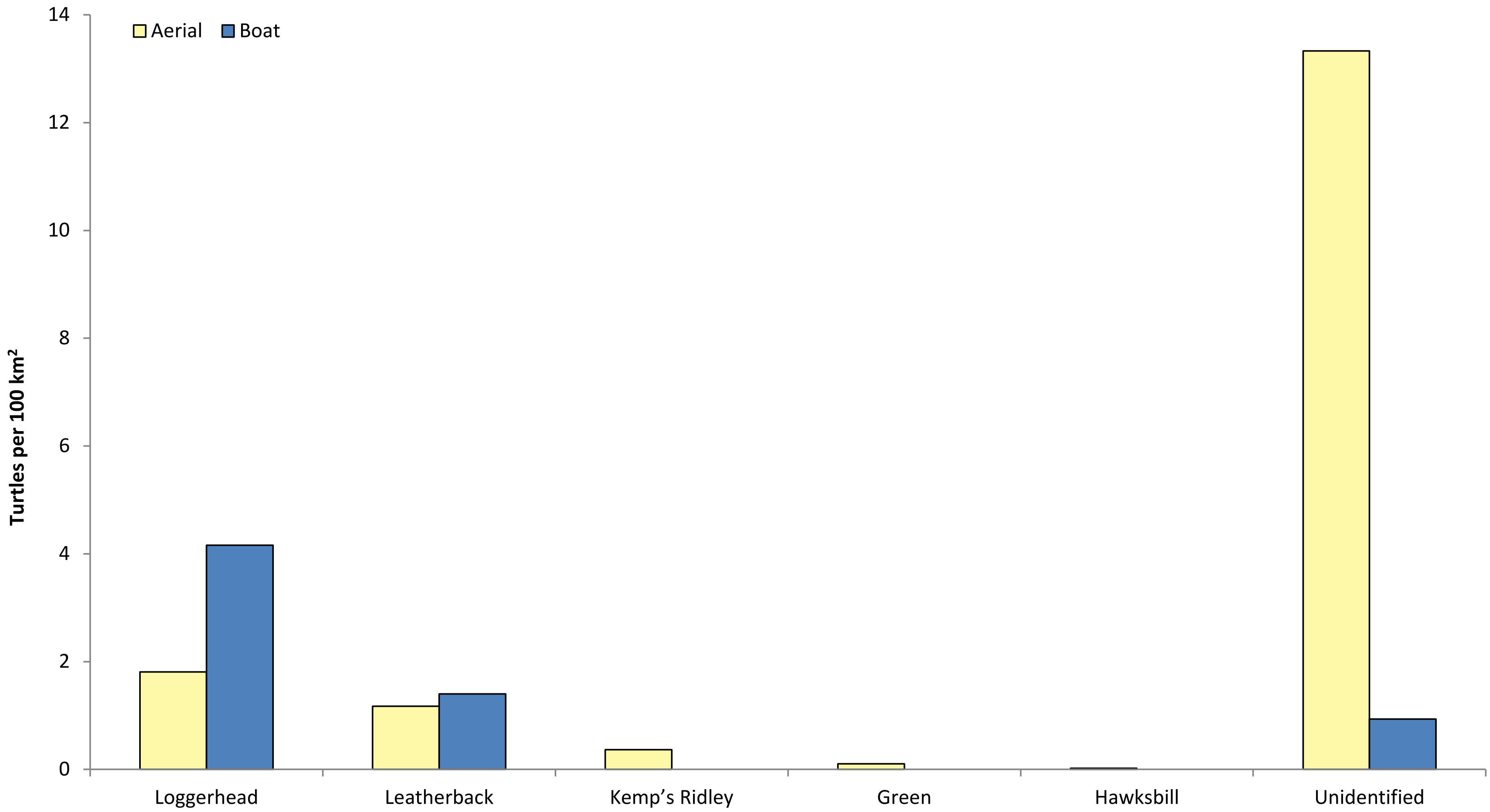

Figure 14-9. Comparison of total effort-corrected boat and aerial survey counts of sea turtles. Densities were calculated by the total number of counts divided by the total survey area across all surveys, and standardized to 100 square km. Aerial surveys had transect strip widths of 200 or 300 m (Chapter 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.

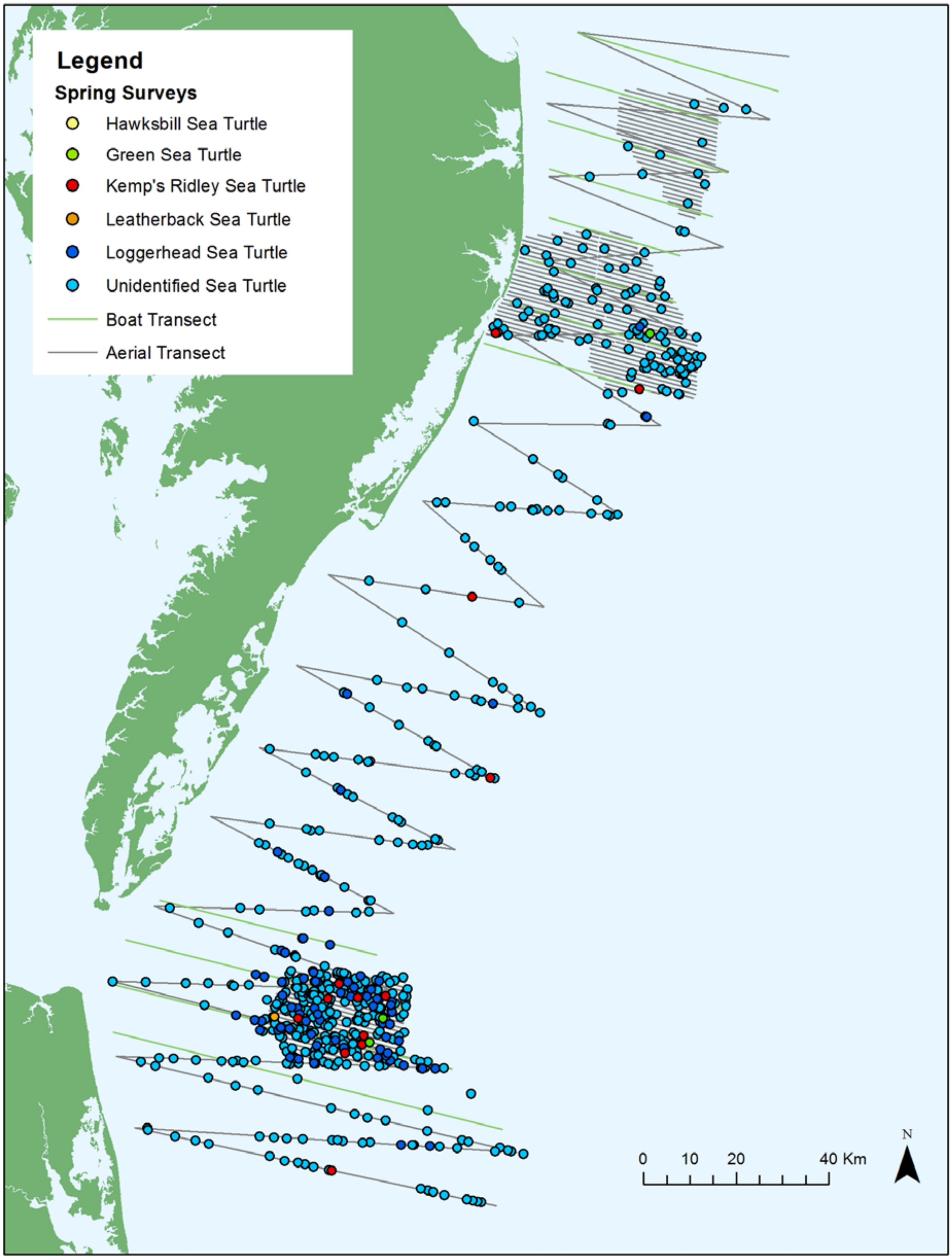

Figure 14-10. Turtles observed in the spring (Mar.-May, 2012-2014) in boat and high resolution video aerial surveys. Unidentified sea turtles are any turtles not identified to species, and could represent any of the four smaller turtle species present in the study area (excluding Leatherback Sea Turtles).

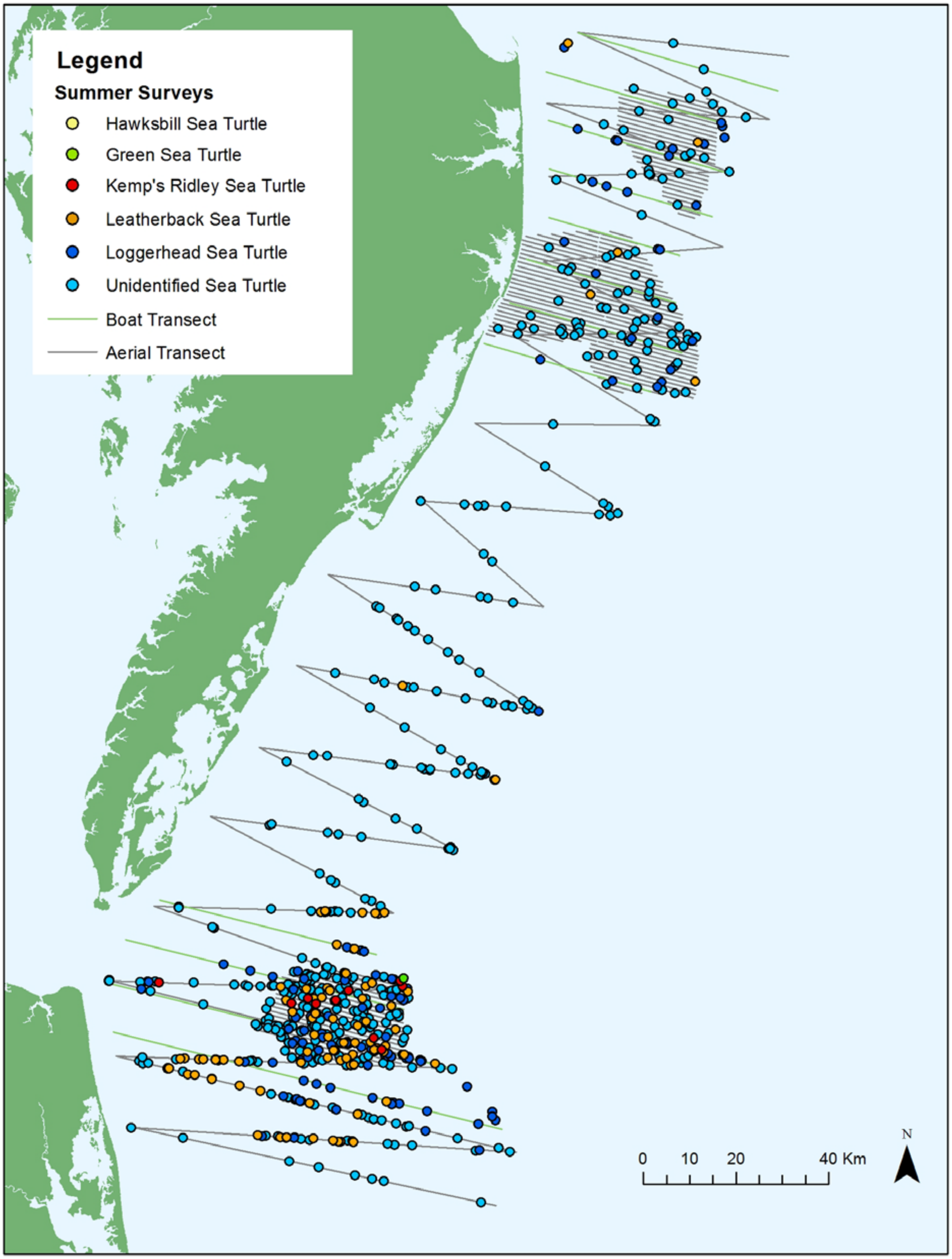

Figure 14-11. Turtles observed in the summer (Jun.-Aug., 2012-2013) in boat and high resolution video aerial surveys. Unidentified sea turtles are any turtles not identified to species, and could represent any of the four smaller turtle species present in the study area (excluding Leatherback Sea Turtles).

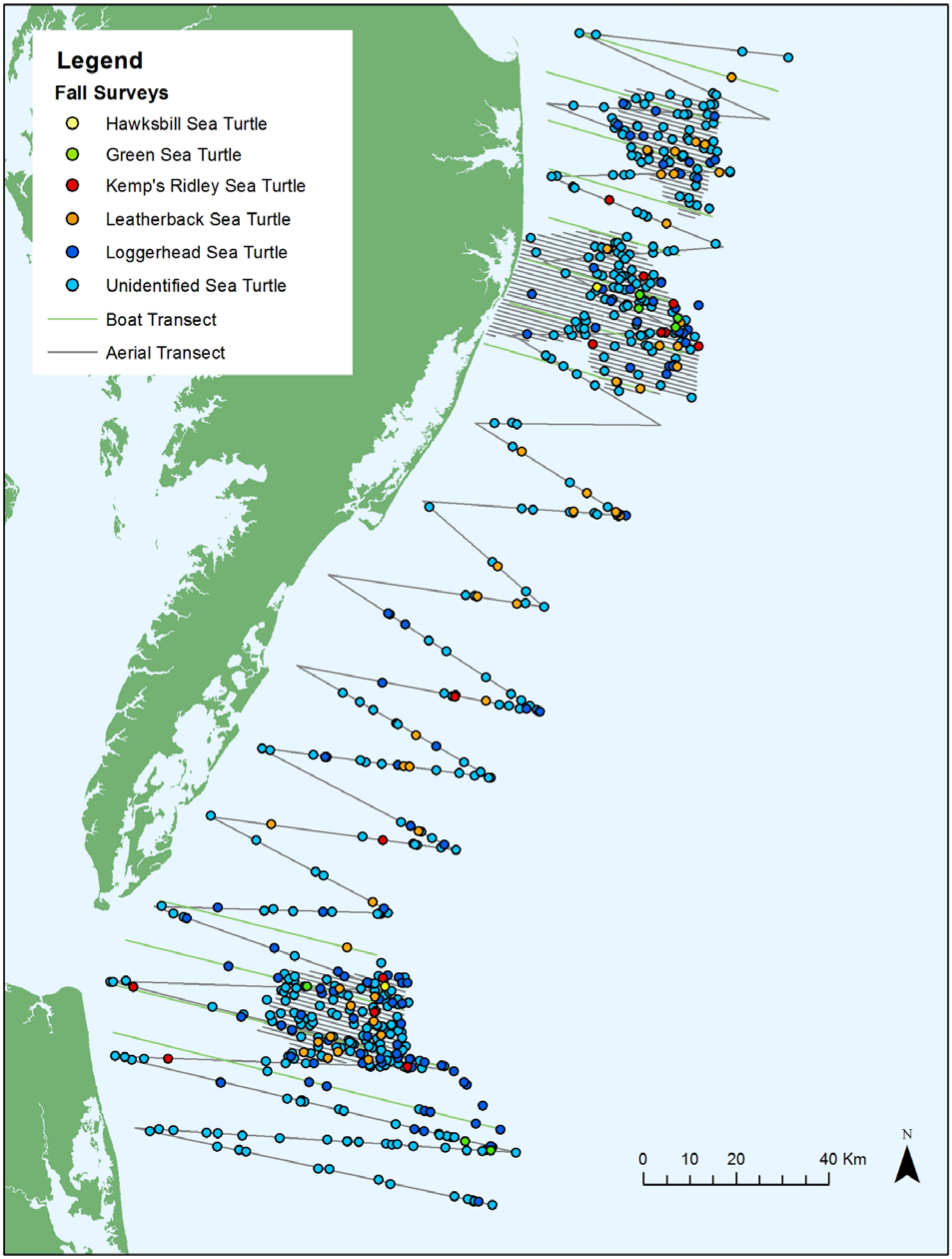

Figure 14-12. Turtles observed in the fall (Sep.-Nov., 2012-2013) in boat and high resolution video aerial surveys. Unidentified sea turtles are any turtles not identified to species, and could represent any of the four smaller turtle species present in the study area (excluding Leatherback Sea Turtles).

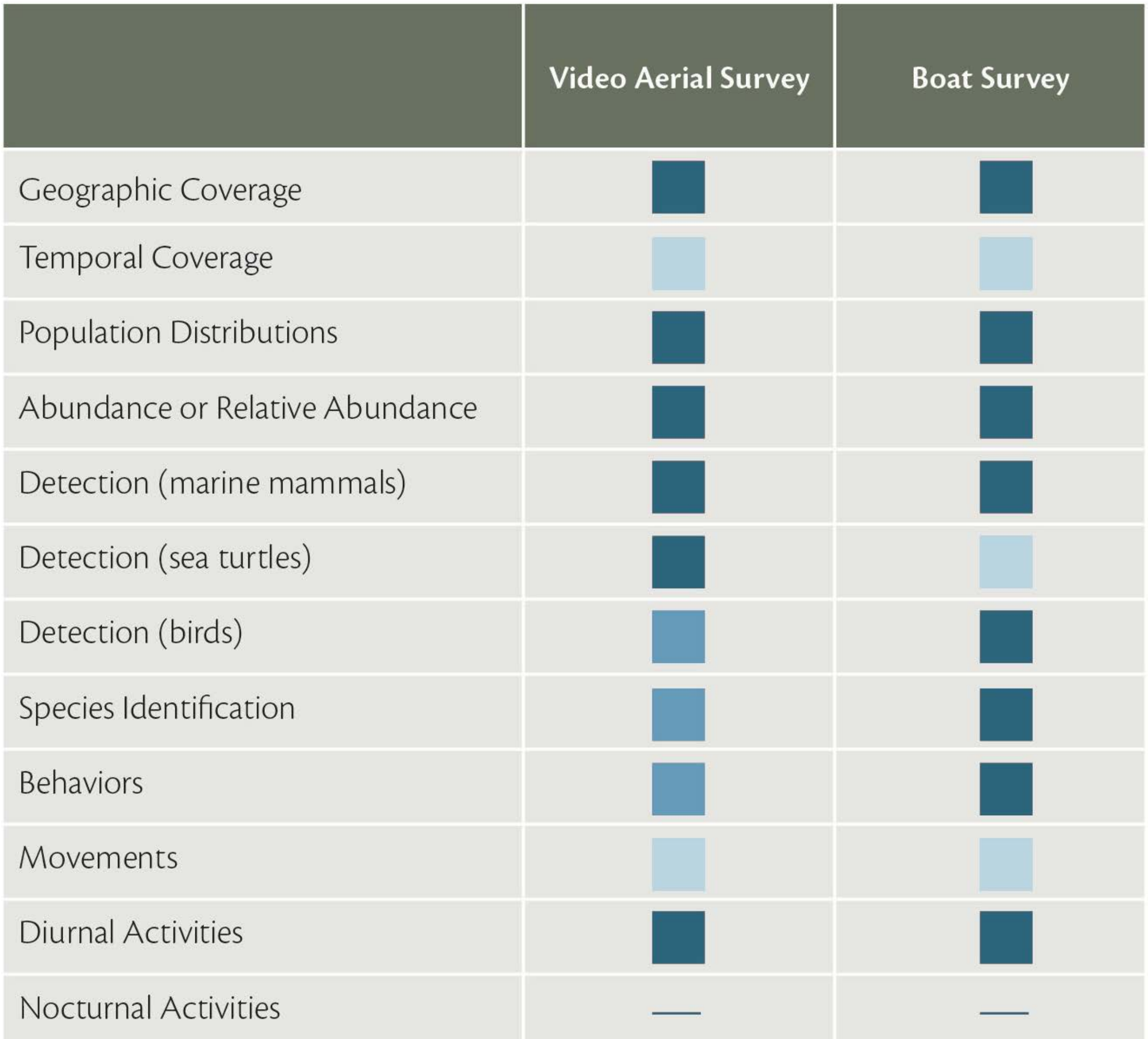

Figure 14-13. Methods for surveying offshore wildlife in this study. Relative strengths and weaknesses of video aerial and boat surveys in this study are indicated by depth of color (dark blue = good, medium blue = fair, light blue = poor). A dash indicates that data are not available from this survey 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 14-1. Total number of individuals observed, species observed, and survey effort for the boat-based and high resolution digital video aerial surveys (2012-2014). 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 falls 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 3 and 7 for more details on data collection methods.

Survey	Avian Animals		Non-Avian Animals		Effort	
	Number observed	Species	Number observed	Species	Linear km	Area (km^2)
Aerial	46,399	47	60,604	19	49,576	10,403
Boat	59,336	94	1,439	12	10,698	3,209-5,349