3.0 RESULTS SUMMARY

3.1 SUMMARY

Persuant to recommendation four of the BRP's Final Report, the NJDEP designed a study to collect scientific data regarding the distribution, abundance, and migratory patterns of birds and mammals within the New Jersey's OCS. Specifically, in order to comply with the Panel's recommendations, NJDEP advertized a Solicitation for Research Proposals for Ocean/Wind Power EBS. GMI was ultimately contracted to conduct this study. To meet the project goal, baseline data were to be collected on avian species, marine mammals and sea turtles, fish and shellfish, and other natural resources over an 18-month period to fill major data gaps identified for each of these categories; the sampling duration was later extended to 24 months. This Ecological Baseline includes the first year-round, systematic survey effort in nearshore waters of New Jersey between Stone Harbor and Seaside Park. The collected data were used to conduct a predictive modeling of species distribution and abundance. An environmental sensitivity index (ESI) was then developed to synthesize the physical, biological, and socioeconomic resources data of the Study Area (**Chapter 4.0**).

This section provides a summary of the results of the avian, marine mammal, sea turtle, and fish and fisheries studies.

3.1.1 Avian Study Results

3.1.1.1 Avian Shipboard and Small Boat Surveys

Avian shipboard offshore surveys were conducted January 2008 through December 2009, with associated small-boat coastal surveys being conducted each month after completion of the shipboard offshore survey. A total of 15,483 km (8,360 NM) and 2,700 km (1,457 NM) of trackline were surveyed on the offshore and coastal surveys, respectively, with >1,100 hrs of combined survey effort. The resultant dataset fills a large gap in the understanding of at-sea bird distribution in the western North Atlantic Ocean.

Species Occurrence

A total of 176,217 birds representing 153 species were recorded; 84,428 birds of 145 species were recorded during the shipboard offshore surveys and 91,789 birds of 82 species were recorded during the small-boat coastal surveys. Federal endangered, threatened, and candidate species were not detected during avian surveys. Fourteen of the 21 federally listed species of concern and 16 of the 20 state-classified endangered, threatened, and special concern species potentially occurring in coastal and offshore waters were observed during the survey.

Avian Density

Avian densities were highest near shore at all seasons, although this finding was much more pronounced in winter than in summer (ratio of abundance on offshore surveys vs. small-boat coastal surveys ranged from 2:5 to 1:5). This was due primarily to the large numbers of coastal-breeding gulls and terns and wintering waterfowl along the New Jersey coast. Although large numbers of Wilson's Storm-Petrels, an austral migrant from the Southern Ocean, were present offshore in the summer, the overall lack of true pelagic seabirds in the Study Area concentrated data in the near shore. Overall, inshore waters supported the highest abundances of birds, and in particular in areas south and east of Hereford Inlet, south and east of Ocean City, and east of Atlantic City. In the offshore area, birds were consistently concentrated near a shoal area east of Barnegat Inlet. The summer data exhibited the lowest absolute abundance of birds, with the majority (54.4%) of individuals being locally-breeding species, primarily Common Tern and the Laughing, Herring, and Great Black-backed gulls.

There was a noticeable geographical shift of the relative abundance of birds between the summer and winter. During the summer, blocks with the highest abundance of birds were located offshore (56% or 37 of 66 highest-abundance blocks) whereas in the winter the highest abundance was in nearshore (3% or 2 of 65 blocks). The winter avifauna was dominated by inshore-foraging species (e.g., scoters) and the summer avifauna by offshore-foraging species (e.g., Common Tern).

There was little change in the seasonal composition of species between 2008 and 2009. Black Scoter was the most abundant bird in winter for both years, as was Northern Gannet in spring and Laughing Gull in summer. In fall, Laughing Gull and Northern Gannet were the two most abundant species in both years. While numbers of many species fluctuated from 2008 to 2009, some of the differences observed between years could be attributed to differences in survey timing. For example, in fall 2008, surveys were evenly spaced compared to those conducted in 2009 which were concentrated at the beginning and end of fall. Thus, species such as Surf Scoter (a mid-season migrant) that migrates through New Jersey in large numbers during mid-fall showed a large decrease in fall abundance from 2008 to 2009.

Avian Flight Altitudes

In addition to examining abundance and distribution, data were also analyzed to determine frequency of occurrence within the potential rotor-swept zone (RSZ) of power-generating wind turbines, defined as 100 to 700 ft (30.5 to 213.4 m). Of the >70,000 flying birds recorded, 3,433 (4.8%) occurred in the RSZ, with 33 species recorded in the RSZ at least once. More species occurred in the RSZ in fall (21 species) than any other season, followed by winter (16), spring (15), and summer (five). Scaup (*Aythya* spp.) accounted for 54.5% of all birds in the RSZ for the small-boat coastal surveys, and 31.8% of all birds in the RSZ overall. The only three species to occur in the RSZ in all four seasons were Northern Gannet, Herring Gull, and Great Black-backed Gull. Red-throated Loon, Common Loon, Osprey (*Pandion haliaetus*), and Laughing Gull were recorded in the RSZ in three of the four seasons. Nearly all scaup in the RSZ (1,088 of 1,091) were recorded during a severe cold snap in January 2009, illustrating the potential effects of a major weather event on avian movements. Offshore, Northern Gannet was the species that occurred most often in the RSZ (594 individuals), though the percentage of the species detected within the RSZ was small (3.9%).

Supplemental Surveys

A supplementary study was conducted (October to December 2009) to determine the seaward distribution of the massive fall migration of waterbirds along New Jersey's coast. The data resulting from conducting boat transects perpendicular to the shore and running from the immediate coast out to the Study Area offshore boundary (20 NM), showed that most migrating waterbirds (77%) were less than 5.56 km (5 NM) from shore. Of the species studied (scoters, Common and Red-throated loons, Northern Gannet, and Herring and Great Black-backed gulls), only Common Loon was found throughout the width of the Study Area in roughly equal numbers.

3.1.1.2 Avian Aerial Surveys

Three avian aerial surveys were initially scheduled: spring 2008, fall 2008, and spring 2009. After the April survey the efficacy of such limited surveying was discussed by the NJDEP committee members, and the pros and cons of conducting aerial surveys were compared. Benefits consisted of a better detection of peak activity (if conducted during peak activity) and a "snapshot" of diurnal bird abundance. The negatives consisted of limited detection of small and darker-colored birds, the temporal variation of migration, the small number of planned surveys (considering the limited data already gathered), the safety of flying at low altitudes, and the cost involved. A vote was taken and it was decided to discontinue aerial surveys and instead increase radar validation surveys.

3.1.1.3 Avian Radar Surveys

Vertically scanning radar (VerCat) and horizontally scanning radar (TracScan) data were analyzed and data filters were developed to remove detections from rain (especially virga) and sea clutter, because these detections generate false tracks. Track counts were adjusted for dropped tracks that received a new track ID when the target was the same as the original track. The thermal imaging-vertically pointing radar (TI-VPR) system sampled targets passing through a 20° cone directed vertically to determine the proportion of each type of biological target (e.g., birds, bats, insects) detected by VerCat. The TI-VPR data were used to develop a correction factor for insects in the radar count data from the VerCat. Data from barge-based, boat-based, and onshore-based observer validation surveys were analyzed and used to evaluate the results of radar analyses.

The results of the studies with VerCat are expressed in terms of three metrics: **median altitude quartile** (the 50% quartile containing the altitude at which half the total number of birds observed were flying below the median, and half were flying above the median), **flux** (adjusted number of bird tracks per cubic kilometer per hour [abt/km^3/hour]), and **adjusted migration traffic rate** (AMTR-number of bird tracks crossing over a kilometer per hour). Data related to cumulative diurnal and nocturnal flux were sorted into three altitude bands with reference to the potential RSZ: (1) below the RSZ (low altitude band, 1 to 99 ft AMSL); (2) within the RSZ (middle altitude band, 100 to 700 ft AMSL); and (3) above the RSZ (high altitude band, 701+ ft AMSL). The AMTR provides a quantitative passage rate. Although many variables affect the possibility of bird-turbine collision risk, in general the greater the AMTR value the greater the potential for bird-turbine collision.

Median altitude quartiles provide information on the frequency of occurrence of birds in the RSZ. The AMTR provides a quantitative passage rate. Although many variables affect the possibility of bird-turbine collision risk, in general the greater the AMTR value the greater the potential for bird-turbine collision. Flux is a measure of bird density in the RSZ and is the most important metric for determining bird collision risk impacts.

Based on the direct visual validation studies, only 10 to 20% of the birds flying at very low altitudes were detected with the radar. This was because of constraints of the marine radar detecting wave clutter that obscured return from low flying birds. Consequently, in the lowest altitude quartile the reported bird counts were underestimated (i.e., lower than the number actually present) and the radar measured median altitudes were likely lower than those given in this report. Bird counts in the RSZ were affected less by return from wave clutter, because the effect was reduced as the height of the radar beam increased.

The TracScan radar was used primarily to determine direction of target movement. Because different offshore study sites were sampled at different times during a season, it was difficult to attribute changes to time of season, or location, or both. Monitoring all offshore sites throughout each season would have been prohibitively expensive even if equipment and personnel had been available.

Offshore Spring 2008

During spring of 2008 the VerCat radar operated for 940.5 hrs and the TracScan radar operated for 1,044.3 hrs. Daytime flux values gradually decreased within the low altitude band and gradually increased within the RSZ for nearshore and offshore sites. During the night greater flux values occurred within the RSZ than below the RSZ as the spring season advanced for both nearshore and offshore grids. The dominant diurnal and nocturnal nearshore and offshore flux directions during most of the survey weeks were from the south and southwest to the north and northeast. AMTR increased as season progressed near shore and offshore. The peak diurnal AMTR occurred offshore on Grid 26 (137.0 abt/kph) from 24 to 30 April and on Grid 17 (113.0 abt/kph) from 07 to 11 May 2008. Peak nocturnal AMTR occurred 30 April to 07 May (320.3 abt/kph) on Grid 26 and from 07 to 11 May 2008 (333.5 abt/kph) on Grid 17. Because the offshore grids were sampled later in the season, one cannot conclude that more birds were offshore than nearshore, because the high counts may have been the result of more migration occurring later in the season than earlier in the season.

Offshore Fall 2008

During fall 2008 radar surveys were limited to two offshore sampling grids in the southern section of the Study Area. The VerCat operated for 442.5 hrs and the TracScan operated for 415.1 hrs. The data are limited and insufficient to make any conclusions. All the median altitudes were within the RSZ for daytime and nighttime samples. The flux was greater in the RSZ than the low altitude band during daytime and nighttime and there was no difference in flux between daytime and nighttime. Cumulative diurnal and nocturnal AMTR decreased from Grid 22 to Grid 26, but Grid 26 was sampled later in the fall. Peak diurnal AMTR was 104.3 abt/kph and peak nocturnal AMTR was 134.3 abt/kph from 30 September through 12 October 2008. The direction of movement was from the north to the south.

Offshore Spring 2009

The VerCat radar operated for 39.8 hrs and the TracScan radar operated for 41.3 hrs. The data collected were limited and insufficient to analyze and make any conclusions. Three onshore sites were sampled: Island Beach State Park (IBSP), Brigantine, and Corson's Inlet-Sea Isle City (CI-SIC).

Onshore Spring/Early Summer 2008

VerCat operated for 657.9 hrs and TracScan operated for 657.3 hrs. The majority of the median altitude quartiles were within the RSZ at all of the onshore sites. The cumulative diurnal flux values varied within and between the onshore sites and were in general greater during the daytime than at night in the RSZ. The cumulative nocturnal flux values were greater within the low altitude band than within RSZ at all onshore sites. At IBSP and CI-SIC flux values were generally similar for low altitude and RSZ. At Brigantine, cumulative diurnal flux values were greater within the low altitude band than within the RSZ. This difference may be the result of the different migratory species passing the site or the behavior of resident species at the site. AMTR values were similar between the onshore sites during the daytime. AMTR values were greater at night than during daylight indicating that some nocturnal migration was probably still in progress from mid-May into mid-June. The cumulative peak diurnal AMTR (17.6 abt/kph) occurred at Brigantine from 29 May through 01 June 2008. The cumulative peak nocturnal AMTR (66.2 abt/kph) was at IBSP from 15 to 18 May 2008. Overall, as expected during spring migration, the dominant movement of birds was from the south and southwest to the north and northeast.

Onshore Fall/Early Winter 2008

VerCat operated for 2,090.2 hrs and TracScan operated for 2,039.4 hrs. Most of the cumulative median diurnal altitude quartiles were within the RSZ at IBSP in early fall 2008, and the majority of the cumulative median altitude quartiles were within the low altitude band at Brigantine, CI-SIC, and at IBSP from mid-fall into early winter 2008. Most of the cumulative nocturnal altitude quartiles were within the RSZ. The majority of the cumulative diurnal flux values were greater within the low altitude band than within the RSZ. For most of the survey dates, the cumulative nocturnal flux values were generally similar between the low altitude band and the RSZ. Cumulative diurnal AMTR values were 10 abt/kph or less and cumulative nocturnal AMTRs were 30 abt/kph or less at all of the onshore sites. At each onshore site peak cumulative AMTR occurred at night. The dominant direction of movement during most weeks was from the north and northeast to the south and southwest.

Onshore Spring/Early Summer 2009

VerCat operated for 1,902.1 hrs and TracScan operated for 1,872.2 hrs. All of the cumulative weekly median altitude quartiles during the daytime were within the low altitude band at IBSP while at Brigantine cumulative weekly altitude quartiles during the day were split almost equally between the low altitude band and the RSZ. At CI-SIC, the cumulative weekly median altitudes during the daytime were all within the low altitude band. Most of the cumulative weekly median altitude quartiles at night at IBSP were within the RSZ. At Brigantine most of the cumulative weekly median altitude quartiles during the night were in the high altitude band (above the RSZ), and at CI-SIC all of the cumulative median altitude quartiles at night were within the RSZ. Cumulative weekly flux values during daylight were greater within the low altitude band than within the RSZ. Cumulative weekly flux values at night varied among sample periods and were likely dependent on when conditions were favorable for migration. The trend was for greater flux values in the low altitude band during migration events. Cumulative diurnal AMTR values were 10 abt/kph or less and cumulative nocturnal values were less than 80 abt/kph at all of the onshore sites. At each onshore site, peak cumulative AMTR occurred at night. The dominant direction of migration was from the south and southwest to the north and northeast. Some of these movements occurred even though winds were unfavorable, and one small scale reverse migration (towards the southwest) was recorded.

Onshore Fall 2009

VerCat operated for 1,299.5 hrs and TracScan operated for 1,372.9 hrs. Most of the median quartiles were below the RSZ during daylight, but most were in the RSZ at night. Flux values in the RSZ were greater at night than during the day and this was particularly so during migration events. The exceptionally high flux rate during the period 08 to 16 November 2009 was associated with a 22 minute period of high winds and many birds aloft. Cumulative AMTR values during daylight hours were less than 20 abt/kph during the majority of the study. The only exception was during the week of 08 to 16 November at CI-SIC when the AMTR increased dramatically but only in the 16+ mph wind category. Except for the peak cumulative nocturnal migration period 05 to 11 October 2009, when the AMTRs were approximately 90 abt/kph, the cumulative weekly AMTRs at night were below 50 abt/kph. The direction of migration during most sample weeks was from the north and northeast to the south and southwest, and many movements occurred with opposing winds from the south to the north.

Offshore-Onshore Comparisons

It is important to realize that statistical comparisons between onshore and offshore samples were possible only when the samples were collected at the same time. Concurrent offshore radar (Grid 22 and Grid 26; 30 September to 12 October 2008) and onshore radar (CI-SIC; 05 to 19 October 2008) sampling only occurred during 05 to 19 October 2008. Radar data from these locations were compared statistically to provide quantitative information on any onshore-offshore differences in cumulative median flight altitudes, cumulative flux values, and cumulative AMTR. The cumulative median altitude quartiles over the offshore girds were all within the RSZ during the daytime, while over the onshore site half of the cumulative altitudes during daylight were within the RSZ and the other half below the RSZ. The cumulative median altitude quartiles over the offshore grids and over the nearshore site at night were all within the RSZ. Cumulative flux values were higher over the offshore grids than the onshore site during daylight and dark. The cumulative AMTRs were noticeably greater over the offshore grids than over the onshore site. For the limited time period of 05 to 19 October 2008, avian activity was concentrated at the offshore sites.

3.1.1.4 Thermal Imaging Vertically Pointing Radar

Use of thermal imagery and vertically pointing radar proved to be very valuable in identifying the sources of echoes detected in VerCat. The TI-VPR system could easily detect targets flying through the rotor swept zone. The vertically pointing radar provided accurate altitudes of flight and the thermal imaging video provided enough information on targets to identify them as birds, foraging bats, or insects. We recommend that all future studies use this technique to validate the identity of the sources of radar echoes.

Offshore Spring 2008

TI-VPR offshore barge-based surveys were conducted at six sites for a total of 180 hrs. Grid 23, approximately 10 miles offshore, in the southern section of the Study Area , showed the highest total target count for the season (783 targets), of which 570 targets (73%) were identified as birds, 204 as insects, and 9 as foraging bats. Other grids had fewer birds (ranging from 6 to 69 birds), and overall 75% of birds were within the RSZ. The mean directions of the movements were towards the north-northwest-northeast and one movement was a reverse migration toward the south-southwest.

Offshore Fall 2008

TI-VPR offshore barge-based surveys were conducted at two sites for a total of 161 hrs. Grid 23 once again showed the highest total target count (1,252 targets) for fall, of which 985 targets were identified as birds (79%), 243 as insects, and 24 as foraging bats. The second grid sampled (Grid 26, also approximately 10 NM offshore in the southern section of the Study Area) had a total target count of 249, and 192 were identified as birds (77%), 57 as insects, and no foraging bats. The mean directions of the movements for both grids were towards the southwest.

Offshore Spring 2009

TI-VPR offshore barge-based surveys were conducted at two sites for a total of 15 hrs. Grid 16 (nearshore in the central section of the Study Area) showed the highest total target count (97 targets), of which 39 were identified as birds (41%), 57 as insects, and no bats. Grid 22 (nearshore in the southern section of the Study Area) had a total target count of 57 targets, with 39 targets being identified as birds (68%) and18 as insects. The majority of the bird movements aloft (96% in Grid 16 and 94% in Grid 22) occurred within the RSZ. The mean directions of the movements for Grids 16 and 22 were towards the north-northeast.

Onshore Fall 2008

TI-VPR surveys were conducted at the Sea Isle City (SIC) site from 08 to15 December for a total of 48 hrs. The site had a total target count of 285. Of this total, 270 targets were identified as birds (95%), 9 as insects, and 6 as foraging bats. Despite the late sampling date, the mean direction of the movement toward the south-southwest suggested a migratory movement; 90% of the birds flew at altitudes within the RSZ.

Onshore Spring 2009

TI-VPR surveys were conducted at the IBSP site during the period 21 to 22 and 27 March 2009 for a total of 17 hrs. The site had a total target count of 54, of which 21 targets were identified as birds (95%), and 33 as insects. Foraging bats identified were not identified. The mean direction for movement was towards the northeast, and100% of the birds were at altitudes above the RSZ.

Onshore Fall 2009

TI-VPR surveys were conducted at SIC, IBSP, and Brigantine Beach (BB) for a total of 10 hrs. SIC had the highest total target count for the season (1,133 targets), of which 738 targets were identified as birds (65%), and 395 as insects (both season highs). IBSP had the second highest total target count with 219 targets, of which 144 were identified as birds (66%), 69 as insects and 6 as foraging bats. BB had 138 targets detected, with 39 targets being identified as birds (28%) and 99 as insects. Two-thirds of the birds (66.2%) were flying in the RSZ and the remainder (33.8 %) flew above the RSZ. The mean directions of the movements over the three sites were toward the southwest-south-southeast, but the movements over IBSP and BB showed some variability in direction.

3.1.1.5 NEXRAD

Year-to-Year Pattern of Migration

During the spring the sum of nightly bird peak density (birds/km^3) differed from year-to-year. As expected, the maximum density of bird migration measured over the coastal sampling areas differed from the maximum density over the offshore sampling areas. This could be attributed to a migrating bird's tendency to follow the coastline. Over the five years of spring data the sum of the nightly peak densities measured over the coastal areas ranged from 347 in the spring of 2006 (area 1A) to 2,836 in the spring of 2009 (area 1A), and the maximum density recorded was 569 in the spring of 2004 (area 1A). The sum of nightly peak densities recorded over the offshore areas ranged from 58 (area 2B) in the spring of 2008 to 264 in the spring of 2007 (area 1B), with a maximum density of 103 recorded in the spring of 2007 in area 1B. Thus during the five-year study the amount of migration in spring passing over the onshore areas was much higher than the amount of migration measured over the offshore areas.

During the fall the sum of nightly peak density also differed from year-to-year. Over the five years of fall data the sum of the nightly peak densities measured over the onshore areas ranged from 1,445 (area 3A) in the fall of 2004 to 4,078 (area 1A) in the fall of 2005, with a maximum density of 705 recorded in the fall of 2005 (area 1A). The range of the sum of nightly peak densities over the offshore areas ranged from 273 (area 1B) in the fall of 2004 to 658 (area 2B) in the fall of 2005, with a maximum density of 144 recorded in the fall of 2005 (area 2B). Just as in the spring the amount of migration passing over the onshore areas was much higher than the amount of migration measured over the offshore areas. Once again, these results suggested that birds have a tendency to follow the coast line during migration. Overall, the density of migration during the fall was on average two to three times greater than the density of migration observed during the spring.

Night-to-Night Pattern of Migration

Nocturnal migration during the spring and fall showed considerable night-to-night variability. In the spring, migration began to build in late April, peaked near the middle of May, and then declined towards the end of May. This pattern could be seen in both the onshore and offshore sampling areas. Within the three onshore areas there were five nights with a mean density of 100 birds/km^3 or greater over the sampling areas during the five years of spring migration (21 April, and 01, 04, 07, 11 May), while within the offshore sample areas the maximum was 21 on 21 April [area 1B]). Within the offshore areas the mean migration density was considerably less than that measured over the onshore areas (mean peak density of 21 birds/km^3). Though sizable flights could occur at anytime from the middle of April through the middle of May, the peak of migration through the area was in early to mid-May. Fall migration intensified in early September and peaked in mid-October to early November. After the peak in late October/early November the density of migration declined, and by mid-November very little migratory movement took place. This pattern was seen both within the onshore and offshore sampling areas. There were 17 nights with a mean density of 100 birds/km^3 or more within the onshore areas during the five years of fall migration (31 August; 01, 10, 13, 15, 23, 26, 29 September; 05, 12, 14, 15, 17, 20, 25 October; and 02, 09 November), while within the offshore sample areas there were no nights with a mean density of 100 birds/km^3 or more. Area 1A measured the highest density for the fall season on 15 October with a mean density of 258 birds/km^3. Similar to the spring, the offshore sample area mean migration densities were considerably less than those measured within the onshore sample area. The maximum mean density was only 34 birds/km^3 on 12 September within Area 1B.

Hour-To-Hour Pattern of Migration

The hour-to-hour pattern of migration over the sampling areas during the spring (2005 to 2009) typically started 30 to 45 min after sunset, peaked on most evenings between 02:00 to 06:00 Coordinated Universal Time (UTC; 11:00 PM to 2:00 AM Eastern Standard Time [EST]), and declined until sunrise. In the fall (2004 to 2008) the quantity of migration was greater than in the spring (see above section on Year-to-Year Pattern of Migration), and the hour-to-hour pattern of percentage of peak hourly density during the evenings was shifted slightly earlier in the evening compared to that observed in spring. Like the spring, migration typically started 30 to 45 min after sunset and the peak of a nightly movement generally occurred from 01:00 to 05:00 UTC (10:00 PM to 12:00 AM EST). The peak density for the night in the spring appeared to be slightly later in the evening and more defined when compared to the peak density for the night in the fall.

Direction of Migratory Movements

In the spring the mean directions (μ) from which the movements originated were 203.58° in 2005, 205.14° in 2006, 205.44° in 2007, 207.37° in 2008, and 211.35° in 2009. The flights were oriented toward the north-northeast (between 23° and 32°). There was some variability in mean direction from year to year but within each year there was relatively strong directionality as indicated by the length of the mean vector [r] (a statistical measure of concentration). All yearly mean directions showed low circular variance and were highly significant ($p<0.0001$). In the fall the mean directions were from 33.57° in 2004, 28.18° in 2005, 17.68° in 2006, 17.72° in 2007, and 28.55° in 2008. The flights were oriented toward the southeast to south-southwest between 197° and 214°. The lengths of the mean vectors from the fall data were comparable to those in spring data. Topographic features such as the shoreline likely influenced the directions of seasonal migrations, particularly those occurring at lower altitudes.

Migration, Weather Conditions, and Collisions

During the five years of spring data, 79 of 365 nights (21.6%) had conditions that would cause birds to fly lower - sometimes with reduced visibility. Twenty-nine of these nights had migration densities of 25 birds/km^3 or greater. During the five years of fall data, 102 of 465 nights (21.9%) had weather conditions that might have caused birds to migrate at low altitudes and 24 of these nights had bird movements of 25 birds/km^3 or greater. There were 23 more total nights over the five fall seasons than in five spring seasons with weather conditions that could have caused birds to fly at low altitudes and sometimes in poor visibility, but generally on these nights there was little or no migration.

3.1.1.6 Avian Predictive Modeling

The primary goal of the study was to develop spatial models for predicting changes in density and spatial distribution of birds and to identify important regions used by birds within the Study Area. The objective was to quantify where birds are most likely to concentrate in relation to geophysical habitat features (e.g., depth, shoals) and predict where birds were likely to occur seasonally. The following questions were addressed: (1) Where and when are birds (species) most likely to concentrate within the Study Area? (2) Are birds more or less concentrated evenly along the coast, or do some species exhibit specific spatial gradients (i.e., lat-lon variation)? (3) What is the relationship between bird density/distribution and depth, distance to shoreline, distance to shoals, and slope?

Interpolation (e.g., kernel density), spatial regression, and generalized additive models (GAMs) were used to quantify the relationship between spatial covariates (e.g., bathymetric and distance based metrics) and birds. The spatial models were developed to quantify the effect of each spatial covariate for predicting changes in bird density and distribution. In summary, along with the kernel density maps (**Volume II: Appendix M**) that identified where and when birds were likely to concentrate, spatial covariates were calculated to develop insight into the geographic distribution and describe the basic attributes of habitat utilized by birds. By incorporating these data in a GIS, changes in bird density were determined as a function of depth, slope, distance to shoreline, distance to shoals, and whether there was a spatial gradient in bird density (north/south or east/west) for a variety of species. Collection of kernel density maps was a valuable tool for identifying important locations where and when (by month and season) birds were most likely to concentrate.

Kernel Density Interpolation

Kernel density maps were estimated for all-behavior and sitting densities (number of birds/km^2) in 2008 and 2009, and the combined two-year period 2008 to 2009. Numerous localized density maxima for all-behavior and sitting birds were located nearshore, midshore, and far-offshore, with the vast majority of these maxima occurring nearshore. A small portion of these density maxima for all-behavior birds were mirrored by the sitting birds, reflecting differences in the numbers of flying and sitting birds. For example, eight and 15 localized sitting density maxima occurred in 2008 and 2009, respectively; and 24 such maxima occurred in the overall cumulative two-year period, most of which occurred nearshore. In 2008, the eight sitting density maxima ranged from 110 to 830 (the latter occurring between Barnegat Light and Seaside Heights); and in 2009, the 15 sitting density maxima ranged from 115 to 735 (the latter occurring north of Little Egg Inlet). In the overall cumulative two-year period, the 24 sitting density maxima ranged from 115 to 1,480 (the latter occurring north of Little Egg Inlet). For the all-behavior birds, the highest density maxima were 1,425 in 2008 (midshore southeast of Little Egg Inlet), 1,730 in 2009 (nearshore north of Little Egg Inlet), and 1,805 (on the offshore edge of the nearshore region, between Little Egg Inlet and Brigantine).

Observing these annual and overall cumulative spatial kernel density maps, the following general conclusions can be made:

- Nearshore densities were higher than offshore densities, supporting an offshore gradient of decreasing densities with increasing offshore distance.
- Within the offshore region, midshore densities were generally higher than far-offshore densities.
- All-behavior densities were higher than sitting densities, reflecting the presence of both all-behavior and sitting birds.
- The highest nearshore densities occurred up against the coastline rather than on the offshore edge of the nearshore region.
- All-behavior density maxima that are mirrored by sitting birds reflected a balance between flying and sitting birds. If the sitting density was less than the all-behavior density, then both flying and sitting birds were present. If the sitting density was equal to or near the all-behavior density, then most/all of the birds in the given region were sitting rather than flying.
- All-behavior density maxima that were not mirrored by sitting birds indicated that the majority of birds in the given region were flying rather than sitting.

Total Birds Seasonal Analysis

For most seasons, nearshore densities were higher than offshore densities (for both all-behavior and sitting birds). Within the offshore region, densities were generally higher midshore than far-offshore.

In fall 2008, numerous localized density maxima were located nearshore, midshore, and offshore as a result of contributions of individual species. A total of 24 detectable density maxima occurred for all-behavior birds within the Study Area, ranging in magnitude from 105 to 1,740 (the latter was located midshore southeast of Little Egg Inlet). The majority of these maxima were not mirrored by the sitting birds, indicating that most of the total birds in the regions of these density maxima were flying rather than sitting. Compared to 24 density maxima for all-behavior birds, only four density maxima occurred for the sitting birds: (1) 945 nearshore between Barnegat Light and Seaside Heights (compared to 1,420 for all-behavior birds); (2) 120 nearshore in the region midway between Little Egg Inlet and Barnegat Light (compared to 135 for all-behavior birds); (3) 145 midshore southeast of Hereford Inlet (compared to 170 for all-behavior birds); (4) 140 far-offshore southeast of Hereford Inlet (compared to 565 for all-behavior birds). Except for this far-offshore density maximum, far-offshore densities were generally lower than midshore densities. Total bird density (all-behavior and sitting) were generally lower in fall 2009 than in fall 2008 (a year earlier). In fall 2009, five localized density maxima occurred for all-behavior birds: (1) 180 nearshore at Barnegat Light (compared to 125 for sitting birds); (2) 260 nearshore between Barnegat Light and Little Egg Inlet (compared to 145 for sitting birds); (3) 300 midshore southeast of Little Egg Inlet (compared to 215 for sitting birds); (4) 300 nearshore just south of Atlantic City (compared to 235 for sitting birds); (5) 100 nearshore just south of Ocean City (mirrored by a sub-maximum density on the order of 50). In addition, numerous density maxima (on the order of 50) for all-behavior birds also occurred, both nearshore and midshore, some of which were mirrored by the sitting birds.

Comparing spring and fall for the 2008 and 2009, densities were relatively lower in spring than in fall. In spring 2008, three distinct localized density maxima occurred for all-behavior birds: (1) 745 nearshore just off Ocean City (compared to 730 for sitting birds, indicating that the majority of the birds in this region were sitting rather than flying); (2) 335 nearshore off Hereford Inlet (mirrored by a sub-maximum density on the order of 50 for sitting birds); (3) 135/km^2 midshore southeast of Ocean City (which is not mirrored by the sitting birds). In spring 2009, four distinct localized density maxima occurred for all-behavior birds: (1) 585 nearshore just south of Barnegat Light (compared to 370 for sitting birds); (2) 130 offshore east of Barnegat Light (which is not mirrored by the sitting birds); (3) 150 nearshore between Great Egg Harbor Bay and Atlantic City (compared to 140 for sitting birds); (4) 120 nearshore just off Hereford Inlet (compared to 110 for sitting birds).

Overall densities were generally lower in summer than in fall and spring for 2008 and 2009. In summer 2008, only one distinct localized density maximum occurred: 110 nearshore off Ocean City. Several sub-maximum densities (on the order of 25) occurred for all-behavior birds around Atlantic City and Brigantine. Densities were generally higher nearshore than offshore, and offshore densities were more patchily distributed for sitting birds than for all-behavior birds. Overall densities were slightly lower in summer 2009 than in summer 2008. In summer 2009, the spatial distribution of all-behavior density was more uniform nearshore than offshore. Nearshore sitting bird densities were lowest around Ocean City and Great Egg Harbor Bay, the region between Brigantine and Little Egg Inlet, and a small region just north of Little Egg Inlet.

Among winter and summer, overall densities were generally higher in winter than in summer (for both all-behavior and sitting birds). Among the three winter seasons, densities were generally lowest in 2008, highest 2009, and intermediate in 2010, partly reflecting the lower survey effort in the latter season. In all three winter seasons, densities were higher nearshore than offshore, and all-behavior densities were higher than sitting densities, reflecting the presence of both flying and sitting birds. In winter 2008, two localized density maxima occurred for all-behavior birds: (1) 475 nearshore between Atlantic City and Brigantine; and (2) 120 nearshore between Great Egg Harbor Bay and Atlantic City. In winter 2009, densities were higher than in winter 2008, with 13 localized nearshore density maxima occurring for all-behavior birds (ranging from 125 to 1,740) along the entire coastline, from the vicinity of Barnegat Light to Hereford Inlet. Eight of these 13 density maxima were mirrored by the sitting birds (ranging from 170 to 1,715). In winter 2010, five localized nearshore density maxima occurred: (1) 135 nearshore in the vicinity of Barnegat Light (compared to 110 for sitting birds); (2) 105 nearshore between Little Egg Inlet and Barnegat Light; (3) 235 nearshore between Brigantine and Little Egg Inlet (compared to 105 for sitting birds); (4) 120 nearshore at Brigantine (compared to 50 for sitting birds); (5) 105 nearshore midway between Ocean City and Hereford Inlet (compared to 50 for sitting birds).

Modeling Results

Modeling results are outlined in **Table 3-1** and **Table 3-2**. In general, depth and distance to shoreline were found to be important predictors of bird density and distribution. For example, using the combined two year dataset, it was determined that bird density and distribution declined in waters greater than 20 m (65.6 ft) in depth and 12.2 km (7.6 mi) from the coastline; however, there was a strong seasonal effect in these values that is important to consider. Although bird density was generally greater in the fall (i.e., migration and seasonal visitors take up residence along the New Jersey coastline), birds were principally concentrated in waters up to 20 m (65.6 ft) in depth and 12.2 km (7.6 mi) from the coastline; the same result was observed for the entire dataset. When the spring season was modeled, birds were found concentrated in deeper waters (>20 m [65.6 ft]) than in the fall (<20 m [65.6 ft]). Moreover, in summer, bird density ranged further offshore (18.3 km [11.4 mi]) and increased significantly in waters greater than 30 m (98.4 ft) in depth. In winter, bird density was concentrated in waters less than 15 m (49.2 ft) in depth and within 12.2 km (7.6 mi) from the coastline.

Total sitting bird density was modeled to identify where birds were most likely to reside, concentrate, and for some species, feed (i.e., loons, ducks, and gulls sitting on the water may indicate foraging locations). In general, sitting birds were most likely to occur in waters less than 15 m in depth and within 3.8 mi from the coastline. In fact, in fall, spring, and winter, sitting bird density was concentrated in waters within 6.1 km (3.8 mi) of the coastline, whereas in summer the distance increased to 18.3 km (11.4 mi).

The seasonal changes in density and distribution of total birds were dynamic and related to changes in bird community composition. For example, in the fall and winter there were dense concentrations of diving ducks that were absent in the summer when the bird community was primarily composed of terns, gulls and petrels. This difference in community composition was likely responsible for the varying degree of bird density clustered inshore and offshore. The models detected this and quantified habitat use by total birds as a function of depth and distance to shoreline. These dynamics were investigated further to quantify the effect of covariates for predicting changes in species distribution. Scoter density and distribution exhibited a peak in waters 10 m (32.8 ft) in depth and were concentrated within 6.1 km (3.8 mi) from the coast and decreased offshore to approximately 30.6 km (19 mi) from the coast. Northern Gannets, which were present in each season, were generally concentrated in waters greater than 10 m (32.8 ft) in depth that were within 25.3 km (9.5 mi) from the coastline. Laughing Gulls and Common Terns, which were seasonal summertime breeders in New Jersey, displayed interesting distribution patterns. Laughing Gulls were generally concentrated within 7.6 km (4.7 mi) from the coast and decreased in waters greater than 15 m in depth. On the other hand, Common Terns ranged further offshore and their density declined around 18.3 km (11.4 mi) from the coast, and thereby occupied a wider range of coastal habitat than Laughing Gulls. The density and distribution of Cory Shearwaters, which were also summertime visitors, showed an increase in density offshore in waters greater than 30 m (98.4 ft) in depth to approximately 27.3 km (17 mi) from the coastline.

Table 3-1. General summary of effect of spatial covariates on bird density based on GAM results: (a) description of effect. [DistShore = distance from shoreline; DistShoal = distance to shoal]

Covariate	Effect on bird density		
	+	-	+/-
Depth	Density increased in shallower water	Density increased in deeper water	Effect on density was mixed
Slope	Density increased with slope	Density decreased with slope	Effect on density was mixed
DistShore	Density increased with distance from shoreline	Density decreased with distance from shoreline	Effect on density was mixed
DistShoal	Density increased with distance to nearest shoal	Density decreased with distance from nearest shoal	Effect on density was mixed
Longitude	Density increase indicated more birds in the eastern portion of the Study Area	Density decrease indicated more birds in the western portion of the Study Area	Effect on density was mixed
Latitude	Density increase indicated more birds in the northern portion of the Study Area	Density increase indicated more birds in the southern portion of the Study Area	Effect on density was mixed

Table 3-2. Covariate effect on bird density. [DistShore = distance from shoreline; DistShoal = distance to shoal]

Bird Variable	Depth	Slope	DistShore	DistShoal	Longitude	Latitude
Total birds	+		-		+	-
Total birds ‘Fall’	+		-		+	-
Total birds ‘Spring’	-		-		-	
Total birds ‘Summer’	+/-		-	+/-	+	-
Total birds ‘Winter’	+	-	-		+	-
Total sitting birds	+	-				
Total sitting birds ‘Fall’	+	+	-			+/-
Total sitting birds ‘Spring’	-	+/-			-	+
Total sitting birds ‘Summer’	+/-		+/-	+/-	+/-	
Total sitting birds ‘Winter’	+		-			
Northern Gannet			-	+	+	-
Scoter Species			+/-	+	-	+
Long-tailed Duck		+/-	-		+	-
Common Loon	-				-	
Red-throated Loon			+/-	+	-	
Herring Gull	+		+	+	-	+
Laughing Gull	+		-		+	-
Common Tern			-	+/-	+	-
Wilson’s Storm Petrel			+		-	+
Cory Shearwater	-		+/-	+/-	+/-	

Overall, bird density and spatial distribution exhibited a striking onshore to offshore gradient that was highly variable among seasons and lined to changes in community composition. The results pinpoint where repeated maximum densities are likely to occur in relation to a variety of species. This information was integral to the understanding of the spatial ecology of marine birds along the New Jersey coastline and should be used to examine potential changes in habitat due to environmental changes from human activity (e.g., offshore wind development, water quality degradation).

Along with the kernel density maps that show where and when birds are likely to concentrate, it was determined that distance to shoreline and depth were useful and important predictors of changes in bird density and distribution. Kernel density maps were a valuable tool for identifying important locations where and when (by month and season) birds are most likely to concentrate. Depth and distance to shoreline were important predictors of bird density and distribution. Overall, bird density declined significantly in waters greater than 20 m (65.6 ft) and 12.2 km (7.6 mi) from the coastline. Total bird density was greater within the southeast portion of the Study Area during fall, summer, and winter but was more concentrated in the north section of the Study Area during spring.

3.1.2 Marine Mammal and Sea Turtle Study Results

This baseline study included the first year-round, systematic survey effort for marine mammals and sea turtles in nearshore waters of New Jersey. Both aerial and shipboard surveys were designed to estimate marine mammal and sea turtle distribution and abundance using standard systematic line transect methodology. The objective of this survey was to determine the spatial distribution and to estimate the abundance/density of marine mammals and sea turtles in the Study Area. This baseline survey was conducted over a 24-month period between January 2008 and December 2009. The three sampling techniques conducted during this study included aerial line transect surveys, shipboard line transect surveys, and PAM.

Shipboard and aerial line transect surveys are a type of distance sampling method and were used to collect data on marine mammal and sea turtle species found in the Study Area. The surveys covered 26,377 km (14,243 NM) of effort. A total of 615 sightings of marine mammals and sea turtles were recorded; 486 of these sightings were recorded while the survey teams were on effort in the Study Area. The on-effort sightings data collected via these surveys were used to assess spatial and temporal distributions in abundance for all species (or groups) for which there were a sufficient number of sightings. Both Conventional Distance Sampling (CDS, design-based approach) and Density Surface Modeling (DSM, model-based approach) methods were used to estimate abundance/density for these species or groups. The CDS method was used to generate abundance/density estimates for the overall Study Area, and the DSM method was used to generate surface maps of predicted density at a finer spatial resolution using various environmental covariates as predictors of density. These spatial outputs were combined with the other natural resource layers of the environmental sensitivity index which can be used to assess more or less suitable portions of the Study Area for energy power facilities based on potential ecological impacts.

Stationary PAM was conducted using autonomous marine audio recorders (pop-ups) for six three-month deployment periods to determine the presence of vocalizing cetaceans in the Study Area. Because whales and dolphins produce sounds in distinctly different frequency ranges, two sampling frequencies were employed to detect for baleen and toothed whales. Baleen whales typically produce sounds below 2 kHz while toothed whales, especially dolphins, produce sounds between about 1 and 130 kHz. Therefore, 2-kHz and 31.25-kHz sample rates were coded into different pop-ups during each deployment to facilitate potential detection of marine mammal vocalizations. The PAM acoustics data often provided additional information on species occurrence in the Study Area that was not captured from visual observations. The data were analyzed with custom software algorithms to detect fin whale and North Atlantic right whale calls. The data were also manually reviewed for delphinid calls because call detection algorithms were not available for other cetacean species. Because a cumulative 4.42 years of audio data were collected during the course of the study, manual review for species with highly variable calls (humpback whales [*Megaptera novaeangliae*]) was not possible.

Ten of the 47 possible species to occur in the Study Area were detected visually and/or acoustically during the baseline study period. Detected species included the following five federally threatened or endangered species: North Atlantic right whale, fin whale (*Balaenoptera physalus*), humpback whale, leatherback turtle, and loggerhead turtle. The minke whale (*Balaenoptera acutorostrata*), bottlenose dolphin, short-beaked common dolphin (*Delphinus delphis*), harbor porpoise (*Phocoena phocoena*), and harbor seal were also detected.

Some clear seasonal patterns in distribution were evident from our study. Although all of the 10 species detected during this survey could occur in the Study Area at any time, only the North Atlantic right whale, fin whale, humpback whale, and bottlenose dolphin were detected during all seasons. The occurrence of dolphins and porpoises, as well as turtles, was largely seasonal. Bottlenose dolphins, loggerheads, and leatherbacks mostly occured in the Study Area in the summer while short-beaked common dolphins and harbor porpoises were common in the Study Area during the winter and spring. The fall season appeared to be a transitional period for seasonal cetacean species. Few sightings of bottlenose dolphins and short-beaked common dolphins were recorded during the fall despite the large amount of survey effort. It is likely that most bottlenose dolphins move south of the Study Area, and most short-beaked common dolphins and harbor porpoises are farther north during this time of year.

Of particular ecologic importance are the sightings/acoustic detections of endangered large whale species, the North Atlantic right whale, fin whale, and humpback whale. Each of these species was detected during all seasons, including those seasons during which North Atlantic right and humpback whales are known to occupy feeding grounds north of the Study Area or breeding/calving grounds farther south of the Study Area. Cow-calf pairs of each of these species were also observed in the Study Area. Two North Atlantic right whales exhibited possible feeding behavior, and one humpback whale was observed lunge feeding off the coast of Atlantic City. Based on these occurrences and behavioral observations, the nearshore waters off New Jersey may provide important feeding and nursery habitat for these endangered species. Peak densities were predicted throughout the Study Area for these species and, although the overall abundance estimates of the whale species were relatively low, the Study Area is only a very small portion of the known ranges of these species. These species may use the waters of the Study Area for short periods of time as they migrate or follow prey movements or they may remain in the Study Area for extended periods of time. High concentrations of these species were not documented in the Study Area at any time during the survey period; however, the presence of these endangered large whale species in New Jersey waters indicated that these animals used the area as habitat. The detections of these species in the Study Area, particularly during times of the year when they are thought to be in other areas, demonstrated the potential importance of the Study Area. The occurrence of these endangered species provided critical information on the distribution of the species in this region.

The density and abundance of the dolphin and porpoise species were relatively high for the Study Area. The highest abundances of marine mammals in the Study Area were estimated for the bottlenose dolphin during spring and summer. These bottlenose dolphins are thought to belong to the coastal northern migratory stock which occupies a small range between Long Island, New York and southern North Carolina. The high abundances of bottlenose dolphins in the Study Area coincided with the known movement of this stock into the northern portion of their range. High abundances of short-beaked common dolphins in the Study Area coincided with their known movement patterns south of 40ºN in the winter/spring. High abundances of harbor porpoises also occurred during the winter when the New Jersey waters and the waters of the New York Bight provide an important habitat for this species.

More information on the results of this baseline survey is summarized below for each species.

3.1.2.1 Endangered Marine Mammals

North Atlantic Right Whale

There is little information on the geographic and temporal extent of the North Atlantic right whale's migratory corridor (Winn et al. 1986); however, our sightings data of females in the Study Area and subsequent confirmations of these same individuals in the breeding/calving grounds a month or less later indicate that the nearshore waters of New Jersey are part of the migratory corridor between feeding grounds in the northeast and breeding/calving grounds in the southeast. The cow-calf pair sighted in the Study Area in May 2008 was previously confirmed in the southeast in January and February and subsequently sighted in the Bay of Fundy in August. Our observations and acoustic detections are consistent with the known migration time periods. Between mid-January and mid-March 2009, North Atlantic right whale calls were detected on the pop-up located 21.4 km (11.6 NM) from shore. All North Atlantic right whale sightings in the Study Area were recorded within 32 km (17 NM) from shore, and high densities of endangered marine mammals were predicted throughout the Study Area between 2 and 37 km (1 and 20 NM) from shore. These distances from shore are consistent with a review of previous sightings data collected in the mid-Atlantic that found that 94% of all sightings of North Atlantic right whales were within 56 km (30 NM) from shore (Knowlton et al. 2002).

The seasonal movement patterns of North Atlantic right whales are well-defined along the U.S. Atlantic coast; however, not all individuals adhere to these patterns and the seasonal distribution of these individuals is unknown. For example, a majority of the population is not accounted for on the breeding/calving grounds during winter, and not all reproductively-active females return to these grounds each year (Kraus et al. 1986). Some individuals, as well as cow-calf pairs, can be seen throughout the fall and winter on the northern feeding grounds with feeding observed (e.g., Sardi et al. 2005), and about half of the population may reside in the Gulf of Maine between November and January based on recent aerial survey data (Cole et al. 2009). Right whale sightings and acoustic detections in the Study Area provide additional evidence of occurrence outside of the typical seasonal migration periods. Although actual feeding could not be confirmed during our survey, the January 2009 sighting of two adult males exhibiting skim feeding behavior off Barnegat Light suggests that feeding may occur outside the typical feeding period of spring through early fall and in areas farther south than the main feeding grounds (Winn et al. 1986; Gaskin 1987; Hamilton and Mayo 1990; Gaskin 1991; Kenney et al. 1995). Acoustic detections of North Atlantic right whale calls confirm the occurrence of this species in the Study Area during all seasons with a peak number of detection days in March through June. The documented detections and sightings of North Atlantic right whales in the Study Area suggest that some individuals occur in the nearshore waters off New Jersey either transiently or regularly.

Due to the low number of sightings recorded during the study period, no estimates of abundance could be generated for this species. The pooled year-round abundance of endangered marine mammals, including North Atlantic right whales, in the Study Area was three individuals which should be considered an underestimate due to perception bias and availability bias for large whales which can make long dives; however, based on the migratory nature of this species, a low abundance of this species could be expected for the Study Area, particularly if the North Atlantic right whales mainly use the nearshore waters of New Jersey as a migratory corridor and are not spending a significant amount of time in the region. This estimate is also reasonable due to the low overall abundance (438 individuals) of this stock of North Atlantic right whales (NARWC 2009). Based on the endangered status and low overall abundance of this species, the detection of even one right whale in the Study Area is an important occurrence. We recommend the inclusion of nearshore waters off New Jersey in future North Atlantic right whale studies to better understand the importance of these waters to this species, particularly during the winter months when migrating individuals and possible feeding were documented in the Study Area.

Humpback Whale

Humpback whales were recorded in the Study Area during all seasons. Seven of the 17 sightings were recorded during the winter when many individuals are known to occur on breeding/calving grounds in the West Indies (Whitehead and Moore 1982; Smith et al. 1999; Stevick et al. 2003). Our winter sightings are consistent with other observations of this species in mid- and high latitudes during this time of year (Clapham et al. 1993; Swingle et al. 1993; Charif et al. 2001). Humpback whales could not be acoustically detected during our study period because of the lack of call detection software for this species which has highly variable vocalizations.

Humpback whale feeding grounds are typically over shallow banks or ledges with high sea-floor relief (Payne et al. 1990; Hamazaki 2002). The main feeding locations off the northeastern U.S. are north of the

Study Area in waters off Massachusetts, in the Gulf of Maine, in the Bay of Fundy and surrounding areas (CETAP 1982; Whitehead 1982; Kenney and Winn 1986; Weinrich et al. 1997). There are documented feeding areas for this species south of the Study Area near the mouth of Chesapeake Bay, as well (Clapham et al. 1993; Swingle et al. 1993; Wiley et al. 1995; Laerm et al. 1997; Barco et al. 2002). The lunge feeding behavior observed by one individual humpback whale in September indicates that New Jersey nearshore waters may also be an alternate feeding area for this species. This humpback whale was lunge feeding in the vicinity of an individual fin whale; multi-species feeding aggregations that include humpback whales have also been observed over the shelf break on the southern edge of Georges Bank (CETAP 1982; Kenney and Winn 1987) and in shelf break waters off the U.S. mid-Atlantic coast (Smith et al. 1996).

An abundance estimate for the humpback whale in the Study Area was generated using the pooled detection function for the endangered marine mammals group. The year-round abundance of this species was estimated at one individual; however, this should be considered an underestimate due to perception and availability bias (i.e., diving). The humpback whales occurring in the Study Area are most likely part of the Gulf of Maine stock. In fact, one individual photographed in the Study Area in August 2009 was previously sighted in the Gulf of Maine the year before. Due to the migratory nature of the humpback whale, the relative low estimated abundance in the Study Area is not unexpected.

Fin Whale

The fin whale was the most commonly-detected baleen whale species in the Study Area during the study period. This is the most commonly sighted large whale in shelf waters of the U.S. north of the mid-Atlantic region (CETAP 1982; Hain et al. 1992; Hamazaki 2002). Fin whales were visually detected in the Study Area during all seasons which is consistent with previous sightings of fin whales year-round in the mid-Atlantic region (CETAP 1982; Hain et al. 1992). Fin whale pulses and downsweeps were detected in every month of acoustic monitoring during this baseline study. Fin whales are believed to follow the typical baleen whale migratory pattern consisting of movement between northern summer feeding grounds and southern winter breeding/calving grounds (Clark 1995; Aguilar 2009); however, not all individuals in the western North Atlantic stock undergo this seasonal migration (Aguilar 2009). Our year-round sightings and acoustic detections further support the occurrence of fin whales in this region outside of the typical migratory periods.

Habitat prediction models demonstrate that preferred fin whale habitat in the mid-Atlantic includes the nearshore and shelf waters from south of the Chesapeake Bay north to the Gulf of Maine (Hamazaki 2002). Relatively high densities of fin whales were predicted throughout most of the Study Area including in waters as shallow as 12 m (39 ft) and very close to shore (2 km [1 NM]). The year-round estimated abundance (two individuals) is low for the Study Area; however, abundance should be considered an underestimate due to perception and availability bias in large whales (i.e., whales making long dives are not available for detection at the surface). The occurrence of fin whales in the Study Area is important due to the endangered status of this species. In addition, the occurrence of a fin whale calf with an adult in August 2008 suggests that nearshore waters off New Jersey may provide important habitat for fin whale calves.

3.1.2.2 Non-Threatened or Endangered Marine Mammals

Minke Whale

Minke whales are most likely to occur in the mid-Atlantic region during winter, but this species is widespread in U.S. waters. Sightings of this species in the Study Area during winter are consistent with the known movement of minke whales southward from New England waters from November through March (Mitchell 1991; Mellinger et al. 2000). Occurrence of minke whales in New England waters increases during the spring and summer and peaks from July through September (Murphy 1995; Risch et al. 2009; Waring et al. 2009). The June sightings recorded during our study period may have been of individuals moving back to New England waters for the summer. Because only four sightings of minke whales were recorded during the study period, no abundance estimates could be generated for this species.

Bottlenose Dolphin

The bottlenose dolphin was the most frequently-sighted species in the Study Area. Although this species was sighted during all seasons, bottlenose dolphin distribution was highly seasonal with most sightings occurring during the spring and summer months, particularly May through August. These sightings data are consistent with the known seasonal distribution patterns of the coastal northern migratory stock of bottlenose dolphins which occur in waters from New York to North Carolina in the summer and are found from southern Virginia to Cape Lookout, North Carolina in the winter (CETAP 1982; Kenney 1990; Garrison et al. 2003; Hohn and Hansen 2009; Waring et al. 2009; Toth et al. in press). Based on our sightings data, bottlenose dolphins move into the Study Area as early as the beginning of March and occur there until at least mid-October. The delphinid whistles detected between March and October are most likely of bottlenose dolphins. The estimated abundances of bottlenose dolphins in the Study Area during the spring (mostly June; 722) and summer (289 ship analysis, 1,297 aerial analysis) are comparable to the estimated abundance of the coastal northern migratory stock (7,789; Waring et al. 2009). A peak number of days (69) with delphinids whistle detections were also recorded during spring and summer. Only seven sightings were recorded during the fall/winter; therefore, abundance is likely much lower during this time of year when most of the coastal northern migratory stock is farther south off the coasts of Virginia and North Carolina. The seasonal occurrence of bottlenose dolphins off New Jersey is thought to be due to the presence of preferred prey species that also occur seasonally in New Jersey waters (Able and Fahay 1998; Gannon and Waples 2004).

Bottlenose dolphins are known to have a fine-scale distribution within the Study Area based on research by Toth-Brown et al. (2007) who found a significant break in the habitat usage of bottlenose dolphins in New Jersey’s nearshore waters (out to 6 km [3.2 NM] from shore). One group appeared to utilize waters within 2 km (1.1 NM) of the shore while the other group occupied waters outside of 2 km (1.1 NM) of shore. Due to limitations obtaining high quality photo-identification data during the baseline survey, this fine-scale distribution pattern was not evident from our results; however, our results emphasize the importance of New Jersey’s nearshore waters to bottlenose dolphins. Sightings were recorded close to shore (minimum 0.3 km [0.16 NM]), and peak densities were predicted in state waters (0 to 5.5 km [0 to 3 NM] from shore) off Atlantic City north to Brigantine and Little Egg Inlet during spring and farther north off Barnegat Light and Barnegat Bay during summer. Toth et al. (in press) identified higher levels of use and increased presence of young individuals in the very nearshore waters off Brigantine, just north of Atlantic City.

Several bottlenose dolphin sightings were also recorded in deeper waters (34 m [112 ft]) of the Study Area and farther offshore (maximum 38 km [21 NM] from shore), suggesting that their distribution within the Study Area is not limited to a particular depth range or distance from shore. High densities were predicted in some regions of the Study Area up to 28 km (15 NM) from shore in the spring and 36 km (19 NM) from shore in the summer. Predicted densities were more interspersed throughout the northern/southern range of the Study Area during summer, indicating that higher densities of bottlenose dolphins extend into the northern portion of the Study Area (north of Barnegat Light) during this time of year. Peak densities were predicted from the shoreline to 36 km (19 NM) offshore of Barnegat Light/ Barnegat Bay and along the federal/state boundary (5.5 km [3 NM] from shore).

Short-beaked Common Dolphin

The occurrence of this species in the Study Area was strongly seasonal; sightings were only recorded during fall and winter, specifically late November through mid-March. The short-beaked common dolphin was the only delphinid species sighted during the winter, except for one bottlenose dolphin sighting recorded in early March. Therefore, the delphinid whistles recorded from December through at least February were likely of short-beaked common dolphins. This occurrence pattern is consistent with the known seasonal movements of short-beaked common dolphins offshore of the mid-Atlantic in colder months (Payne et al. 1984; Jefferson et al. 2009; Waring et al. 2009).

Although short-beaked common dolphins primarily occur offshore (>37 km [20 NM]) in waters of 200 to 2,000 m in depth (656 to 6,562 ft; Ulmer 1981; CETAP 1982; Canadian Wildlife Service 2006; Jefferson et al. 2009), our sightings data support the occurrence of this species in shallower waters close to shore. Short-beaked common dolphins were sighted throughout the Study Area in waters 3 to 37 km (2 to 20 NM) from shore and 10 to 31 m (33 to 102 ft) in depth. Almost all of the sightings of delphinids recorded during winter were of short-beaked common dolphins. High densities of delphinids were predicted south of Barnegat Light during the winter. Peak densities were predicted in nearshore waters (0 to 5.5 km [0 to 3 NM] from shore) from Brigantine to Little Egg Inlet and 30 km (16 NM) offshore of Little Egg Harbor. Peak densities were also predicted between 21 and 32 km (11 to 17 NM) from shore in the southeastern portion of the Study Area.

A winter abundance estimate was generated for this species using the pooled detection function of all delphinids during this season. The estimated abundance was 82 individuals; this estimate may be high due to the attraction of delphinids to the ship (e.g., bowriding); however, because perception and availability bias were not accounted for, the abundance estimate should be considered underestimated. Only eight short-beaked common dolphin sightings were recorded during the fall. Although abundance estimates could not be generated for this season, the abundance of this species is expected to be lower during this time of year. No sightings of short-beaked common dolphins were recorded during spring or summer. Although this species has been recorded near the Study Area during these seasons (CETAP 1982; Canadian Wildlife Service 2006), abundance in the Study Area is expected to be very low during this time of year.

Harbor Porpoise

Harbor porpoise distribution in the western North Atlantic is seasonal, and New Jersey waters are a known important habitat for harbor porpoises from January through March (Westgate et al. 1998). The sightings of harbor porpoises recorded during the study period support this statement with over 90% of sightings recorded during winter (mainly February and March). Few sightings were also recorded in April, May, and July which indicates that this species could occur in the Study Area during other times of the year. No harbor porpoise sightings were recorded during the fall surveys; however, weather conditions were often above a Beaufort sea state (BSS) of 2 which makes sighting this species very difficult. The densest concentrations of harbor porpoises are thought to occur from New Jersey to Maine from October through December (NMFS 2001a). Therefore, harbor porpoises are likely to occur in the Study Area throughout the fall. Due to the low number of sightings throughout the year, an abundance estimate for the harbor porpoise could only be generated for the winter. The winter abundance of harbor porpoises in the Study Area was estimated at 98 individuals. Abundance is likely underestimated due to this species' known responsive movement away from ships and perception and availability bias (Barlow 1988; Polacheck and Thorpe 1990; Palka and Hammond 2001).

Harbor porpoises are known to occur most frequently over the continental shelf and are most often found in waters cooler than 17°C (Read 1999). Sightings data from the study period provide support for these habitat associations of the harbor porpoise. Sightings of this species were recorded between 1.5 and 37 km (1 and 20 NM) from shore in waters ranging from 12 to 30 m (39 to 98 ft). SSTs for the harbor porpoise ranged from 4.5 to 18.7°C (40.1 to 65.7°F) which is just slightly higher than the typical maximum SST of 17°C (Read 1999). High densities of harbor porpoises were predicted in the center of the Study Area between 39°04'10"N and 39°45'34"N and between -74°26'41"W and -73°53'36"W. Peak densities were predicted between 5.5 and 15 km (3 and 8 NM) from shore and also 34 km (18 NM) from shore north of Brigantine.

Harbor Seal

Only one harbor seal was recorded in the Study Area during the study period. This seal was sighted in shallow waters east of Little Egg Inlet in June. Other unidentified pinnipeds recorded near Ocean City in April were likely also harbor seals but could not be confirmed. Harbor seals regularly haul out near Great Bay inshore of the Study Area and along the northern shore of the New York Bight, including Sandy Hook and the coasts of Rhode Island, Connecticut, and Massachusetts (Payne and Selzer 1989; Barlas 1999;

Schroeder 2000; DeHart 2002; Di Giovanni et al. 2009; Antonucci et al. n.d.). The harbor seal observed in June was likely from one of these haulout regions. No haulout sites were detected along the beach adjacent to the Study Area during the shoreline aerial surveys. Although harbor seals could be found in the Study Area during any time of year, they are known to make seasonal movements in New Jersey waters during the winter (Slocum et al. 1999). Although no sightings of harbor seals were confirmed in the Study Area during winter, one probable harbor seal was sighted south of the Study Area near Lewes, Delaware, where the survey vessel was docked in March 2008.

3.1.2.3 Sea Turtles

Leatherback Turtle

Leatherback turtles have a seasonal occurrence in the mid-Atlantic; they are most common off the mid-Atlantic and southern New England coasts in the spring and summer (CETAP 1982; Shoop and Kenney 1992; Thompson et al. 2001; James et al. 2006). All 12 sightings of this species were recorded in the Study Area during summer. Sightings were recorded in deeper, offshore waters of the Study Area ranging from 10 to 36 km (5 to 19 NM) from shore and water depths of 18 to 30 m (59 to 98 ft). Leatherbacks foraging in the western North Atlantic are known to associate with waters between 16 to 18°C (60 to 64°F; Thompson et al. 2001; James et al. 2006), and SSTs between 10 to 12°C (50 to 54°F) may represent the lower thermal limit of this species (Witt et al. 2007). The sightings recorded during the study period had a mean SST of 19.0°C (66°F) which is only slightly higher than the preferred SST for foraging leatherbacks; the lack of sightings during the colder months is consistent with this species preference for warmer SST. Abundance of leatherback turtles in the Study Area is unknown because abundance estimates could not be generated for this species.

Loggerhead Turtle

Loggerhead turtle occurrence along the U.S. Atlantic coast is strongly seasonal. Although sightings are recorded in mid-Atlantic and northeast waters year-round, loggerheads occur mainly north of Cape Hatteras between May and October (CETAP 1982; Lutcavage and Musick 1985; Shoop and Kenney 1992). Loggerheads sighted during the study period were consistent with this seasonal occurrence pattern; sightings were recorded between June and October. The mean SST associated with these sightings was 18.5°C (65.3°F) which is within the preferred SST range for this species (13° to 28°C [55° to 82°F]; Mrosovsky 1980). Sightings were recorded throughout the Study Area from 1.5 to 38 km (1 to 21 NM) from shore and in water depths ranging from 9 to 34 m (30 to 112 ft). Due to difficulties in measuring the perpendicular distances of the loggerhead sightings from the aerial survey tracklines, abundance estimates could not be generated for the Study Area.

3.1.3 Fish and Fisheries Results

3.1.3.1 Commercial Fisheries

Fish and fisheries are among the most important and economically valuable natural resources to the State of New Jersey. In terms of economic value, the total value of commercial fisheries landed in New Jersey from 2003 through 2007 was nearly one billion dollars; however, the actual value to the region is likely far greater in terms of the jobs, goods, and services associated with these fisheries. In 2007, commercial fisheries in New Jersey ranked eighth in value and tenth in landings in the U.S.[13] The top 5 commercial species landed in New Jersey during this five-year period were Atlantic surfclam, Atlantic sea scallop, ocean quahog, goosefish (monkfish), and summer flounder. Within the Study Area, the clam dredge, targeting Atlantic surfclam and ocean quahog, is the primary commercial fishing gear utilized in terms of value and landings (43%). The Atlantic surfclam is the primary landed commercial species, whereas the Atlantic sea scallop is the most economically valuable species.[13]

3.1.3.2 Recreational Fishing Locations

Recreational fishing within and adjacent to the Study Area is an important social and economic activity. The annual number of angler trips in New Jersey from 2003 through 2007 ranged from 6.5 million in 2004 to 7.4 million in 2007. According to NMFS (MRIP), the primary species landed from 2003 to 2007 was summer flounder. Summer flounder represented 40.8% of the total landings, while bluefish and black sea bass represented 18.9 and 18.2%, respectively.[14] There are numerous fishing hotspots (143 – see **Volume IV: Figure 3-18**) with 57% of these located in the southern half of the Study Area. These areas consist of structural features, such as shoals, ridges, lumps, banks, shipwrecks, and reefs (artificial and natural: rocks). Each of these structural features provides prime fishing sites for anglers targeting specific species, such as Atlantic striped bass and bluefish around shoals; bluefish and flounder near ridges; and black sea bass and tautog around shipwrecks/reefs (Saltwater Directions 2003c; 2003b; 2003a). In addition, the New Jersey Artificial Reef Program is one of the largest on the East Coast consisting of over 1,000 reefs and 100 vessels dispersed among 15 ocean sites of which 9 sites are located within the Study Area (NJDEP 2008a). Organized fishing tournaments are popular public events that take place within or in the vicinity of the Study Area.[18,19,20]

3.1.3.3 New Jersey Fisheries Independent Monitoring Data

The Study Area also provides important habitats to many juvenile fish and invertebrates having economic and ecological importance. Trends in these juvenile fish and invertebrate populations were analyzed by utilizing the ocean trawl data (New Jersey OSA survey program) from 2003 to 2008. New Jersey Fisheries independent monitoring program provided information on the spatial and temporal variability of the fish community in the Study Area (NJDEP 2009). Data were compiled and sorted into two separate groups according to landings (i.e., top 10 species numerically collected) and economic value (i.e., top 5 species [$US]). According to the New Jersey OSA defined strata (areas 15 to 23: see **Volume IV: Figure 4-1**), it was demonstrated that the coastal fishery landings within the Study Area are equally important numerically to juvenile butterfish, scup, squid, and Atlantic herring and economically to squid. Numerically, scup was the dominant fishery in 2003, squid in 2004 and 2005, and butterfish from 2006 to 2008. Economically, squid was dominant from 2003 to 2008. Summer and fall were the most important seasons in terms of relative juvenile fish abundance, while winter and spring the least important. Summer was dominated numerically by butterfish, spring and fall by Atlantic herring and scup, and winter by Atlantic herring, with squid economically dominating both summer and fall. Juvenile butterfish abundance was widely distributed and numerically dominant in 56% of OSA defined areas. In summer, butterfish abundance was highest in areas 16 and 19 and scup and squid abundance highest in areas 17 and 23, respectively. Atlantic herring abundance was highest in area 22. Economically, the squid abundance was highest in all areas in the summer except areas 18 and 21, which were the most diverse areas within the Study Area (NJDEP 2009).

3.1.3.4 Essential Fish Habitat

Marine resources (fish and invertebrates) that are found within the Study Area are managed through an elaborate process that includes the State of New Jersey, Fishery Management Councils (FMCs), ASMFC, and NMFS. The Magnuson-Stevens Fishery Conservation and Management Act (MSFMCA), as amended by the Sustainable Fisheries Act (SFA), requires the identification and description of EFH in the fishery management plans (FMPs) and the consideration of actions to ensure the conservation and enhancement of such habitat. The EFH regulatory guidelines (50 Code of Federal Regulations [CFR] 600.815) state that NMFS should periodically review and revise EFH, as warranted, based on available information.

On June 12, 2009, NMFS announced the availability of a final integrated EIS and Amendment 1 to the 2006 Consolidated Atlantic HMS FMP pursuant to the National Environmental Protection Act (NEPA) that amended the existing EFH identifications and descriptions for 44 managed (NMFS 2009b). Currently, 14 managed HMS species occur within the Study Area. Updated EFH descriptions and maps for all 14 species are described in **Volume IV: Appendix A** and illustrated in **Figures A-25** through **A-38**.

In addition to the updated EFH for the Atlantic HMS managed by NMFS, both the NEFMC and the MAFMC are also in the process of proposing changes to the EFH components of the FMPs under their jurisdiction (NEFMC 2007; MAFMC 2010). Approval of the updated textual descriptions and geographical identifications of EFH may result in changes to the EFH designations for some of the current species and/or add new (i.e., juvenile Atlantic sea scallop) species in the Study Area.

3.1.3.5 Federal Protected Species

Within or near the vicinity of the Study Area, there are various fish species found that are either protected by the federal government (e.g., USFWS and NMFS) and/or State of New Jersey.[16,21] Although the endangered shortnose sturgeon is the only federally listed fish species that may be found in the vicinity of the Study Area (i.e., Delaware River), there are also no known shortnose sturgeon populations in the rivers between the Hudson and Delaware rivers (NMFS 1998). This species is not known to make coastal migrations (Dadswell et al. 1984). In addition, there are five species of concern (alewife [*Alosa pseudoharengus*], blueback herring [*Alosa aestivalis*], dusky shark [*Carcharhinus obscures*], sand tiger shark [*Carcharias taurus*], and barndoor skate [*Dipturus laevis*]) and one candidate species found within or in the vicinity of the Study Area. The migratory Atlantic sturgeon, a candidate species, commonly aggregates in shallow (10 to 50 m [32.8 to 164.1 ft]) near shore areas within the Study Area (Stein et al. 2004; Atlantic Sturgeon Status Review Team 2007). NMFS is currently preparing a determination on whether listing the species or multiple DPSs of the Atlantic sturgeon as threatened or endangered is warranted (NMFS 2010).