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Spatial Distribution, Abundance, and Flight Ecology of Birds in Nearshore and Offshore Waters of Rhode Island

Interim Technical Report for the Rhode Island Ocean Special Area Management Plan 2010

by

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Executive Summary

This interim report for the Rhode Island Special Area Management Plan (SAMP) summarizes our research conducted from January 2009 through mid-February 2010. This research is the first attempt to quantify the spatial distribution and abundance of birds using the nearshore and offshore waters of Rhode Island. Avian research is still ongoing, with ship-based line transect surveys and land-based seawatches continuing from Feb through July 2010. In addition, aerial surveys are planned to continue from Feb 2010 through May 2011. Results from this ongoing research will be presented in another technical report in 2011.

Our objectives for avian research as part of the Ocean Special Area Management Plan (SAMP) were to: (1) Summarize historical studies of avian use of nearshore and offshore waters within Ocean SAMP study area boundaries, (2) Assess seasonal variation in the spatial distribution and abundance of birds in RI nearshore and coastal waters, (3) Assess diel patterns of avian use of RI nearshore and offshore waters, (4) Quantify flight ecology for birds in RI nearshore and offshore waters, and (5) Investigate Roseate Tern use of the Ocean SAMP study area.

The Ocean SAMP study area encompasses 3,800 km^2 (about 1,500 miles^2) that includes Block Island Sound, Rhode Island Sound, and the Inner Continental Shelf. One of the primary factors determining the spatial distribution and abundance of birds using nearshore and offshore areas is bathymetry. Water depths in the Ocean SAMP study area are relatively deep compared to adjacent areas and average 35 m ± 10 m deep, with 8% of the SAMP area <20 m deep and 86% of the area between 20-50 m deep.

Prior to the current Ocean SAMP avian study, only two systematic surveys of offshore avian communities had been conducted within the Ocean SAMP area. First, avian observers stationed on National Marine Fisheries Service (NMFS) and Coast Guard vessels in 1978-79 detected 4,532 birds in 665 different flocks and 21 bird species. Gulls [38% of detections], shearwaters [26%], and storm-petrels [13%] dominated NMFS surveys. Second, the largest historical offshore survey was the Cetacean and Seabird Assessment Program (CSAP) conducted from 1980 to 1988. CSAP surveyed 101 15-min transects throughout the year using Manomet Bird Observatory observers stationed on vessels conducting plankton, groundfish, and shellfish surveys. CSAP surveys detected 34 species of birds from a total of 14,045 detections, with gulls (69% of detections), shearwaters (16% of detections), and storm-petrels (6% of detections) dominating counts. However, data were too sparse to map the historical spatial distribution and density of birds in the Ocean SAMP study area.

Much more historical information about avian use of nearshore habitats of Narragansett Bay, coastal promontories and peninsulas, and coastal ponds is available from surveys conducted by DEM biologists, volunteers coordinated by EPA, and biologists from US Fish and Wildlife

Service's Rhode Island National Wildlife Refuge complex. Narragansett Bay is home to thousands of wintering waterfowl, with an average of 21,256 ± 12,051 (SD) individuals counted annually, with a maximum of 58,706 individuals in 2001. The most abundant species in the Narragansett Bay based on DEM aerial surveys over the past 27 years included scaup (mean = 6,600 individuals ± 5100 (SD) annually), Canada Geese, (6,300 ± 5400), American Black Duck (2,200 ± 1200), and Common Eider (1250 ± 3000).

Exposed promontories along the coast, such as Sachuest Point NWR, were surveyed by USFWS biologists in the winters from 1992-2003. These areas were dominated by seaducks including Common Eider (560 ± 880 annually), Surf Scoter (110 ± 130), Harlequin Ducks (80 ± 16), and Common Goldeneye (90 ± 30). Surveys conducted throughout the year by DEM biologist C. Raithel at Napatree from 1982 to the present provide valuable information on migration phenology and relative abundance of birds in the northwest corner of the Ocean SAMP area.

Coastal ponds, such as Trustom and Ninigret NWR, have been surveyed during winter by USFWS biologists since 1992. The abundance of dabbling ducks (e.g., American Black Duck, Mallard, American Wigeon, Green-winged Teal and Gadwall) and diving ducks (Greater and Lesser Scaup, Canvasback, Ring-necked Duck and Ruddy Duck) in these coastal ponds demonstrate the value of these habitats for wintering waterfowl.

We used five primary survey methods to assess avian use of the Ocean SAMP area: (1) six 1-2 hr land-based seawatches (≤ 3 km from shore) per month at 11 stations along coastal mainland Rhode Island from 23 Jan 2009 to mid-Feb 2010; (2) systematic ship-based line-transect surveys approximately once a month from February to May 2009 on two 4 by 5 nm grids and then approximately four times per month from June 2009 until March 2010 on eight 4 by 5 nm grids; (3) aerial strip-transect surveys (24 transects, 3 km apart) flown from November 2009 to March 2010 at a fixed altitude of 152 m and at a constant speed of 160 km/hr; (4) boat-based line transect surveys in nearshore waters in the NW corner of the Ocean SAMP area conducted during July and August 2009 to assess the distribution and abundance of Roseate Terns; and (5) a study by ornithologists from New Jersey Audubon Society using both a dual horizontial and vertical radar unit on Block Island to monitor the movement ecology of birds from March to mid-December 2009, 24 hrs per day, 7 days per week (see Appendix K).

We conducted 796 1-2 hr land-based seawatches during this 13-month period. We had 465,039 detections of 121 species during land-based seawatches. The most commonly detected species were scoters, eiders, Herring Gulls, and Great Black-backed Gulls (all scientific names are given in Appendix A). From these data, we were able to assess spatial variation the relative abundance of birds and to model the phenology of common waterbirds using the Ocean SAMP study area.

We conducted 54 ship-based line transect surveys of 8 grids on 27 days between 10 June 2009 and 13 February 2010. We detected 56 species during these surveys, of which 11 species were relatively common: Herring Gull, Wilson’s Storm-Petrel, Northern Gannet, Great Black-backed Gull, Cory’s Shearwater, Common Loon, Greater Shearwater, Black-legged Kittiwake, Razorbill, Common Murre, and Dovekie. Using program DISTANCE, we estimated the seasonal change in the spatial distribution and density of these common species.

We conducted 10 aerial surveys between 18 November 2009 and 22 February 2010. During aerial surveys, we had 9,414 detections of 17 species or guilds, of which the following were most common: Common Eider, unidentified gulls, Northern Gannet, Herring Gulls, unidentified scoters, Common Loon, and unidentified alcids. We compared these data to the spatial distribution and density estimates for common species from the ship-based line transect surveys and developed bathymetry profiles for select species.

We had 125 Roseate Tern detections during land-based point counts, with most detections at the NW corner of the Ocean SAMP study area. We had 8 Roseate Tern detections on 3 ship-based line transect grids in Block Island Sound, but we did not detected Roseate Terns in Rhode Island Sound or the Inner Continental Shelf during ship-based surveys.

Highlights for avian guilds include:

Loons: Both Common and Red-throated Loon are abundant species during winter months in the Ocean SAMP area. Estimates of the number of Common Loons wintering in the Ocean SAMP area (2,901 individuals (95% CI = 2535-3321), suggest this area provides critical wintering habitat for a significant number of loons. In 2009, an estimated 5,400 adult loons were nesting in New York, Vermont, New Hampshire, Massachusetts, and Maine (NE Loon Study Group, pers. comm.). Therefore the Ocean SAMP area supports the equivalent of 54% of the Northeast loon breeding population during the winter. We primarily detected loons in nearshore waters that are <35 m deep, but some loons were documented in deeper offshore waters of Rhode Island Sound.

Grebes: Two species were observed, Horned and Red-necked Grebe, wintering in the Ocean SAMP area. Both species generally occurred only in nearshore areas.

Shearwaters: Four migratory species were detected in offshore waters from May through August, with two species seasonally abundant (Cory’s and Greater Shearwaters). Cory’s Shearwater was more likely to venture into nearshore areas, but peak densities for both species occurred in southern, central sections of Rhode Island Sound. On average 3,350 (95% CI = 3005-3712) Greater Shearwaters and 2,643 (1979-3530) Cory’s Shearwaters occur in the Ocean SAMP study area from May through August. Since we could not estimate the passage rate of shearwaters through the area, we could not calculate the total number of birds using the Ocean

SAMP area during the summer of 2009. However, tens of thousands of shearwaters likely migrate through and forage in the SAMP study area.

Storm-Petrels: We detected two species, Wilson's and Leach's Storm-petrel, of which only Wilson's Storm-Petrel was abundant. These migratory, pelagic species are found in deep, offshore sections of the Ocean SAMP study area throughout the summer, with peak numbers in July. We estimated 16,335 Wilson's Storm-Petrel (95% CI = 10,879-24,527) were within the Ocean SAMP study area on an average day in summer. We do not know passage rates of this species in the Ocean SAMP study area, thus were unable to estimate the total number of Wilson's Storm-Petrels that used the area during summer 2009. However, this species is one of the most abundant birds in the world and it is conceivable that tens of thousands of Wilson's Storm-Petrels pass through the Ocean SAMP study area every summer.

Gannet: Northern Gannets are a common spring and fall migrant through the Ocean SAMP study area. This piscivorous specialist tends to occur in areas where water depths were >30 m deep. In addition, gannets tended to be concentrated around active fishing vessels in the western half of the study area. Gannet densities peaked in a zone approximately 3 miles offshore from Block Island and mainland Rhode Island in both fall and winter. We estimated an average density of 4,474 individuals during days in winter (95% CI = 3688-5187), however we do not know passage rates of gannets, so were unable to estimate the total number of gannets using the area.

Cormorants: We detected two species of cormorant that were both restricted to nearshore habitats. Double-crested Cormorants are an abundant local breeding species (>2,000 nesting pairs in Narragansett Bay), with thousands of individuals migrating along the coast in fall. Great Cormorants are much less abundant during the winter months.

Waterfowl: We detected two species of swans (Mute and Tundra), two species of geese (Canada Goose and Brant), seven species of dabbling ducks (Wood Duck, Mallard, American Black Duck, Gadwall, Northern Pintail, American Wigeon, and Green-winged Teal), and one species of bay duck (Greater Scaup) during fieldwork, all of which were associated with nearshore habitats along coastal mainland Rhode Island.

Seaducks: Eiders, scoters, and related species were among the most abundant birds we observed using nearshore habitats during the winter months. The most common species we observed included Common Eider, Surf, and Black Scoter. We documented substantial interannual variation in scoter and eider abundance during land-based seawatches, with fewer birds in the area in 2009-10 when ship-based line transect surveys and aerial surveys were conducted. . We primarily detected seaducks in nearshore areas in the NE corner of Rhode Island Sound, the northern edge of Block Island Sound, and south and southwest of Block Island.

Previous research suggested that the primary foraging depths for seaducks was <20 m. We found seaducks were consistently foraging in waters up to 25 m deep in the SAMP study area. It is important to note that night time roosting locations of seaducks in the Ocean SAMP area are still unknown. We found that seaducks traveled offshore daily just before or after dusk to roost in deeper waters (1 to 5 km offshore), likely to avoid nearshore predators. A Surf Scoter satellite telemetry project being conducted by URI biologists in the winter of 2010-2011 will hopefully provide us with more insight regarding important roosting areas for seaducks.

Shorebirds: We documented four species of plover and 13 species of sandpipers, primarilyduring land-based seawatches. We had a few detections of six species of shorebirds during ship-based line transects. No shorebird species was detected frequently using any survey method because shorebirds mainly use nearshore and intertidal areas. We were unable to model their spatial distribution and density within the Ocean SAMP study area due to low detection rates.

Jaegers: We detected three species, but all species were rare (< 20 detections). We were only able to model their migration phenology. We were unable to model their spatial distribution and density within the Ocean SAMP study area due to low detection rates.

Gulls: We detected six gull species, of which two were local breeding species and the other species were migrants into the Ocean SAMP study area. Herring Gulls and Great Black-backed Gulls are two of the most abundant waterbirds utilizing the Ocean SAMP study area. During the summer, their movements appear to be restricted to nearshore habitats by nesting colonies. In summer, we estimated 1,454 individual Herring Gulls in the Ocean SAMP study area (95% CI = 1,246 – 1,697). For Great Black-backed Gulls, we estimated 1,869 individuals in summer (95% CI = 1,255 -2,786). During the fall, both species dispersed to offshore habitats and their numbers in the Ocean SAMP study area increased dramatically (7,332 individual Herring Gulls (6,000-8,961) and 2,680 individual Great Black-backed Gulls (2366-3036). By winter, their numbers declined dramatically to 1,082 individual Herring Gulls (1,042-1,124) and 682 Great Black-backed Gulls (627-743) estimated throughout the Ocean SAMP area.

Kittiwakes: Black-legged Kittiwakes are an offshore specialist that winter in the Ocean SAMP study area. They are primarily found far offshore in deeper water (>50 m deep). During winter, we estimated that a daily average of 291 (95% CI = 548-707) kittiwakes winter in the Ocean SAMP study area. We do not know the passage rate of kittiwakes through the area, so cannot estimate the total number of kittiwakes using the Ocean SAMP area.

Terns and skimmer: We detected seven species of terns and Black Skimmer during fieldwork, of which only Common, Least, and Roseate Terns were moderately common in nearshore areas. All terns were detected in the Ocean SAMP area only during summer months, with more birds in the area during the post-breeding season. Few terns were detected during ship-based line transect surveys, so we were unable to model their spatial distribution or density. We did detect small number of Roseate Terns, primarily in NW corner of Ocean SAMP, with a few detections around Block Island. One observer on Block Island detected moderate numbers of Roseate Terns on the Island during post-breeding staging.

Alcids: We detected six species of alcids during fieldwork including Razorbills, Common and Thick-billed Murres, Atlantic Puffin, Black Guillemot, and Dovekie. All alcids are migrants that winter in the Ocean SAMP study area. Three of the species were rarely observed (Thick-billed Murre, Atlantic Puffin, and Black Guillemot), while the other three species were relatively common. We were able to model the spatial distribution and density of Razorbills, Common Murre, and Dovekie. These species exhibited spatial segregation in the Ocean SAMP study area, with Razorbills specializing in the northern sections that were shallower and closer to land, Common Murre tending to use the central latitudes of the area, while Dovekies were the offshore specialist that reached peak densities in the southern sections of Rhode Island Sound and the Continental Shelf. We were able to estimate average daily abundance for three alcids in winter: Razorbill averaged 1,390 individuals (95% CI = 996-1,940), Dovekie had an estimated 5,771 individuals (4,222-7,888), and Common Murre was the least abundant with 623 individuals (548 – 707). As with other migrants, we do not know passage rates of any of these species through the study area, so we were unable to estimate the total number of individuals using the Ocean SAMP study area during the winter of 2009-2010.

Landbirds and Passerines: During land-based seawatches, we detected 7 species of raptors and 27 other species of landbirds including Mourning Dove, Short-eared Owl, Chimney swift, Ruby-throated Hummingbird, Belted Kingfisher, Northern Flicker, a flycatcher, three species of jays and crows, Horned Lark, six species of swallows, a thrush, a pipit, a waxwing, three species of warblers, a bunting, three species in the blackbird family, and a goldfinch. However, with the exception of Tree Swallows, which are diurnal migrants along the coast, we detected very few songbirds or other types of landbirds during our land-based seawatches. During ship-based line transect surveys, we detected Mourning Dove and 7 species of songbirds (Bank and Tree Swallow; Blackpoll and Yellow-rumped Warbler; Dark-eyed Junco, Savannah Sparrow, and Snow Bunting). This is not surprising as most landbirds, particularly songbirds, are nocturnal migrants, and can therefore only be monitored by radar. We did have a radar unit on Block Island throughout 2009 and results from that research are included in an appendix to this interim report (see Appendix K).

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Abstract

This interim report for the Rhode Island Special Area Management Plan (SAMP) summarizes research conducted from January 2009 through mid-February 2010. This research is the first attempt to quantify the spatial distribution and abundance of birds using the offshore waters of Rhode Island. Avian research is still ongoing and will continue through at least May 2011. Our objectives were to: (1) Summarize historical studies of avian use of nearshore and offshore waters, (2) Assess seasonal variation in the spatial distribution and abundance of birds in RI nearshore and coastal waters, (3) Assess diel patterns of avian use of RI nearshore and offshore waters, (4) Quantify flight ecology for birds in RI nearshore and offshore waters, and (5) Investigate Roseate Tern use of the study area.

There are no similar avian studies within the Ocean SAMP boundaries, although avian offshore research has been conducted in continental shelf waters of the NE Atlantic Ocean. In addition, ongoing research along the coast, in coastal ponds, and in Narragansett Bay that we summarized provides valuable long-term baseline information for avian species that use nearshore habitats. We used five survey methods to assess avian use of the study area: (1) land-based seawatches at 11 stations along coastal mainland Rhode Island from 23 Jan 2009 to mid-Feb 2010 to survey birds out to 3 km offshore; (2) systematic ship-based line-transect surveys on up to 8 grids from February 2009 - March 2010; (3) aerial strip-transect surveys spaced at 3 km intervals perpendicular to the coast from November 2009 to March 2010; (4) boat-based nearshore line transect surveys for Roseate Terns from August 2009 to early September 2009; and (5) observations monitoring the movement ecology of birds 24 hrs per week, 7 days a week from March to mid-December 2009 using horizontal and vertical radars on Block Island.

We conducted 796 1-2 hr land-based seawatches and had 465,039 detections of 121 species. We used these surveys to model the phenology of common species and spatial variation to assess relative abundance. We conducted 54 ship-based surveys on 8 grids over 27 days and detected 56 species. We used these results in program DISTANCE to model the distribution and abundance of 11 common species that included loons, shearwaters, storm-petrels, gannets, gulls, and alcids in summer, fall and winter. During summer, we estimated 16,335 Wilson's Storm-Petrels (95% CI = 10,879-24,527) were using deeper sections of Rhode Island Sound and the Inner Continental Shelf. In winter, the average daily abundance of Common Loons (average = 2,901, 95% CI = 2535-3321) suggests the Ocean SAMP study area provides critical wintering habitat for loons. We also detected large number of alcids in winter (Razorbill =1,390 individuals [95% CI = 996-1,940], Dovekie = 5,771 individuals [4,222-7,888]), with strong evidence of spatial segregation among species in bathymetry preferences. During 10 aerial surveys, we had a total of 9,414 detections from 17 species or guilds. We used aerial survey results to verify spatial distribution patterns and to assess bathymetry preferences for various species. We occasionally detected Roseate Tern during land-based point counts in the NW corner of the Ocean SAMP study area, while we rarely observed Roseate Terns offshore. Once surveys are complete, we will use this quantitative information to aid the Ocean SAMP process in determining where various types of development can take place that would minimize impacts to avian populations.

1 Introduction

1.1 Ocean SAMP background and the scope this report.

This interim report summarizes avian research conducted for the Rhode Island Special Area Management Plan (SAMP) from January 2009 through March 2010. We will continue to collect original data from March 2010 to at least May 2011. Our goal for this preliminary summary of results is to present the results and identify patterns in the spatial distribution and abundance of birds in the Ocean SAMP study area that are evident from data collected for over one year (up to March 2010). We will provide a final analysis of land-based and boat-based surveys in an updated report in December 2010, and a full report of all surveys in a final report in mid 2011. What is lacking from this preliminary report is longer-term information on interannual variation in avian distribution patterns or movement ecology in the Ocean SAMP study area. Avian studies in Nantucket Sound associated with the Cape Wind offshore wind farm documented considerable interannual variation in the distribution of large flocks of various species of seaducks (Perkins et al. 2004, 2005). This is why it is important that we continue to conduct surveys over time so that an accurate baseline assessment of the distribution and abundance of birds is available for comparison with data collected before, during, and after proposed development projects.

The focus of this report is avian use of Rhode Island's offshore waters. Based on previous research primarily in Europe, birds are likely to be one of the taxonomic groups most affected by energy development (e.g., offshore wind farm development) through: (1) increased mortality from collisions, (2) displacement from used habitats, or (3) enhancement of existing habitats (JNCC 2004; Maclean 2006). Therefore, understanding avian abundance, spatial distribution, phenology and movement ecology in the Ocean SAMP study area is crucial. The scientific information summarized in this report provides essential biological data that will inform development of Ocean SAMP policy. Federal agencies such as the U.S. Fish and Wildlife Service and the U.S. Army Corps of Engineers, and state agencies including the R.I. Department of Environmental Management, will review this and other SAMP documents because these agencies are responsible for assessing potential impacts of offshore development on all wildlife, including birds. In addition, the public will have opportunities throughout the SAMP process to have input into SAMP documents and to shape policies.

Special Area Management Plans, or SAMPs, are federally recognized management and regulatory documents that promote ecosystem-based management, as well as coastal-dependent economic activity. Rhode Island's coastal management agency, the Coastal Resource Management Council (CRMC), is the state agency in charge of the SAMP process. CRMC has regulatory functions and is responsible for preserving, protecting, developing, and where possible, restoring the state's coastal resources.

CRMC has already worked with scientists, planners, and public stakeholders to create six Rhode Island SAMPs in nearshore waters. These SAMPs encompass a variety of uses from industrial ports to conservation areas. As with other SAMPs, the Ocean SAMP will define use zones for offshore waters using a research and planning process, with input from the public. Using the best available science from a variety of disciplines and open public input and involvement, the SAMP is an adaptive planning tool that promotes comprehensive ecosystem-based management. It is the intent of the SAMP to facilitate coordination between state and federal agencies and the people of Rhode Island.

The Ocean SAMP will make Rhode Island the first state in the nation to zone its offshore waters for diverse activities including renewable energy development. This process will also protect current uses and habitats through zones for commercial fishing; critical habitats for fish, marine animals, and birds; marine transport; and other important uses of offshore waters. This planning process involves data collection by scientists from a variety of disciplines, including biologists.

1.2 Description of the study area.

The Ocean SAMP study area encompasses about 3,800 km^2 that includes Rhode Island Sound, Block Island Sound, and the Inner Continental Shelf. The Inner Continental Shelf is defined as the area south of Rhode Island and Block Island Sounds that extends to the Continental Shelf Slope (Armsby 2010; Fig. 1). In the Ocean SAMP Ecology Chapter, Armsby (2010) effectively described the geological, physical, chemical, and biological oceanogeography of the Ocean SAMP region, thus we urge readers interested in an in-depth overview of any of these characteristics of the region to read the Ecology chapter. However, we describe below some of the key geological and physical features that likely affect the spatial distribution of avian populations within the Ocean SAMP.

Bathymetry is one of the primary physical features determining where many species of waterbirds roost and forage. The Ocean SAMP study area is characterized by shallow, nearshore continental shelf waters, with water depths averaging 34.9 m ± 9.9 (SD); about 8% of the area is <20 m deep and 86% is between 20-50 m deep (Fig. 2). The area is interconnected to Narragansett Bay, Buzzards Bay, Long Island Sound, and the Atlantic Ocean via the Inner Continental Shelf. Outflow from large freshwater rivers (e.g., Connecticut River) enter Block Island Sound via Long Island Sound, which affects the physical, chemical, and biological characteristics of the Ocean SAMP study area (Armsby 2010). A 15-25 m deep glacial end moraine extends from Montauk Point to Block Island, which partially buffers Block Island Sound from large wave impacts from the Continental Shelf. The deepest water of the Ocean SAMP study area is Block Channel (maximum depth of about 60 m), which is an undersea canyon between Block Island and Martha’s Vineyard formed by outflow from a glacial lake about 20,000 years ago (Uchupi et al. 2001) that now forms an underwater connection between Block Island Sound and the Inner Continental Shelf .

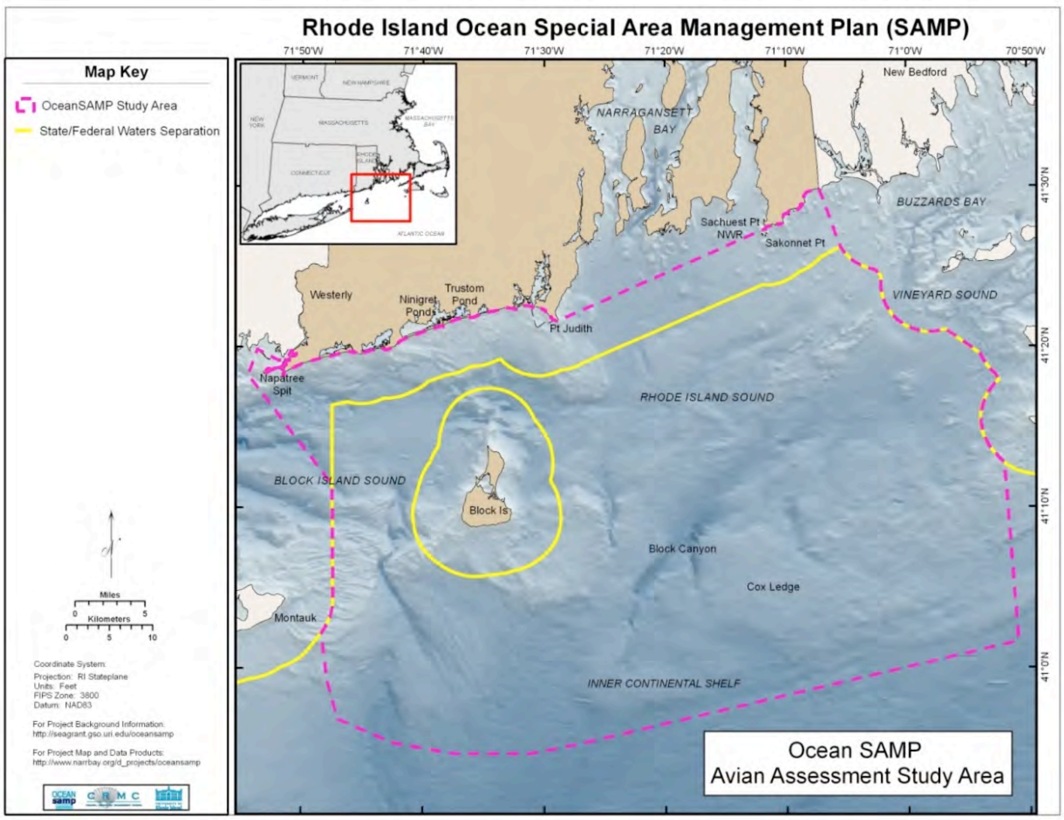

Fig. 1. Study boundaries for the Rhode Island Ocean Special Area Management Plan. Yellow line represents a boundary 3 miles offshore and in state waters, pink line is 16 miles offshore at its nearest point, hence in federal waters.

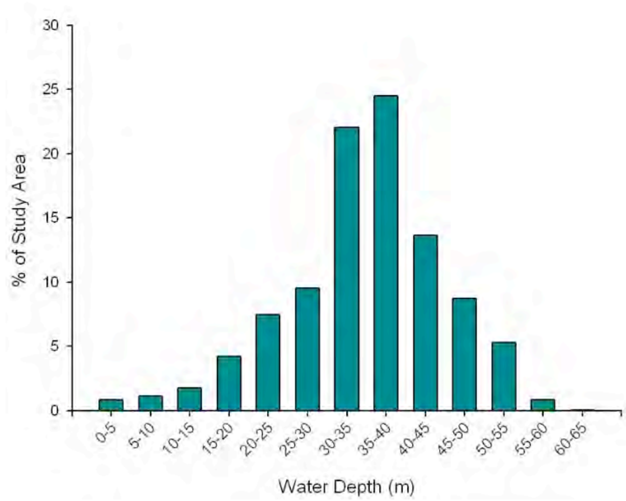

Fig. 2. Bathymetry of the Ocean SAMP study area based on 6500 uniformly distributed points placed within study area boundaries. Approximately 8% of the area is <20 m deep and 86% is 20-50 m deep.

Water temperatures in winter ranges from 3-6°C, with water on the bottom several degrees warmer than surface temperatures. In summer, water temperature ranges from 10-21°C, with surface temperatures 10°C warmer than bottom water. Thus, the water column tends to be stratified in the summer, while there is less stratification in the winter. During the summer, this stratification can reduce dissolved oxygen to levels that are detrimental to benthic marine fauna and the animals that eat them. During winter, the warmest waters occur offshore in the area around Cox Ledge, while the lowest temperatures occur next to mainland Rhode Island. In the summer, the warmest waters occur in northern and central Rhode Island Sound, while cool water from Long Island Sound makes western portions of the area cooler (Codiga and Ullman 2010).

The benthic community in the Ocean SAMP study area is dominated by tube-dwelling amphipod species, with bivalves, marine polychaete worms, and small crustaceans also common in the region. Some of these benthic species are important prey for a number of avian species including seaducks and other diving ducks during winter, as well as demersal fish. Unfortunately, there currently are no large-scale studies that have mapped the spatial distribution of the benthic community in the Ocean SAMP study area, nor are the habitat associations of various species of benthic fauna clearly understood. Thus, we know little about the spatial distribution patterns of the benthic community within the Ocean SAMP boundaries. We know even less about variation between years in abundance and distribution of benthic prey, which could be one of the main factors determining where seaducks forage annually.

The topography and composition of the seafloor within the Ocean SAMP study area is primarily the result of glacial processes. The seafloor has been subdivided into four depositional environments, which vary as a function of particle grain size: (1) depositional platform sand sheet [medium-grained sand], (2) cross-shore swaths [medium to coarse sand], (3) depositional gravel pavement [cobble gravel], and (4) glacial moraine [gravels to boulders]) (Boothroyd in prep). The glacial moraines are relatively static, while other depositional environments can be dynamic and move during storm events. In addition, upwelling, downwelling, and ocean currents, among other forces, can affect their characteristics and location.

Winds in the Ocean SAMP region tend to be diurnal during summer months. Dominant wind direction varies seasonally, with southwest winds in the summer and northwest winds in winter. Average wind speeds tend to be at least two times greater in winter. Northwest winds in winter can generate up to 7 m waves in Block Island Sound, which probably affects the local distribution of birds in the Ocean SAMP study area. Mean wave height in the area is 1.2 m, with most waves coming from a southerly direction. Tides in the Ocean SAMP study area are semi-diurnal (about twice per day) and have a range of about 1 m.

Water circulation patterns in the Ocean SAMP study area vary between Rhode Island Sound, Block Island Sound, and the Inner Continental Shelf. In general, water circulates from the SW to

SE in Rhode Island Sound. In contrast, outflow of fresher water from Long Island Sound causes shallow water to flow from west to east or south in Block Island Sound, while deeper water tends to flow from east to west (Codiga and Ullman 2010; Armsby 2010: Fig 2.13).

1.3 Research objectives

Most baseline investigations of seabird use of an area prior to construction of some major development occur for two or three years before construction in the seasons in which birds are most likely to be present in significant numbers (JNCC 2004; Maclean et al. 2006), although this obviously varies between projects. Several years of baseline information is needed because avian populations can fluctuate dramatically among years, as can the spatial distribution of preferred foraging habitat. Thus, multiple years of data are often needed to obtain a clear understanding of avian abundance, spatial distribution, phenology and movement ecology (Maclean 2006).

In New England, the largest concentrations of offshore birds occur in winter, although large numbers of some migratory birds (shearwaters, storm-petrels) use offshore habitats in the summer. There are no major seabird colonies located in the Ocean SAMP area (although there are wading bird, gull, cormorant, and tern colonies in adjacent nearshore waters in Narragansett Bay and in coastal Rhode Island; there is also a small wading bird colony on Block Island and some gulls also nest on Block Island). Thus, our avian monitoring efforts were primarily designed to assess the abundance and distribution of migrants and birds wintering in Rhode Island's offshore waters.

As Maclean et al. (2006) pointed out, baseline surveys conducted for at least two full seasons are needed to assess the seasonal abundance of birds and its annual variability (JNCC 2004; Kahlert et al. 2002, 2004). The principal methods used to assess habitat use by seabirds in relation to offshore wind farms are ship and aerial surveys (Innogy 2003), with land-based seawatches also used to assess the phenology of migration and abundance trends (e.g., Wynn and Yesou 2007).

Our objectives for assessing avian distribution and abundance for this Ocean SAMP include:

1) *Assess historical avian use of nearshore and offshore waters*. We conducted a thorough review of peer-reviewed literature that was pertinent to avian use of any part of the Ocean SAMP study area. We also summarized unpublished data obtained from local state and federal biologists that included surveys of birds in nearshore and offshore waters of Rhode Island.

2) *Assess seasonal variation in the spatial distribution and abundance of birds in RI nearshore and offshore waters*. We conducted a coordinated series of systematic land-based sea watches, ship-based line transect surveys on randomly placed grids, and aerial strip transect surveys that

enabled us to estimate bird distribution and abundance across the entire study area. All surveys were conducted monthly so that we could assess seasonal variation in the spatial distribution and movement ecology of birds throughout the study area.

3) *Assess diel patterns of avian use of RI nearshore and offshore waters*. We conducted land-based seawatches from dawn to dusk to determine how avian distribution and movements changed throughout the day in nearshore habitats. In addition, we stationed a radar unit on Block Island that monitored avian abundance throughout the day and night (24 hrs per day/7 days per week).

4) *Quantify flight ecology for birds in RI nearshore and offshore waters*. We gathered flight ecology information as part of all surveys and radar monitoring. During land-based seawatches, we recorded altitude and flight direction for all flying birds. During ship-based line-transect surveys, we also recorded altitude and flight direction for all flying birds. Radar data from Block Island included flight altitude, flight direction, and number of targets passing by the radar unit throughout each day and night from March to December 2009.

5) *Determine foraging and roosting sites for Roseate Terns*. The Roseate Tern is the only bird species regularly detected flying over the Ocean SAMP study area that is listed by the federal government as endangered. Piping Plovers occur within the Ocean SAMP study area, but are generally restricted to coastal beaches, with the exception of migratory periods. Thus, in addition to recording Roseate Terns during the standard monthly land-based and boat-based surveys, we also conducted additional land-based seawatches during late-summer that focused on the movement phenology of Roseate Terns in nearshore habitats. We also conducted additional boat-based line transect surveys during late-summer in nearshore waters from Point Judith to Napatree to investigate the spatial distribution, abundance, and foraging ecology of post-breeding Roseate Terns.

NOTE: Scientific names of all bird species mentioned in this report are given in Appendix A.

1.4 Review of Historical Data

1.4.1 Offshore surveys

We could not find any publications or reports that focused solely on avian use of offshore waters within either Block Island Sound or Rhode Island Sound. Most previously conducted systematic surveys that focused on Rhode Island birds have concentrated effort on nearshore habitats along mainland coastal Rhode Island, coastal ponds along the south shore, or within Narragansett Bay (see sections below). Two systematic ship-based bird surveys were conducted along the entire northeastern United States that recorded bird species and numbers within the RI Ocean SAMP study area. These ship-based surveys were conducted by US Fish and Wildlife Service observers on National Marine Fisheries Service (NMFS) and U.S. Coast Guard vessels during 1978 and 1979 (hereafter NMFS surveys). NMFS survey transects were recorded in 10-min periods from January 1978 through February 1980, with a total of 42 days of survey effort in the RI Ocean SAMP study area during 1978 (19 days of survey effort) and 1979 (23 days) (Table 1). NMFS surveys in the RI Ocean SAMP study area occurred throughout the year, with more surveys conducted in March, July, and November (Table 2).

Table 1. Number of days per year when ship-based surveys were conducted within the Ocean SAMP study area from 1978 to 1988 during NMFS and CSAP avian surveys (MBO 1988).

Year	Number of Surveys
NMFS	
1978	19
1979	23
Subtotal	42
CSAP	
1980	9
1981	10
1982	5
1983	12
1984	19
1985	12
1986	11
1987	15
1988	8
Subtotal	101

The other systematic offshore survey effort in Rhode Island was the Cetacean and Seabird Assessment Program (CSAP) conducted by observers from Manomet Bird Observatory (now the Manomet Center for Conservation Sciences). This unprecedented program was conducted for the Northeast Fisheries Science Center (NEFSC) of the National Marine Fisheries Service from 1980 to 1988. CSAP was designed to provide a quantitative assessment of the abundance and distribution of cetaceans, seabirds and marine turtles in the shelf waters of the northeastern United States. These data represent the largest, highest quality historical dataset for the northwest Atlantic U.S. waters (USGS 2010). There is no other dataset for the northeastern United States that includes observations of birds at this large spatial and temporal scale. A total of 101 survey days during 1980-1988 were conducted within Rhode Island waters, with 5 to 19 survey days in a given year (Table 1). These 101 surveys within the RI Ocean SAMP study area were distributed across months such that on average 8.4 surveys were conducted each month (Table 2).

During 42 days of NMFS surveys in the RI Ocean SAMP study area, observers detected 4,532 birds in 665 different flocks and documented 21 bird species (Table 3; Fig. 3). About 17.5% of all detections were not identified to species, but most observations were identified to at least a guild (e.g., unidentified loon). Although we were unable to standardize survey effort to develop quantitative abundance estimates of birds based on NMFS surveys, it appears that species that tend to be most common during summer months dominated their survey results because gulls (37.9% of detections), shearwaters (25.8%) and storm-petrels (13%) were the most common taxa detected. One of the most interesting species detected during these surveys was an unidentified albatross, which was probably a Yellow-nosed Albatross, as this is the only species of albatross to have been detected in Rhode Island waters (D. Ferren, unpubl. manuscript).

Table 2. Seasonal variation (number of days per month when surveys were conducted) in survey effort during NMFS and CSAP offshore ship-based surveys conducted from 1978-1988 within RI Ocean SAMP study area boundaries.

Month	**CSAP Number of surveys**	**NMFS Number of Surveys**
January	9	1
February	2	0
March	12	6
April	2	4
May	11	4
June	5	4
July	15	7
August	8	1
September	14	1
October	9	7
November	10	6
December	4	1
Total	**101**	**42**

Few alcids (i.e., puffins, Razorbills, murres, etc) were detected during NMFS surveys (43 detections, <1% of total detections), with only Razorbills identified to species. The paucity of alcid detections during NMFS surveys is not unexpected, as only 2 surveys were conducted from December through Feb, when alcids tend to be most common (see Alcid section below). Apparently the few offshore NMFS surveys that took place were in nearshore areas, as no deep water species (e.g., Common Murre or Dovekies) were detected.

During the nine years of CSAP surveys, observers recorded 34 species from a total of 14,045 detections of 1447 flocks (Table 3; Fig. 3). During CSAP surveys, gulls accounted for the majority of detections (6 species; 69.1% of all detections), while shearwaters (4 species; 15.7%), and storm-petrels (2 species; 6%) were the other most common taxa detected.

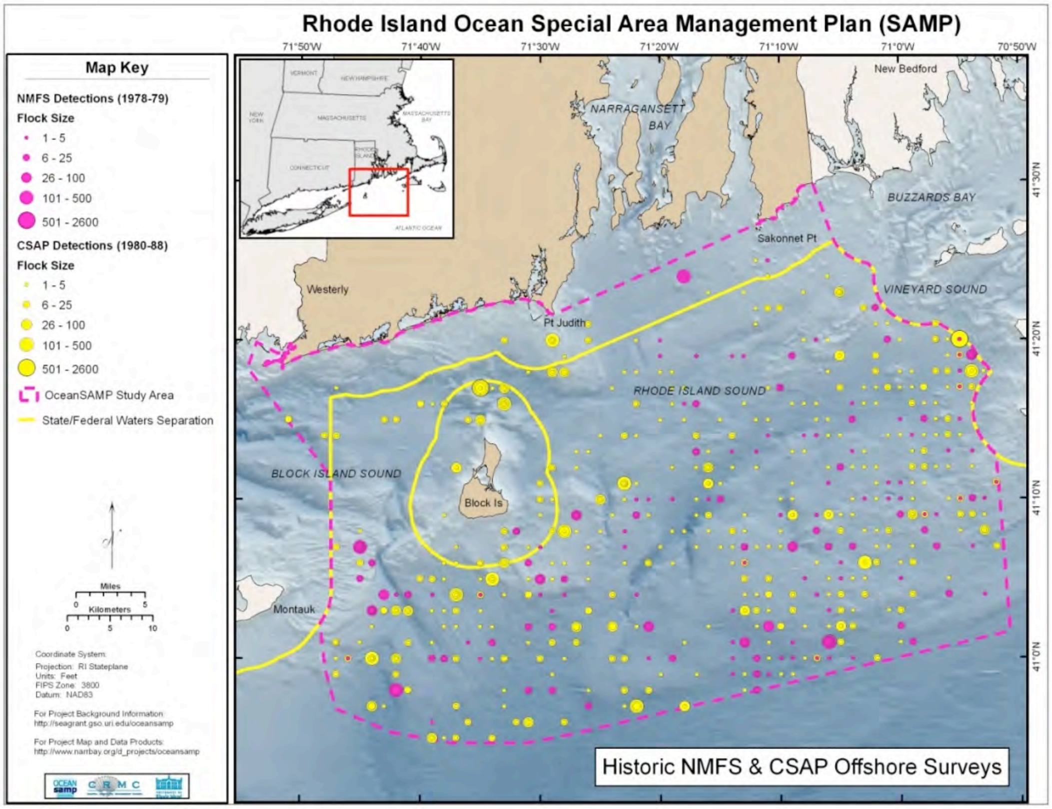

Fig. 3. Distribution of avian flocks detected during NMFS (1978-1979) and CSAP (1980-1987) offshore surveys within the RI Ocean SAMP study area. Both surveys encompassed offshore waters throughout the Northeast, thus these detections in the RI Ocean SAMP study area represent only a small fraction of the total number of birds detected during the all surveys. See Table 3 for a summary of species detected during these surveys.

Similar to NMFS surveys, alcids were rarely observed during CSAP surveys (4 species including Dovekie and Atlantic Puffin; 0.3% of all detections; Table 3). Although 15 survey days were conducted from December through February during CSAP, the paucity of alcid sightings (81 total detections in NMFS and CSAP datasets combined) in these historical datasets is somewhat puzzling because much of the sampling took place in offshore waters where alcids occur (Fig. 3). Because we could not determine survey effort within RI Ocean SAMP boundaries during NMFS and CSAP surveys, we cannot directly compare these historical datasets to our own ship-based results.

Table 3. Total number of detections and flocks recorded for 32 species of birds detected during CSAP and NMFS offshore ship-based surveys within the RI Ocean SAMP study area boundaries from 1978 to 1987 (MBO 1988). See Fig. 3 for locations of birds detected during these historical offshore surveys.

	CSAP 1980-1987			**NMFS 1978-1979**		
Species	**Birds**	**%detections**	**Flocks**	**Birds**	**%detections**	**Flocks**
Unidentified bird	0	0	0	208	4.59	2
Unidentified Loon	7	0.05	4	2	0.04	2
Common Loon	41	0.29	30	11	0.24	5
Red-throated Loon	14	0.10	8	0	0	0
Unidentified Albatross	0	0	0	1	0.02	1
Northern Fulmar	28	0.20	12	0	0	0
Unidentified Shearwater	150	1.07	12	23	0.46	5
Manx Shearwater	8	0.06	6	1	0.02	1
Greater Shearwater	1198	8.52	74	432	9.53	45
Sooty Shearwater	48	0.34	17	89	1.96	22
Cory's Shearwater	799	5.68	61	625	13.78	43
Unidentified storm-petrel	8	0.06	6	4	0.09	3
Wilson's Storm-petrel	796	5.66	66	587	12.95	35
Leach's Storm-petrel	32	0.23	10	1	0.02	1
Northern Gannet	781	5.56	160	135	2.98	51
Unidentified Cormorant	14	0.10	3	5	0.11	2
Double-crested Cormorant	204	1.45	6	70	1.54	2
Great Cormorant	9	0.06	3	2	0.04	1
Common Eider	56	0.40	2	0	0	0
Long-tailed Duck	5	0.04	2	0	0	0
Unidentified Scoter	0	0	0	120	2.65	3
White-winged Scoter	50	0.36	12	72	1.59	0
Surf Scoter	1	0.01	1	18	0.40	1
Unidentified Phalarope	1	0.02	1	18	0.40	1
Red-breasted Merganser	1	0.01	1	0	0	0
Unidentified Jaeger	3	0.02	3	3	0.07	3
Pomarine Jaeger	5	0.04	4	1	0.02	1
Parasitic Jaeger	4	0.03	4	0	0	0
Long-tailed Jaeger	0	0	0	1	0.02	1
Unidentified Gull	4,824	34.31	43	405	8.93	27
Black-legged Kittiwake	818	5.82	161	131	2.89	36
Bonaparte's Gull	163	1.16	11	94	2.07	3
Ring-billed Gull	65	0.46	15	2	0.04	2
Laughing Gull	125	0.89	48	2	0.04	2
Herring Gull	2,033	14.46	385	1,084	23.91	244
Great Black-backed Gull	1,687	12.00	247	339	7.48	108
Arctic Tern	8	0.06	2	0	0	0
Common Tern	22	0.16	7	25	0.55	2
Roseate Tern	3	0.02	2	0	0	0
Unidentified Alcid	10	0.08	1	22	0.49	3
Razorbill	7	0.05	3	21	0.46	4
Common Murre	12	0.09	5	0	0	0
Dovekie	4	0.03	2	0	0	0
Atlantic Puffin	5	0.04	4	0	0	0

Total	**14,045**	**1447**	**4,532**	**665**

NEARSHORE SURVEYS

Most of the historical information available regarding phenology, abundance and spatial distribution of different avian groups in Rhode Island are from surveys of nearshore waters, coastal ponds, and the Narragansett Bay estuary that were conducted by several state and federal biologists over the past 30 years. These data were provided by biologists from the Rhode Island Department of Environmental Management Division of Fish and Wildlife (RIDFW, Jay Osenkowski, Waterfowl Biologist, Chris Raithel, Non-game Biologist), the U.S. Fish and Wildlife Service's Rhode Island National Wildlife Refuge Complex (USFWS, Suzanne Paton, Senior Refuge Biologist), and the Environmental Protection Agency (EPA, Dr. Rick McKinney). We also present long-term data on landbird abundance and phenology from the bird banding program at Kingston Wildlife Research Station, operated by the University of Rhode Island in conjunction with the Audubon Society of Rhode Island. Most data were land-based surveys (with the exception of aerial surveys conducted by RI Division of Fish and Wildlife Biologists) that were conducted in areas along the northern boundary or inland of the RI Ocean SAMP study area. These data provide useful baseline information on avian abundance and phenology in parts of the Ocean SAMP study area that were helpful for designing avian surveys for the RI Ocean SAMP.

Below we describe these various surveys:

RIDFW Mid-Winter Aerial Survey of Narragansett Bay and coastal wetlands

The Rhode Island Division of Fish and Wildlife (RIDFW) conducted a mid-winter waterfowl survey every January since 1955. We had access to data collected over 27 years from 1979 to 2008 that were collected in three zones, with Zones 1 and 2 adjacent to the RI Ocean SAMP study area (Fig. 4). These aerial surveys were conducted from a helicopter by Charlie Allin from 1979-2003, and Jason Osenkowski from 2004-2008. This survey takes place one day per year in January, with efforts focused on assessing the abundance of each species of waterfowl present in Narragansett Bay and coastal ponds. This survey does not follow a strict sampling protocol (e.g., flight elevation was not consistent throughout the survey, there were not predetermined transects to follow, the time when various sites are surveyed varies among years, and these surveys did not use either a strip transect or line transect methodology), so density of birds cannot be estimated from these surveys. However, these data can be used to assess interannual changes in relative abundance. Using total counts for Zones 1-3 for each survey, we calculated mean annual abundance, two estimates of variance (SD and Coefficient of Variation [CV]; SD/Mean X 100), the maximum number of individuals during any survey over the 27 winters, and the percent of years when the species was detected. Similar aerial surveys were conducted during mid-winter in every state in the eastern U.S. during the same time period, so that annual and spatial variation in waterfowl abundance can be assessed on a larger scale as well.

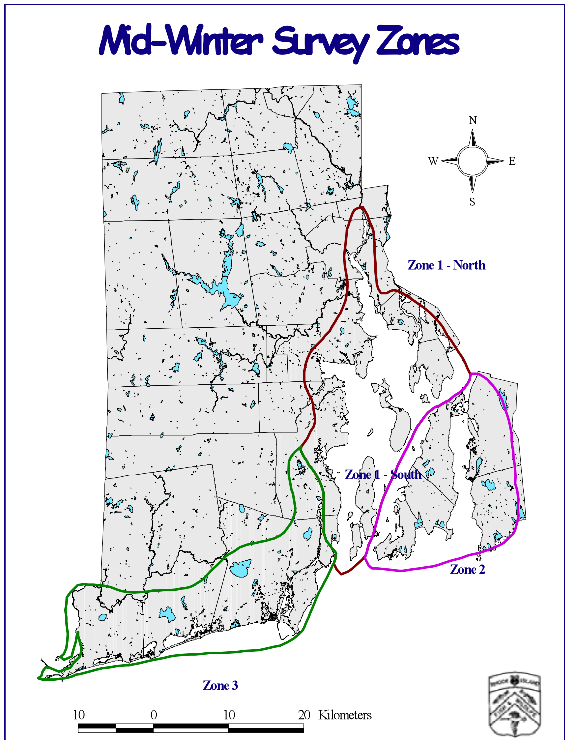

Fig. 4. Flight zones of aerial surveys conducted every January by the Rhode Island Fish and Wildlife Service (1979-present) to monitor waterfowl population trends (J. Osenkowski, unpubl. data).

Napatree Avian Surveys

Chris Raithel of the Rhode Island Division of Fish and Wildlife (RIDFW) conducted land-based transect surveys at Napatree Point in Watch Hill, RI from 1982 to the present. For this report, we analyzed surveys conducted by Raithel approximately every 1-2 weeks from 1982 to mid-2005 (1,418 total surveys; an average of 59.1 ± 15.5 (SD) surveys per year). In fact, this dataset is unique in that Raithel was the only observer and the duration of the surveys was extensive (in terms of being conducted for all months of the year over such a long time period). Most surveys took ca. 2-3 hours to complete. Weather data were also recorded at the beginning and end of each survey and included: weather condition, temperature, wind direction and speed, moon phase, tide and recent weather. Although these data are from one location, the strength of this dataset is that it was collected by the same experienced observer using the same methodology every year since 1982 and it includes counts of all bird species observed. Thus, these data provide strong quantitative insights into the migration phenology of birds in the region. They also provide useful information about annual variation in avian abundance at one study site. To assess annual variation, we calculated the maximum number of individuals detected per year for each species. We then used these maximum counts to quantify mean abundance per year, two estimates of variance (Standard Deviation [SD] and Coefficient of Variation [CV]), the maximum count over all surveys, and the percent of years when the species was detected.

US EPA Land-based Mid-winter Narragansett Bay Waterfowl Survey

Dr. Rick McKinney (US Environmental Protection Agency; EPA) has been coordinating a winter (mid-January) waterfowl survey in Narragansett Bay since 2004 with biologists from the EPA, URI, and RIDFW, as well as local birders (EPA 2010). This land-based survey provides a one-day assessment of waterfowl abundance throughout Narragansett Bay every January. Surveys were conducted at a standardized set of survey locations on one day using six teams of at least two biologists each. At each survey site, observers used spotting scopes and binoculars to record the abundance of each species, along with weather conditions. Surveys began at dawn and took most of the day to be completed. Surveys conducted close to the mouth of Narragansett Bay were adjacent to the RI Ocean SAMP study area. Since this survey was conducted one day a year (similar to the RIDFW aerial mid-winter survey), it only provides a snapshot view of waterfowl abundance in Narragansett Bay. However, it captures the interannual variation in the number of waterfowl overwintering in the bay at a given time during winter, as many individual waterfowl exhibit site fidelity to the same wintering location between years. For the EPA data, we calculated mean annual abundance, two estimates of variance (SD and Coefficient of Variation [CV]; CV = SD/mean X 100), the maximum number of individuals during any survey over the 6 winters, and the percent of years when the species was detected.

Sachuest Point NWR

Land-based waterbird surveys have been conducted from 1992 to the present at Sachuest Point National Wildlife Refuge by volunteers working with USFWS refuge staff. We had access to data collected from 1992 to 2003. We summarized 94 surveys that occurred from November through the end of April when waterfowl and waterbirds were most abundant. Over the 11 years, there was an average of 8.6 ± 3.8 surveys per year during this winter period. Most surveys were conducted in the morning hours from 10 observation points on both the east and west sides of Sachuest Point. At each survey point, observers used a spotting scope to identify species and numbers of all birds detected. Weather data were also recorded including temperature, wind direction and speed, percent clouds and precipitation. Surveys were conducted by numerous observers so that there is the potential for observer variation to bias these survey results. However, these data provide useful information about annual variation in avian abundance at a site used by relatively large numbers of waterbirds, particularly seaducks. For each winter (1 Nov to 30 April), we first calculated the maximum number of individuals detected for each species. We then used these estimates of maximum abundance within a winter to calculate mean annual abundance, two estimates of variance (SD and Coefficient of Variation [CV]; CV = SD/mean X 100), the maximum number of individuals during any survey over the 10 winters, and the percent of years when each species was detected. To assess annual variation in the total number of birds using Sachuest, we summed the maximum counts for each species within a winter season. We then calculated the mean, SD, CV, and maximum for these summed winter counts to determine total abundance.

Pt. Judith Waterbird Surveys

The movement ecology of waterbirds was investigated from the fall of 1997 to the fall of 1998 at Pt. Judith by researchers from the University of Rhode Island as part of an assessment for wind farm development at this coastal site. Observers recorded species abundance, flock size (total number of individuals), time the flock was detected, flight direction (compass bearing), and estimated height above the water (in meters) for birds in flight. Also recorded was the behavior of the birds(s) including flying, loafing on water, roosting on the breakwater, hovering, or circling. Weather variables were recorded including: wind speed, direction, temperature, cloud cover, ceiling height, vertical visibility, precipitation, and sea swell height. Vertical visibility was recorded if the clouds were <300 m high. These surveys were conducted by the same observers through time.

Coastal Ponds

Ninigret Pond: We summarized waterbird surveys conducted annually by USFWS biologists at 11 sites at Ninigret Pond from 1992-2008 (16 winters), with surveys conducted approximately 2-4 weeks apart. On average, 7.4 ± 2.1 (SD) surveys were conducted each winter between 1 November to 30 March (a total of 119 surveys), which coincided with peak waterfowl use of this coastal pond. We calculated mean abundance, two estimates of variance (SD and Coefficient of Variation [CV]; CV = SD/Mean X 100), the maximum number of individuals during any survey over the 10 winters, and the percent of years when the species was detected. To assess annual variation in the total number of birds using Ninigret, we summed the maximum counts for each species within a winter season. We then calculated the mean, SD, CV, and maximum for these summed winter counts to determine total abundance.

Trustom Pond: Waterbird surveys have been conducted by biologists with the US Fish and Wildlife Service at Trustom Pond NWR, Mud Pond, and Card's Pond intermittently from 1992 to the present. We report here data for 10 winters from 1992 to 2006 (1992-93 to 1993-94, 1998-99 to 2005-2006). The timing of surveys varied annually, but typically occurred at two-week intervals from October through April, which represents the peak of waterfowl use of coastal ponds in southern New England. We analyzed 88 total surveys, with an average of 8.8 ± 2.4 (SD) surveys per winter. Most surveys were conducted in the morning hours from 10 fixed observation points. At each survey point, all individuals were recorded to species. Weather data were also recorded including temperature, wind direction and speed, percent clouds and precipitation. Surveys were conducted by numerous observers. To characterize interannual variation in waterbird abundance, we calculated the maximum number of individuals detected each winter for each species. We then calculated mean abundance, two estimates of variance (SD and Coefficient of Variation [CV];CV = SD/mean X 100), the maximum number of individuals during any survey over the 10 winters, and the percent of years when the species was detected. To assess annual variation in the total number of birds using Trustom, we summed the maximum counts for each species within a winter season. We then calculated the mean, SD, CV, and maximum for these summed winter counts to determine total abundance.

Trustom Pond offers some of the best waterfowl habitat for diving and dabbling ducks in the region during the winter months. These data provide quantitative information on the phenology of waterfowl and relative abundance of waterbirds using this important wintering and stopover habitat along the south coast of Rhode Island.

SUMMARY OF THE PHENOLOGY, DISTRIBUTION, ABUNDANCE AND BEHAVIOR OF AVIAN GROUPS INHABITING THE OCEAN SAMP STUDY AREA BASED ON HISTORICAL DATASETS

Waterfowl

Waterfowl occur in Rhode Island throughout the year, but are most abundant during winter months (November to April) in Rhode Island. Mid-winter aerial surveys conducted by Rhode Island Division of Fish and Wildlife every January since 1979 have detected an average of 21,256 ± 12,051 (SD) waterfowl annually, with a maximum of 58,706 individuals in 2001 (RIDFW; Table 4). On average 12.7 ± 2.6 species were detected during these RIDFW surveys, with a cumulative total of 24 species detected over the years (Table 4). The most abundant species (>1,000 individuals annually) during these mid-winter surveys include scaup (which were primarily Greater Scaup, with some Lesser Scaup based on EPA land-based survey results of Narragansett Bay – Table 5), Canada Goose, American Black Duck, and Common Eider (Table 4). There was considerable interannual variation in RIDFW survey results, with coefficients of variation (CV) averaging 240.1 ± 167.7 (SD). However, the most abundant species tend to have CV's <100, although Common Eider exhibit considerable interannual variation (CV = 237.9).

The other large-scale investigation of annual variation in waterbird abundance in Rhode Island was the EPA's mid-winter survey of Narragansett Bay (EPA). This land-based, one day survey counted an average of 22,725.0 ± 3,557.4 (SD) waterbirds annually (Table 5). Dominant species during these surveys were Greater Scaup, Canada Goose, Brant, Common Eider, Lesser Scaup, and American Black Duck. Coefficients of variation (CV) for these land-based point counts of Narragansett Bay averaged 83.4 ± 60.2 which were considerably lower than that of the RIDFW surveys. Given that the same areas were sampled from land-based stations in a similar manner during the EPA mid-winter counts, the EPA surveys were probably more accurate and precise than RIDFW aerial surveys. Therefore, the CVs detected during the EPA land-based surveys (Table 5) are probably more reflective of annual variation in waterbird counts for birds in Rhode Island.

At a smaller spatial scale, surveys of waterbirds at Sachuest Point NWR from 1992-2003 provided another estimate of annual variation in bird abundance in nearshore habitats (Table 6). During these surveys at Sachuest Point NWR, a cumulative total of 31 species were detected with an average of 1,300.6 ± 1,056.0 individuals counted annually (Table 6). Dominant waterfowl species were Common Eider, Surf Scoter, Harlequin Duck, Common Goldeneye, Bufflehead, Black Scoter, and American Black Duck (Table 6). There was considerable annual variation in these land-based surveys, with Coefficients of Variation (CV) averaging 174.1 ± 89.9 (SD) and 26 of 31 species having CVs greater than 100 (Table 6).

Surveys at Napatree by Raithel provided the best long-term dataset for a wide variety of waterbirds in the region. We summarized annual variation in waterbirds that are typically associated with nearshore and offshore waters (i.e., loons, grebes, cormorants, tubenoses, waterfowl, gulls and alcids; Table 7). There were 14 species whose maximum count on a survey within a year averaged over 100 individuals per year, with 12 of 14 of these common species having CVs <100 (mean CV for these 14 species = 89.9 ± 65.1). However, Northern Gannet abundance was more variable between years (CV = 313.3).

Terns often forage and roost at Napatree, plus many terns migrate past this sandy promontory. Raithel detected 10 species of terns over the years, with three species consistently detected (Least, Common, and Roseate). Mean maximum annual counts for these three species (56, 262, and 161 individuals, respectively; Table 7) were relatively consistent over the years, as CVs for these three species (mean = 70.0 ± 18.1 [SD]) were relatively low.

Table 4. Mean abundance per year, interannual variation, maximum number observed in a given year, and frequency of occurrence (% of years detected) for 21 species of waterfowl detected over 27 years during RIDFW mid-winter waterfowl surveys of Narragansett Bay and nearshore habitats along coastal mainland from 1979-2008 from Zones 1-3 combined (J. Osenkowski, RIDFW, unpubl. data; see Fig. 4 for zones). These helicopter-based aerial surveys were conducted on one day during January each year.

Species	Mean	SD	CV	Maximum	% of years
Mute Swan	845.1	438.4	51.9	1,788	100
Canada Goose	6,262.3	5,401.1	86.2	28,096	100
Brant	761.9	954.6	125.3	3,165	74
Mallard	860.8	692.0	80.4	3,220	100
American Black Duck	2,174.2	1,205.4	55.4	6,697	100
Gadwall	33.7	70.2	208.0	290	37
American Wigeon	148.0	206.7	139.6	835	70
Green-winged Teal	0.1	0.8	519.6	4	4
Canvasback	359.6	425.3	118.3	1,693	96
Redhead	0.3	1.3	519.6	7	4
Ring-necked Duck	0.7	3.8	519.6	20	4
Scaup unidentified	6,558.0	5,090.9	77.6	23,095	100
Common Eider	1,249.8	2,973.0	237.9	14,100	56
Harlequin Duck	11.3	25.2	222.4	100	30

Long-tailed Duck	2.6	7.9	299.6	30	11
Scoter unidentified	260.4	692.3	265.9	3,600	56
White-winged Scoter	9.3	39.3	424.6	200	7
Common Goldeneye	331.9	437.8	131.9	1,590	82
Bufflehead	608.7	409.3	67.2	1,387	93
Hooded Merganser	11.7	43.9	375.9	225	15
Merganser unidentified	590.2	538.4	91.2	2,396	93
Common Merganser	2.2	9.7	438.3	50	7
Red-breasted Merganser	170.2	352.9	207.4	1,187	30
Ruddy Duck	2.9	14.4	499.3	75	7
Overall abundance	21,256.0	12,050.6	56.7	58,706	
Species richness	12.7	2.6			

Table 5. Mean abundance per year, interannual variation, maximum number observed in a given year, and frequency of occurrence (% of years detected) for 23 species of waterbirds detected during EPA mid-winter surveys within the Narragansett Bay estuary from 2004-2009 (see EPA 2010). Birds were counted from land-based routes one day during January each year.

Species	**Mean**	**SD**	**CV**	**Max**	**% of surveys**
Common Loon	63.2	36.6	57.9	119	100.0
Horned Grebe	145.7	230.2	158.0	609	100.0
Cormorants unidentified	33.3	33.9	101.6	90	100.0
Mute Swan	572.5	147.7	25.8	775	100.0
Canada Goose	2,655.5	1,467.0	55.2	4,882	100.0
Brant	2,402.2	853.2	35.5	3,808	100.0
Mallard	1,012.5	449.3	44.4	1,478	100.0
American Black Duck	1,267.7	183.2	14.5	1,474	100.0
Gadwall	133.5	129.6	97.1	395	100.0
American Wigeon	481.3	369.3	76.7	1,060	100.0
Greater Scaup	4,638.2	2,978.3	64.2	7,889	100.0
Lesser Scaup	1,214.2	2,578.6	212.4	6,462	66.7
Common Eider	1,423.0	669.2	47.0	2,465	100.0
Harlequin Duck	71.7	25.6	35.7	105	100.0
Long-tailed Duck	1.5	2.1	138.2	5	50.0
White-winged Scoter	97.5	160.7	164.8	411	83.3
Surf Scoter	74.0	66.9	90.5	165	100.0
Black Scoter	125.0	67.2	53.8	204	100.0
Common Goldeneye	1,485.3	629.9	42.4	2,323	100.0
Barrow's Goldeneye	0.2	0.4	244.9	1	16.7
Bufflehead	901.5	424.3	47.1	1,530	100.0
Hooded Merganser	106.3	66.0	62.1	187	100.0
Red-breasted Merganser	710.8	209.6	29.5	1,022	100.0
Common Merganser	12.7	12.9	101.9	27	66.7
Gulls unidentified	3,095.8	854.0	27.6	4,015	100.0
Overall abundance	**22,725.0**	**3,557.4**	**15.7**	**26,950**	**100.0**
Species richness[1]	**21.8**	**1.2**			

[1]unidentified cormorants or gulls were not included in this calculation

Table 6. Mean abundance per year, interannual variation, maximum number observed in a given year, and frequency of occurrence (% of years detected) for 32 species of waterbirds detected in nearshore waters at Sachuest Point National Wildlife Refuge from 1992-2003 (USFWS, unpubl. data). Birds were counted from land-based routes every 2-4 weeks during November-April each year.

Species	Mean	SD	CV	Maximum	% of surveys
Common Loon	33.9	51.2	150.9	182	91
Red-throated Loon	1.8	2.2	122.5	6	55
Horned Grebe	16.2	20.3	125.6	72	91
Red-necked Grebe	2.2	3.9	177.3	11	36
Double-crested Cormorant	3.1	9.0	291.3	30	18
Great Cormorant	0.6	1.4	225.2	4	18
Mute Swan	2.6	3.4	130.6	10	64
Snow Goose	0.5	1.8	331.7	6	9
Canada Goose	5.1	11.6	227.6	37	46
Brant	12.4	14.3	115.4	38	73
Mallard	0.7	1.0	138.7	2	36
American Black Duck	55.3	46.3	83.7	160	100
American Wigeon	0.4	0.8	222.5	2	18
Gadwall	1.9	4.9	257.1	16	18
Redhead	0.1	0.3	331.7	1	9
Lesser Scaup	2.4	6.6	277.6	22	27
Greater Scaup	49.3	41.6	84.5	155	100
Common Eider	559.0	880.1	157.4	3011	100
King Eider	2.6	6.1	229.6	19	27
Harlequin Duck	80.5	16.0	19.9	107	100
Common Merganser	2.5	8.1	331.7	27	9
Long-tailed Duck	1.9	2.5	131.4	8	55
White-winged Scoter	31.4	40.4	128.9	115	100
Surf Scoter	109.1	128.3	117.6	368	91
Black Scoter	57.3	90.8	158.6	300	82
Common Goldeneye	87.7	31.8	36.2	143	100
Barrow's Goldeneye	0.2	0.4	222.5	1	18
Bufflehead	57.7	46.2	80.1	165	100
Hooded Merganser	0.3	0.9	331.7	3	9
Red-breasted Merganser	48.6	20.4	42.0	77	100
Ruddy Duck	8.3	12.0	144.7	30	46
Purple Sandpiper	65.2	94.1	144.4	250	46
Overall abundance	**1,300.6**	**1,056.0**	**81.2**	**4,053**	**100**

COASTAL PONDS

In coastal ponds, more species of dabbling ducks and diving ducks were detected at Trustom Pond NWR and Ninigret Pond NWR than within Narragansett Bay. For example, 41 species of waterbirds were detected at Trustom Pond, with 34 species of waterfowl detected and an average of 26.4 species of waterbirds detected annually during systematic surveys (Table 8). Nine species of dabbling ducks (genus *Anas*) were detected during Trustom Pond surveys, with Mallards and American Black Ducks the most abundant species. For the five most common species of dabbling ducks (American Black Duck, Mallard, American Wigeon, Green-winged Teal, and Gadwall), the overall mean CV was 94.7 ± 34.1 (SD), which was similar to land-based point counts of waterfowl during EPA mid-winter Narragansett Bay surveys (83.4 ± 60.2; Table 5). Large numbers of diving ducks (genus *Aythya*) were also prevalent at Trustom, with six species detected; Greater Scaup was the most abundant diving duck at Trustom with maximum counts of over 600 detected annually (Table 8). Ruddy Ducks were also prevalent at Trustom (over 300 annually), which is one of the few places where this species is common in Rhode Island. For the four common diving ducks (Greater and Lesser Scaup, Canvasback, and Ring-necked Duck) and Ruddy Duck, the overall mean CV was 128.5 ± 58.9, which was slightly higher than the estimate for dabbling ducks at Trustom (94.7 ± 34.1).

At Ninigret Pond, USFWS biologists detected 30 species of waterfowl over the years, with an average of 13.5 ± 2.9 (SD) species detected each winter (Table 9). Thus species richness was lower at Ninigret compared to Trustom. The number of dabbling ducks tends to be much lower at Ninigret than at Trustom, although American Black Ducks (over 200 individuals annually) were common at Ninigret. Certain species of ducks tended to be more abundant at Ninigret compared to Trustom, specifically Buffleheads, Common Goldeneye, and Red-breasted Mergansers. CVs for common diving ducks and seaducks (Greater and Lesser Scaup, Common Goldeneye, Bufflehead, Hooded and Red-breasted Merganser) averaged 115.9 ± 79.4, which was similar to that for diving ducks at Trustom (above).

Table 7. Mean abundance per year, interannual variation, maximum number observed in a given year, and frequency of occurrence (% of years detected) for 72 species of birds detected from Napatree Spit, Rhode Island during land-based surveys conducted over 24 years from 1982 to 2005 at Napatree Spit (C. Raithel, RI Div of Fish and Wildlife, unpubl. data). Birds were counted from land-based routes every 2 weeks throughout each year (1,418 total surveys). .

Species	Mean	SD	CV	Maximum	% of years
Common Loon	26.9	17.7	65.7	80	100
Red-throated Loon	15.0	10.3	68.9	35	100
Horned Grebe	27.9	8.9	32.0	47	100
Red-necked Grebe	1.1	1.0	89.9	4	75
Pied-billed Grebe	0.0	0.2	489.9	1	4
Eared Grebe	0.1	0.3	270.3	1	13
Sooty Shearwater	0.0	0.2	489.9	1	4
Wilson’s Storm-Petrel	0.5	1.7	363.8	8	13
Leach’s Storm-Petrel	0.0	0.2	489.9	1	4
Double-crested Cormorant	1528.7	1678.6	109.8	7640	100
Great Cormorant	26.6	12.6	47.3	50	100
Northern Gannet	193.1	605.0	313.3	3000	92
American White Pelican	0.0	0.2	489.9	1	4
Brown Pelican	0.0	0.2	489.9	1	4
G. White-fronted Goose	0.1	0.4	489.9	2	4
Snow Goose	37.3	112.9	303.0	495	42
Brant	424.6	130.7	30.8	580	100
Canada Goose	216.5	178.6	82.5	735	100
Mute Swan	116.2	67.3	57.9	250	100
Tundra Swan	0.1	0.6	489.9	3	4
Wood Duck	1.5	1.9	131.0	6	50
Gadwall	10.0	7.9	79.8	29	96
Eurasian Wigeon	0.0	0.2	489.9	1	4
American Wigeon	7.5	8.8	117.4	35	79
American Black Duck	222.6	181.3	81.4	750	100
Mallard	39.5	82.6	209.4	400	100
Blue-winged Teal	1.7	4.2	247.4	20	42
Northern Shoveler	0.2	0.6	282.4	2	13
Northern Pintail	2.0	2.7	132.0	10	54
Green-winged Teal	4.4	5.4	123.3	21	71
Canvasback	0.8	2.8	373.5	13	8
Redhead	0.1	0.4	358.7	2	8
Ring-necked Duck	0.0	0.2	489.9	1	4
Greater Scaup	44.9	88.9	197.9	400	96
Lesser Scaup	0.6	1.1	188.6	4	29
King Eider	0.4	0.9	222.9	4	25
Surf Scoter	35.2	44.2	125.6	171	100
Black Scoter	35.5	39.8	112.2	140	100
Harlequin Duck	0.4	0.7	156.9	2	33
White-winged Scoter	21.9	16.2	74.2	66	100
Common Eider	76.7	152.5	198.7	620	96
Bufflehead	42.5	42.1	99.1	220	100

Common Goldeneye	101.3	57.1	56.4	199	100

Table 7 continued. Birds observed at Napatree by Raithel (RIDEM).

Species	**Mean**	**SD**	**CV**	**Maximum**	**% of years**
Barrow's Goldeneye	0.7	2.2	315.6	11	29
Hooded Merganser	0.7	1.3	201.1	6	33
Common Merganser	1.1	2.5	221.4	11	33
Red-breasted Merganser	247.7	103.6	41.8	500	100
Ruddy Duck	0.1	0.4	489.9	2	4
Laughing Gull	283.3	255.6	90.2	1000	96
Little Gull	0.1	0.3	338.8	1	8
Black-headed Gull	0.1	0.3	270.3	1	13
Bonaparte's Gull	53.3	57.0	107.0	250	100
Ring-billed Gull	121.5	118.2	97.3	400	100
Herring Gull	496.8	313.6	63.1	1500	100
Lesser Black-backed Gull	0.3	0.4	176.9	1	25
Glaucous Gull	0.1	0.3	338.8	1	8
Great Black-backed Gull	167.5	143.7	85.8	500	100
Black-legged Kittiwake	0.8	1.4	181.2	6	38
Iceland Gull	0.3	0.5	159.2	1	29
Least Tern	55.8	34.3	61.5	140	96
Gull-billed Tern	0.1	0.3	270.3	1	13
Caspian Tern	1.3	1.4	105.8	5	63
Black Tern	1.3	1.8	132.1	7	63
Roseate Tern	160.9	146.1	90.8	500	96
Common Tern	261.9	151.2	57.7	700	96
Royal Tern	0.8	1.7	217.1	7	33
Sandwich Tern	0.3	0.9	275.0	4	17
Forster's Tern	2.4	2.1	89.4	7	83
Parasitic Jaeger	0.0	0.2	489.9	1	4
Dovekie	0.0	0.2	489.9	1	4
Razorbill	0.1	0.3	270.3	1	13
Black Guillemot	0.1	0.3	338.8	1	8
Osprey	20.3	15.9	78.2	53	100
Bald Eagle	0.5	0.9	172.0	4	38
Northern Harrier	5.8	3.1	53.4	15	100
Sharp-shinned Hawk	118.3	149.1	126.1	532	96
Cooper's Hawk	4.0	4.3	106.6	16	88
Northern Goshawk	0.5	0.8	143.8	3	42
Red-shouldered Hawk	0.3	0.5	159.2	1	29
Red-tailed Hawk	1.4	1.3	95.5	5	75
Broad-winged Hawk	1.9	5.1	266.4	25	42
Rough-legged Hawk	0.1	0.3	338.8	1	8
American Kestrel	51.9	58.6	113.0	195	96
Merlin	8.0	5.9	73.3	22	96
Gyrfalcon	0.1	0.3	338.8	1	8
Peregrine Falcon	1.6	1.6	100.2	8	88

Table 8. Mean abundance per year, interannual variation, maximum number observed in a given year, and frequency of occurrence (% of years detected) for 41 species of waterbirds detected using the coastal pond at Trustom Pond National Wildlife Refuge over 11 winters from fall 1992 thru spring 2006 (data were not available from Dec 1995 through spring 1998). Birds were counted from land-based routes every 2-4 weeks during November-April each year.

Species	Mean	SD	CV	Maximum	% of years
Common Loon	14.8	19.9	134.2	45	45
Red-throated Loon	3.4	5.4	158.8	14	45
Red-necked Grebe	0.9	1.3	143.0	3	36
Horned Grebe	11.2	21.4	191.1	59	45
Eared Grebe	0.3	0.7	225.0	2	18
Pied-billed Grebe	4.9	4.7	96.4	17	82
Great Cormorant	2.6	8.2	316.2	26	9
Mute Swan	21.5	23.9	111.3	78	91
Canada Goose	684.8	359.1	52.4	1260	91
Brant	0.9	2.2	248.2	7	18
Greater White-fronted Goose	0.3	0.9	316.2	3	9
Snow Goose	30.2	59.2	196.1	185	73
Wood Duck	6.1	13.6	222.3	44	55
Mallard	119.4	97.8	81.9	338	91
Mallard/Black Duck Hybrid	0.2	0.6	316.2	2	9
American Black Duck	167.0	78.0	46.7	309	91
Gadwall	15.9	20.4	128.6	72	91
Northern Pintail	8.4	6.0	71.7	18	91
American Wigeon	38.0	48.0	126.3	129	82
Northern Shoveler	1.2	1.8	151.1	5	36
Blue-winged Teal	2.5	6.2	249.6	20	27
Green-winged Teal	28.8	25.9	89.9	96	91
Eurasian Wigeon	0.5	0.8	170.0	2	27
Canvasback	75.1	78.1	104.0	210	91
Redhead	2.3	2.8	119.6	7	55
Tufted Duck	0.1	0.3	316.2	1	9
Ring-necked Duck	15.3	23.5	153.8	75	73
Greater Scaup	622.3	300.3	48.3	1260	91
Lesser Scaup	88.5	182.8	206.6	598	64
Common Eider	10.2	23.3	228.0	75	36
King Eider	0.1	0.3	316.2	1	9
Unidentified seaduck	1.0	3.2	316.2	10	9
Unidentified scoter	5.0	15.8	316.2	50	9
Long-tailed Duck	0.1	0.3	316.2	1	9
Surf Scoter	18.5	56.8	306.8	180	36
Black Scoter	4.2	8.3	198.2	25	45

Species	Mean	SD	CV	Maximum	% of years
White-winged Scoter	15.2	43.9	288.7	140	45

Table 8. continued. Birds observed at Trustom Pond NWR.

Species	Mean	SD	CV	Maximum	% of years
Common Goldeneye	110.9	57.5	51.8	196	91
Bufflehead	21.6	17.5	80.8	57	91
Hooded Merganser	69.6	39.4	56.6	138	91
Common Merganser	12.2	30.4	249.0	98	64
Red-breasted Merganser	97.7	49.1	50.2	179	91
Ruddy Duck	342.5	393.5	114.9	1,244	91
American Coot	81.2	99.1	122.1	304	82
Overall abundance	2,757.4	1,004.2	36.4	4,324	
Species richness	**26.4**	**4.9**			

Table 9. Mean abundance per year, interannual variation, maximum number observed in a given year, and frequency of occurrence (% of years detected) for 32 species of waterfowl detected at Ninigret Pond from 1992-2008 (S. Paton, USFWS, unpubl. data).

Species	**Mean**	**SD**	**CV**	**Maximum**	**% of years**
Mute Swan	10.4	7.2	69.3	26	100
Canada Goose	55.8	52.0	93.3	150	88
Brant	4.3	7.2	169.3	25	44
Snow Goose	0.1	0.3	273.3	1	13
Wood Duck	0.4	0.8	215.0	2	19
Mallard	15.4	14.4	93.7	46	100
American Black Duck	202.4	155.9	77.0	642	100
Gadwall	2.9	5.8	198.7	22	31
Northern Pintail	1.1	2.5	231.7	8	19
American Wigeon	7.2	24.9	346.1	100	31
Blue-winged Teal	0.1	0.3	400.0	1	6
Green-winged Teal	0.8	1.5	197.8	5	25
Canvasback	5.6	11.2	198.9	35	38
Redhead	0.3	0.7	225.3	2	19
Ring-necked Duck	0.6	1.8	317.8	7	13
Greater Scaup	196.2	200.5	102.2	534	69
Lesser Scaup	34.4	93.9	272.7	306	25
Common Eider	0.1	0.3	400.0	1	6
King Eider	0.1	0.3	400.0	1	6
Long-tailed Duck	0.4	1.0	235.6	3	19
Surf Scoter	0.8	1.1	150.1	3	38
Black Scoter	0.3	0.8	309.8	3	13
White-winged Scoter	2.0	6.2	309.8	24	13
Common Goldeneye	215.4	186.3	86.5	768	100
Barrow's Goldeneye	0.1	0.3	400.0	1	6
Bufflehead	550.6	453.4	82.3	1745	100
Hooded Merganser	45.9	47.7	103.7	147	100
Common Merganser	7.7	8.0	103.8	22	81
Red-breasted Merganser	280.1	134.9	48.2	418	100
Ruddy Duck	2.6	5.9	223.4	21	31
Overall abundance	1,643.8	891.5	54.2	3,055	100

Species richness	13.5	2.9

SEADUCKS

Seaducks are among the most common waterbirds inhabiting the Ocean SAMP study area in winter. Common seaducks in the Ocean SAMP study area include: Common Eider, Black Scoter, White-winged Scoter, Surf Scoter, and Long-tailed Duck. With the exception of Sachuest Point (Table 6) and Napatree (Table 7), there is little historical information available on seaduck abundance in the nearshore and offshore waters of Rhode Island. The RIDFW mid-winter survey primarily focuses on Narragansett Bay and the coastal ponds, and thus does not adequately sample Rhode Island nearshore and offshore waters (J. Osenkowski, RIDFW, pers. comm.; Table 4). We know that large numbers of seaducks (>10,000 scoters) have been observed in some years on the southwest ledge of Block Island (C. Raithel, RIDFW, pers. comm.), but this area southwest of Block Island has not been systematically surveyed by boat or plane prior to our Ocean SAMP surveys.

Based on our analyses of Raithel's surveys at Napatree (Fig. 5) and USFWS surveys at Sachuest (Fig. 6), we know that seaduck numbers tend to peak in Rhode Island from November to March. A few first-year nonbreeding seaducks (e.g., Common Eiders) spend the summer in Rhode Island rather than migrating to their northern breeding grounds. Groups of 30 Common Eiders at the Harbor of Refuge just west of Pt. Judith in July are not uncommon.

Fig. 5. Seasonal changes in number of seaducks detected during surveys at Napatree Point from 1982-2008 (C. Raithel, RIDFW, unpubl. data). For survey date, first number represents month, second number is 10-day period (1 = 1-10, 2 = 11-20, 3 = 21-31).

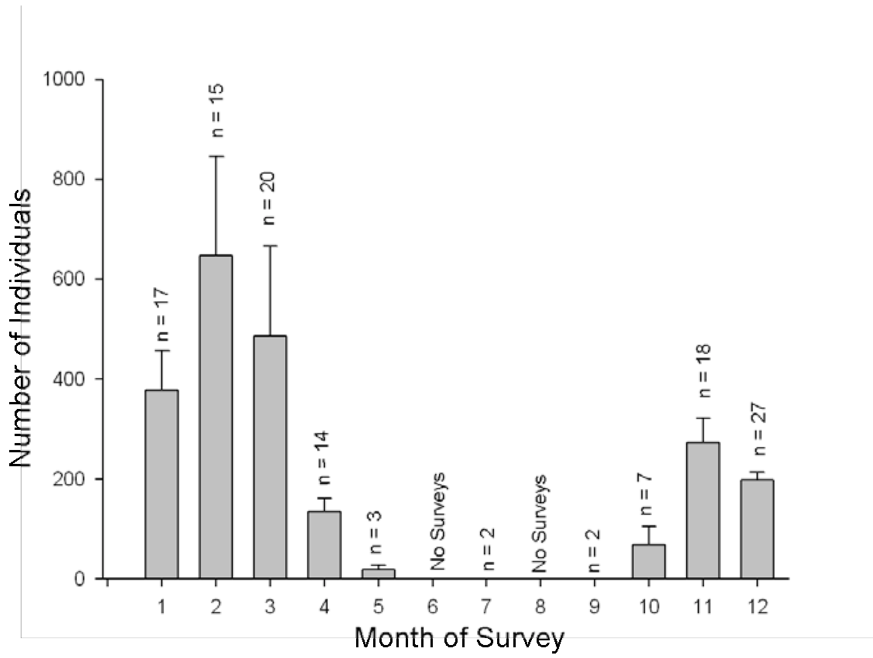

Fig. 6. Seasonal change (mean ± SD) in the number of seaducks detected each month at Sachuest Point NWR from 1993-2002 (USFWS, unpubl. data). January is Month 1. Sample sizes (n) above bar refer to number of surveys per month.

Harlequin Ducks winter along the south coast of Rhode Island and are currently a state-listed species of special concern. They are also currently listed as endangered in Canada and threatened in the state of Maine. Harlequin Ducks are common in RI from November to May (USFWS; Fig. 7). In Rhode Island, Harlequin Ducks are typically found close to shore in areas with rocky shorelines, with most birds detected at either Sachuest or Beavertail (Caron and Paton 2007). At Sachuest, an average of 80 Harlequin Ducks was detected (Table 6), although their numbers have declined recently at Sachuest, and birds have apparently shifted to Beavertail (Caron and Paton 2007). Harlequins have been found foraging to 20 m depths, but commonly dive in much shallower nearshore waters (<10 m) and usually stay within 15 m of the shoreline (Robertson and Goudie 1999). Their diet on their wintering grounds mainly consists of crabs, amphipods and gastropods (Fischer 1998; Gaines and Fitzner 1987; Goudie and Ankney 1986; Vermeer 1983; Palmer 1949).

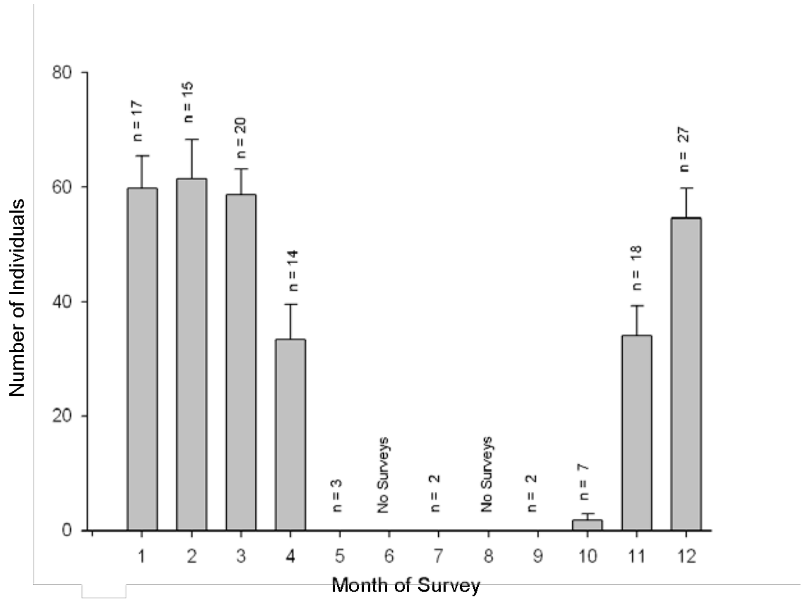

Fig. 7. Seasonal change (mean ± SD) in the mean number of Harlequin Ducks (*Histronicus histronicus*) detected per survey at Sachuest Point NWR from 1993-2002 (USFWS, unpubl. data). January is Month 1. Sample sizes (n) above bar refer to number of surveys per month.

Preferred sea duck foraging areas are strongly correlated with environmental variables such as water depth, bottom substrate, bivalve community, and bivalve density and size (Vaitkus and Bubinas 2001). Currently, bathymetric data (water depth, bottom substrate) for the Ocean SAMP study area is well known, but relatively little is known about bivalve communities and densities, especially further offshore. Foraging depths of seaducks differ among species and are a function of preferred diet, but average depths tend to be less than 20 m for most species (Table 10). Common Eiders typically forage in water <10 m during the winter when diving over rocky substrate and kelp beds (Goudie et al. 2000; Guillemette et al. 1993). The preferred diet of Common Eiders changes with season and foraging location, but mainly consists of mollusks and crustaceans (Goudie et al. 2000; Palmer 1976; Cottam 1939).

Table 10. Foraging depths of seaducks based on the literature.

Species	Dive depth	Reference
Common Eider	0-15 m	Ydenberg and Guillemetter 1991.
Common Eider	<16 m deep	NERI Report 2006.
Surf Scoter	90% of dives <20 m depth during diurnal period – used deeper waters at night – but rarely dived at night	Lewis et al. 2005.
Black Scoter	>95% of observations were in waters <20m deep	Kaiser et al. 2006.
Black Scoter	<20 m deep	NERI Report 2006.
White-winged Scoter	~90% of diver <20 m depth – might use deeper waters at night	Lewis et al. 2005.

Maximum diving depths of scoters are about 25 m, although most birds probably forage in water less than 20 m deep, particularly during the winter months (Vaitkus and Bubinas 2001; Bordage and Savard 1995). Scoter diet in marine environments predominantly consists of mollusks (Bordage and Savard 1995; Durinck et al. 1993; Madsen 1954; Cottam 1939). Long-tailed Ducks forage deeper (>60 m) and forage father offshore than other sea duck species (Robertson and Savard 2002; Ellarson 1956; Schorger 1947, 1951). Their diet on the wintering grounds consists mainly of epibenthic crustaceans including: amphipods, isopods, and mysids (Robertson and Savard 2002; Jamieson et al. 2001; Goudie and Ankney 1986, Johnson 1984; Cottam 1939). Much of the study area is relatively deep (> 25 m), thus much of the SAMP area is probably not preferred foraging habitat for seaducks, although seaducks can roost in deeper waters (Fig. 8).

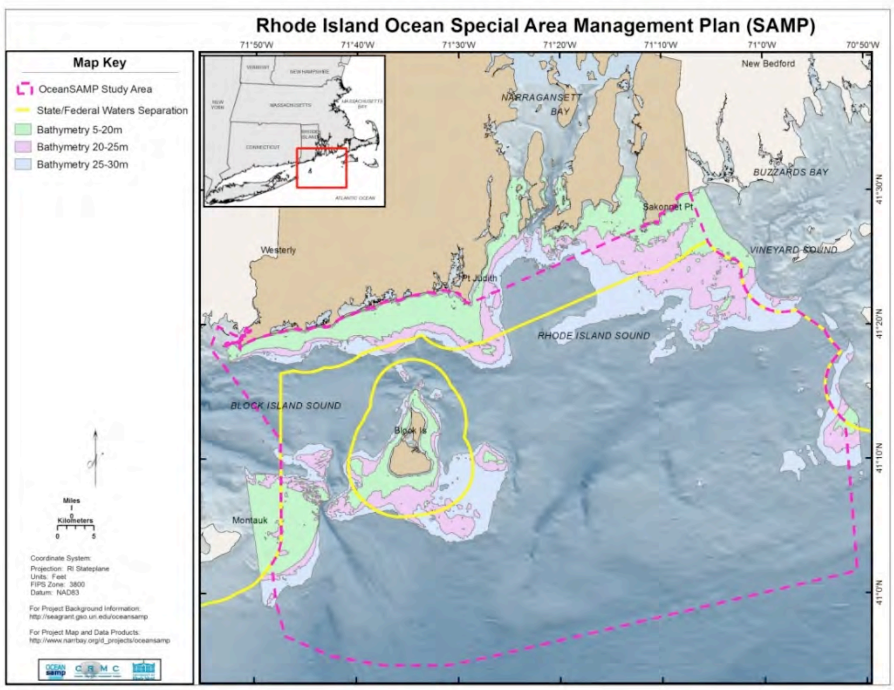

Fig. 8. Areas of the Ocean SAMP potentially suitable for seaduck foraging based on water depths ranging from 5 – 20 m deep (light green), which literature suggests are primary foraging depths.

Seaducks tend to forage and roost in different locations. Movements to feeding locations from roosting locations usually takes place just after sunrise and movements back to roosting locations usually occur just before or after sunset. Distances between foraging areas and roosting locations can be >10 km, although little is known about sea duck roosting locations in Rhode Island. Long-tail Ducks that forage around the area of Nantucket Shoals roost farther offshore in Nantucket Sound (Kerlinger and Hatch 2001). Sea ducks also tend to move short distances during daytime hours. Rafts of resting sea ducks are often moved off of forage areas by strong tides and wind and these ducks frequently fly short distances to return to areas with high prey densities. Seaducks generally fly low over the water surface (<15 m), but are known to fly at higher when flying over land, to roosting locations, or during migration (Fig. 9).

DIVING DUCKS

Diving ducks are another common winter resident in Rhode Island and the Ocean SAMP study area. The most abundant species include Common Goldeneye, Bufflehead, Greater Scaup, Lesser Scaup, Ruddy Duck, Canvasback and Redhead. Diving duck species are most common from November to March (USFWS; Fig. 10), with abundance greatest in Narragansett Bay where thousands of Greater and Lesser Scaup were detected during both RIDFW (max >23,000 scaup in one year, Table 4) and EPA (max = 7,889

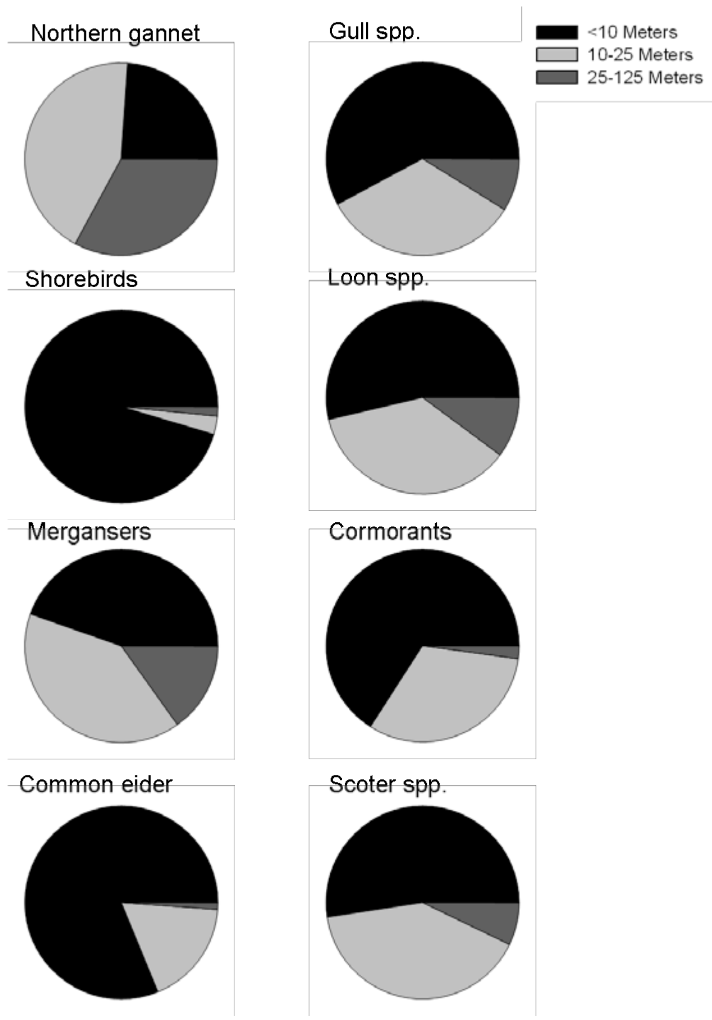

Fig. 9. Estimated flight altitude above ocean surface for various avian guilds based on ocular estimates during land-based surveys at Pt. Judith in 1998 (URI, unpubl. data).

Greater Scaup and 6,452 Lesser Scaup; Table 5) mid-winter surveys. Scaup are also relatively common in the southern coastal ponds (Tables 8 and 9) along the northern border of the SAMP area, but not as abundant in nearshore waters along the Rhode Island coastline (e.g., Napatree [Table 7] or Sachuest Point NWR [Table 6]). Dietary preferences differ among species and vary between seasons, but many species forage on bivalves, snails and other benthic invertebrates

(Kessel et al. 2002; Gauthier 1993). Diving duck species migrate through the Ocean SAMP study area during fall and spring migration, although abundance and migration corridors are poorly known. Available evidence suggests that diving ducks typically fly low over the ocean surface (typically <25 m above the water surface), but can also be found flying relatively high (>50 m), especially during migration (Kerlinger and Hatch 2001).

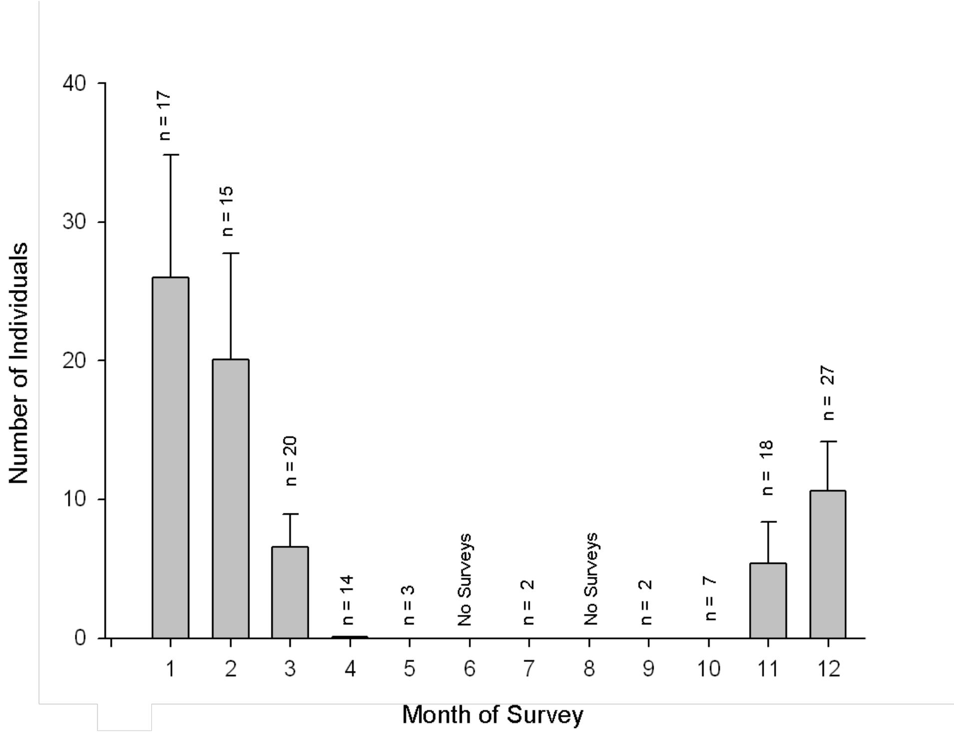

Fig. 10. Seasonal change (mean ± SD) in mean number of diving ducks detected per survey at Sachuest Point NWR from 1993-2002 (USFWS, unpubl. data). January is month 1. Sample sizes (n) above bar refer to number of surveys per month.

DABBLING DUCKS

Dabbling ducks commonly winter in nearshore and inland coastal ponds in southern Rhode Island. They are more abundant in freshwater, coastal ponds and salt marsh habitats (e.g., Trustom Pond NWR [Table 8] and Ninigret Pond [Table 9]), but can also be found along protected rocky and sandy beaches bordering Narragansett Bay and Block Island Sound. Common dabbling duck species include American Black Duck, Mallard, Gadwall, American Wigeon, Green-winged Teal and Northern Pintail. Dabbling ducks occur in Rhode Island year round, but are much more abundant from November to April (USFWS; Fig 11). Dabbling ducks likely migrate through much of the Ocean SAMP study area. Dabblers tend to fly high when migrating, sometimes reaching elevations > 125 m.

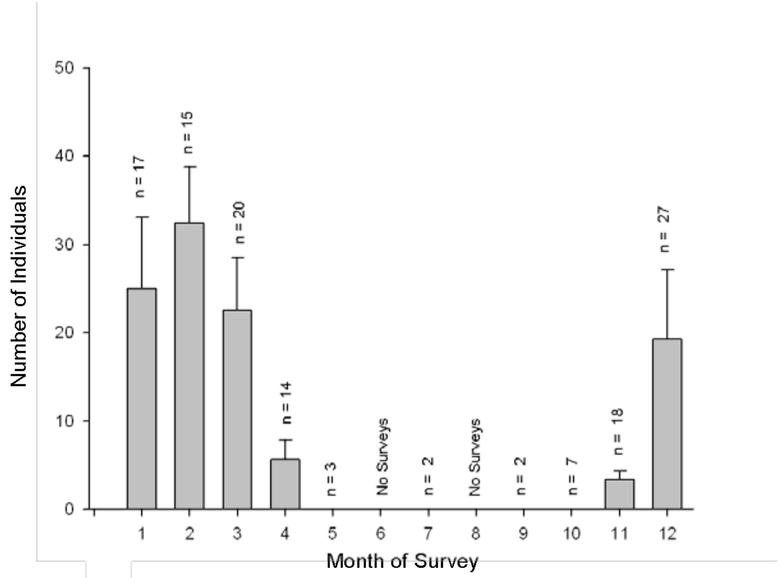

Fig. 11. Seasonal change (mean ± SD) in the mean number of dabbling ducks detected per survey at Sachuest Point NWR from 1992-2005 (USFWS, unpubl. data). January is month 1. Sample sizes (n) above bar refer to number of surveys per month.

MERGANSERS

Red-breasted Mergansers are abundant Rhode Island residents during the winter months, while Common Mergansers are uncommon migrants (see survey results for Napatree and Ninigret, Tables 7 and 9). Common Mergansers prefer freshwater bodies of water for foraging, while red-breasted mergansers tend to forage in harbors, estuaries, and tidal rivers (Mallory and Metz 1999). Common Mergansers become more common along the coast when freshwater lakes and rivers freeze during prolonged cold spells.

Red-breasted Mergansers are common in RI from November to April (USFWS; Fig. 12). Their wintering numbers apparently fluctuate less than many species of waterfowl in the region because CVs were relatively low (e.g., CV = 29.5, 41.8, and 48.2, for EPA [Table 5], Napatree [Table 7], and Ninigret [Table 9], respectively). Red-breasted Mergansers are an abundant species in nearshore waters, especially in Narragansett Bay. Red-breasted Merganser diets in the winter along the New England coast consist primarily of small fish including; mummichog (*Fundulus heteroclitus*), silversides (*Menidia menidia*) and blueback herring (*Alosa aestevalis*) (Titman 1999; Stott and Olson 1973). Red-breasted Mergansers generally fly low over the water (<15 m), but can be seen flying at heights up to <50 m during migration (Fig. 9).

GEESE

Brant and Canada Geese are common winter residents in Rhode Island and common migrants in coastal Rhode Island and Narragansett Bay (e.g., almost 800 Brant and over 6,000 Canada Geese are counted annually during RIDFW mid-winter survey; Table 4). Canada Geese are also common breeding birds throughout the state. Snow Geese are uncommon migrants that pass through Rhode Island during spring and fall migration on their way to and from mid-Atlantic wintering grounds (see Napatree survey results; Table 7). Brant arrive from the breeding grounds in October and are common residents until April. Brant densities in the winter are highest in the upper portions of Narragansett Bay

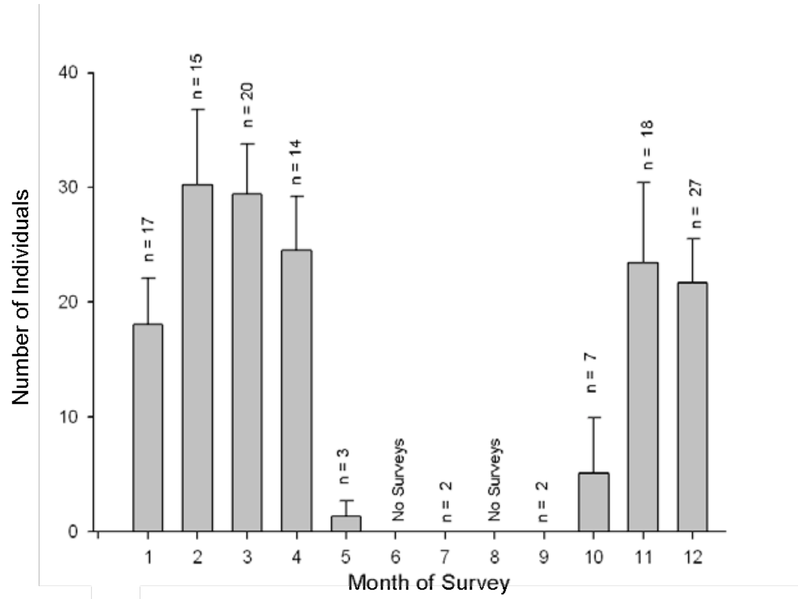

Fig. 12. Seasonal change (mean ± SD) in the mean number of Red-breasted Mergansers recorded per survey at Sachuest Point NWR from 1993-2002 (USFWS, unpubl. data). January is month 1. Sample sizes (n) above bar refer to number of surveys per month.

(e.g., an average of approx. 2,400 are counted during EPA mid-winter survey; Table 5), but are also common along the mouth of Narragansett Bay and the south shore (e.g., over 400 annually at Napatree, Table 7). Brant spend much of their time foraging close to shore on eel grass, macro algae, and salt marsh cord grass (Reed et al. 1998). In some areas, Brant are found foraging frequently in terrestrial habitats on lawn grass and agricultural fields (Ward et al. 2005). Canada Geese spend a majority of their time foraging in terrestrial environments including agricultural fields and turf grass farms (Mowbray et al. 2002). They often roost in coastal ponds and on Narragansett Bay. Like other waterfowl, wintering populations of geese tend to fluctuate annually depending on weather and available forage , although CVs for Canada Geese (CV = 55) and Brant (CV = 36) during EPA mid-winter surveys (Table 5) suggest that geese populations tend to fluctuate less annually than other waterfowl in the region. Brant fly relatively low (<30 m) when moving from roost locations to foraging locations. Canada Geese generally fly higher (>50 m) when moving from roost to foraging locations.

Waterbirds

TERNS

Terns are a common inhabitant of the study area from May through September (Fig. 13). Common species of terns in the SAMP area include Common Tern, Least Tern, Forster's Tern, and Roseate Tern (see survey results from Napatree spit; Table 7). Common Terns nest in Rhode Island and breed in a number of locations on the northern border of the Ocean SAMP study area (Ferren and Myers 1997).

Roseate Terns are federally-listed as an endangered species. The total number of breeding pairs averages 3,500 – 4,000 in the northeastern United States. The population is concentrated in two colonies near Rhode Island: Great Gull Island, NY is within 20 km of Rhode Island waters, and both Bird and Ram Island, MA which are just over 40 km away. Great Gull and Bird Island colonies contain over 80% of the Northeastern United States population (Nisbet 1989). Their numbers peaked at 4,310 breeding pairs in 2000, but have declined to just over 3,200 in 2008, coupled with a long term drop in the total number of breeding sites (Mostello 2007). Adult Roseate Terns disperse up to 30 km on foraging flights for their young, particularly in years with low fish productivity (Nisbet 1981, Duffy 1986; Heinemann 1992), thus Rhode Island may be within foraging range of some breeding birds (see Grist 2010 for a more detailed description of Roseate Terns in Rhode Island). We know of no recent nesting records of Roseate Terns in Rhode Island. However, Roseate Terns were commonly detected in Rhode Island from late July to early September at Napatree Point (Fig. 14; RIDFW).

In addition, adults and young can disperse large distances during the post-breeding season, but dispersal studies have only recently been initiated. In particular, observations of large congregations of Roseate and Common Terns occur at Cape Cod, Massachusetts, with over 20 staging sites documented which had 1,000 to 20,000 birds per site. Post-breeding terns from as far away as Great Gull Island, NY and Nova Scotia were documented at staging sites on Cape Cod (MAS 2010)

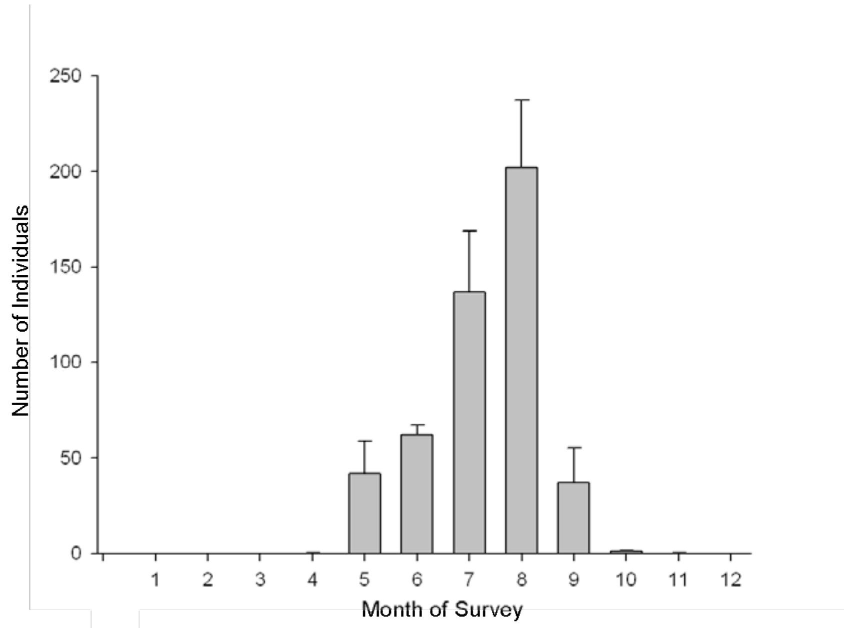

Fig. 13. Seasonal change (mean ± SD) in the number of terns recorded during surveys at Napatree Point. Surveys were conducted 1982-2008 (C. Raithel, RIDFW). All tern species were pooled for this analysis.

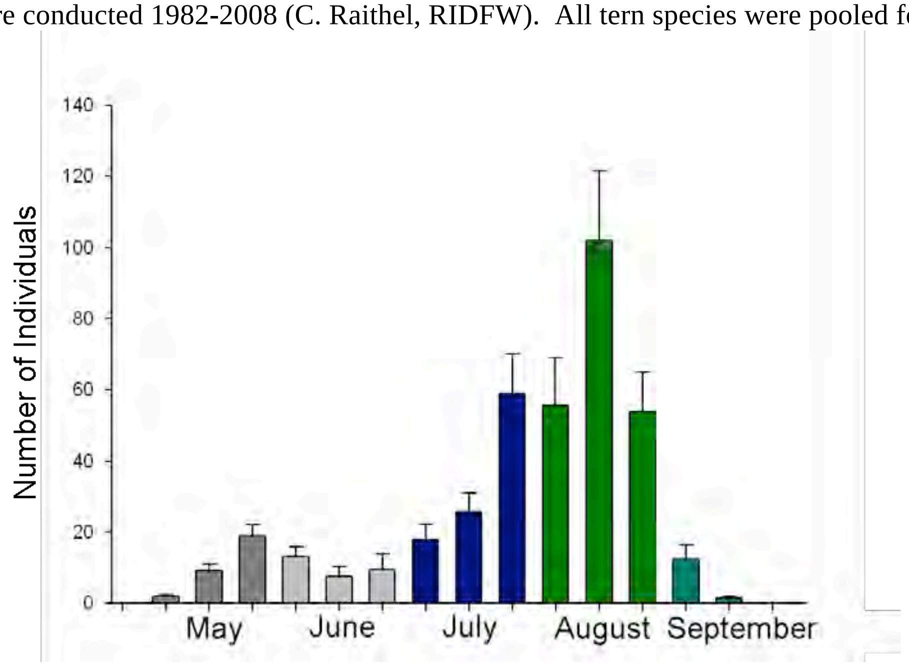

Fig. 14. Seasonal change (mean ± SD) in the mean number of Roseate Terns recorded during surveys at Napatree Point from 1982 to 2008 (C. Raithel, RIDFW). (Each similarly-colored bar represents a 10-day period within the same month. (Each similarly-colored bar represents a 10-day period. Bar 1 = 1-10, Bar 2 = 11-20, Bar 3 = 21-31).

Least Terns are listed as State Threatened by the state of Rhode Island (RINHP 2006). In 2008, 193 pairs of Least Terns nested along the south shore beaches and coastal ponds that border the northern edge of the Ocean SAMP study area (USFWS, unpubl. data). Most tern species generally stay close to shore (<5 km) during the breeding season, but are occasionally found in low densities offshore along the continental shelf during spring and fall migration (Nisbet 2002; Powers et al. 1980; Haney and Stone 1988). Terns forage primarily on small fish including Atlantic silversides (*Menidia menidia*), American sand lance (*Ammodytes dubius*), and Atlantic herring (*Clupea harengus*). Terns observed during surveys for the Cape Wind project generally flew low, at elevations less than 18 m above the water surface (Kerlinger and Hatch 2001).

LOONS

Common Loons and Red-throated Loons are more abundant during migration and the winter months, but they have been recorded year round in Narragansett Bay and the Ocean SAMP study area (C. Raithel at Napatree; Fig. 15). Common Loons tend to be more abundant than Red-throated Loon; for example, at Sachuest NWR peak counts for Common Loons were 34 birds compared to only two Red-throated Loons (Table 6). Less than 70 Common Loons are typically counted in Narragansett Bay during the mid-winter aerial survey (Table 4), whereas survey data at Napatree suggest that peak counts of Red-throated Loons (mean = 15 individuals) are 50% lower than peak counts of Common Loons (mean = 27 individuals; Table 7). Loon abundance also changed between years (CV = ca. 65, Table 7). Red-throated Loons and Common Loons are most concentrated within nearshore areas (<10 km from shore) and prefer water <20 m deep for foraging, although they can be found much farther offshore depending on weather conditions and the locations of forage fish (Daub 1989). The diet of Red-throated and Common Loons consists mainly of live fish, but also includes other aquatic vertebrates and invertebrates (McIntyre and Barr 1997). Loons generally fly low over the water (<15 m), but can be detected flying over 50 m high when migrating (McIntyre and Barr 1997; Sibley 1993).

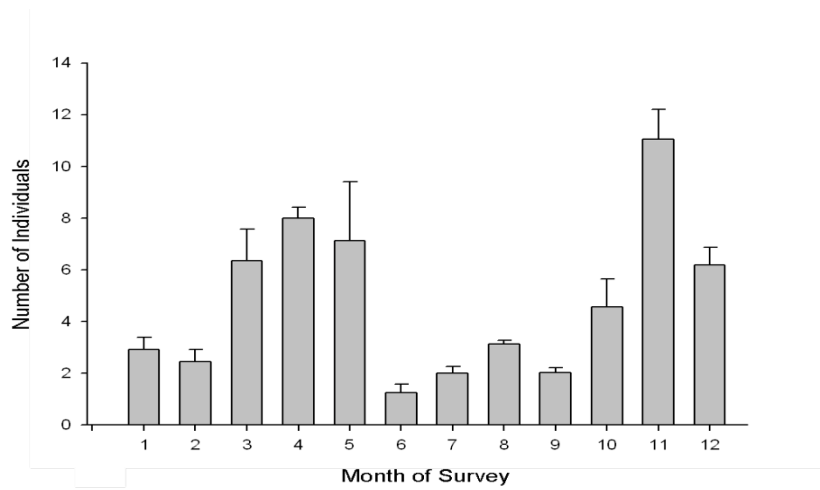

Fig. 15. Seasonal change (mean ±SD) in the mean number of loons detected during surveys at Napatree Point. Surveys were conducted from 1982-2008 (C. Raithel, RIDFW). January is month 1.

GREBES

In nearshore coastal waters, the most common grebe species occurring in Rhode Island is Horned Grebe mean annual peak count of 27.9 ± 8.9, with a maximum of 47 during Napatree surveys,

Table 7), while Pied-billed Grebe is more common in coastal ponds such as Trustom (mean annual peak count of 4.9 ± 4.7, maximum = 17; Table 8). In addition, small numbers of Red-necked Grebes winter in nearshore waters (see Tables 6 and 7). Horned Grebe and Red-necked Grebes are migratory winter residents in the Ocean SAMP study area, whereas Pied-billed Grebes breed in coastal ponds in Rhode Island. Grebes forage in nearshore and inshore areas within relatively shallow water (<6 m) on small schooling fish (Stedman 2000; Dewar 1924). Grebes generally fly low over the water when moving to and from foraging areas (<5 m).

CORMORANTS

Double-crested Cormorants and Great Cormorants are common in Rhode Island and the SAMP area. Mean annual peak counts of Double-crested Cormorants averaged 1,529 ± 1,679 individuals, with a maximum daily count of 7,640 at Napatree (Table 7). In contrast, Great Cormorants, were much less abundant with mean peak counts of 26.6 ± 12.6 individuals and a maximum daily count of 50 at Napatree (Table 7). CVs were higher for Double-crested Cormorants compared to Great Cormorants, 110 vs. 47, respectively during Napatree surveys (Table 7). Double-crested Cormorants reed in Rhode Island and often forage in large flocks on Narragansett Bay and the Ocean SAMP area during summer and during migration (RIDFW; Fig. 16). Great Cormorants are common winter residents in coastal Rhode Island . Double-crested and Great Cormorants are generally found close to shore (<5 km) and tend to forage in shallow (<8 m) open water (Hatch and Weseloh 1999). Great Cormorants tend to forage in water that is less than 20 m deep (Hatch et al. 2000). Their diets consist primarily of schooling species of fish (Hatch and Weseloh 1999). Cormorants generally fly low over the water (<15 m) when moving from foraging areas to roosting areas or wing-drying perches, but are found flying much higher (>100 m) when flying over land or during migratory flights when they are often seen flying in formation (Fig. 9).

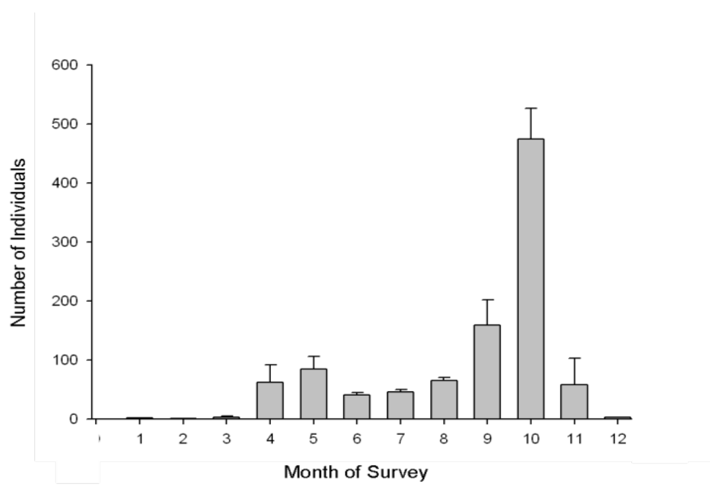

Fig. 16. Seasonal change (mean ± SD) in the mean number of Double-crested Cormorants detected during surveys at Napatree Point. Surveys were conducted from 1982-2008 (C. Raithel, RIDFW). January is month 1.

GULLS

There are at least 15 species of gulls that could occur in the Ocean SAMP study area, and gulls are among the most abundant avian groups using the Ocean SAMP study area. Common gull species using Rhode Island's nearshore and offshore waters include Great Black-backed Gull, Herring Gull, Bonaparte's Gull, Laughing Gull, Ring-billed Gull and Black-legged Kittiwake. Herring and Great Black-backed Gulls breed in Rhode Island and are abundant in the study area throughout the year (Ferren and Myers 1998). Black-legged Kittiwakes and Bonaparte's Gulls are only found in the area during the winter months. Laughing Gulls breed north of Rhode Island and winter in the southern US, and thus are found migrating through the Ocean SAMP study area prior to the nesting season and during early fall. Gulls are generally found in nearshore habitats, with the exception of Black-legged Kittiwakes which are almost always found offshore. Most species of gulls also venture offshore, except Ring-billed Gull, which are rarely found offshore. Dietary preferences differ among gull species but they are generally opportunistic and prey on intertidal marine invertebrates, fish, insects, and human waste (Good 1998; Pierotti and Good 1994). Gulls are usually found flying low to the water when actively foraging (<15 m) but are also commonly seen flying high, especially when they are soaring to search food over a large area (Fig. 9).

NORTHERN GANNETS

Northern Gannets are abundant in the Ocean SAMP study area during migration and are winter residents in offshore waters. Northern Gannets generally forage far offshore on larger surface-schooling pelagic fish (i.e., herring, mackerel) and squid (Mowbray 2002). However, they can be detected from land-based survey stations. Raithel regularly detected gannets flying off of Napatree, with mean annual peak counts of 193 ± 605 (SD), and a peak daily count of 3,000 birds. Gannet numbers are highly variable (e.g., CV at Napatree = 313), probably because they actively follow concentrations of small bait fish which tend to vary in space and time. They can be seen foraging in small groups, but are often in large flocks foraging on large concentrations of surface schooling fish (Mowbray 2002). They are often seen in mixed flocks with Herring and Great Black-backed Gulls foraging behind commercial trawlers (K. Winiarski, pers. obs.). Common flight elevations are 5-50 m when not foraging (Fig. 9).

ALCIDS

Common alcid species (Alcidae) in Rhode Island include Razorbills, Common Murre, and Thick-billed Murre. They are common offshore winter residents, although little is known about their abundance and distribution in the Ocean SAMP study area. These species were rarely detected during NMFS or CSAP surveys from 1978-1988 (Table 3). They are generally found in small groups (<40 individuals). Dovekie, Black Guillemot, and Atlantic Puffin are uncommon off the coast of Rhode Island because they usually winter farther north. Alcids mainly forage on fish, but will also forage on crustaceans and other invertebrates (Hipfner and Chapdelaine 2002; Ainley et al. 2002). In the Atlantic, alcids are typically found foraging on the continental shelf or slope, regularly in relatively shallow water 20 to 40 m deep (Hipfner and Chapdelaine 2002; Gaston and Hipfner 2000). They generally fly lower than 10 m above the water.

STORM-PETRELS

Wilson's Storm-Petrel are one of the most abundant seabird species in the world (IUCN 2006) and are common in Rhode Island's offshore waters. They are rarely detected during land-based surveys, with <1 seen most years at Napatree (Table 7). They are most common off of the New England coast from May to September (they breed in southern hemisphere during October-April) (Quillfeldt 2001). Leach's Storm-Petrels are uncommon and only found in small numbers off of the New England coast during the late fall. Storm-petrels are generally found in offshore areas where upwellings or floating debris concentrate forage on the surface (Huntington *et al.* 1996). Petrels are generally omnivorous and forage primarily on plankton, nekton, fishes, squids, crustaceans and jelly fishes (Huntington et al. 1996) Wilson's Storm-Petrels observed during surveys for the Cape Wind project were found flying below 3 m (Kerlinger and Hatch 2001).

SHEARWATERS

Greater Shearwater and Sooty Shearwater are common migrants in the offshore areas of the Ocean SAMP area, but are rarely seen from land-based survey locations (Table 7). Manx Shearwater and Cory's Shearwater are found in small numbers off of the coast of New England in late summer and during fall when they migrate through the area. In northern New England, shearwaters are commonly found in shallower areas of the continental shelf foraging in areas where water depth is between 20 to 200 m (Lee and Haney 1996). Shearwaters feed mainly on small fish and squid (Brown et al. 1981) and tend to fly just above the ocean surface.

JAEGERS

Pomarine Jaeger and Parasitic Jaeger are common offshore migrants in New England from July to October, but are rarely seen from land (e.g., Napatree survey results, Table 7). Parasitic Jaegers are generally found closer to shore than Pomarine Jaegers because of their kleptoparasitic foraging strategy which commonly targets tern species (Haven and Lee 1999). Pomarine Jaegers are not commonly found foraging in nearshore coastal waters and tend to be found foraging along the continental shelf (Lee 1995). Jaegers forage primarily on fish and squid and generally fly at low elevations (5-10 m), while foraging and migrating (Haven and Lee 2000).

Wading Birds

HERONS AND EGRETS

Herons and egrets are common colonial breeders and migrants in Rhode Island (Myers and Ferren 1998). Narragansett Bay and the coastal ponds offer acres of shallow water habitat that these birds prefer for hunting nekton (small fish and crustaceans). Common species include Great Blue Heron, Little Blue Heron, Black-crowned Night Heron, Great Egret and Snowy Egret. Herons and egrets breed on many of the islands in Narragansett Bay, just north of the SAMP area (Myers and Ferren 1998). Herons and egrets likely migrate in small numbers in nearshore habitats north of the Ocean SAMP study area during fall and spring migration, with much of the study area too deep for foraging. Herons and egrets are known to fly relatively high (>150 m) during migration.

Shorebirds

Shorebirds are common in Rhode Island from May to September (RIDFW; Fig. 17). Large numbers of shorebirds probably migrate over the Ocean SAMP study area and forage in intertidal areas at the edges of the SAMP area. Piping Plovers breed in Rhode Island and are federally listed as a threatened species. They breed on both the south shore beaches of Rhode Island, and rarely on Block Island (USFWS, unpubl. data).

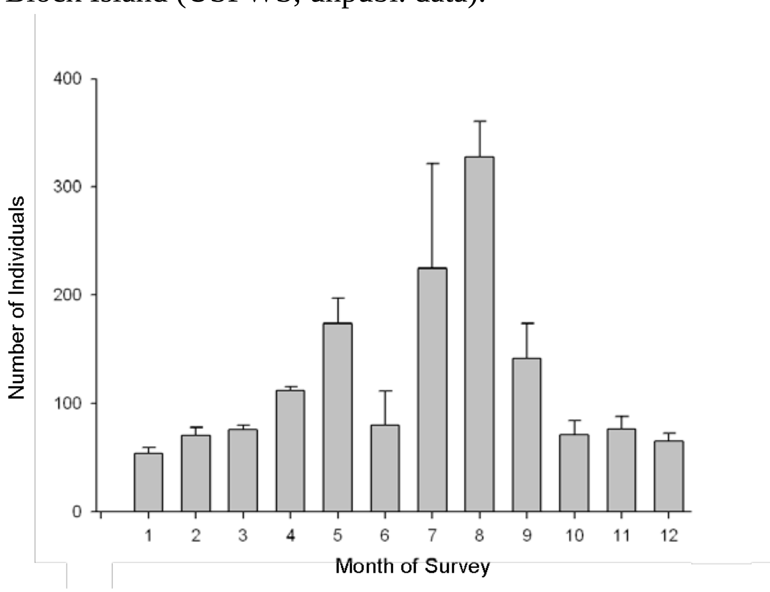

Fig. 17. Seasonal change (mean ± SD) in the mean number of shorebirds recorded during surveys at Napatree Point. Surveys were conducted from 1982-2008 (C. Raithel, RIDFW). January is month 1.

Plovers and Sandpipers

The most common plover and sandpiper species in Rhode Island include Piping Plover, Semipalmated Plover, Black-bellied Plover, Semipalmated Sandpiper, Dunlin, Purple Sandpiper, Least Sandpiper and Sanderling. Piping Plovers breed on coastal beaches in mainland Rhode Island and Block Island and are likely common migrants through the Ocean SAMP study area (Ferren and Myers 1998). Since Piping Plovers are federally listed as a threatened species, they are closely monitored by the USFWS and local conservation organizations. In 2008, a total of 63 pairs were found breeding along the south coast of Rhode Island (USFWS, unpubl. data). All nests were along the south shore of RI and within the northern border of the SAMP area. Piping Plover forage primarily on marine invertebrates in the intertidal zone and are believed to stay close to their nest location while breeding (Elliot-Smith and Haig 2004).

Semipalmated Plover, Black-bellied Plover, Semipalmated Sandpiper, and Least Sandpiper are common spring and fall migrants through the area. Sanderlings, Dunlin, and Purple Sandpipers are winter residents in Rhode Island. Shorebirds mainly forage on marine invertebrates in tidal flats, beaches and coastal ponds. It is likely that tens of thousands of shorebirds migrate over the study area, but since they are known to migrate at high elevations (>400 m) they are difficult to detect. However, they are often found flying at lower elevations (<10 m) when foraging or after initial takeoff or when descending after a migratory flight (Fig. 9).

Phalaropes

Red-necked Phalarope and Red Phalarope are common offshore migrants during late summer and early fall. Distribution and abundance of phalaropes in the Ocean SAMP area is not well known (see Table 3). Phalaropes are members of the shorebird family, but unlike many shorebird species they spend up to 11 months annually offshore (Tracy et al. 2002; Rubega et al. 2000). Phalaropes forage primarily on plankton and are usually found in areas where there is significant upwelling and mixing, areas which support high plankton concentrations (Rubega et al. 2000). In the southeastern United States, they are generally found 40 to 80 km from shore, in water that is 20 to 40 m deep (Rubega et al. 2000). Phalaropes generally fly low to the water when foraging, but likely fly at much higher elevations when migrating long distances.

Landbirds

Passerines

Songbirds spend most of their time on land, but during migration, large numbers of passerine species migrate over large water bodies and concentrate along the southern coast of Rhode Island and Block Island. Block Island has been designated by The Nature Conservancy as an important bird area because of a high abundance of songbirds during migration (Parrish 2000). Due to the consistency of cold fronts and associated northwest winds during the fall, larger numbers of songbird migrants pass through the area during fall migration than during the spring migration when southwest winds that provide optimal conditions for bird movement through the area are less consistent (Reinert et al. 2002; Drury and Keith 1962). Fall migration peaks in October and the most common migrants captured in Rhode Island and Block Island include: Yellow-rumped Warbler, Gray Catbird, Golden-crowned Kinglet and Red-eyed Vireo (KWRS; Fig. 18 and 19). In the fall, nearly 97% of individuals captured are hatch year birds that fledged 1-4 months prior to being captured (Reinert et al 2002). Spring migration peaks in May and the most common migrants captured in the area include: Gray Catbird, Common Yellowthroat, Yellow-rumped Warbler and White-throated Sparrow.

Large numbers of songbirds likely migrate through the Ocean SAMP study area at high elevations (>500 m), but likely fly at much lower elevations when beginning or ending migratory flights. Occasionally songbirds have been observed flying low over the offshore water surface (<5 m) during ship-based avian surveys off of the coast of Block Island (Winiarski, unpubl. data). It is unclear if these individuals were attracted to the ship at the end of a migratory flight or if they commonly move across the study area at low elevations.

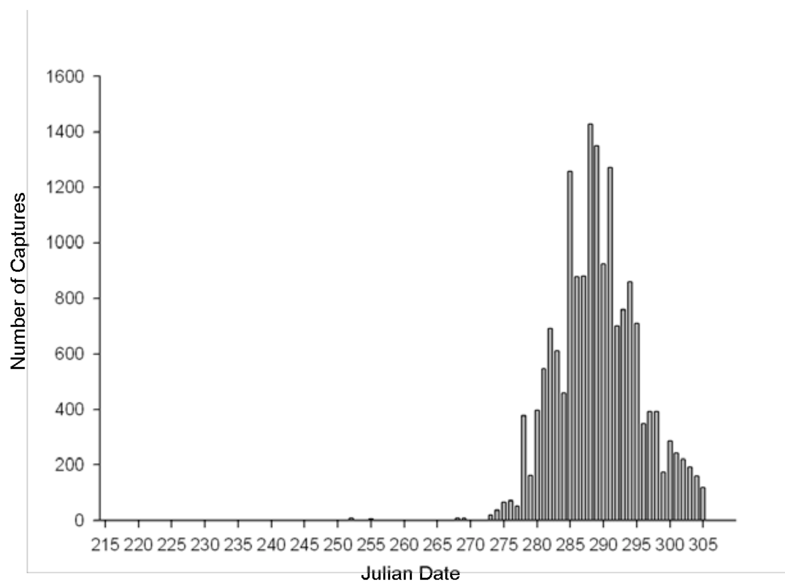

Fig. 18. Seasonal change in the total number of Yellow-rumped Warblers captured at the Kingston Wildlife Research Station from 1960-2007. Day 275 is 2 October in most years.

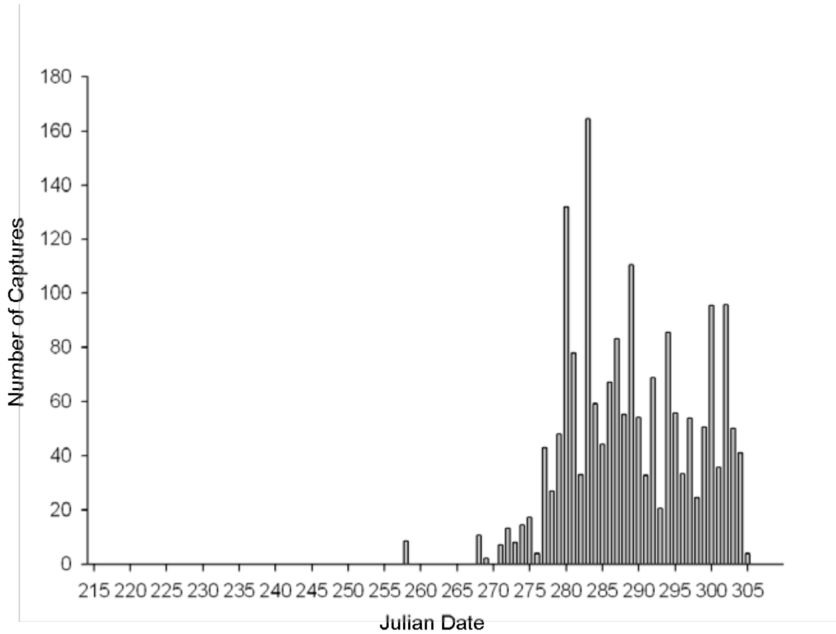

Fig. 19. Seasonal change in the total number of Golden-crowned Kinglets captured at the Kingston Wildlife Research Station from 1960-2007. Day 275 is 2 October in most years.

DIURNAL RAPTORS

Common diurnal raptor species in Rhode Island include: Red-tailed Hawk, Sharp-shinned Hawk, Cooper's Hawk, Northern Harrier, Broad-winged Hawk, Peregrine Falcon, Merlin and Osprey (e.g., see Napatree surveys by Raithel, Table 7). Raptors spend the majority of their time on land, but like songbirds are found in large numbers during migration in southern Rhode Island especially in September and October (RIDFW; Fig. 20). Most raptor species will only migrate over narrow water bodies, in particular buteos (e.g., Red-tailed Hawk) are rarely seen along the coast during migration (mean daily peak counts of 1.4 ± 1.3 (SD) individuals per year at Napatree; Table 7) and rarely venture out to Block Island. Accipters, particularly Sharp-shinned Hawk (Napatree mean daily peak counts = 118.3 ± 149.1) and Cooper's Hawk (4.0 ± 4.3) often migrate along the coast during fall migration on days with strong NW winds (Table 7), but are much less common on Block Island. In contrast, falcons (Merlin and Peregrine Falcon), ospreys and harriers will fly over large expanses of open water and are commonly observed on Block Island.

In addition, Napatree is an area well known for raptor concentration during fall migration. Peregrine Falcons observed during a ship-based survey off of the coast of Block Island were seen flying at altitudes up to 50 m, while Merlins were observed flying less than 5 m above the ocean surface (Winiarski unpublished data).

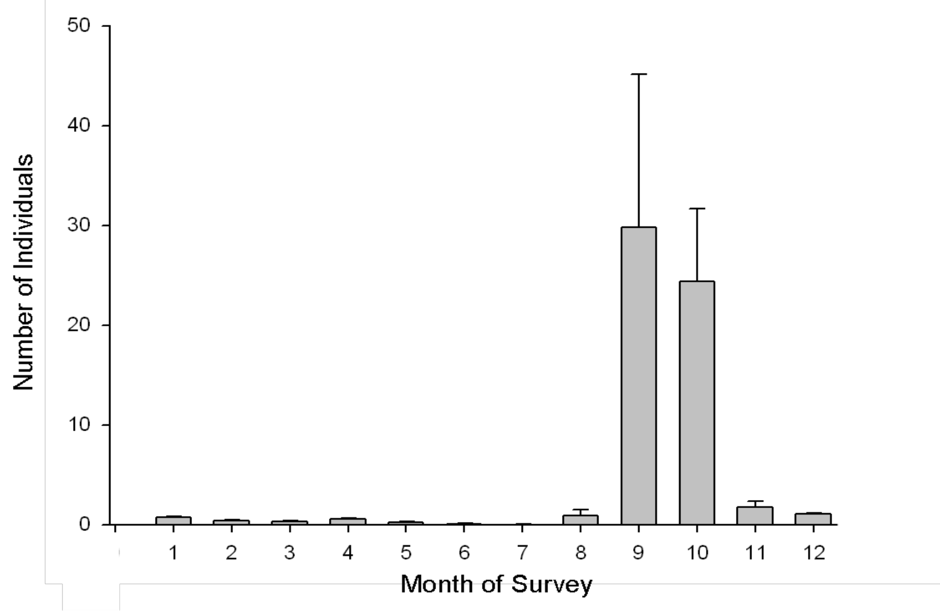

Fig. 20. Seasonal change (mean ± SD) in the number of raptors recorded during surveys at Napatree Point. Surveys were conducted from 1982-2008 (C. Raithel, RIDFW). January is month 1.

SUMMARY OF PREVIOUS AVIAN RESEARCH IN OCEAN SAMP STUDY AREA

Data sets available from prior avian surveys conducted within the Ocean SAMP study area document the phenology, abundance, spatial distribution in nearshore habitats, and movement ecology of many avian groups, but also highlight the lack of information regarding a number of avian groups, particularly those groups common to offshore waters. Surveys conducted in a manner that allow for a quantitative analysis of avian density and spatial distribution (especially in offshore waters) will be crucial to assess potential and actual impacts of future development. Additional research effort must target threatened and endangered species and those species considered of conservation concern.

1.5 Rationale for selected survey and analysis techniques.

Ship-based surveys that involve observers recording all birds observed on the water have been used extensively for surveying seabirds (Camphuysen et al. 2004; JNCC 2004). The advantages of ship-based surveys are that they can provide accurate information on the density and behavior of species present in the area of interest. Ship-based transects surveys have been used by ornithologists for almost 100 years (Jespersen 1924) and have been the primary means to estimate seabird abundance for almost 50 years (Brown et al. 1974). Standardized survey protocols have been in place for over 25 years (Tasker 1984). Recent advances in density estimation based on line transect methods have increased the accuracy and precision of model estimates of seabird distribution and abundance (Ronconi and Burger 2009).

Most current ship-based surveys use line transect distance-sampling methods (Buckland et al. 2001), with observers recording the number of each species present, their behavior, and flight direction (Innogy 2003; Camphuysen et al. 2004). Importantly, if observers also accurately record the distance of each observed bird from the boat, then a detection function for each species can be determined and then used to more accurately estimate density for each bird species within the survey area (Buckland et al. 2001).

Aerial surveys are used extensively in western Europe to investigate the spatial distribution and abundance of offshore birds, particularly when assessing the potential impacts of wind farms. In fact, standardized aerial survey protocols have been developed by COWRIE (Camphuysen et al. 2004) and are now widely adopted as standard protocols. COWRIE recommends a twin-engine (for safety) high-wing aircraft be used, that allows good visibility for observers. Helicopters are not recommended because they have a tendency to disturb seabirds on the water (Camphuysen et al. 2004). Standardized protocols in the UK and Denmark recommend a line-transect methodology with the aircraft flying at 185 km/hr at 80 m altitude, with transects spaced 2 km apart to minimize the probability of double-counting birds. They also record birds in three-band distances from the line of flight (44-163 m; 164-432 m and 433-1000 m), so that detection functions can be calculated. Finally, Camphuysen et al. (2004) recommend that two trained observers be used for each aerial survey, one conducting observations on each side of the aircraft, with all observations recorded continuously on a Dictaphone. The time of each bird sighting is recorded, ideally to the nearest second. Locations are later determined by cross-referencing these with a GPS track that is obtained throughout the flight with locations and times recorded at least every 5 seconds.

Effective study designs for conducting aerial surveys place line transects perpendicular to major environmental axes (Buckland et al. 2001, Maclean et al. 2006). For example, seabirds are often distributed according to food availability and water depth. Thus, transects should be established perpendicular to the coast to gather information on the entire range of densities for each individual transect, as the sampling unit is each transect. For investigators using Distance sampling, Laursen et al. (1997) recommended 20 transects within an area of interest. Maclean et al. (2006) also recommended that at least four flights of the whole area be undertaken during the winter (mid-October to mid-March), with counts carried out across the whole period if possible.

2 Methods

2.1 Nearshore Avian Assessment: Land-based Point Counts (Jan 2009 to 12 Mar 2010)

2.1.1 Survey Techniques

We initiated systematic land-based avian point counts on 23 January 2009 and they will be continued until the end of July 2010. These land-based sea watches occurred at 11 fixed point count stations (“stations”) located along four survey routes (“routes”) from Watch Hill to Sakonnet Point (Fig. 21). Three routes had three stations each, while the eastern route (Sakonnet area) had two stations. We surveyed each station at least six times per month, with three morning surveys and three afternoon surveys.

During morning surveys, we surveyed the first station on the route for 120 min starting at dawn, whereas the next two stations were surveyed for 60 min each. For afternoon surveys, the first two stations were surveyed for 60 min each, whereas the last station of the day was surveyed for 120 min. Afternoon surveys were scheduled so that they were completed just prior to dusk when low light levels made it difficult to see and identify individuals to species or guild. We varied the order that stations were surveyed using a stratified random selection sampling scheme. We ensured that each station was surveyed once per month during the 120-min early morning and late afternoon sampling blocks.

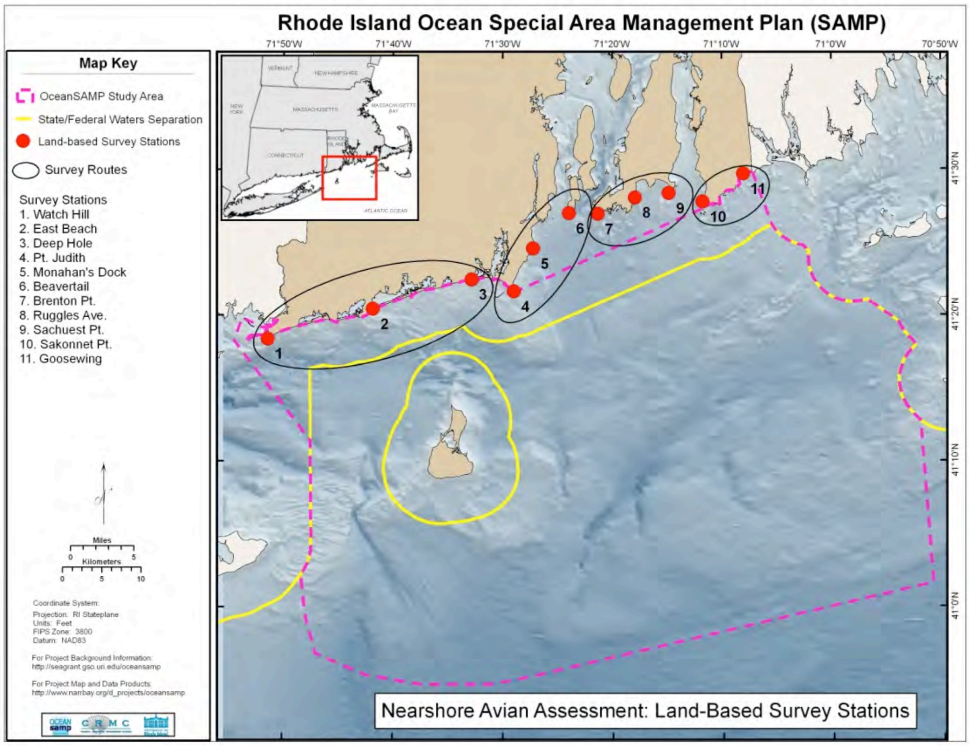

Fig. 21. Distribution of 11 land-based seawatch stations (red circles) along 4 survey routes (black ovals) where 1-2 hr morning and evening seawatches were conducted from January 2009 through July 2010. Stations include: 1) Watch Hill Lighthouse, 2 = East Beach, 3 = Deep Hole, 4 = Point Judith, 5 = Monahan's Dock, 6 = Beavertail Lighthouse, 7 = Brenton Point, 8 = Ruggles Ave., 9 = Sachuest Point NWR, 10 = Sakonnet Point, and 11 = Goosewing Beach.

During land-based surveys, one observer recorded all birds on or flying over the water that were within 3 km of the station (Fig. 22). Observers used a combination of a 20-60 power spotting scope (Swarovski HD-ATS 80) and a pair of 10 x 42 binoculars (Swarovski EL) to effectively scan the point count area. Observers scanned the ocean surface out to 3 km and equally scanned the airspace above the water surface (>200m) and recorded the number and species for all flying individuals or flocks for the specified survey period 60 or 120 minutes). For birds on the water, we separately recorded abundance of birds at four distance increments: 0-0.5 km, 0.5 – 1 km, 1 – 2 km and 2 – 3 km from the observer (Fig. 22). If individuals were observed in flight, we categorized flight elevation into five altitude categories: <10 m above the ocean, 10-25 m, 26-125 m, 126-200 m, >200 m. In addition, we also estimated true flight direction (N, NE, E, SE, S, SW, W, NW, variable). We also recorded environmental parameters and observation conditions at the beginning of each survey or when conditions changed including: wind speed (km/hr), wind direction, visibility distance, cloud cover (0-100%), and weather (e.g., precipitation). We did not conduct land-based surveys when the Beaufort sea state was 5 or higher (Table 11). We recorded observations in the field using a handheld PDA (Juno Trimble) equipped with Cybertracker data collection software (Cybertracker: www.cybertracker.co.za).

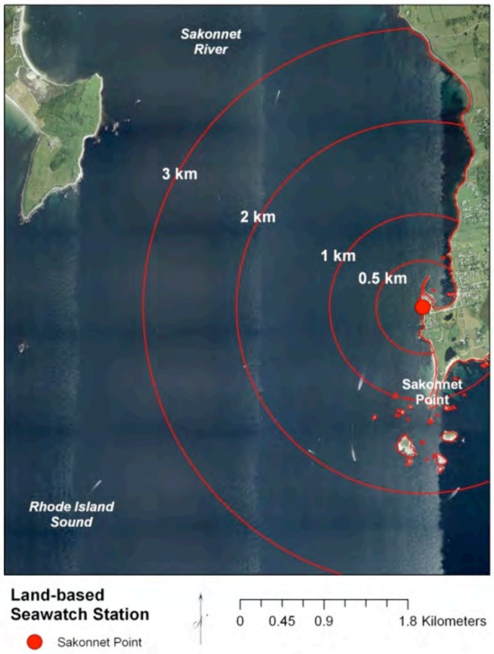

Fig. 22. During land-based point counts, birds were counted out to 3 km offshore in 4 distance bands. Here is an example of distance bands at Sakonnet Point.

Table 11. Beaufort scale used to describe sea state. We only list up to Beaufort 6, as no surveys were conducted in sea states above a 5.

Beaufort number	Description	Wind speed	Wave height	Sea conditions
0	Calm	<1 km/hr (< 1 mph)	0 m	Flat
1	Light air	1.1-5.5 km/hr (1-3 mph)	0-0.2 m	Ripples without crests
2	Light breeze	5.6 – 11 km/hr (4-7 mph)	0.2-0.5 m	Small wavelets, Crests of glassy appearance, not breaking
3	Gentle breeze	12-19 km/hr 8-12 mph	0.5 – 1 m	Large wavelets, crests begin to break, scattered whitecaps
4	Moderate breeze	20-28 km/hr (13-17 mph)	1-2 m	Small waves with breaking crests. Fairly frequent white caps
5	Fresh breeze	29-38 km/hr (18-24 mph)	2-3 m	Moderate waves of some length, many white caps, small amounts of spray
6	Strong breeze	39-49 km/hr (25-30 mph)	3-4 m	Long waves begin to form, white foam crests are frequent, some airborne spray present.

2.2 Offshore Avian Assessment: Ship-based Surveys (Feb 2009 to Feb 2010)

2.2.1 Survey Techniques

We conducted systematic ship-based surveys approximately once a month from February to May 2009 and then approximately once a week from June 2009 until Feb 2010 to quantify the abundance of all species of waterbirds within the Ocean SAMP study area. We conducted all surveys on a 27.5 m (90ft) ship operated by the Frances Fleet (Galilee, RI). From February 2009 to May 2009 surveys were conducted on two sampling grids, one grid (A) located south of Block Island and one grid (B) located to the east of Block Island (Fig. 23). The ship traversed each sampling grid along four 9.3 km (5 nautical miles [nm]) long parallel transects (i.e., 37 km [20 nm] surveyed) that were oriented north to south. Starting June 2009, we added 6 more grids, and change the survey pattern within grids to be a sawtooth pattern using program DISTANCE to generate the transects (Fig. 24).

All ship-based surveys used the following line-transect sampling method (modified from Camphuysen et al. 2004) so that we could later estimate density of each bird species or guild in the study area given their likelihood of detection. Two sampling grids were sampled per survey day and the order of surveying of these grids was randomized from month to month. We began surveys at sunrise when there was enough light to allow observers to identify individuals to species. During surveys, the ship traveled at a constant speed of 10 knots (11.5 mph), which was slow enough to allow for detection of all individuals along the ships trackline. We conducted all observations from the upper level of the vessel at the bow of the ship and from either the port or starboard side of the ship (depending on which side offered optimal viewing conditions). Observers used their unaided eye or a pair of 10 x 42 binoculars to detect birds. We conducted all surveys using an observer and an observer/recorder. We recorded observations in the field using a handheld PDA (Juno Trimble) equipped with Cybertracker data collection software (Cybertracker: www.cybertracker.co.za).

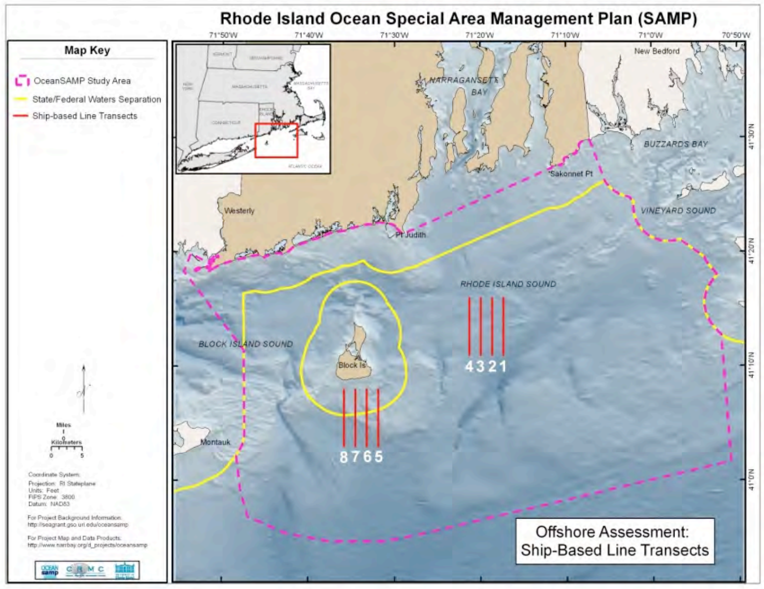

Fig. 23. Location of two ship-based line-transect grids S and E of Block Island that were monitored from Feb to May 2009.

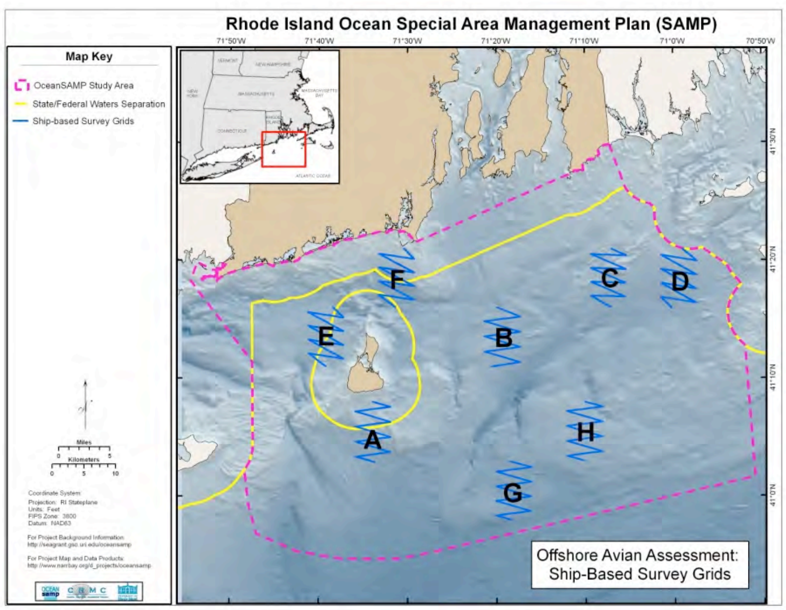

Fig. 24. Distribution of eight survey grids used for ship-based line transect surveys from June 2009 through mid-Feb 2010. Each grid was 4 by 5 nm and had 25 nm of line transects.

Occasionally, when viewing conditions were difficult (e.g., birds were backlit) or birds quickly dove underwater upon detection, we identified individuals to a guild (e.g., large shearwater, Surf or Black scoter (either Surf or Black Scoter, alcid). We visually estimated perpendicular distance from the trackline to each bird on the water and in flight. From February 2009 to

September 2009, we only measured distance to birds on the water and we estimated this distance from the ships trackline as <50m, 50-100m, 101-200m, 201-300m. From September 2009 to July 2010, we estimated the actual distance (m) and the bearing to each detection (an individual bird or a flock of birds) regardless of whether the bird was on the water or in flight. We estimated the bearing by using a large protractor mounted at the bow of the ship. This allowed us to calculate a perpendicular distance to the transect line for all individuals using the formula $x = r * \sin(\text{bearing angle})$, where x is the distance to the transect line from the bird or flock, r is the estimated distance from bird or flock to observer, and bearing angle was estimated by the observer using the large protractor (Fig. 25).

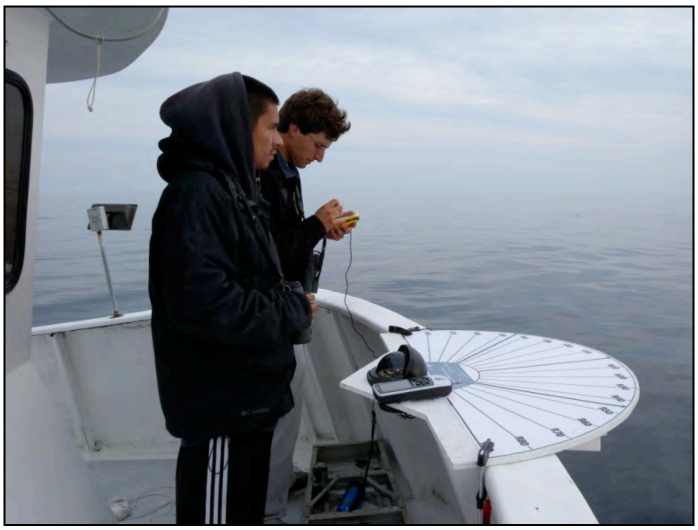

Fig. 25. Ship-based line transect surveys were conducted on a large vessel (>27.5 m), with one primary observer and one observer/recorder. Angle to birds was measured using a large protractor mounted to bridge railing. Note recorder (K. Winiarski) taking observations on a PDA, while primary observer (B. Harris) is actively searching for birds with both naked eye and binoculars.

We also recorded the behavior of all observed individuals or flocks as feeding, loafing, resting, or millingfor bird(s) on the water. For birds in flight, we recorded birds as feeding if so observed. For individuals or flocks in flight, vertical flight elevation was estimated into discrete elevation bins (<10m, 10-25m, 26-125m, 126-200, >200m) along with the individual or flocks flight direction (N, NE, E, SE, S, SW, W, NW, variable). Birds following the ship (“ship followers”) were ignored and not recorded. Information on anthropogenic influences during the survey that may have been attracting birds to the sampling area was also recorded (e.g., fishing boats or floating debris).

We recorded environmental data at the beginning of each line transect including: wind speed, wind direction, sea state, visibility and weather (% cloud cover, precipitation). Surveys did not take place when the Beaufort sea state was 4 or higher (Table 11). Data were recorded with a handheld GPS-enabled PDA (Trimble Juno) loaded with Cybertracker data collection software (www.cybertracker.org). A handheld Garmin unit (Garmin Marine GPS 76) recorded a trackline when the ship was on survey (unit recorded a GPS location every 15 seconds).

2.2.2 Analytic Methods: Detection Functions and Density Surface Modeling (DSM)

We utilized the 'count method' of Hedley and Buckland (2004) and used sighting data collected on ship-based surveys to model the surface density and to visually depict the foraging area of those species common to the Ocean SAMP study area. Species were modeled by season: Summer (surveys conducted from 10 June 2009 to 25 August 009), Fall (surveys conducted from 8 Sept 2009 to 17 Nov 2009) and Winter (surveys conducted from 19 Nov 2009 to 13 Feb 2010). Creating a surface density model is a multiple step process (Fig. 26) that first includes modeling a detection function based on the observed distance data collected from line transect sampling. These detection functions are then included in the creation of models that relate observation data with spatial covariates to predict densities across both areas sampled and those not sampled (Fig 26; Katsanevakis 2007).

It is important to note that the standard line transect sampling methods that we used (e.g. surveying within a set 300m distance) violated key assumptions of Distance sampling when recording birds in flight, so we opted not to fit a detection function to data on birds in flight. Instead, we assumed 100% detection of flying individuals in the 300m sampling "box" (e.g., strip transect). For all surface density models we used either data for birds in flight or for birds on the water, and we used the frequency of observations to determine which data to use for a given species. For example, Greater Shearwater, Cory's Shearwater and Wilson's Storm-Petrel were rarely sighted on the water, and so we used only data on birds in flight to model their surface density. Most other species were predominately observed on the water and so we used these data to model surface density. For the few species (e.g., gulls and gannets) that were frequently observed both flying and on the water, we selected the data set with the greatest number observations to construct the predictive models.

The detection function, g(y), was estimated using Distance 6.0 software (Thomas et al. 2006) following the method outlined by Buckland et al. (2001). A single parameter half-normal function or a two parameter hazard rate formula were considered as possible detection functions. Akaike Information Criteria was used to select the "best" model and Q-Q plots were used to assess model fit. The highest ranking detection functions were chosen for each avian species and each season that was modeled.

We used two physical spatial covariates, depth and distance to land, to model the foraging distribution of species common to the Ocean SAMP study area. Each line transect was divided into 830 m long segments using ArcMap 9.3 (total of 465 segments). Depth was measured at the midpoint of the segment from the NOAA Coastal Relief Model data set. Distance to land was also calculated from the midpoint of the segment, and measured to the nearest point of land using ArcMap 9.3. The total number of birds within each segment, independent of spatial covariates, was calculated using the Horvitz-Thompson-like estimator (Hedley et al. 2004). Expected values of abundance in each segment were calculated using Generalized Additive Models (GAMs; Hastie and Tibshirani 1990). Four different GAMs were fitted for each density surface model: two univariate models for depth and distance to land, a model including both depth and distance to land, and a model with a depth and distance to land interaction. Model selection was based on the lowest Generalized Cross Validation score (GCV; Wood 2006). For this analysis we used the mgcv package (Wood 2000, 2006) written in R v.2.9.1 (R Development Core Team 2009) within Distance 6.0 (Thomas et al. 2006). The steps we took to develop a DSM are shown in Fig. 26.

Using ArcMap 9.3 software (ESRI), a prediction grid was created overlaying the map of the study area with 920 square cells, each 4 km^2 in area (Fig. 26). Abundance in the study area for each species and season was estimated as the sum of prediction cells, where abundance predictions for each cell were calculated with the selected GAM model. The abundance estimation was conducted using the DSM analysis engine of the Distance 6 software (Thomas et al. 2006). Based on the predictions for each of the 920 grid cells, we produced a distribution map of individual species for the Ocean SAMP study area using ArcMap 9.3.

A variance component was calculated for each model following Seber (1982) that included both the variance associated with fitting the detection function and that associated with the density surface model (e.g. the two steps in creating a density surface model). To calculate the variability associated with the density surface model estimates, we ran a parameteric bootstrap with 499 reiterations for each model (Efron and Tibshirani 1993). The bootstrap used a moving block of three segments to reduce the effects of spatial autocorrelation.

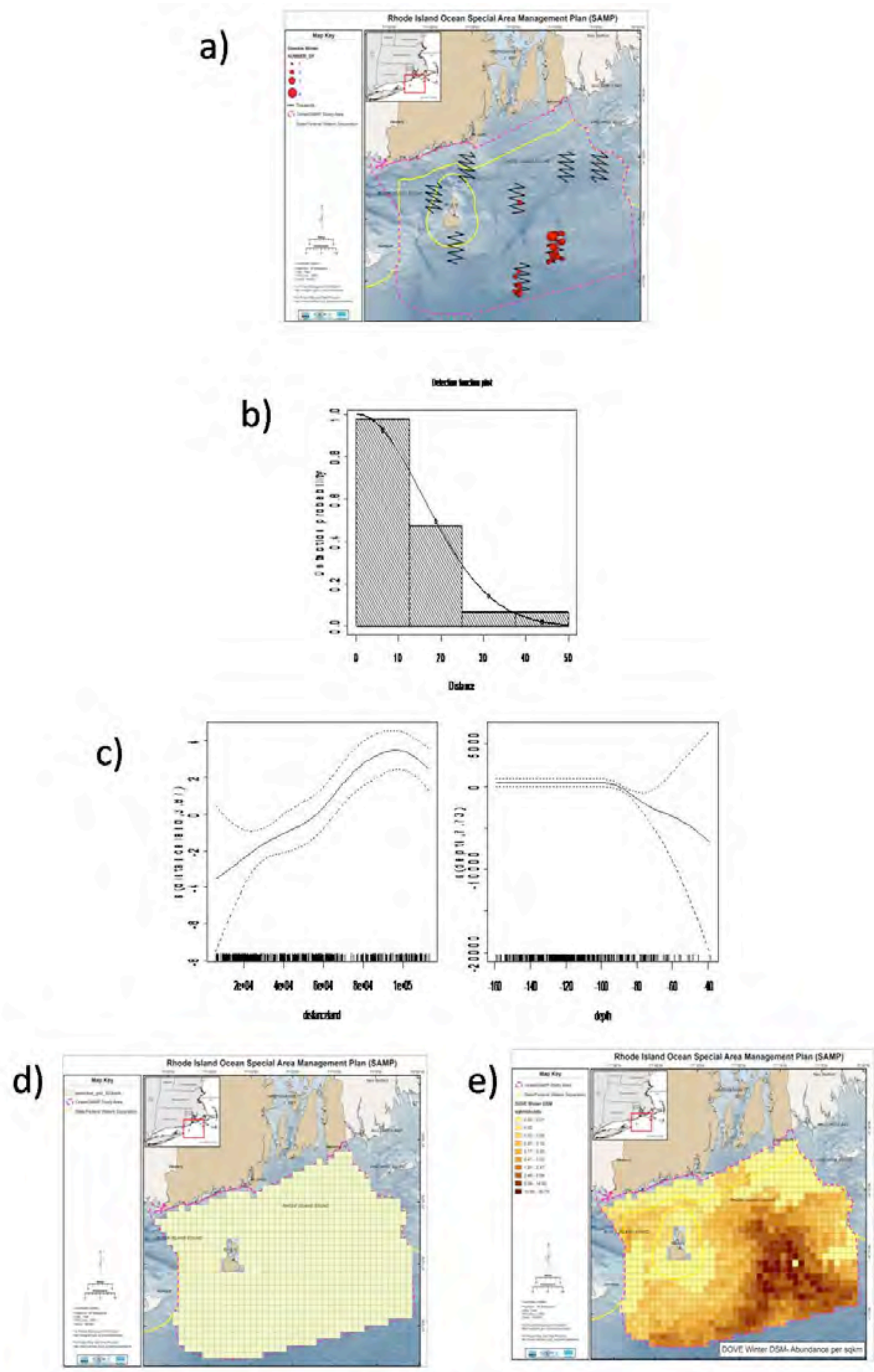

Fig. 26. Example of the steps involved in creating a surface density model (DSM) for Dovekie in winter: (a) Raw data collected from ship-based line-transects (b) Detection function (Half-normal) fitted to distance data. (c) Generalized additive models (GAMs) modeled with two physical variables, depth and distance from shore. (d) Grids (each cell is 4 km^2) created to predict avian densities across study area. (e) Predicted density in cells based on GAM model output with water depth and distance to shore (calculated at the midpoint of each cell).

2.3 Offshore Avian Assessment: Aerial Surveys (Nov 2009 to Feb 2010)

2.3.1 Survey Techniques

We performed aerial surveys approximately once a week starting in November 2009. Aerial surveys will continue monthly through May 2011. Based on our observations of the movement phenology of waterbirds during land-based point counts of nearshore habitats from January to Feb 2009, we conducted the aerial surveys during mid-day (usually 1000-1500 hrs) to coincide with when birds had completed their post-dawn or pre-sunset movements from roosting to feeding areas. We conducted surveys along 24 transect lines that were spaced 3 km apart, with average transect length of 46.26 km ± 12.34 km (SD) (min = 7.77 km, max = 57.97 km) (Fig. 27). Transects were oriented perpendicular to the coast and equally covered all of the SAMP study area. We conducted all aerial surveys from a twin engine Cessna Skymaster aircraft that flew at an altitude of 152 m (500ft) above mean sea level at a constant speed of 160 km/hr (100 miles/hr).

We realize that many previous aerial surveys for seabirds were conducted at a lower altitude (76-80 m or 250 feet) and at a speed of 185 km/hr (Camphuysen et al. 2004; Maclean et al. 2006). However, we flew at an altitude of 152 m for three reasons: (1) if these data were used for pre-construction surveys for wind power, we wanted to maintain constant detection probabilities post-construction. Since offshore wind turbines can be over 120 m tall, we needed to fly above the height of wind turbine blades, (2) aerial surveys for the adjacent Cape Wind project were conducted at an altitude of 152 m to minimize disturbance to seaducks (Perkins et al. 2004), thus we hoped our survey results could be compared to abundance estimates from Cape Wind avian surveys directly, and (3) current Federal Aviation Administration regulations for these types of surveys restricted our Part 135 certified pilot to elevations greater than 152 m.

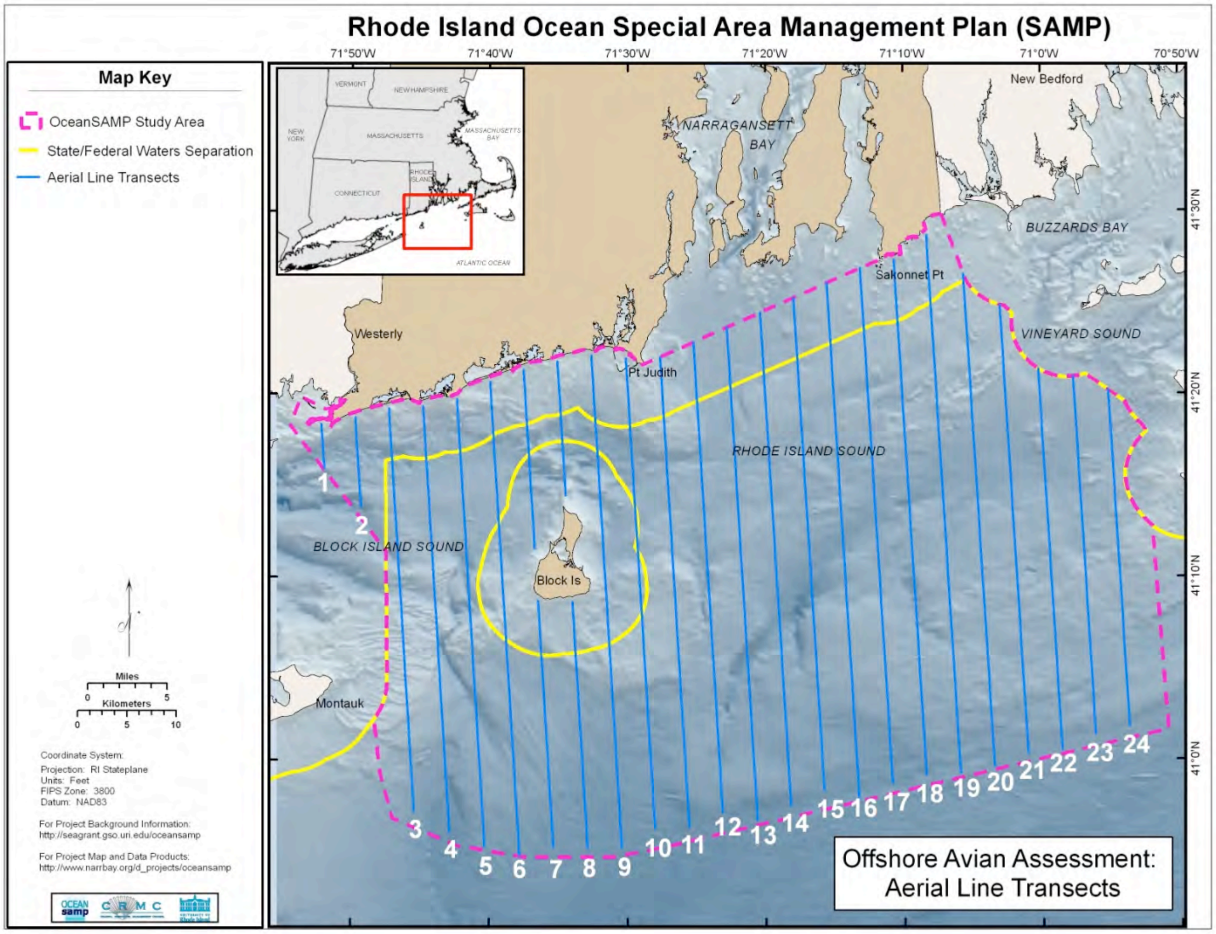

Fig. 27. Location of 24 aerial transects sampled from 18 Nov 2009 to 22 Feb 2010 for this report. Surveys continued after Feb 2010 and current plans are to continue sampling through May 2011.

We had two observers on each survey flight who were located behind the pilot and co-pilot seats (one on each side of the plane). Observers scanned a fixed-width strip transect (107 m [350ft]) on their side of the plane. To ensure that observers only recorded birds within this fixed distance, we used a clinometer to mark set angles (38 to 58 degrees) with black electrical tape on the aircraft's wing struts to aid observers in determining which individuals were in or out of the strip transect. Observers recorded all individuals and flocks to species when possible or to an avian guild (e.g., alcid spp., loon spp.) when necessary. Individuals or flocks were recorded as either on the water or in flight.

We also recorded whether any anthropogenic influences during the survey were apparently attracting birds to the area (e.g., fishing boats, whales or floating debris). We recorded the following environmental data at the beginning of each transect line or when conditions changed: wind direction, wind speed, wave height, glare (none, minimal, moderate, and heavy) and whitecaps (none, minimal, moderate, and heavy).

Observers recorded individual sightings with a time stamp (to the nearest second) into a digital voice recorder. Each observer had a digital stopwatch that was time stamped to a handheld Garmin (Garmin handheld Marine 76) that recorded the aircraft's position every 5 seconds. Surveys were not performed when wind speed was greater than 20 knots (23 mph) and waves were > 1.2 m (4 ft) tall. Unfortunately, due to the orientation of the transect lines and the orientation of the sun; glare was an issue on sunny days when surveying transect lines from north to south. If glare compromised detection of birds on one side of the plane, these data were not included in the final analyses.

Analytic Methods

For this report, we provide descriptive statistics on the number of detections for aerial surveys. We also used GIS to calculate depth at each observed flock to compare the depth profile of the Ocean SAMP study area to locations were each species (or guild) was detected.

2.4 Roseate Tern specific surveys (July 2010 to September 2010)

We designed some surveys specifically to focus on Roseate Tern use of coastal and nearshore waters along mainland Rhode Island. We conducted surveys of potential roosting sites for Roseate Terns, particularly tidal sandflats. We identified three main areas as previous or potential Roseate Tern roosting habitat (Raithel, pers comm.): Ninigret Pond, Quonochotaug Pond and Napatree Point, which were surveyed once a week during mornings or evenings from mid July to the end of August with 10 x 42 power binoculars and a 20-60 power spotting scope. Each survey was conducted for one hour, with the order determined by random generation. All tern species present were counted and identified, and where possible, identified down to individual level by field-readable leg bands. Flying terns were also recorded and additional data was collected for these individuals including flight elevation (<10m, 10-25m, 26-125m, 126-200m, >200m), distance offshore, flight direction and behavior (e.g.. feeding, commuting). During this same time period, each beach in southern Rhode Island was also walked during different time periods and in a random order to determine any further sites of interest. Three more sites were identified at the beginning as being possible roosting sites and included in surveys: Sandy Point, Moonstone Beach and East Beach. Behavioral observations were conducted during roosting surveys. Focal observations were conducted for 100-sec periods on randomly selected birds to determine foraging rate and food type.

To assess spatial distribution and abundance of foraging aggregations of Roseate Terns, we conducted nearshore boat surveys along a 104 km long sawtooth transect line (Fig. 28) on 8 days from 10 August to 3 September 2009. These surveys were designed to focus on terns using nearshore water within the Ocean SAMP study area. Surveys were conducted during August when Roseate Terns are known to be most abundant (Fig. 14) and dispersing from nesting colonies in Long Island and Connecticut through the study area to staging areas in Cape Cod prior to migration to wintering grounds (Harris 2008). We conducted surveys in the morning hours (06:25 to 12:45), using a 6.4 m (21ft) center-console boat, with a 250 hp outboard.

Each survey sampled the sawtooth grid that covered nearshore waters extending out to 7.4 km from shore from Watch Hill to Pt. Judith (Fig. 28). During each survey, we had two observers and a boat operator. Observers used 10 x 42 power binoculars to scan a 300-m wide strip transect on the port and starboard side of the boat, moving at a constant speed of 10 knots (11.5 mph). For each observed tern, the species, age, behavior, flight elevation (<10m, 10-25m, 26-125m, 126-200m, >200m) and flight direction was recorded, as well as location (with a GPS). We also recorded wind direction and speed, cloud cover, visibility and sea state (Table 11). When approaching a large flock of feeding terns, we often stopped the boat to get an accurate estimate of species composition and age composition of the flock. Stopping the boat also allowed observers to listen for Roseate Tern calls, which often enabled observers to pick out Roseate Terns in large tern flocks when they often only made up less than 5% of the flock. Surveys were conducted when the Beaufort sea state was below state three to ensure identification of terns to the species level (Table 11). We recorded all observations using a handheld GPS enabled PDA (Trimble Juno), which used Cybertracker data collection software that we had programmed for ease of date entry (www.cybertracker.org).

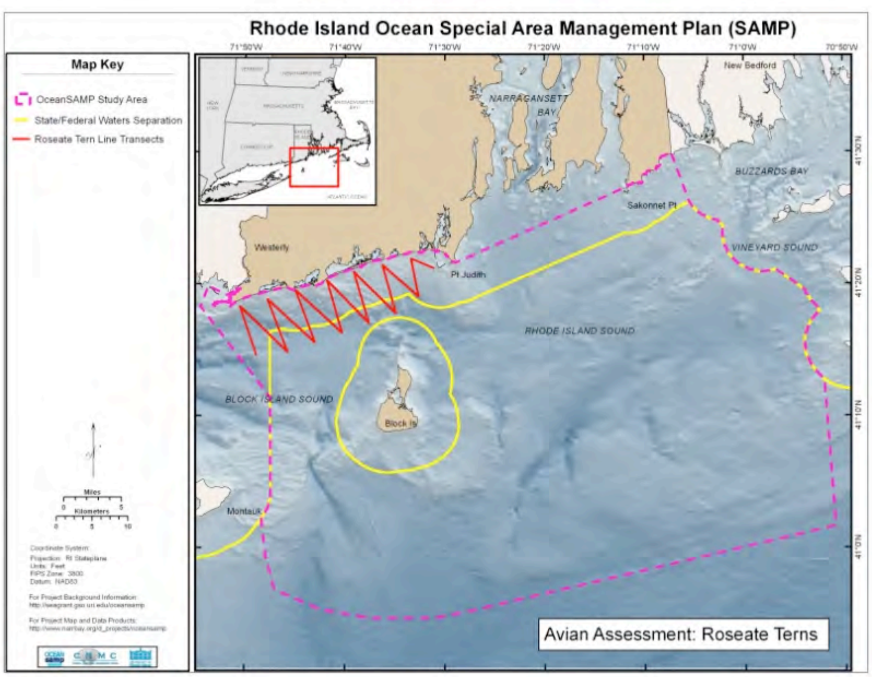

Fig. 28. Location of boat-based sawtooth line-transects used to survey Roseate Terns on 8 days from 10 August to 3 September 2009.

2.5 Radar studies – See Appendix K.

3 Results

3.1 Summary Statistics

3.1.1 Land-based Point Counts

We conducted a total of 796 surveys from 23 January 2009 to 21 February March 2010, with a total of 66,517 minutes (1,108 hours) of survey effort conducted at the 11 point count stations (Table 12). We conducted an average of 72.3 ± 11.7 (SD) surveys per station (1-hr and 2-hr surveys combined). We conducted an average of 42.6 ± 10.9 1-hr long surveys per station and 26.8 ± 4.2 2-hr long surveys per station. Although the survey protocol called for 3 morning and 3 evening surveys per site per month, we ended up averaging slightly more morning surveys (average = 39.9 ± 8.1 surveys per site) than evening surveys (mean = 32.5 ± 4.5 surveys per site) because weather conditions tended to be poorer in the afternoon. Overall, we averaged about 100 hours of observation time (mean = 100.8 ± 13.5 hr per site) at each land-based survey site (Table 12).

Table 12. Summary of survey effort during 796 land-based seawatches from 11 stations along coastal Rhode Island (see Fig. 21) from 23 January 2009 to 21 February 2010.

	Total number of surveys					Mean number of surveys		
Location	All	1-hr long*	2-hr long *	AM	PM	1-hr per month**	2 hr per month**	Hours of Observation
Watch Hill	77	48	27	44	33	6.9	3.8	104
East Beach	78	47	28	47	31	6.7	3.9	108
Deep Hole	80	50	28	48	32	7.1	3.9	109
Pt. Judith	85	47	35	47	38	6.7	4.9	122
M. Dock	90	63	23	51	39	9.0	3.2	115
Beavertail	81	48	32	43	38	6.9	4.4	114
Brenton Point	65	40	23	31	34	6.2	3.5	89
Ruggles	65	37	22	34	31	5.3	3.4	90
Sachuest	62	37	22	34	28	5.3	3.1	86
Sakonnet Point	56	24	27	30	26	3.7	4.1	86
Goosewing	57	28	28	30	27	4.3	3.9	86
Grand Total	796	469	295	439	357	67.0	41.4	1109

*Note: Total number of 1- and 2-hr surveys will not equal 796 because some surveys in Jan 2009 were intermediate in length.
**Note: In January 2009 we did not survey for a complete month, did not conduct 1-hr surveys, and did not yet conduct 2-hr surveys at all sites; therefore, January 2009 surveys were not included in the calculation of monthly mean.

During land-based seawatches throughout the year conducted from 23 Jan 2009 to 21 Feb 2010, we had a total of 465,039 detections from 121 species (Table 13). We detected three species of loons (Gaviidae), two species of grebes (Podicipedidae), four species of shearwaters (Procellariidae), two species of storm-petrels (Hydrobatidae), two species of cormorants (Phalacrocoracidae), one species of gannet (Sulidae), six species of herons/egrets (Ardeidae), one ibis (Threskiornithidae), 26 species of waterfowl (Anatidae), 7 species of diurnal raptors (Acciptridae and Falconidae), 18 species of shorebirds [four plovers (Charadriidae), one oystercatcher (Haematopodidae), 13 sandpipers and allies (Scolopacidae)], two species of jaegers (Stercorariidae), 15 larids [7 species of gulls (Laridae), 7 species of terns (Sternidae) and a skimmer (Rynchopidae)], four alcids (Alcidae), and 28 species of landbirds (Columbidae, Strigidae, Apodidae, Trochilidae, Alcedinidae, Picidae, and various Passeriformes).

As expected, seaducks and gulls were the most frequently observed birds in these nearshore habitats during land-based seawatches. The 15 most abundant species (or species groups), in terms of overall detections, were unidentified scoter (105,656 detections; these were primarily either Surf or Black Scoters),Common Eider (80,445), Herring Gull (59,614), Surf Scoter (42,704), Black Scoter (32,274), Double-crested Cormorant (25,626), unidentified gull (23,860), Tree Swallow (14,025), Great Black-backed Gull (12,583), Laughing Gull (12,097), Northern Gannet (8,718), Red-breasted Merganser (7,926), Common Loon (6,770), White-winged Scoter (6,750), unidentified seaducks (5,303, mainly eider and scoters far offshore), and Ring-billed Gull (3,723) (Table 13).

Since Herring Gulls and Great Black-backed Gulls are widespread, year-round residents that breed in coastal Rhode Island, is it not surprising that those two species were detected on more land-based seawatches than all other species, 96.7% and 89.9% of all surveys, respectively (Table 13). Other species seen on over 50% of land-based seawatches included Common Loon (75.8%), Common Eider (66.5%), Double-crested Cormorants (59.8%), Red-breasted Merganser (55.8%), and Ring-billed Gull (Table 13).

There were considerable differences in detection rates among months during land-based seawatches (Fig. 29; Appendix D). Because there were more seaducks using nearshore habitats in 2009 compared to 2010, detection rates were much higher in 2009. However, seasonal trends were still evident with greater detection rates during the winter and early spring (Nov through March). There was a pulse of birds coming through in October, which was due in part to the influx of Tree Swallows in coastal areas.

Species richness per individual survey during land-based seawatches tended to be lowest in the summer months (June through September; Fig. 30, Appendix D). However, the cumulative number of species detected over all surveys within a month was actually greatest from May to

Sept (50, 51, 58, 39, and 57 total species detected per month, respectively). In contrast, fewer species were detected from Dec through Feb (40, 40, 36 total species per month, respectively).

Table 13. Relative abundance of 121 species of birds detected during 796 land-based seawatches from 23 January 2009 to 21 February 2010 at 11 stations along the Rhode Island coast (Fig. 21). We summarized for each species the mean (SD) number of detections per survey, total number of detections, the frequency of detections (% of surveys with a detection), and percent of surveys where detections were of birds on the water or in flight.

Species	Mean Number of Detections per Survey	SD Number of Detections per Survey	Total Number of Detections Over All Surveys	% of Surveys with a Detection	% of Surveys with a Detection, On the Water	% Surveys with a Detection, In Flight
Red-throated Loon	3.11	8.78	2473	40.1	28.0	26.3
Pacific Loon	0.00	0.06	3	0.4	0.1	0.3
Common Loon	8.51	18.20	6770	75.8	66.0	40.8
Loon spp.	0.83	4.53	661	13.9	1.5	13.2
Red-necked Grebe	0.10	0.57	82	6.5	4.4	2.3
Horned Grebe	1.90	13.11	1515	30.7	29.5	4.8
Cory's Shearwater	3.02	26.06	2401	5.7	0.9	5.7
Greater Shearwater	0.02	0.30	14	0.8	n/a	0.8
Manx Shearwater	0.01	0.11	7	0.8	n/a	0.8
Sooty Shearwater	0.01	0.09	5	0.5	n/a	0.5
Shearwater spp.	1.92	33.19	1526	2.9	0.1	2.9
Wilson's Storm-Petrel	1.56	14.55	1241	6.3	0.1	6.3
Leach's Storm-Petrel	0.00	0.04	1	0.1	n/a	0.1
Storm-petrel spp.	0.00	0.04	1	0.1	n/a	0.1
Great Cormorant	2.82	7.89	2243	41.6	13.2	39.3
Double-crested Cormorant	32.19	79.88	25626	59.8	45.9	57.8
Northern Gannet	10.95	45.80	8718	42.0	4.4	41.6
Great Blue Heron	0.05	0.56	38	1.8	n/a	1.8
Great Egret	0.06	0.39	45	3.3	0.4	3.0
Snowy Egret	0.02	0.18	12	0.9	0.1	0.8
Cattle Egret	0.00	0.05	2	0.3	n/a	0.3
Green Heron	0.01	0.13	5	0.3	n/a	0.3
Black-crowned Night-Heron	0.01	0.07	4	0.5	n/a	0.5
Glossy Ibis	0.04	0.91	34	0.5	n/a	0.5
Mute Swan	0.14	0.76	111	5.5	1.6	3.9
Tundra Swan	0.00	0.07	2	0.1	n/a	0.1
Canada Goose	3.16	16.13	2513	14.1	2.3	12.9
Atlantic Brant	1.84	8.06	1464	13.6	2.4	11.9
Wood Duck	0.01	0.21	10	0.4	n/a	0.4
Mallard	0.09	0.58	74	4.1	0.9	3.4
American Black Duck	0.88	5.53	700	13.2	6.9	9.0
Gadwall	0.03	0.28	22	1.1	0.4	0.8
Northern Pintail	0.01	0.18	7	0.4	n/a	0.4
American Wigeon	0.02	0.25	14	0.8	0.6	0.3

Green-winged Teal	0.05	0.73	38	0.6	0.1	0.5
Teal spp.	0.00	0.04	1	0.1	n/a	0.1
Anas spp.	0.08	0.92	65	1.9	n/a	1.9
Greater Scaup	1.26	12.10	1000	4.3	2.8	1.8

Table 13 continued. Relative abundance of birds during land-based seawatches.

Species	Mean Number of Detections per Survey	SD Number of Detections per Survey	Total Number of Detections Over All Surveys	% of Surveys with a Detection	% of Surveys with a Detection, On the Water	% Surveys with a Detection, In Flight
Scaup spp.	0.57	9.58	454	1.9	0.4	1.6
Aythya Spp.	0.06	0.80	49	0.9	n/a	0.9
Common Eider	101.06	296.80	80445	65.6	55.8	50.8
King Eider	0.03	0.29	26	1.8	1.6	0.1
Harlequin Duck	1.64	5.60	1305	14.1	11.6	7.3
Long-tailed Duck	0.59	3.01	470	13.3	4.3	10.1
Surf Scoter	53.65	385.48	42704	34.5	17.2	24.1
Black Scoter	40.55	193.38	32274	41.1	22.1	28.6
Surf or Black Scoter	4.21	22.23	3350	18.2	1.3	18.0
White-winged Scoter	8.48	39.81	6750	40.6	19.5	29.4
Scoter spp.	100.54	517.05	80030	35.4	9.0	32.0
Common Goldeneye	2.47	7.64	1966	24.4	21.5	9.5
Barrow's Goldeneye	0.00	0.05	2	0.3	0.3	n/a
Bufflehead	0.84	3.61	668	10.1	8.0	3.6
Hooded Merganser	0.02	0.34	12	0.3	n/a	0.3
Red-breasted Merganser	9.96	23.51	7926	55.8	43.8	42.5
Common Merganser	0.00	0.05	2	0.3	n/a	0.3
Seaduck spp.	6.66	89.65	5303	2.5	0.4	2.1
Ruddy Duck	0.02	0.40	16	0.3	0.3	n/a
Northern Harrier	0.01	0.09	7	0.9	n/a	0.9
Sharp-shinned Hawk	0.00	0.08	3	0.3	n/a	0.3
Cooper's Hawk	0.00	0.04	1	0.1	n/a	0.1
Osprey	0.06	0.29	48	5.0	n/a	5.0
Merlin	0.01	0.09	6	0.8	n/a	0.8
American Kestrel	0.01	0.09	6	0.8	n/a	0.8
Peregrine Falcon	0.01	0.10	8	1.0	0.1	0.9
Falcon spp.	0.00	0.05	2	0.3	n/a	0.3
Black-bellied Plover	0.02	0.28	19	1.1	n/a	1.1
Piping Plover	0.01	0.15	9	0.8	0.3	0.5
Semipalmated Plover	0.20	1.63	158	4.8	0.4	4.5
Killdeer	0.01	0.07	4	0.5	n/a	0.5
American Oystercatcher	0.02	0.17	14	1.3	n/a	1.3
Greater Yellowlegs	0.03	0.68	22	0.5	n/a	0.5
Lesser Yellowlegs	0.02	0.27	13	0.6	n/a	0.6
Yellowlegs spp.	0.00	0.04	1	0.1	n/a	0.1
Willet	0.03	0.42	22	0.9	n/a	0.9
Spotted Sandpiper	0.01	0.14	8	0.6	0.3	0.5
Whimbrel	0.03	0.40	26	0.9	n/a	0.9
Ruddy Turnstone	0.17	1.56	138	3.8	n/a	3.8
Purple Sandpiper	2.55	11.62	2029	11.8	1.4	11.1

Sanderling	3.21	20.34	2558	11.1	0.5	10.9
Dunlin	0.11	1.08	87	1.4	0.1	1.4
White-rumped Sandpiper	0.00	0.04	1	0.1	n/a	0.1
Semipalmated Sandpiper	1.66	24.94	1318	5.7	0.3	5.4

Table 13 continued. Relative abundance of birds during land-based seawatches.

Species	Mean Number of Detections per Survey	SD Number of Detections per Survey	Total Number of Detections Over All Surveys	% of Surveys with a Detection	% of Surveys with a Detection, On the Water	% Surveys with a Detection, In Flight
Sandpiper spp.	1.00	6.28	799	5.3	n/a	5.3
Least Sandpiper	0.06	0.50	50	2.1	n/a	2.1
Short-billed Dowitcher	0.29	2.80	231	2.0	n/a	2.0
Shorebird spp.	1.26	6.74	1000	10.7	n/a	10.7
Pomarine Jaeger	0.00	0.07	2	0.1	n/a	0.1
Parasitic Jaeger	0.02	0.37	19	0.8	n/a	0.8
Jaeger spp.	0.00	0.06	3	0.4	n/a	0.4
Bonaparte's Gull	0.55	2.76	436	9.7	2.3	9.0
Laughing Gull	15.20	53.86	12097	36.7	8.2	36.4
Ring-billed Gull	4.68	15.22	3723	52.6	9.7	50.0
Herring Gull	74.89	368.88	59614	96.7	51.3	94.5
Iceland Gull	0.00	0.04	1	0.1	0.1	n/a
Great Black-backed Gull	15.81	79.01	12583	89.9	46.1	82.9
Black-legged Kittiwake	0.07	0.67	58	2.8	0.3	2.5
Gull spp.	29.97	134.37	23860	26.8	1.9	25.9
Caspian Tern	0.00	0.07	2	0.1	n/a	0.1
Royal Tern	0.01	0.10	6	0.6	n/a	0.6
Common Tern	4.58	19.41	3647	18.8	0.3	18.6
Forster's Tern	0.01	0.17	11	0.8	n/a	0.8
Roseate Tern	0.16	1.08	125	3.9	n/a	3.9
Least Tern	0.61	3.17	485	9.9	n/a	9.9
Black Tern	0.02	0.20	15	1.1	n/a	1.1
Sterna spp.	1.65	15.70	1317	9.0	0.1	9.0
Black Skimmer	0.00	0.11	3	0.1	n/a	0.1
Thick-billed Murre	0.00	0.05	2	0.3	0.3	n/a
Murre spp.	0.00	0.04	1	0.1	n/a	0.1
Razorbill	0.36	2.15	290	6.7	3.0	4.5
Dovekie	0.001	0.04	1	0.1	0.1	n/a
Black Guillemot	0.00	0.05	2	0.3	0.1	0.1
Alcid spp.	0.14	1.16	110	3.3	0.3	3.0
Mourning Dove	0.01	0.09	5	0.5	n/a	0.5
Short-eared Owl	0.00	0.04	1	0.1	n/a	0.1
Chimney Swift	0.00	0.06	3	0.4	n/a	0.4
Ruby-throated Hummingbird	0.00	0.05	2	0.3	n/a	0.3
Belted Kingfisher	0.00	0.05	2	0.3	n/a	0.3
Northern Flicker	0.00	0.04	1	0.1	n/a	0.1
Eastern Kingbird	0.00	0.04	1	0.1	n/a	0.1
Blue Jay	0.03	0.85	24	0.1	n/a	0.1
American Crow	0.03	0.42	26	1.0	n/a	1.0
Fish Crow	0.01	0.25	11	0.4	n/a	0.4

Corvid spp.	0.03	0.51	21	0.9	n/a	0.9
Horned Lark	0.00	0.05	2	0.3	n/a	0.3
Purple Martin	0.01	0.11	7	0.8	n/a	0.8
Northern Rough-wd Swallow	0.13	1.16	102	2.5	n/a	2.5

Table 13 continued. Relative abundance of birds during land-based seawatches.

Species	Mean Number of Detections per Survey	SD Number of Detections per Survey	Total Number of Detections Over All Surveys	% of Surveys with a Detection	% of Surveys with a Detection, On the Water	% Surveys with a Detection, In Flight
Bank Swallow	0.02	0.32	18	1.0	n/a	1.0
Tree Swallow	17.62	359.01	14025	6.3	0.1	6.3
Cliff Swallow	0.00	0.04	1	0.1	n/a	0.1
Barn Swallow	0.29	1.37	230	8.7	n/a	8.7
Swallow spp.	0.25	2.07	196	5.2	n/a	5.2
American Robin	0.01	0.26	9	0.3	n/a	0.3
American Pipit	0.01	0.09	5	0.5	n/a	0.5
Cedar Waxwing	0.00	0.05	2	0.3	n/a	0.3
Yellow Warbler	0.02	0.19	13	0.9	n/a	0.9
Yellow-rumped Warbler	0.05	1.21	36	0.4	n/a	0.4
Palm Warbler	0.00	0.04	1	0.1	n/a	0.1
Warbler spp.	0.01	0.18	9	0.5	n/a	0.5
Snow Bunting	0.04	0.80	30	0.5	n/a	0.5
Bobolink	0.00	0.04	1	0.1	n/a	0.1
Brown-headed Cowbird	0.01	0.20	9	0.4	n/a	0.4
Common Grackle	0.01	0.19	10	0.5	0.1	0.4
American Goldfinch	0.02	0.47	16	0.4	n/a	0.4
Passerine spp.	0.02	0.29	19	1.1	n/a	1.1

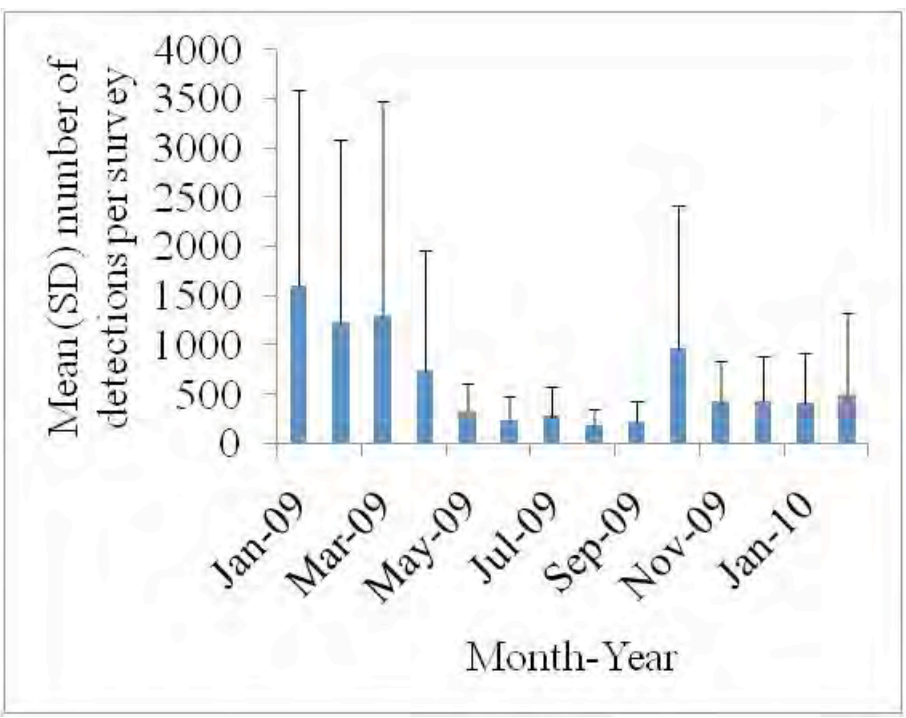

Fig. 29. Seasonal change in overall detection rate (mean ± SD detection per survey) during land-based seawatches (N = 796) from 23 January 2009 to 21 February 2010 at 11 stations (Fig. 21).

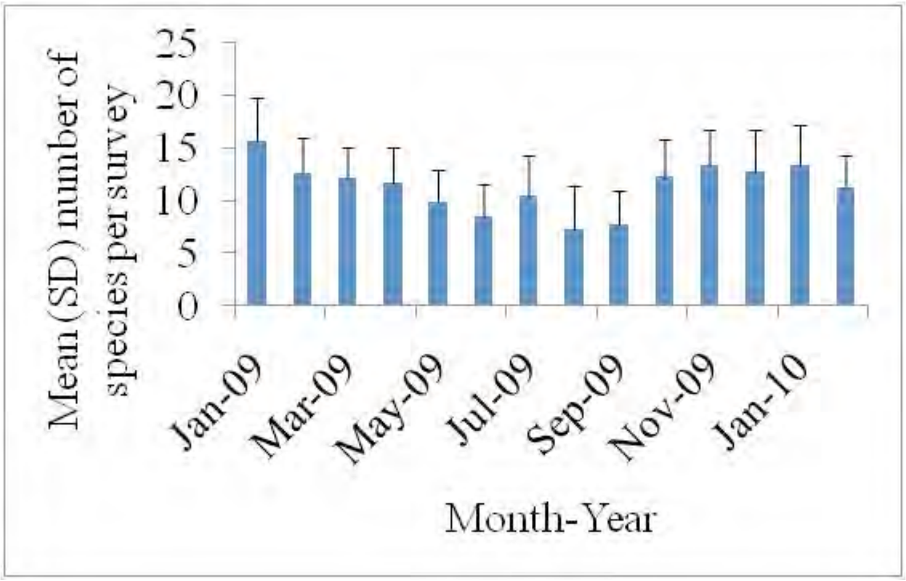

Fig. 30. Seasonal change in species richness (mean ± SD number of species detected per survey) during land-based seawatches (N = 796) from 23 January 2009 to 21 February 2010 at 11 stations (Fig. 21).

Overall detection rates varied considerably among land-based seawatch stations (Tables 1, Fig. 31). Detection rates were greatest at Brenton Point on the SW corner of Aquidneck Island, with an average of 1,379 ± 2,279 (SD) detections per surveys. This was primarily due to the large numbers of seaducks (scoters and eiders) that used this site throughout the winter. Ruggles Ave, on Aquidneck Island, had the second highest detection rates (889 ± 1563), likely also due to large rafts of wintering seaducks. Goosewing (771 ± 1280) and Watch Hill (692 ± 1481) had relatively high detection rates as well. In contrast, detection rates were lowest at Monahan's Dock (239 ± 224), which was located in the SW corner of Narragansett Bay, south of Narragansett Town Beach.

Table 14. Differences among 11 land-based stations in number of detections per survey, and species richness per survey based on pooled 1-hr and 2-hr seawatches from Jan 2009 through Feb 2010.

	Number of detections per survey				Species detected per survey			
Station	Mean	SD	CV	Total	Mean	SD	Total	N
Watch Hill	692.5	1481.4	214	53,321	10.5	3.6	69	77
East Beach	607.4	955.7	157	47,377	10.6	3.8	72	78
Deep Hole	397.2	539.3	136	31,778	10.3	3.5	67	80
Pt. Judith	362.6	502.5	139	30,823	12.2	4.8	78	85
M. Dock	239.1	223.8	94	21,518	10.5	3.6	68	90
Beavertail	409.7	641.8	157	33,182	11.0	4.3	60	81

Brenton Pt.	1379.7	2279.2	165	89,683	11.7	3.9	62	65
Ruggles Ave.	890.0	1563.1	176	57,849	11.8	4.2	52	65
Sachuest Pt.	430.0	501.2	117	26,663	11.8	4.3	61	62
Sakonnet Pt.	516.0	485.2	94	28,894	11.5	4.3	66	56
Goosewing	771.1	1280.9	166	43,951	11.2	3.1	59	57

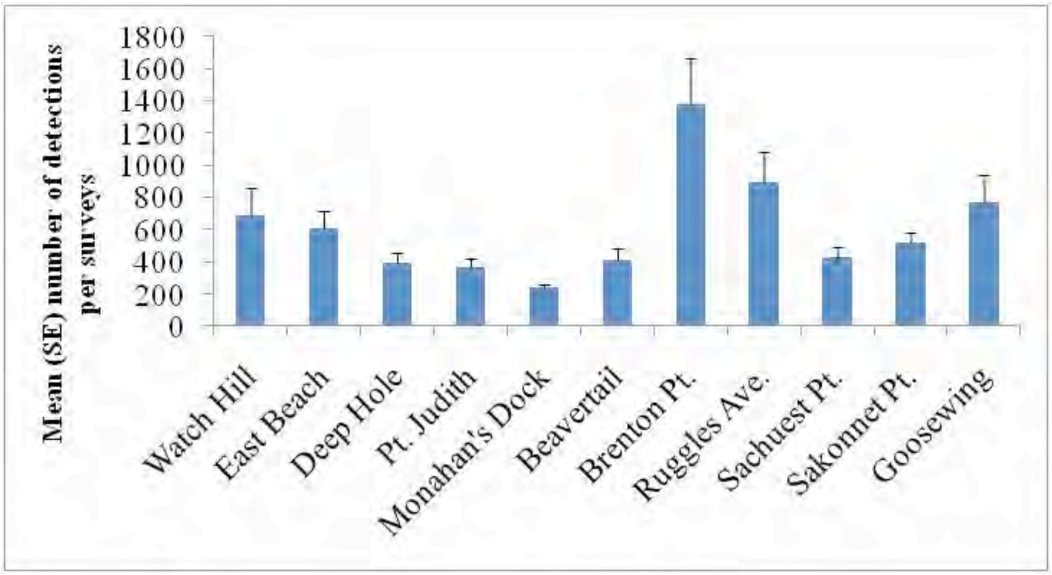

Fig. 31. Mean (SE) number of detections per survey at 11 land-based seawatch stations from January 2009 through February 2010 (see Fig. 21 for locations).

The 11 land-based seawatch stations averaged between 10.3 (Deep Hole) to 12.2 (Point Judith) species per survey from January 2009 through February 2010 (Fig. 32), with the cumulative number of species detected at each station ranging from 52 (Ruggles) to 78 (Point Judith; Table 1). There was a tendency for stations located at the north end of Rhode Island Sound to have greater species richness than stations located at the north end of Block Island Sound.

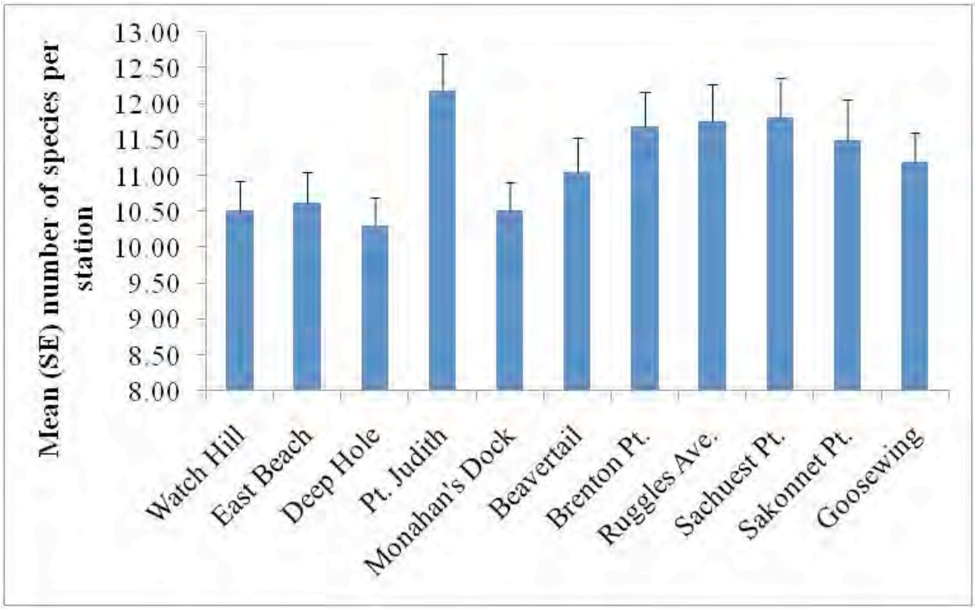

Fig. 32. Mean (SE) number of species detected per survey at 11 land-based point count stations during seawatches from Jan 2009 through Feb 2010.

We estimated flight altitude (m above sea level) for 250,992 detections of birds in flight during land-based seawatches into four height categories (Table 15). Most detections (69%) were of birds flying < 10 m altitude. Certain guilds of birds almost always flew <10 m altitude including shearwaters, storm-petrels, seaducks (although many flew between 10-25 m altitude), and alcids. About 24% of detections were of birds flying between 10-25 m. About 7.7% of detections were of birds flying over 25 m, with only 0.4% of detections >125 m altitude. There was considerable variation among species in altitudes, and altitudes tended to vary throughout the year for some species. For example, loons were generally observed on the water, but during migration periods large numbers of Common Loons were observed flying >25 m high (24% of all detections; Table 15).

Table 15. Altitude (m) above sea level for birds detected in flight during land-based seawatches.

	Percent Detections by Elevation (m)				
	<10	10-25	25-125	>125	Total
Red-throated Loon	80.5	12.4	6.0	1.1	1,226
Pacific Loon	50.0	50.0	0.0	0.0	2
Common Loon	58.0	19.2	20.1	2.7	2,762
Loon spp.	58.9	23.4	14.8	2.9	615
Red-necked Grebe	91.7	8.3	0.0	0.0	24
Horned Grebe	76.5	0.0	23.5	0.0	85
Cory's Shearwater	99.6	0.4	0.0	0.0	2,229
Greater Shearwater	100.0	0.0	0.0	0.0	14
Manx Shearwater	100.0	0.0	0.0	0.0	7
Sooty Shearwater	100.0	0.0	0.0	0.0	5
Shearwater spp.	100.0	0.0	0.0	0.0	1,525
Wilson's Storm-Petrel	100.0	0.0	0.0	0.0	1,240
Leach's Storm-Petrel	100.0	0.0	0.0	0.0	1

Storm-petrel spp.	100.0	0.0	0.0	0.0	1
Great Cormorant	79.8	12.9	5.8	1.5	2,014
Double-crested Cormorant	81.3	9.4	7.9	1.4	22,328
Northern Gannet	54.6	35.4	9.9	0.1	8,560
Great Blue Heron	18.4	5.3	73.7	2.6	38
Great Egret	60.0	32.5	7.5	0.0	40
Snowy Egret	54.5	27.3	18.2	0.0	11
Cattle Egret	0.0	0.0	100.0	0.0	2
Green Heron	0.0	40.0	60.0	0.0	5
Black-crowned Night-Heron	25.0	50.0	25.0	0.0	4
Glossy Ibis	5.9	82.4	11.8	0.0	34
Mute Swan	60.2	32.5	7.2	0.0	83
Tundra Swan	100.0	0.0	0.0	0.0	2
Canada Goose	31.7	35.9	30.2	2.2	2,021
Atlantic Brant	53.1	22.2	22.5	2.2	1,152
Wood Duck	70.0	0.0	30.0	0.0	10
Mallard	9.4	29.7	53.1	7.8	64
American Black Duck	24.1	39.2	35.5	1.2	324
Gadwall	25.0	41.7	16.7	16.7	12
Northern Pintail	0.0	100.0	0.0	0.0	7
Species	<10	10-25	25-125	>125	Total
American Wigeon	33.3	66.7	0.0	0.0	6
Green-winged Teal	100.0	0.0	0.0	0.0	37
Teal spp.	0.0	0.0	100.0	0.0	1
Anas spp.	6.2	52.3	38.5	3.1	65
Greater Scaup	65.7	31.5	2.8	0.0	143
Scaup spp.	85.3	14.7	0.0	0.0	224
Aythya Spp.	20.4	8.2	57.1	14.3	49
Common Eider	92.9	6.9	0.2	0.0	24,195
King Eider	100.0	0.0	0.0	0.0	1
Harlequin Duck	99.3	0.7	0.0	0.0	291
Long-tailed Duck	90.3	9.7	0.0	0.0	259
Surf Scoter	94.1	5.2	0.7	0.0	3,498
Black Scoter	94.1	5.7	0.2	0.0	4,756
Black or Surf Scoter	77.5	21.2	1.4	0.0	2,764
White-winged Scoter	78.0	15.0	4.1	2.9	2,973
Scoter spp.	92.2	7.0	0.7	0.0	34,373
Common Goldeneye	50.6	38.1	11.3	0.0	336
Bufflehead	80.3	19.7	0.0	0.0	142
Hooded Merganser	75.0	0.0	25.0	0.0	12
Red-breasted Merganser	78.2	16.4	5.4	0.0	2,245
Common Merganser	0.0	0.0	100.0	0.0	2
Seaduck spp.	94.0	4.8	0.7	0.5	2,228
Northern Harrier	28.6	57.1	14.3	0.0	7
Sharp-shinned Hawk	33.3	66.7	0.0	0.0	3
Cooper's Hawk	0.0	100.0	0.0	0.0	1
Osprey	2.1	31.3	60.4	6.3	48
Merlin	16.7	66.7	16.7	0.0	6
American Kestrel	16.7	66.7	16.7	0.0	6
Peregrine Falcon	28.6	28.6	28.6	14.3	7

Falcon spp.	0.0	50.0	50.0	0.0	2
Black-bellied Plover	57.9	5.3	36.8	0.0	19
Piping Plover	100.0	0.0	0.0	0.0	6
Semipalmated Plover	87.5	8.3	4.2	0.0	144
Killdeer	0.0	25.0	75.0	0.0	4
American Oystercatcher	64.3	35.7	0.0	0.0	14
Greater Yellowlegs	90.9	0.0	9.1	0.0	22
Lesser Yellowlegs	38.5	53.8	7.7	0.0	13
Yellowlegs spp.	0.0	0.0	100.0	0.0	1
Willet	54.5	31.8	13.6	0.0	22
Spotted Sandpiper	100.0	0.0	0.0	0.0	5
Whimbrel	26.9	15.4	57.7	0.0	26
Ruddy Turnstone	71.7	25.4	2.9	0.0	138
Purple Sandpiper	99.9	0.1	0.0	0.0	1,594
Sanderling	90.8	6.6	2.6	0.0	2,262
Dunlin	100.0	0.0	0.0	0.0	75
White-rumped Sandpiper	100.0	0.0	0.0	0.0	1
Semipalmated Sandpiper	73.6	19.4	7.1	0.0	1,316
Peep spp.	82.6	10.9	6.5	0.0	799
Least Sandpiper	68.0	26.0	6.0	0.0	50
	<10	10-25	25-125	>125	Total
Short-billed Dowitcher	66.2	25.1	8.7	0.0	231
Shorebird Spp.	81.6	12.0	6.4	0.0	1,000
Pomarine Jaeger	100.0	0.0	0.0	0.0	2
Parasitic Jaeger	63.2	15.8	21.1	0.0	19
Jaeger spp.	100.0	0.0	0.0	0.0	3
Bonaparte's Gull	70.3	28.9	0.8	0.0	357
Laughing Gull	58.7	36.2	4.9	0.1	11,350
Ring-billed Gull	50.8	39.5	9.5	0.1	3,227
Herring Gull	51.9	33.2	14.7	0.3	51,036
Great Black-backed Gull	65.8	25.8	8.0	0.5	8,610
Black-legged Kittiwake	76.8	23.2	0.0	0.0	56
Gull spp.	66.6	22.5	10.3	0.7	22,808
Caspian Tern	0.0	100.0	0.0	0.0	2
Royal Tern	33.3	66.7	0.0	0.0	6
Common Tern	53.5	42.7	3.8	0.0	3,644
Forster's Tern	36.4	63.6	0.0	0.0	11
Roseate Tern	40.0	60.0	0.0	0.0	125
Least Tern	56.1	39.0	4.9	0.0	485
Black Tern	73.3	26.7	0.0	0.0	15
Sterna spp.	29.9	58.6	11.4	0.0	1,293
Black Skimmer	100.0	0.0	0.0	0.0	3
Murre spp.	100.0	0.0	0.0	0.0	1
Razorbill	100.0	0.0	0.0	0.0	135
Black Guillemot	100.0	0.0	0.0	0.0	1
Alcid spp.	100.0	0.0	0.0	0.0	106
Mourning Dove	20.0	80.0	0.0	0.0	5
Short-eared Owl	100.0	0.0	0.0	0.0	1
Chimney Swift	0.0	100.0	0.0	0.0	3
Ruby-throated Hummingbird	0.0	50.0	50.0	0.0	2

Belted Kingfisher	0.0	100.0	0.0	0.0	2
Northern Flicker	0.0	100.0	0.0	0.0	1
Eastern Kingbird	0.0	100.0	0.0	0.0	1
Blue Jay	0.0	0.0	100.0	0.0	24
American Crow	0.0	69.2	3.8	26.9	26
Fish Crow	0.0	100.0	0.0	0.0	11
Corvid spp.	4.8	19.0	76.2	0.0	21
Horned Lark	0.0	0.0	100.0	0.0	2
Purple Martin	28.6	28.6	28.6	14.3	7
Northern Rough-wd. Swallow	62.7	32.4	4.9	0.0	102
Bank Swallow	27.8	72.2	0.0	0.0	18
Tree Swallow	11.2	83.3	5.4	0.0	14,017
Cliff Swallow	100.0	0.0	0.0	0.0	1
Barn Swallow	65.2	29.1	5.7	0.0	230
Swallow spp.	53.6	41.8	4.6	0.0	196
American Robin	0.0	0.0	100.0	0.0	9
American Pipit	0.0	0.0	100.0	0.0	5
Cedar Waxwing	0.0	0.0	100.0	0.0	2
Yellow Warbler	0.0	7.7	92.3	0.0	13
Yellow-rumped Warbler	0.0	38.9	61.1	0.0	36
	<10	10-25	25-125	>125	Total
Warbler spp.	22.2	0.0	77.8	0.0	9
Snow Bunting	73.3	0.0	26.7	0.0	30
Bobolink	0.0	0.0	100.0	0.0	1
Brown-headed Cowbird	0.0	55.6	44.4	0.0	9
Common Grackle	0.0	25.0	75.0	0.0	8
American Goldfinch	0.0	18.8	81.3	0.0	16
Passerine spp.	42.1	47.4	5.3	5.3	19
Overall	68.9	23.5	7.3	0.4	250,992

3.1.2 Ship-based Surveys

We conducted a total of 54 surveys of 8 grids on 27 days between 10 June 2009 and 13 February 2010 (Table 16). We had planned on surveying each of the 8 grids one time per month during this eight month period. However, because we only conducted ship-based surveys when the sea state was ≤3 (Table 11), we had a difficult time some months surveying all eight grids

Table 16. Days when we conducted ship-based surveys on 8 grids from 10 June 2009 to 13 Feb 2010. We conducted at total of 54 grid survey days. See Fig. 24 for survey grid locations.

Date	A	B	C	D	E	F	G	H
6/10/2009	X	X						
6/30/2009	X	X						
7/10/2009			X	X				
7/15/2009					X	X		
7/22/2009							X	X
8/5/2009	X				X			
8/10/2009			X	X				
8/25/2009		X				X		

9/8/2009							X	X
9/15/2009	X				X			
10/6/2009			X	X				
10/9/2009		X				X		
10/22/2009							X	X
10/27/2009			X	X				
11/5/2009		X				X		
11/17/2009	X				X			
11/19/2009							X	X
12/2/2009			X	X				
12/8/2009		X				X		
12/18/2009	X				X			
12/31/2009							X	X
1/5/2010		X				X		
1/11/2010			X	X				
1/21/2010	X				X			
2/3/2010							X	X
2/5/2010		X				X		
2/13/2010			X	X				
Total	**7**	**8**	**7**	**7**	**6**	**7**	**6**	**6**

During ship-based surveys, we detected a total of 56 species, which included 6 species of Procelliformes (tubenoses), 9 Anseriformes (waterfowl), 5 species of gulls, two species of terns, three species of jaegers, and five species of alcids (Table 17). The five most abundant species, in terms of mean number of detections per survey were Herring Gull (30.6 detections per survey), Wilson's Storm-Petrel (28.0), Northern Gannet (23.7), Great Black-backed Gull (18.5), and Cory's Shearwater (9.6). Herring (94.4% of surveys) and Great-Black-backed Gulls (94.4% of surveys) were detected more frequently than other species; Northern Gannets (68.5%) and Common Loon (59.3%) were also frequently seen.

We have summarized variation in the average number of detections per grid for all birds detected during ship-based surveys from 10 June 2009 through mid-Feb 2010 (Table 18). Species richness was greatest on grid A (33 species detected; south of Block Island) and grid F (32 species detected; SW of Harbor of Refuge/Pt. Judith), which were also the two grids closest to shore. The average abundance of birds was greatest on grids A (343 detections per survey) and E (338 detections per survey; Table 18). We used these data to model the spatial distribution and abundance of the most commonly detected species of waterbirds (see species accounts below).

We have also summarized the average number of detections across all grids for 24 species during the summer (10 June to 25 August 2009; Appendix E), when tubenoses (shearwaters and storm-petrels) were common, and jaegers were observed. In the fall, 29 species were detected (8 Sept thru 19 Nov 2009; Appendix F), with seaducks, gannets, gulls (both Herring and Great Black-backed Gulls) becoming common in offshore areas of the Ocean SAMP study area. Finally in winter 21 species we detected (18 Dec 2009 to 13 Feb 2010; Appendix G), and overall detections declined, although detection rates for Common Loons and Northern Gannets increased. We have presented these summary statistics in appendices for those readers interested in the total number of detections for individual grids for a particular species at a specific time of year (see Appendices E, F, and G).

Table 17. Mean (SD) number of detections per grid, CV of detection rate, total number of detections, and % of surveys (n = 54) with a detection within a grid) during ship-based line transect surveys on all 8 grids (see Fig. 24) conducted from 10 June 2009 through 13 Feb 2010.

Species	Mean	SD	CV	Total	% of surveys
Common Loon	5.41	7.69	142.19	292	59.3
Red-throated Loon	1.96	4.68	238.53	106	29.6
Loon unid.	0.09	0.45	481.55	5	5.6
Red-necked Grebe	0.02	0.14	734.85	1	1.9
Great Cormorant	0.28	0.94	338.41	15	11.1
Double-crested Cormorant	0.19	0.52	279.00	10	13.0
Northern Gannet	23.67	78.19	330.36	1278	68.5
Wilson's Storm-Petrel	27.98	72.24	258.16	1511	31.5
Manx's Shearwater	0.04	0.19	514.69	2	3.7
Sooty Shearwater	0.30	1.18	396.80	16	7.4
Greater Shearwater	4.43	13.04	294.68	239	31.5
Cory's Shearwater	9.63	24.02	249.41	520	33.3
Shearwater small unid.	0.04	0.27	734.85	2	1.9
Shearwater unid.	0.50	1.97	393.82	27	13.0
Northern Fulmar	0.09	0.40	433.45	5	5.6
Great Blue Heron	0.02	0.14	734.85	1	1.9
Brant	0.31	2.31	734.85	17	1.9
Mallard	0.02	0.14	734.85	1	1.9
Dabbling duck unid.	0.20	1.50	734.85	11	1.9
Green-winged Teal	0.19	1.36	734.85	10	1.9
Bay duck unid.	0.15	1.09	734.85	8	1.9
Scaup unid.	1.02	5.26	516.89	55	3.7
Common Eider	5.44	21.00	385.73	294	25.9
Black Scoter	5.13	18.86	367.75	277	20.4
Surf Scoter	3.87	23.80	614.98	209	16.7
White-winged Scoter	2.98	5.68	190.46	161	40.7
Surf or Black Scoter	4.41	14.75	334.55	238	16.7
Scoter unid.	0.07	0.54	734.85	4	1.9
Long-tailed Duck	0.39	1.16	297.27	21	16.7
Red-breasted Merganser	0.04	0.19	514.69	2	3.7
Semipalmated Plover	0.04	0.27	734.85	2	1.9
Least Sandpiper	0.04	0.27	734.85	2	1.9
Purple Sandpiper	0.07	0.54	734.85	4	1.9
Lesser Yellowlegs	0.07	0.54	734.85	4	1.9
Short-billed Dowitcher	0.09	0.68	734.85	5	1.9
Whimbrel	0.09	0.56	603.27	5	3.7
Red-necked Phalarope	0.44	3.27	734.85	24	1.9
Phalarope unid	0.04	0.19	514.69	1	3.7
Shorebird unid.	0.06	0.30	543.57	2	3.7
Bonaparte's Gull	0.33	1.08	324.47	18	13.0
Laughing Gull	3.15	13.59	431.78	170	27.8
Ring-billed Gull	0.59	1.70	286.75	32	20.4
Herring Gull	30.59	109.43	357.71	1652	94.4

Great Black-backed Gull	18.54	71.35	384.89	1001	94.4

Table 17 continued. Abundance of birds during ship-based line transect surveys.

Species	Mean	SD	CV	Total	% of surveys
Gull spp.	1.07	5.03	468.09	58	9.3
Black-lg. Kittiwake	1.02	1.90	186.38	55	27.8
Common Tern	1.13	5.15	455.97	61	11.1
Roseate Tern	0.15	0.68	461.87	8	5.6
Tern unid	0.22	0.63	285.50	11	13.0
Parasitic Jaeger	0.02	0.14	734.85	1	1.9
Pomarine Jaeger	0.02	0.14	734.85	1	1.9
Long-tailed Jaeger	0.02	0.14	734.85	1	1.9
Razorbill	1.72	4.41	255.83	93	29.6
Common Murre	2.43	8.54	352.02	131	20.4
Thick-billed Murre	0.06	0.30	543.57	3	3.7
Murre unid.	0.11	0.60	543.57	6	3.7
Dovekie	2.31	10.87	469.78	125	11.1
Atlantic Puffin	0.09	0.68	734.85	5	1.9
Alcid unid	1.54	6.49	422.15	83	20.4
Merlin	0.02	0.14	734.85	1	1.9
Mourning Dove	0.02	0.14	734.85	1	1.9
Bank Swallow	0.04	0.27	734.85	2	1.9
Tree Swallow	0.15	0.86	577.65	8	3.7
Swallow unid.	0.04	0.19	514.69	2	3.7
Blackpoll Warbler	0.04	0.19	514.69	2	3.7
Yellow-rumped Warbler	0.02	0.14	734.85	1	1.9
Warbler unid.	0.06	0.30	543.57	3	3.7
Dark-eyed Junco	0.04	0.27	734.85	2	1.9
Savannah Sparrow	0.02	0.14	734.85	1	1.9
Snow Bunting	0.02	0.14	734.85	1	1.9

Table 18. Mean (SD) number of detections per survey for 56 bird species recorded on eight grids (A-H; see Fig.24) over all ship-based line transects conducted from 10 June 2009 to 15 Feb 2010. Total represents the cumulative number of detections over all surveys. Unid = Unidentified to species.

Species	A	B	C	D	E	F	G	H	Total
Loon Unid	0.4 ± 1.0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.1 ± 0.3	0 ± 0	0 ± 0	5
Common Loon	13.8 ± 19.1	6.0 ± 8.5	11.2 ± 14.1	5.7± 4.9	18.9 ± 20.3	12.3 ± 10.6	1.0 ± 2.1	1.5 ± 2.3	611
Red-throated Loon	5.4 ± 7.0	2.3 ± 4.7	0.6± 1.0	1.7± 2.9	4.3 ± 7.3	5.2 ± 7.1	1.1 ± 2.11	0.9 ± 1.8	190
Pacific Loon	0.1 ± 0.3	0.1 ± 0.3	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	2
Red-necked Grebe	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.1 ± 0.4	0.1 ± 0.3	0 ± 0	0 ± 0	2
Shearwater Unid	0.1± 0.3	0.3 ± 0.7	1.4 ± 4.0	0.2 ± 0.7	0 ± 0	0 ± 0	1.0 ± 2.8	0.3 ± 0.7	29
Cory's Shearwater	7.2 ± 14.1	2.0 ± 4.2	14.7± 35.0	14.7± 36.3	3.1 ± 8.3	1.9 ± 6.0	10.8 ± 29.2	5.5 ± 12.2	520
Greater Shearwater	1.4 ± 4.0	1.3 ± 3.5	4.4 ± 9.9	1.1 ± 2.3	0.14 ± 0.4	0 ± 0	8 ± 19.5	12.3 ± 25.1	239
Manx Shearwater	0.1 ± 0.3	0.1 ± 0.3	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.1 ± 0.4	0.1 ± 0.4	4
Sooty Shearwater	0.1 ± 0.3	0.1 ± 0.3	0.7 ± 2	0.6± 1.7	0 ± 0	0 ± 0	0.1 ± 0.4	0.6 ± 1.4	19
Wilson's Storm-Petrel	44.4 ± 69.8	9.6 ± 16.5	10.1 ± 24.9	6.7± 14.1	11 ± 29.1	5.2 ± 10.9	21.5 ± 40.9	70.4 ± 164.1	1511
Leach's Storm-Petrel	0 ± 0	0.2 ± 0.6	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	2
Northern Fulmar	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.4 ± 0.7	0.3 ± 0.7	5
Northern Gannet	16.6 ± 23.5	12.5 ± 20.3	9 ± 13.4	4.8± 5.1	70.1 ± 168.9	43.8 ± 113.8	4.5 ± 7.7	9.3 ± 9.3	1437
Double-crd Cormorant	0.1 ± 0.3	0 ± 0	0 ± 0	0.2 ± 0.4	1.3 ± 2.9	4.7 ± 12.4	0 ± 0	0 ± 0	59
Great Cormorant	0.9 ± 1.5	0.5 ± 1.3	0 ± 0	0.1 ± 0.3	0 ± 0	0.5 ± 1.6	0 ± 0	0 ± 0	19
Great Blue Heron	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.14 ± 0.4	0 ± 0	0 ± 0	0 ± 0	1
Brant	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	1.7 ± 5.4	0 ± 0	0 ± 0	17
Canada Goose	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.3 ± 0.7	2
Dabbling duck Unid	1.2± 3.7	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	11
Mallard	0 ± 0	0.1 ± 0.3	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	1
Green-winged Teal	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.1 ± 0.3	0 ± 0	0 ± 0	10
Bay Duck Unid	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.8 ± 2.5	0 ± 0	0 ± 0	8
Scaup Unid	0 ± 0	0 ± 0	3.3 ± 10	0 ± 0	0 ± 0	2.5 ± 7.9	0 ± 0	0 ± 0	55
Red-bd. Merganser	0.1 ± 0.3	0 ± 0	0 ± 0	0 ± 0	0.3 ± 0.8	0.2 ± 0.4	0 ± 0	0 ± 0	5
Common Eider	8.4 ± 21.7	1.5 ± 4.7	3.7± 10.6	4.3 ± 6.1	3.4 ± 5.7	33.1 ± 55.6	0 ± 0	0 ± 0	518
Scoter Unid.	88.8 ± 266.6	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.5 ± 1.4	804

Table 18 continued. Abundance of birds detected during ship-based grid surveys on individual grids.

Species	A	B	C	D	E	F	G	H	Total
Black Scoter	1.7 ± 2.6	17.5 ± 38.9	3.8± 9.9	0.2 ± 0.7	0.1 ± 0.4	8.6 ± 16.6	0 ± 0	0 ± 0	313
Surf Scoter	6.3 ± 15.7	39.2 ± 82.9	2.6 ± 5.8	0 ± 0	3.3 ± 7.4	2.3 ± 3.4	0 ± 0	5.6 ± 15.9	563
White-winged Scoter	54.9 ± 148.7	3.7 ± 6.8	2.1 ± 2.6	6.1 ± 8.7	2.9 ± 2.9	4.0 ± 6.5	0.6 ± 1.8	1.5 ± 2.1	682
Black or Surf Scoter	14.4 ± 21.9	38.9 ± 100.9	0 ± 0	6 ± 11.7	0.4 ± 1.2	10.4 ± 23.5	0 ± 0	7.3 ± 20.5	738
Long-tailed Duck	0.6 ± 1.1	0.1 ± 0.3	0 ± 0	0.3 ± 0.7	0.6 ± 1.1	1.0 ± 2.2	0 ± 0	0.1 ± 0.4	24
Merlin	0 ± 0	0 ± 0	0.1 ± 0.3	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	1
Shorebird Unid	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.3 ± 0.8	0 ± 0	0 ± 0	0.1 ± 0.4	3
Short-billed Dowitcher	0 ± 0	0 ± 0	0 ± 0	0.6± 1.7	0 ± 0	0 ± 0	0 ± 0	0 ± 0	5
Semipalmated Plover	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.3 ± 0.8	0 ± 0	0 ± 0	0 ± 0	2
Purple Sandpiper	0.4 ± 1.3	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	4
Lesser Yellowlegs	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.5 ± 1.4	4
Whimbrel	0.1 ± 0.3	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.4 ± 1.3	0 ± 0	0 ± 0	5
Phalarope Unid	0 ± 0	0.1 ± 0.3	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.1 ± 0.4	0 ± 0	2
Red-necked Phalarope	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	3.0 ± 8.5	24
Gull Unid	0 ± 0	0.1 ± 0.3	0.1 ± 0.3	0 ± 0	0 ± 0	5.6 ± 10.9	0.8 ± 2.1	0 ± 0	64
Herring Gull	25.7± 20.6	28.1 ± 44.8	9.9 ± 7.3	5.8± 5.9	129.4 ±	36.8 ± 64.2	12.8 ± 13.1	11.1 ± 8.8	2118
Great Black-bd. Gull	19.3± 17.9	13.7 ± 21.2	5 ± 5.5	3.1 ± 2.8	80.9 ± 196.3	27.7 ± 56.5	10 ± 12.4	4.1 ± 3.6	1340
Ring-billed Gull	0.2 ± 0.7	0.8 ± 2.2	0.1 ± 0.3	0 ± 0	0.9 ± 1.5	5.6 ± 12.8	0 ± 0	0 ± 0	73
Laughing Gull	0.3 ± 0.7	0.8 ± 1.5	1 ± 2.3	1.3 ± 2.6	2.1 ± 4.8	12.4 ± 30.7	0 ± 0	0 ± 0	171
Bonaparte's Gull	0.44 ± 1.0	0.2 ± 0.6	0.44 ± 1.3	0 ± 0	0.14 ± 0.4	0.3 ± 0.9	0.8 ± 2.1	0.1 ± 0.4	21
Black-ld Kittiwake	0.9 ± 1.5	0.9 ± 2.0	0.6± 1.3	0.6± 1.7	0.14 ± 0.4	0.3 ± 0.7	2.0 ± 2.8	1.1 ± 2.1	56
Long-tailed Jaeger	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.1 ± 0.4	1
Parasitic Jaeger	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.1 ± 0.3	0 ± 0	0 ± 0	1
Pomarine Jaeger	0.1 ± 0.3	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	1
Razorbill	13.8 ± 24.5	4.3 ± 8.8	4.8 ± 8.1	6.22 ± 15.1	2.1 ± 2.7	3.3 ± 7.5	1.8 ± 4.6	4.4 ± 7.5	363
Dovekie	0.2 ± 0.4	2.1 ± 6.6	0.1 ± 0.3	0.1 ± 0.3	0 ± 0	0 ± 0	4.6 ± 9.9	9.6 ± 25.6	139
Murre Unid	0.1 ± 0.3	0.2 ± 0.6	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.5 ± 1.4	0 ± 0	7
Common Murre	5.7± 16.3	4.2 ± 11.3	1.1 ± 2.9	2.1 ± 5.9	0.3 ± 0.8	0.8 ± 2.2	0.8 ± 1.4	0.6 ± 1.2	143
Thick-billed Murre	0 ± 0	0.2 ± 0.6	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.1 ± 0.4	3
Atlantic Puffin	0 ± 0	0 ± 0	0 ± 0	0.2 ± 0.7	0 ± 0	0 ± 0	0.8 ± 1.7	0.1 ± 0.4	9

Table 18 continued. Abundance of birds detected during ship-based grid surveys on individual grids.

Species	A	B	C	D	E	F	G	H	Total
Alcid Unid	5.1 ± 14.9	0.9 ± 2.0	0.7 ± 1.4	2 ± 5.3	0.4 ± 1.1	0.1 ± 0.3	1.1 ± 2.1	0.6 ± 1.2	97
Common Tern	2.3 ± 6.3	0.4 ± 1.3	0 ± 0	0 ± 0	0 ± 0	3.4 ± 10.4	0 ± 0	0.3 ± 0.7	61
Roseate Tern	0.1 ± 0.3	0 ± 0	0 ± 0	0 ± 0	0.4 ± 1.1	0.4 ± 1.3	0 ± 0	0 ± 0	8
Tern Unid	0.44 ± 0.9	0.2 ± 0.6	0 ± 0	0.1 ± 0.3	0.4 ± 1.1	0.1 ± 0.3	0 ± 0	0.1 ± 0.4	12
Mourning Dove	0 ± 0	0 ± 0	0 ± 0	0.1 ± 0.3	0 ± 0	0 ± 0	0 ± 0	0 ± 0	1
Swallow Unid	0 ± 0	0 ± 0	0 ± 0	0.1 ± 0.3	0 ± 0	0.1 ± 0.3	0 ± 0	0 ± 0	2
Tree Swallow	0 ± 0	0 ± 0	0 ± 0	0.9 ± 2.0	0 ± 0	0.2 ± 0.6	0 ± 0	0 ± 0	10
Barn Swallow	0 ± 0	0 ± 0	0 ± 0	0.1 ± 0.3	0 ± 0	0.2 ± 0.6	0 ± 0	0 ± 0	3
Warbler Unid	0 ± 0	0 ± 0	0.1 ± 0.3	0.2 ± 0.7	0 ± 0	0 ± 0	0 ± 0	0 ± 0	3
Blackpoll Warbler	0 ± 0	0.1 ± 0.3	0 ± 0	0.1 ± 0.3	0 ± 0	0 ± 0	0 ± 0	0 ± 0	2
Yellow-rp. Warbler	0 ± 0	0 ± 0	0 ± 0	0.1 ± 0.3	0 ± 0	0 ± 0	0 ± 0	0 ± 0	1
Dark-eyed Junco	0.2 ± 0.7	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	2
Savannah Sparrow	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.1 ± 0.4	0 ± 0	1
Snow Bunting	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.1 ± 0.4	0 ± 0	0 ± 0	0 ± 0	1
Summary total	342.9±459.9	193.3±257.9	91.6±52.5	76.4±36.4	338.1±645.5	237.2±207.5	85.1±63.9	152.4±186.4	13170
Species richness	33	30	23	28	27	32	20	26	56

During ship-based surveys, we recorded flight altitudes of birds into 5 categories (< 10 m, 10-25 m, 25-125 m, 125-200 m, >200 m) altitude above the ocean surface; Table 19). Of 8,927 detections during ship-based surveys from June 2009 through mid-Feb 2010, most birds were in flight at <10 m altitude (58%), while substantial percentages were either on the water (22%) or flying at intermediate altitudes of 10-25 m (15 %). Few birds were observed between 25-125 m elevation (6%), and <1% were >125 m high (Table 19).

Table 19. Summary of flight altitude (m above sea level) for 54 species of birds detected during ship-based line-transect surveys from June 2009 through mid-February 2010. Altitude for each detection was based on ocular estimates, with observers stationed at 6 m elevation on the flying bridge of a ship.

	% of birds detected in altitude category (m)					
Species	**0**	**<10**	**10-25**	**25-125**	**>125**	**N**
Common Loon	81.8	7.9	4.5	5.1	0.7	292
Red-thd. Loon	5.7	30.2	35.8	21.7	6.6	106
Loon spp.	100.0	0.0	0.0	0.0	0.0	5
Red-nd. Grebe	100.0	0.0	0.0	0.0	0.0	1
Northern Fulmar	20.0	80.0	0.0	0.0	0.0	5
Cory's Shearwater	21.7	78.3	0.0	0.0	0.0	520
Greater Shearwater	9.6	90.4	0.0	0.0	0.0	239
Manx Shearwater	50.0	50.0	0.0	0.0	0.0	2
Sooty Shearwater	0.0	100.0	0.0	0.0	0.0	16
Small shearwater unid	0.0	100.0	0.0	0.0	0.0	2
Shearwater unid	48.1	51.9	0.0	0.0	0.0	27
Wilson's Storm-Petrel	49.8	50.2	0.0	0.0	0.0	1511
Double-ct. Cormorant	30.0	70.0	0.0	0.0	0.0	10
Great Cormorant	13.3	80.0	6.7	0.0	0.0	15
Northern Gannet	9.0	46.1	38.1	6.7	0.2	1278
Great Blue Heron	0.0	100.0	0.0	0.0	0.0	1
Brant	0.0	100.0	0.0	0.0	0.0	17
Mallard	0.0	0.0	100.0	0.0	0.0	1
Green-winged Teal	0.0	100.0	0.0	0.0	0.0	10
Dabbling duck unid.	0.0	36.4	63.6	0.0	0.0	11
Bay duck unid.	0.0	100.0	0.0	0.0	0.0	8
Scaup unid.	0.0	0.0	45.5	54.5	0.0	55
Common Eider	8.8	90.8	0.3	0.0	0.0	294
Long-tailed Duck	9.5	76.2	14.3	0.0	0.0	21
Surf Scoter	0.0	9.6	90.4	0.0	0.0	209
Black Scoter	0.0	92.4	7.6	0.0	0.0	277
White-winged Scoter	2.5	70.2	27.3	0.0	0.0	161
Surf or Black Scoter	3.4	81.1	15.5	0.0	0.0	238
Scoter unid.	0.0	0.0	100.0	0.0	0.0	4
Red-brd. Merganser	0.0	0.0	100.0	0.0	0.0	2
Merlin	0.0	0.0	100.0	0.0	0.0	1
Semipalmated Plover	0.0	100.0	0.0	0.0	0.0	2
Least Sandpiper	0.0	100.0	0.0	0.0	0.0	2
Purple Sandpiper	0.0	100.0	0.0	0.0	0.0	4
Lesser Yellowlegs	0.0	100.0	0.0	0.0	0.0	4
Whimbrel	0.0	100.0	0.0	0.0	0.0	5

Table 19 cont. Flight altitude of birds detected during ship-based surveys.

	% of birds detected					
Species	**0**	**<10**	**10-25**	**25-125**	**>125**	**N**
Short-bd Dowitcher	0.0	100.0	0.0	0.0	0.0	5
Red-nd. Phalarope	95.8	4.2	0.0	0.0	0.0	24
Phalarope unid.	0.0	100.0	0.0	0.0	0.0	2
Shorebird unid.	0.0	100.0	0.0	0.0	0.0	3
Long-td. Jaeger	0.0	0.0	100.0	0.0	0.0	1
Parasitic Jaeger	0.0	100.0	0.0	0.0	0.0	1
Pomarine Jaeger	0.0	100.0	0.0	0.0	0.0	1
Bonaparte's Gull	27.8	50.0	22.2	0.0	0.0	18
Laughing Gull	31.2	48.2	17.6	2.9	0.0	170
Ring-billed Gull	3.1	37.5	37.5	18.8	3.1	32
Herring Gull	7.6	64.7	13.9	12.8	1.0	1652
Great-Black-bd Gull	15.8	67.3	8.1	8.0	0.8	1001
Black-lg. Kittiwake	9.1	32.7	47.3	10.9	0.0	55
Gull spp.	0.0	0.0	1.7	39.7	58.6	58
Common Tern	4.9	36.1	47.5	11.5	0.0	61
Roseate Tern	0.0	37.5	50.0	12.5	0.0	8
Tern unid.	0.0	33.3	66.7	0.0	0.0	12
Common Murre	55.0	45.0	0.0	0.0	0.0	131
Thick-billed Murre	33.3	66.7	0.0	0.0	0.0	3
Murre unid	33.3	66.7	0.0	0.0	0.0	6
Razorbill	41.9	58.1	0.0	0.0	0.0	93
Dovekie	77.6	22.4	0.0	0.0	0.0	125
Alcid unid.	13.3	86.7	0.0	0.0	0.0	83
Atlantic Puffin	100.0	0.0	0.0	0.0	0.0	5
Mourning Dove	0.0	100.0	0.0	0.0	0.0	1
Bank Swallow	0.0	100.0	0.0	0.0	0.0	2
Tree Swallow	0.0	50.0	37.5	12.5	0.0	8
Swallow unid.	0.0	0.0	100.0	0.0	0.0	2
Blackpoll Warbler	0.0	100.0	0.0	0.0	0.0	2
Yellow-rd Warbler	0.0	100.0	0.0	0.0	0.0	1
Warbler unid	0.0	100.0	0.0	0.0	0.0	3
Dark-eyed Junco	0.0	0.0	100.0	0.0	0.0	2
Savannah Sparrow	0.0	100.0	0.0	0.0	0.0	1
Snow Bunting	0.0	100.0	0.0	0.0	0.0	1
Grand Total	**21.5**	**57.6**	**14.6**	**5.5**	**0.8**	**8,927**

3.1.2 Aerial Surveys

Survey Effort

We conducted 10 flights between 18 Nov 2009 and 22 Feb 2010 (Table 20). During Round 1 in 2009, we surveyed 6 transects during each flight which took approximately 2.5 hours to complete, thus it took 4 flights to completely sample all 24 transects. During Rounds 2 and 3, we surveyed 8 transects per day, which took approximately 3 hours of flight time on transects, thus we could survey all 24 transects in 3.35 flights.

Table 20. Summary of dates and transects sampled during aerial surveys of Ocean SAMP study area from 18 Nov 2009 to 22 Feb 2010 (see Fig. 27 for locations of transects).

	Round 1 (2009)				**Round 2 (2010)**			**Round 3 (2010)**		
Transect	**18 Nov**	**2 Dec**	**7 Dec**	**8 Dec**	**11 Jan**	**14 Jan**	**27 Jan**	**5 Feb**	**13 Feb**	**22 Feb**
1	X						X			X
2			X			X				
3				X	X			X		
4		X					X			X
5	X					X			X	
6			*		X			X		
7				X			X			X
8		X				X			X	
9	X				X			X		
10			X				X			X
11				X		X			X	
12		X			X			X		
13	X						X			X
14			X			X			X	
15				X	X			X		
16		X					X			X
17	X					X			X	
18			X		X			X		
19				X			X			X
20		X				X			X	
21	X				X			X		
22			X				X			X
23				X		*			X	
24		X			X			X		

*data discarded due to navigational error

During aerial surveys, we had a total of 9,414 detections from 17species or guilds (i.e., cormorants, scoters, shorebirds, gulls, alcid; Table 21). The most common species, in terms of total detections, were Common Eider (3,571 detections), unidentified gulls (1,293 detections), Northern Gannet (885 detections), Herring Gulls (856), unidentified scoters (716 detections), Common Loon (632 detections), and unidentified alcids (589 detections).

There was considerable variation among survey flights in detection rates between days. During Round 1, when 6 transects were sampled per fight, there were an average of 878 ± 561 total detections per day (CV = 63.8). During Rounds 2 and 3, there was less variation among days (CV = 39.0) based on an average of 983 ± 383 total detections per day

Table 21. Total number of detections for 17 avian species or guilds during 10 aerial surveys of the Ocean SAMP study area from 18 Nov 2009 to 22 Feb 2010.

Species	**18 Nov**	**2 Dec**	**7 Dec**	**8 Dec**	**11 Jan**	**14 Jan**	**27 Jan**	**5 Feb**	**13 Feb**	**22 Feb**	**Total**
Loons	20	79	19	45	13	94	126	34	60	170	660
Cormorants	1	0	4	1	0	0	0	0	0	0	6
N. Gannet	225	200	17	285	21	94	35	1	6	1	885
Common Eider	345	44	22	781	406	137	604	303	275	654	3571
Scoter spp.	2	2	3	35	130	128	604	2	20	20	946
Long-tailed Duck	0	0	0	0	0	0	0	0	0	15	15
R-b. Merganser	0	0	0	0	3	0	0	0	0	2	5
Shorebird spp.	0	0	0	0	0	0	3	0	0	14	17
Bonaparte's Gull	0	0	0	0	0	0	1	0	0	0	1
Herring Gull	59	207	37	215	97	67	19	8	72	75	856
Great B-b. Gull	8	70	21	85	10	13	18	2	25	17	269
B-l Kittiwake	3	2	7	11	117	20	12	18	2	0	192
Gull spp.	347	265	6	31	11	286	36	310	0	1	1293
Razorbill	0	0	0	0	4	0	13	7	1	21	46
Murre spp.	0	0	0	0	0	0	1	0	0	0	1
Dovekie	0	0	0	0	0	59	1	2	0	0	62
Alcid spp.	0	1	3	5	63	426	97	47	24	32	698
Total	**1010**	**870**	**139**	**1494**	**871**	**1265**	**1555**	**725**	**484**	**1001**	**9414**

During aerial surveys, 68% of all detections were birds observed on the water, although this varied among species (Table 22). Cormorants, shorebirds, and gulls were more likely to be detected while in flight, whereas seaducks and alcids were more likely to be observed on the water. Since observers only estimated the number of detections in one distance band, we were unable to calculate detection functions for birds detected during aerial surveys. We were unable to estimate avian density based on aerial survey due to time limitations in preparing this report, however raw plotted data has been provided within the sections covering individual species and groups below. We will present DSM modeled estimates of avian densities within the Ocean SAMP study area based on aerial strip-transect surveys.

Table 22. Percent of flocks in flight or on the water for 14 avian guilds during aerial surveys in 2009 and 2010 in the Ocean SAMP study area.

Species	**% fly**	**% water**	**N**
Loons	6	94	454
Cormorants	100	0	3
Northern Gannet	49	51	209
Common Eider	11	89	118
Scoters	37	63	38
Long-tailed Duck	0	100	2
R-b. Merganser	100	0	4
Shorebirds	100	0	2
Bonaparte's Gull	100	0	1
Herring Gull	81	19	296
Great B-b. Gull	58	42	146
B-l Kittiwake	98	2	62
Gulls	29	71	28
Alcids	4	96	435
Total	32	68	1803

3.2 Endangered Species Assessment

Roseate Terns:

We detected small numbers of Roseate Terns during systematic ship- and land-based surveys. During ship-based surveys, Roseate Terns were relatively uncommon and we only had 8 Roseate Tern detections on 3 grids (Table 23). Roseate Terns were detected on ship-based line transect surveys in Block Island Sound from mid-July to late August 2009; SW of the Harbor of Refuge, NW of Block Island and S of Block Island (Fig. 33). No Roseate Terns were detected on grids in Rhode Island Sound or within Inner Continental Shelf during ship-based surveys.

Table 23. Spatial distribution of tern detections on survey grids (see Fig. 33 for locations) during ship-based offshore line transect surveys in the summer and fall of 2009.

	Grid Cell						
Species	**A**	**B**	**D**	**E**	**F**	**H**	**Total**
Common Tern	21	4	0	0	34	2	61
Roseate Tern	1	0	0	3	4	0	8
Sterna spp.	4	2	1	3	1	1	12
Total	**26**	**6**	**1**	**6**	**39**	**3**	**81**

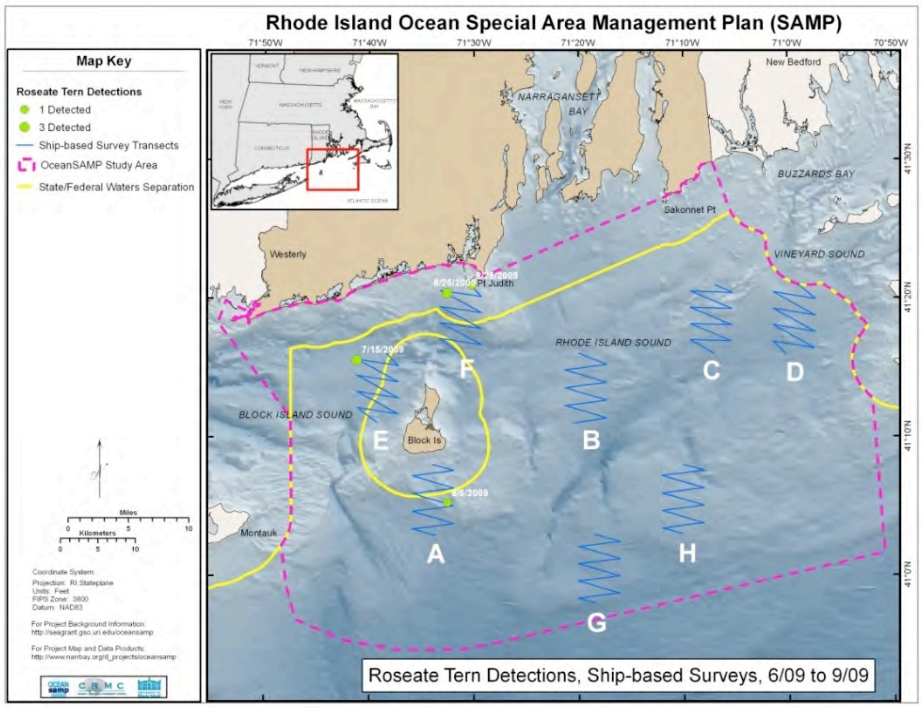

Fig. 33. Spatial distribution of Roseate Tern detections (green circles) during ship-based surveys on 8 grids from June through September 2009.

We had 125 Roseate Tern detections during land-based seawatches, with most detections at the NW corner of the Ocean SAMP study area (Table 24). Detections were concentrated at Watch Hill Lighthouse (34% of 125 detections) and Point Judith (25%). In contrast, Common Tern detections during land-based surveys tended to be more uniformly dispersed throughout the 11 survey stations. Finally, there were large numbers of unidentified terns, particularly at Watch Hill Lighthouse and at Ruggles Ave. survey stations. It is likely that a low percentage of these birds were in fact Roseate Terns, as Common and Roseate Terns often forage together on aggregations of sand lance (Grist 2009).

Table 24. Distribution and abundance (total number of detections) of Common (COTE), Roseate (ROST), and unidentified terns (UNID) at 11 seawatch stations (Fig. 21) from May to Sep 2009.

	Station*											
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Total**
COTE	682	170	237	637	289	555	448	129	150	203	147	3647
ROST	42	11	18	31	5	5	1		4	8		125
UNID	104	195	55	126	23	47	18	414	119	159	57	1317
Total	828	376	310	794	317	607	467	543	273	370	204	5089

*1 = Watch Hill, 2 = East Beach, 3 = Deep Hole, 4 = Pt. Judith, 5 = Monahan's Dock, 6= Beavertail, 7 = Brenton Point, 8 = Ruggles Ave., 9 = Sachuest Pt., 10 = Sakonnet Pt, 11 = Goosewing.

During onshore roosting surveys, Grist (2009) observed 5 banded Roseate Terns at Charlestown Breachway, all of which came from the Great Gull Island, NY colony (Table 25).

Table 25. Observations of banded Roseate Terns at Charlestown Breachway from June to Aug 2009 by Grist (2009). All birds were originally banded at Great Gull Island, New York.

Age	Left leg	Right leg	Age banded	Date banded
Adult	1182-07600	00/B6	Chick	23/06/1996
Adult	9822-43697	A6/97	Chick	28/06/2003
Adult	1182-078?1	?1/B8	Chick	XX/06/03
Adult	1182-04883	83/H8	Adult	23/06/2002
Adult	6B/88	1182-03688	Chick	23/06/2000

We had 935 detections of terns during boat-based surveys of nearshore habitats between Point Judith and Napatree on 8 survey days between 10 Aug and 3 Sept 2009 (Table 26). Roseate Terns were detected on 4 of 8 survey days, with a total of 29 detections (15 adults, 4 juveniles, and age was not known for 4 detections). Common Terns were much more abundant than other tern species during these boat surveys (87% of 935 detections). We also detected three other species (Black, Forster's, and Least). Terns tended to be more abundant on the western half of the sawtooth grid (Fig. 34). The few Roseate Terns that were detected also were on the western half of the grid, with most detections occurring near the western edge of Quonochotaug Pond (Fig. 35)

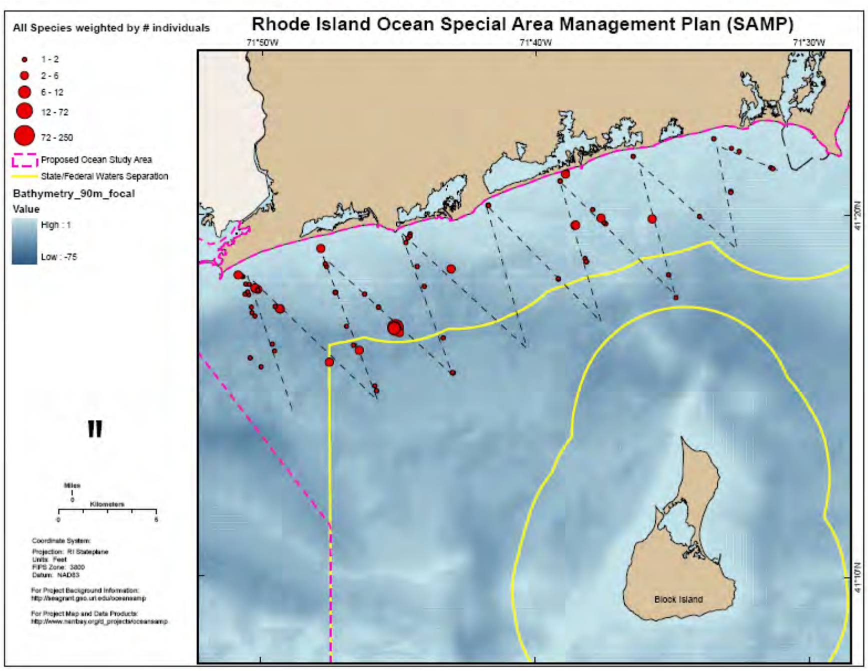

Fig. 34. Distribution of terns (all species: Common, Roseate, Least, Forster's, and Black) detected during boat-based strip surveys in nearshore habitats during summer 2009.

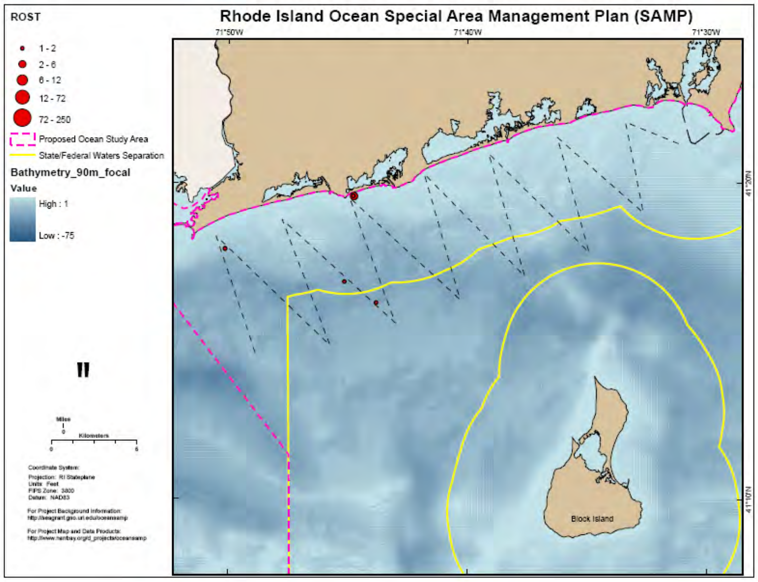

Fig. 35. Distribution of Roseate Terns detected during boat-based strip-transect surveys in nearshore habitats from Napatree to Point Judith during July and August 2009.

Table 26. Total number of terns detected during boat-based surveys in nearshore habitats between Pt. Judith and Napatree from 10 Aug to 3 Sept 2009 (see Fig. 34 for location of transects).

Species	**Age**	**10 Aug**	**14 Aug**	**18 Aug**	**19 Aug**	**25 Aug**	**27 Aug**	**1 Sept**	**3 Sept**	**Total**
Roseate Tern	Adult		7		1		4	3		15
Roseate Tern	Juv		3				1			4
Roseate Tern	Unk		10							10
Common Tern	Adult	4	50	1	86	12	3	2		158
Common Tern	Juv	1	50	1	15	11	1	17	1	97
Common Tern	unk		255	1	3	6	254	40		559
Black Tern	Adult							1		1
Black Tern	Juv						1	3		4
Black Tern	Unk							38		38
Forster's Tern	Adult		1					1		2
Least Tern	Adult	5	5		5					15
Sterna spp.	Unk		3					24	5	32
Total		10	384	3	110	29	264	129	6	935

During 2009, an ornithologist working for New Jersey Audubon Society maintaining the radar unit on Block Island consistently observed Roseate Terns at a number of sites (Table 27). Magarian (pers. comm.) detected Roseate Terns on the island from 21 July through 30 August, where he observed up to 100 Roseate Terns observed on the island on any given day.

Table 27. Observations of adult and immature Roseate Terns on Block Island during July and August 2009 (Tom Magarian, New Jersey Audubon Society, pers. comm.)

		Age		
Date	**Location**	**Adult**	**Immature**	**Unknown**
21-Jul	Andy's Way	2		
22-Jul	Westside Beach/Beane Pt			3
24-Jul	Andy's Way	75	20	
25-Jul	North end	1		
25-Jul	Cormorant Cove	25	5	
26-Jul	Andy's Way	5	3	
27-Jul	Andy's Way	30	10	
28-Jul	Andy's Way	3	5	
29-Jul	Andy's Way	3	2	
30-Jul	North end	1		
31-Jul	Andy's Way	4		
1-Aug	Cormorant Cove	5	3	
2-Aug	North end	1		
2-Aug	Andy's Way			1
7-Aug	Andy's Way	15	3	
9-Aug	North end	2		
9-Aug	Andy's Way	2		
11-Aug	Andy's Way			1
12-Aug	Andy's Way	3		
15-Aug	Andy's Way	2		
16-Aug	Andy's Way			1
17-Aug	Andy's Way	2		
20-Aug	Andy's Way	1		
22-Aug	Andy's Way	50	20	
23-Aug	North radar site			2
23-Aug	Sandy Point			100
24-Aug	Cormorant Cove	2		
25-Aug	Trimms Pond	45	5	
29-Aug	Andy's Way	3	1	
29-Aug	Trimms Pond	7	1	
30-Aug	Spring Street	4		

3.3 Loons

We detected three species of loons (Gaviidae) in the Ocean SAMP study area: Common Loon, Red-throated Loon, and Pacific Loon. Common Loons were the most abundant species of loon in the Ocean SAMP area, and this species had detection rates 2 to 4 times greater than Red-throated Loons during land-based seawatches. We detected one species of loon rare to the east coast, Pacific Loon, twice during land-based seawatches.

Seasonal changes in abundance - Loons are primarily winter residents and migrants in the Ocean SAMP area (Sibley 2000). Common and Red-throated Loons that winter farther south migrate through Rhode Island waters during their fall migration mostly in October and November, and then pass through again in April and May during spring migration to their northern breeding lakes (Figs. 36 and 37).

Large numbers of loons, both Common and Red-throated Loons, also are winter residents in the Ocean SAMP area from October through May. Loon abundance in nearshore waters peaked in December (birds on water, Figs. 36 and 37), and then gradually declined through May. There is some indication that loons disperse farther offshore starting in January, when they are in flightless molt. Thus, this decline in nearshore areas could be a redistribution of birds offshore and not an actual reduction in overall abundance in the study area. A few Common Loons were detected during land-based seawatches during the summer, when no Red-throated Loons were detected.

Flight altitude of birds - Most loons that we observed during land-based and ship-based surveys were flying at elevations of <10 m (49% of observations), although 9% of birds flew at altitudes greater than 25 m (1% flew over 125 m high; Fig. 38).

Spatial patterns in abundance in nearshore waters - In nearshore areas, Common Loons tend to be more abundant off of sandy beaches in Block Island Sound than rocky headlands of Rhode Island Sound, although loons were common at Brenton Point and Ruggles Ave. on the southern end of Aquidneck Island (Fig. 39). See Appendices B and C for data on loon abundance at each of the land-based seawatch stations for each month surveyed.

During fall ship-based line transect surveys, we primarily detected Common and Red-throated Loons in southerly-directed flight at the northern end of the Ocean SAMP study area (Figs. 40 and 41). However, in late winter, both species of loons were more widely dispersed in the Ocean SAMP area as birds in flight were detected throughout the Ocean SAMP area (Figs. 40 and 41).

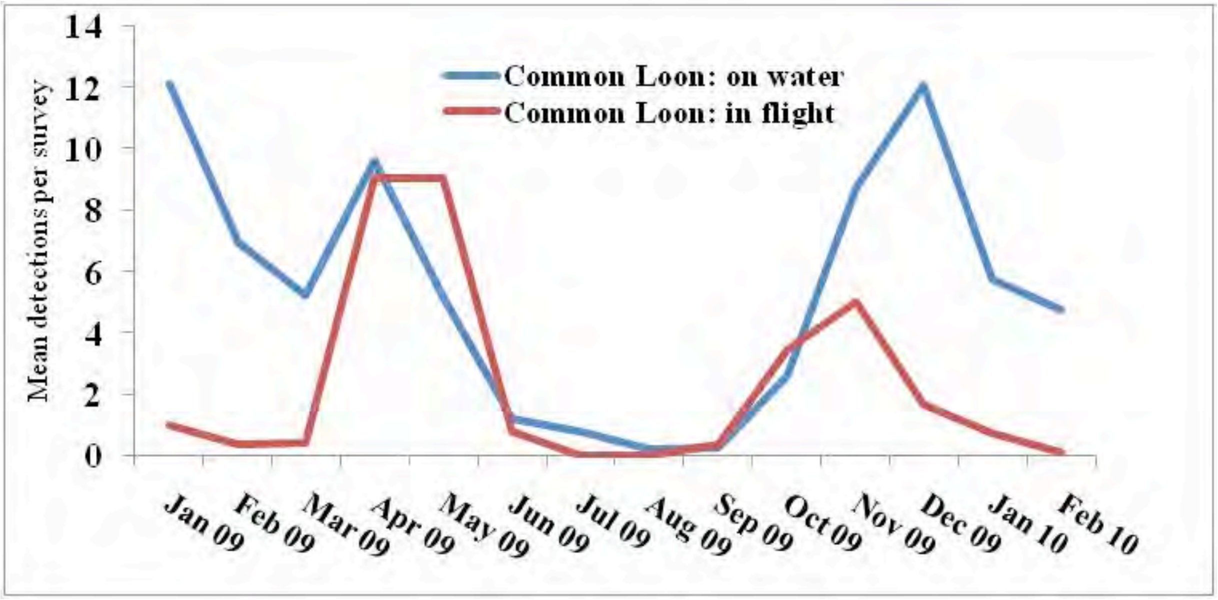

Fig. 36. Monthly differences in the mean number of Common Loons detected on the water and in flight (birds per hr) during surveys at 11 land-based seawatch stations along the Rhode Island coastline

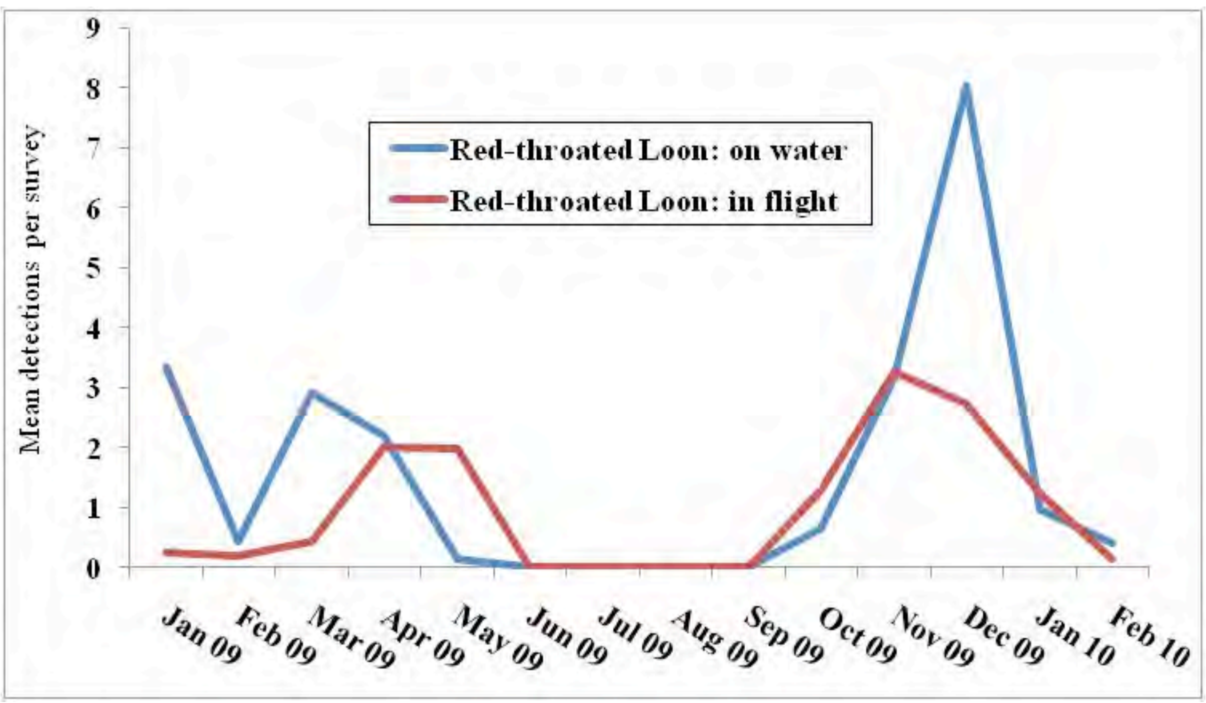

Fig. 37. Mean number of Red-throated Loons detected on the water and in flight (birds per hr) per survey per month at 11 land-based seawatch stations along the Rhode Island coastline

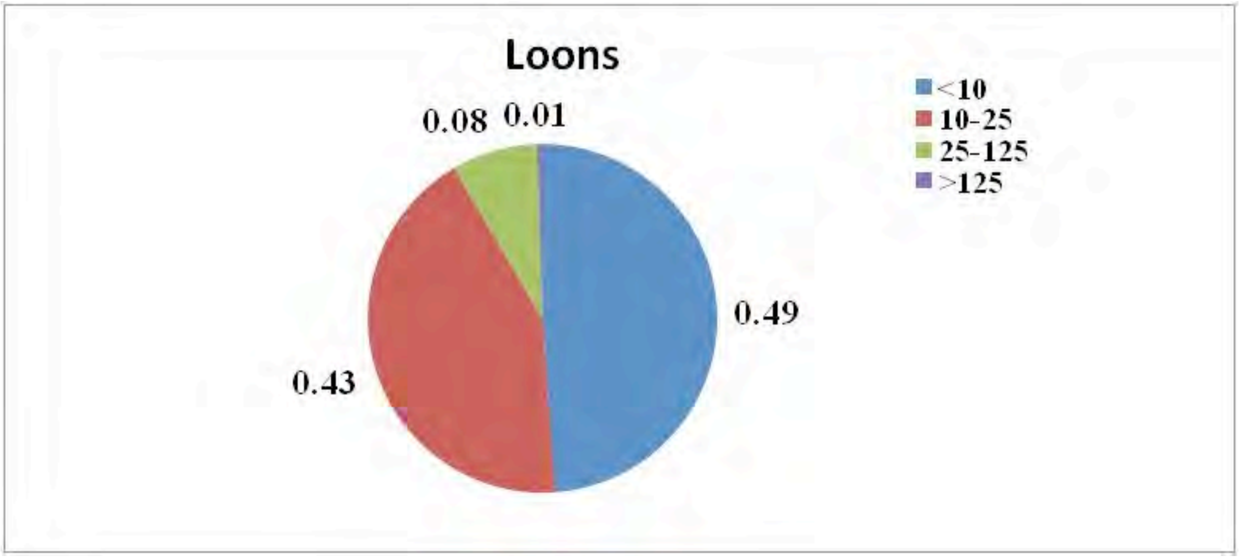

Fig. 38. Flight altitude of loons (m above sea level; N = 1,806 detections) based on visual estimates during land-based seawatches and ship-based line transects. Proportion of birds in four altitude categories is shown.

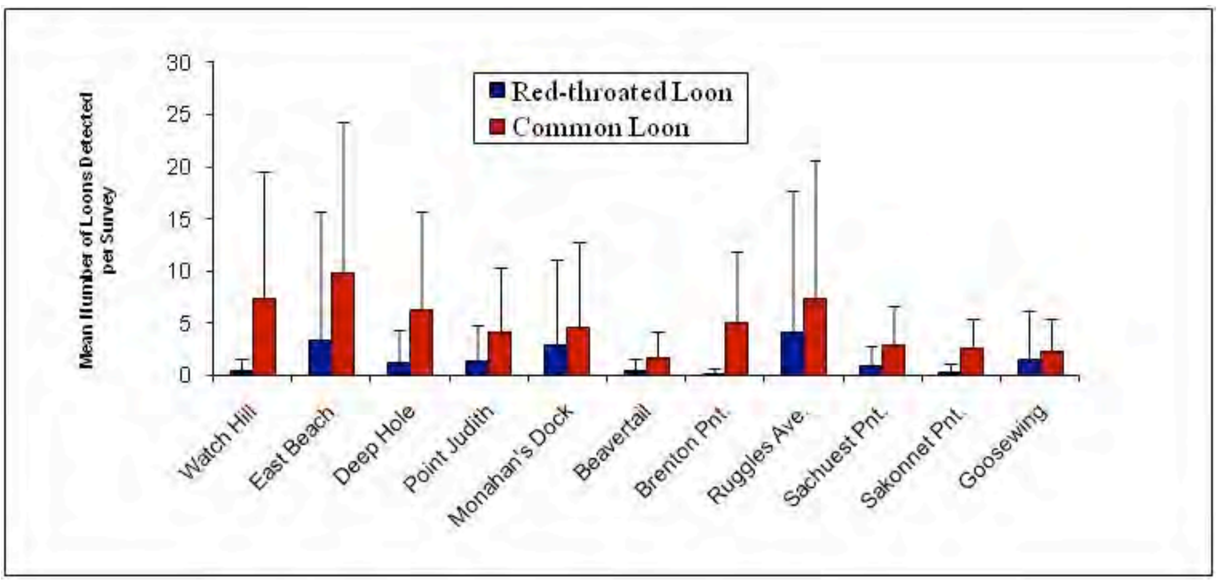

Fig. 39. Mean (SD) number of Common and Red-throated Loons detected per survey at 11 land-based seawatch stations (see Fig. 21 for locations of stations).

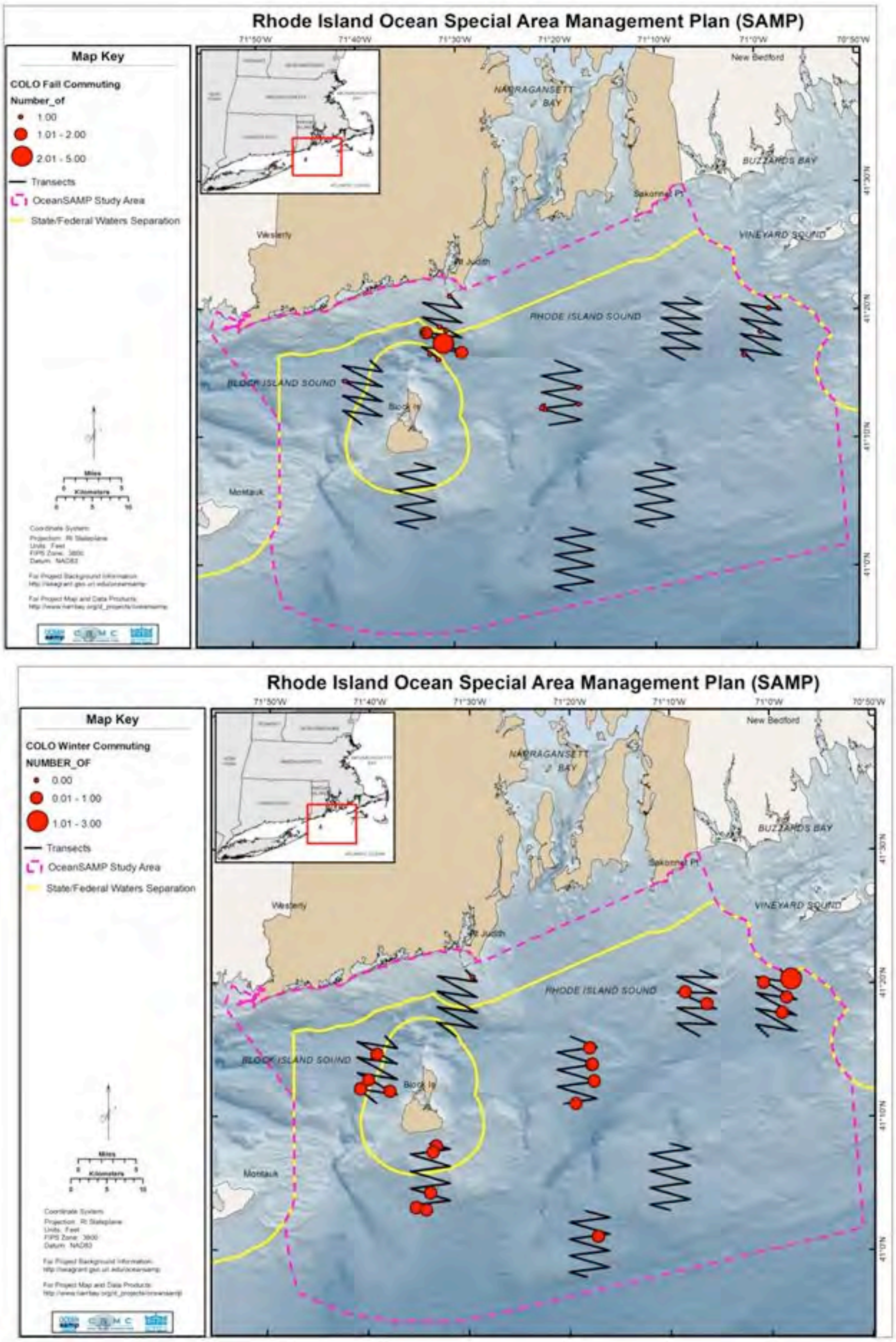

Fig. 40. Locations of Common Loons in flight in fall (upper) and winter (lower) in the Ocean SAMP study area during on ship-line transect surveys.

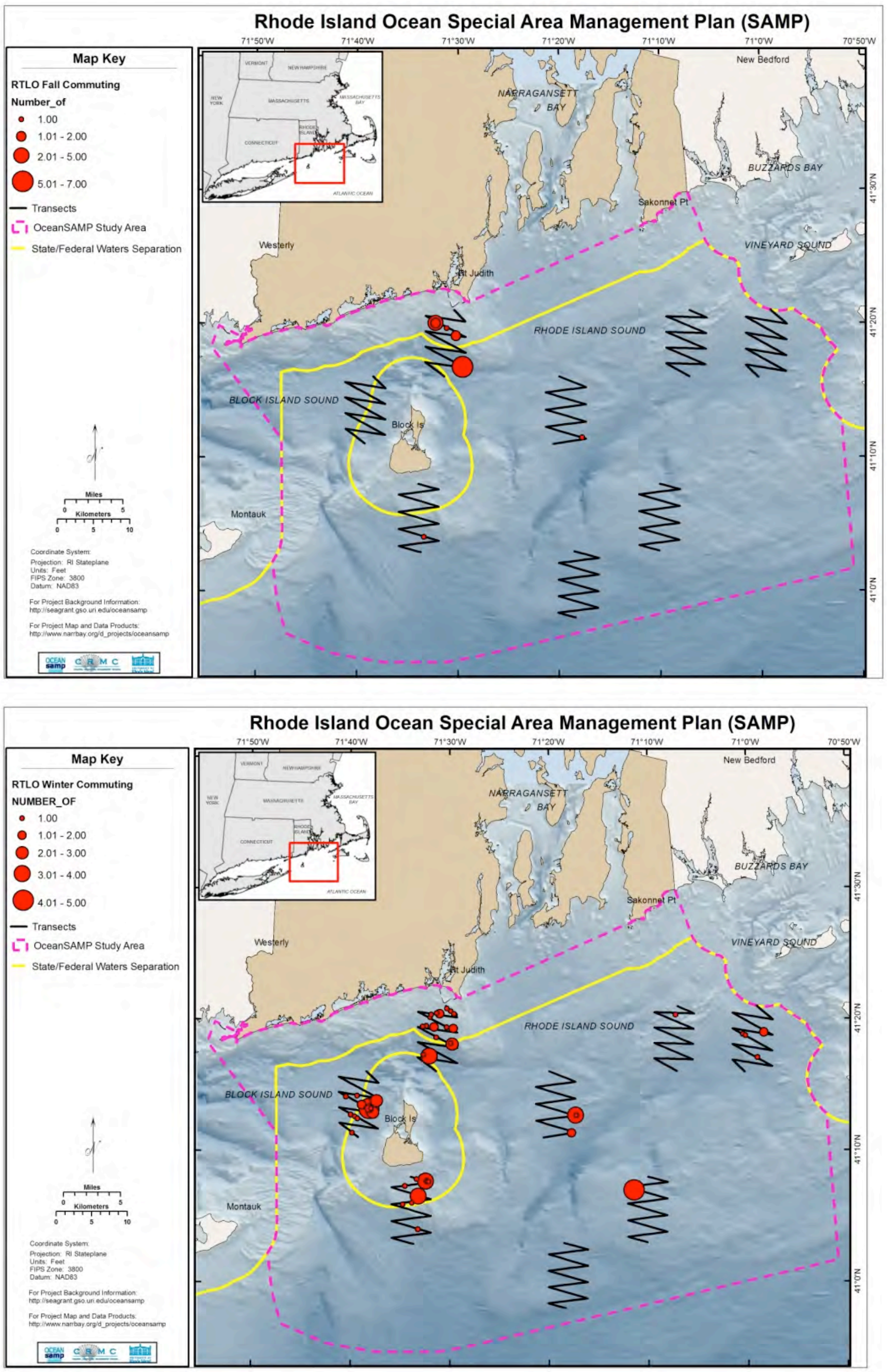

Fig. 41. Locations of Red-throated Loons in flight in fall (upper) and winter (lower) in the Ocean SAMP study area during on ship-line transect surveys.

Spatial patterns in abundance in nearshore and offshore waters – We present the detection function plot that was derived from the observed abundance of Common Loons on the water from ship-based surveys, and the associated GAM plot in Appendix J. The best-fit Density Surface Model (DSM) explained 21.5% of the spatial variation in observed abundance of Common Loons (see Appendix H for full model results). Common Loon densities during winter were highest closer to shore (densities of up to 5 loons per km^2), particularly along the northern edge of the Ocean SAMP study area, and in waters surrounding Block Island (Fig. 42). In addition, estimated densities during winter were relatively high in Block Island Sound between Block Island and Long Island. In contrast, estimated loon densities during winter were lower in the southern, central sections of Rhode Island Sound and all of the Inner Continental Shelf, where waters tend to be much deeper. However, there is less certainty about the density estimates in these southern sections of Rhode Island Sound during winter, where CVs for model density estimates were relatively high (Fig. 43). We were unable to model Common Loon densities in offshore areas during summer and fall due to low detection rates during ship-based line transects. We had too few detections of Red-throated Loons during ship-based line transects to model their density or spatial distribution. The literature, and our low detection rate for Red-throated Loons, suggests that Red-throated Loons are particularly sensitive to disturbance and appear to disperse from the ship's path before they can be detected.

Population size in the Ocean SAMP area - Based on the Common Loon DSM (Appendix H), we estimated that during the winter of 2009-2010, there were 2,901 Common Loons (95% CI = 2,525 to 3,321) in the Ocean SAMP study area (Appendix I). We provide no population estimate for Red-throated Loons because we detected too few during ship-based surveys for reliable DSM modeling. However, Red-throated loons were abundant at times in nearshore habitats, with an average of 3.1 individuals detected during land-based seawatches (Table 13). It is unknown what proportion of loons detected in offshore waters and recorded as "loon species" during aerial surveys were Red-throated Loons.

Spatial patterns in abundance in relation to bathymetry – The distribution and abundance of loons detected during aerial surveys were consistent with the estimated densities from the Common Loon DSM (Fig.44). Most observations of loons during aerial surveys were in nearshore habitats in Block Island Sound, at the northeast corner of the Ocean SAMP study area, south of Sakonnet Pt., and in nearshore waters south and southwest of Block Island. Based on locations where loons were detected during aerial surveys, loons were primarily found in areas where the water depth was < 35 m deep (Fig. 45).

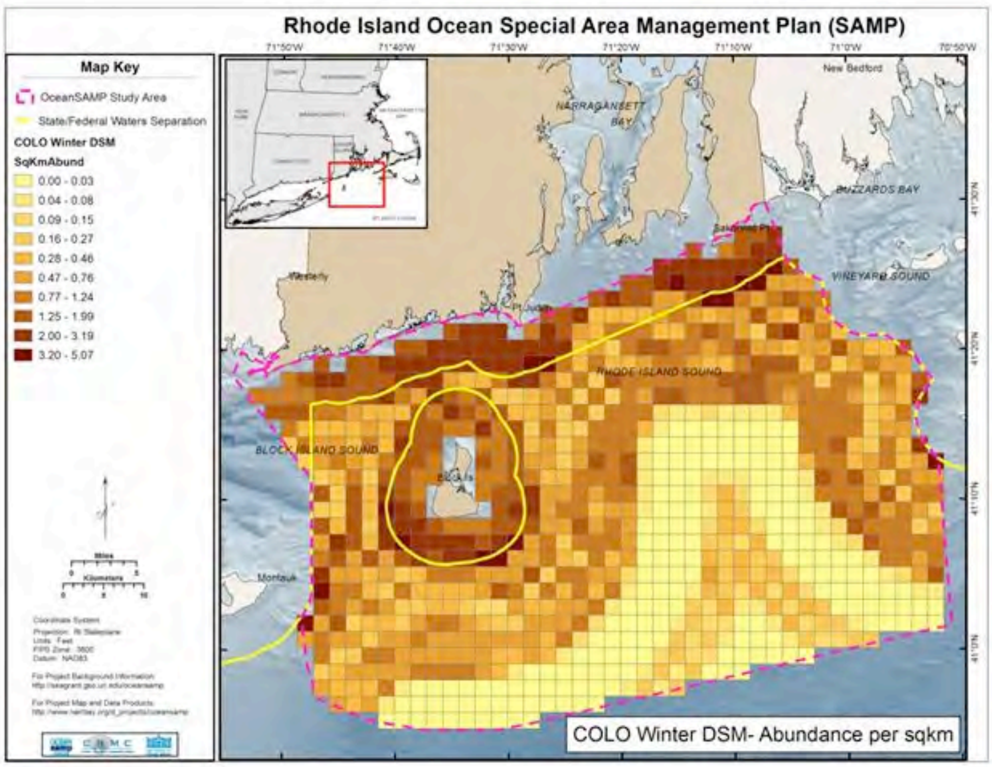

Fig. 42. DSM estimates of the spatial distribution and density of Common Loons in winter in the Ocean SAMP study area based on ship line-transect surveys. Densities were as great as 5 birds per km^2.

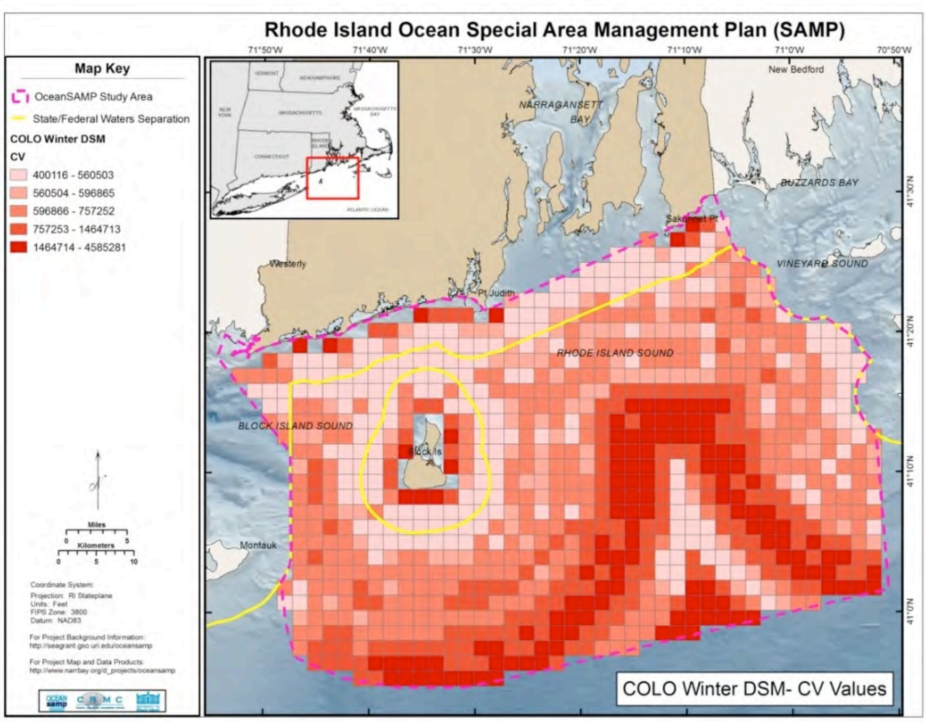

Fig. 43. Coefficient of Variation for DSM modeled loon density estimates based on ship line transect surveys shown in Fig. 43. Areas that are deeper red have less certainty in density estimates

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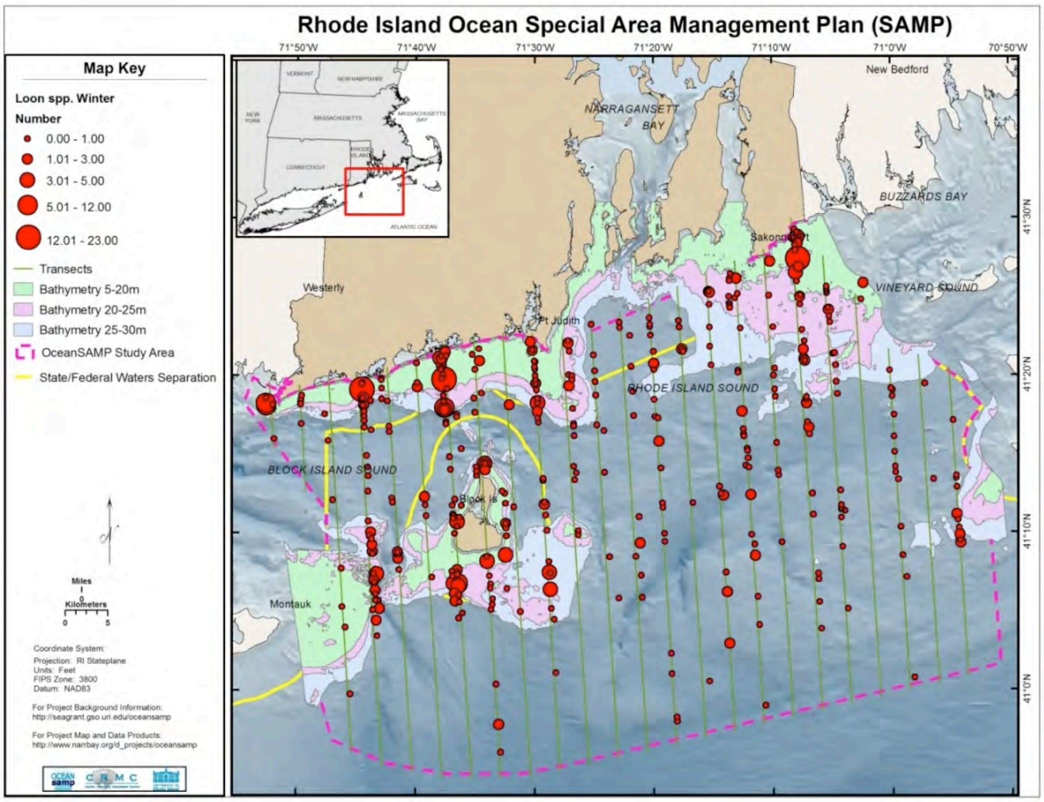


Fig. 44. Distribution of loons during aerial surveys in the winter of 2009-2010 in the Ocean SAMP study area.

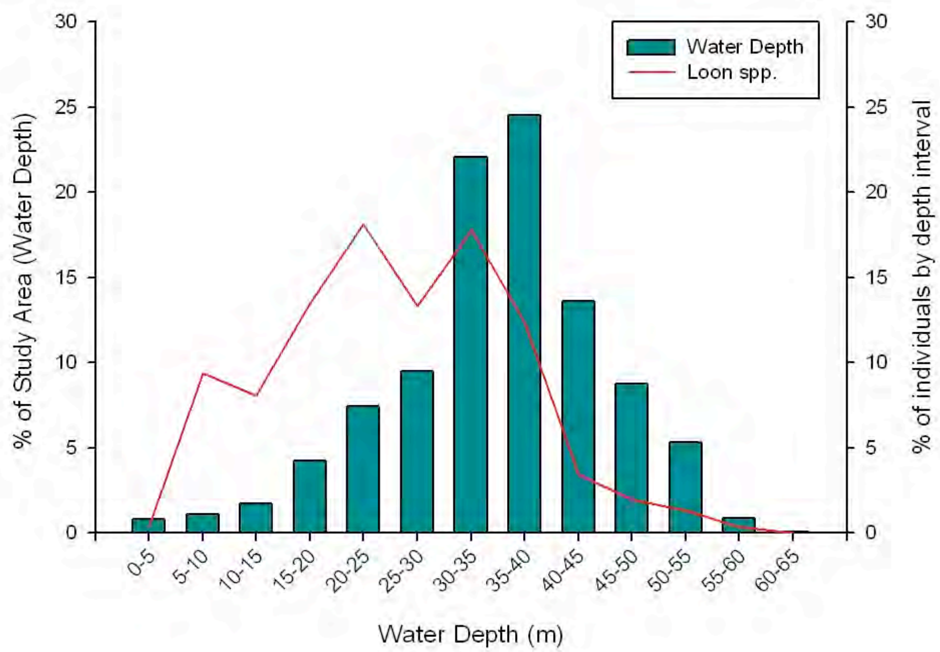


Fig. 45. Bathymetry of Ocean SAMP study area (green histogram) compared to depths where loons were detected during aerial surveys (red line)(Fig 44).

3.4 Grebes

We detected two species of grebes (Podicipedidae) in the Ocean SAMP study area: Horned Grebe and Red-necked Grebe. Horned Grebes are relatively common in small numbers in nearshore habitats, while Red-necked Grebes are also found in nearshore habitats but are relatively uncommon.

Seasonal changes in abundance - Both species of grebe occur in Rhode Island only during winter (Fig. 46) and then spend the breeding season north of Rhode Island. Peak abundance of Horned Grebes occurred in March indicating that birds wintering farther south migrate through Rhode Island waters during their spring migration to more northerly breeding lakes (Fig. 46, Appendices B and C).

Flight altitude of birds - Neither species of grebe were detected often in flight (Tables 15 and 19); however, those detected flying during daytime surveys were at altitudes <10 m (Fig. 47).

Spatial patterns in abundance in nearshore waters - Horned Grebes were relatively common at East Beach, Brenton Point, and Ruggles Ave., while Red-necked Grebes were seen more often at Pt. Judith and Sachuest Pt. (Fig. 48). See Appendices B and C for data on grebe abundance at each of the land-based seawatch stations for each month surveyed.

Spatial patterns in abundance in nearshore and offshore waters – We had too few detections of Horned and Red-necked Grebe during ship-based line transects to model their density or spatial distribution. However, a comparison of grebe detections during land-based versus ship-based surveys clearly shows that they almost exclusively were found in nearshore habitats. For example, Horned Grebes were never observed during offshore ship-based surveys (Table 17), and we detected only two Red-necked Grebes during offshore surveys (Table 17).

Population size in the Ocean SAMP area - We had too few detections of grebes during ship-based line transects in all seasons to estimate their population size in the study area.

Spatial patterns in abundance in relation to bathymetry – We did not detect grebes during winter aerial surveys, thus we did not explore grebe abundance in relation to water depth in the Ocean SAMP study area. During land-based seawatches, grebes were detected in waters <20 m deep.

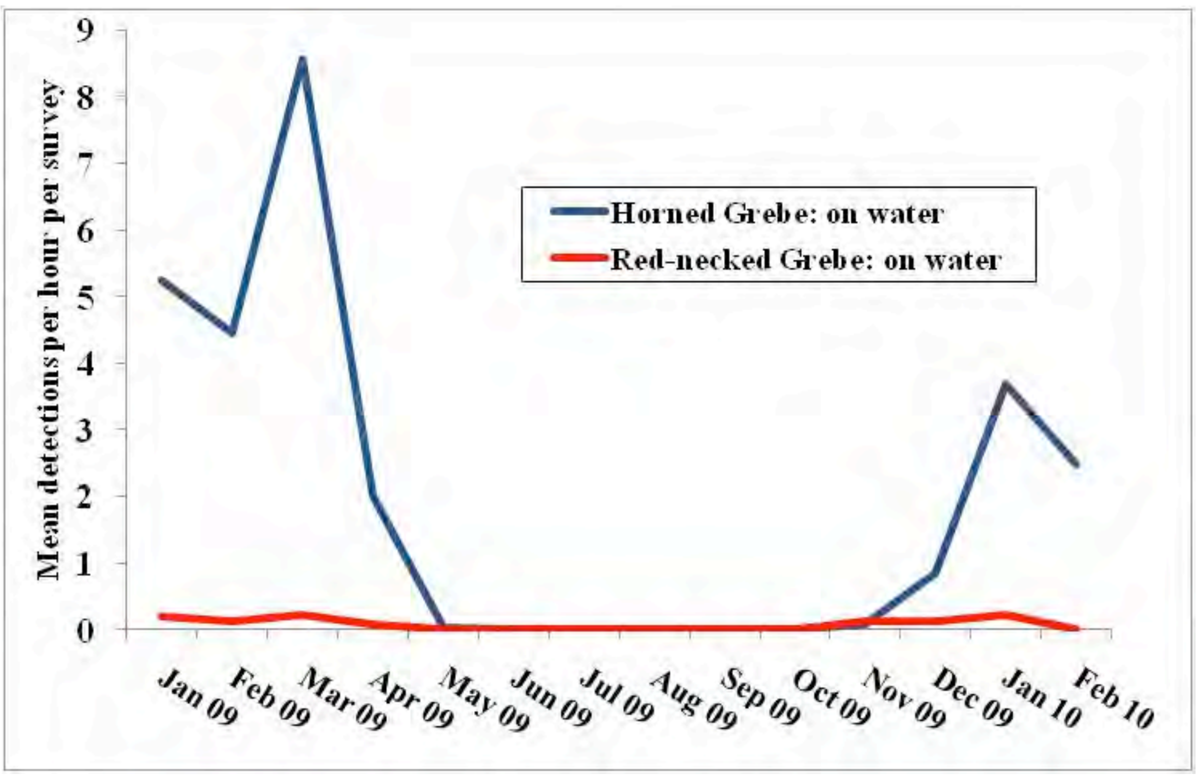


Fig. 46. Mean number of Horned and Red-necked Grebes detected on the water per survey per month at 11 land-based seawatch stations along the Rhode Island coastline.

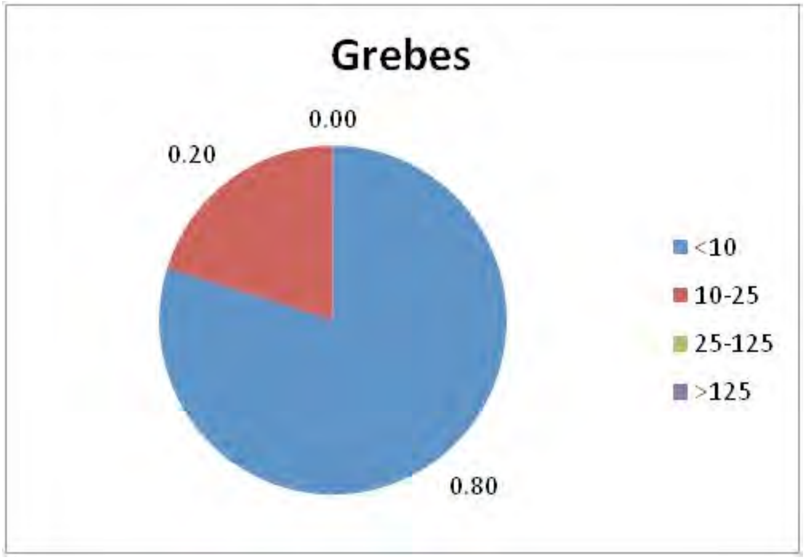


Fig. 47. Flight altitude of grebes (m above sea level; N = 109 detections) based estimates during land-based seawatches and ship-based line transects. Shown are proportion of birds in four altitude categories.

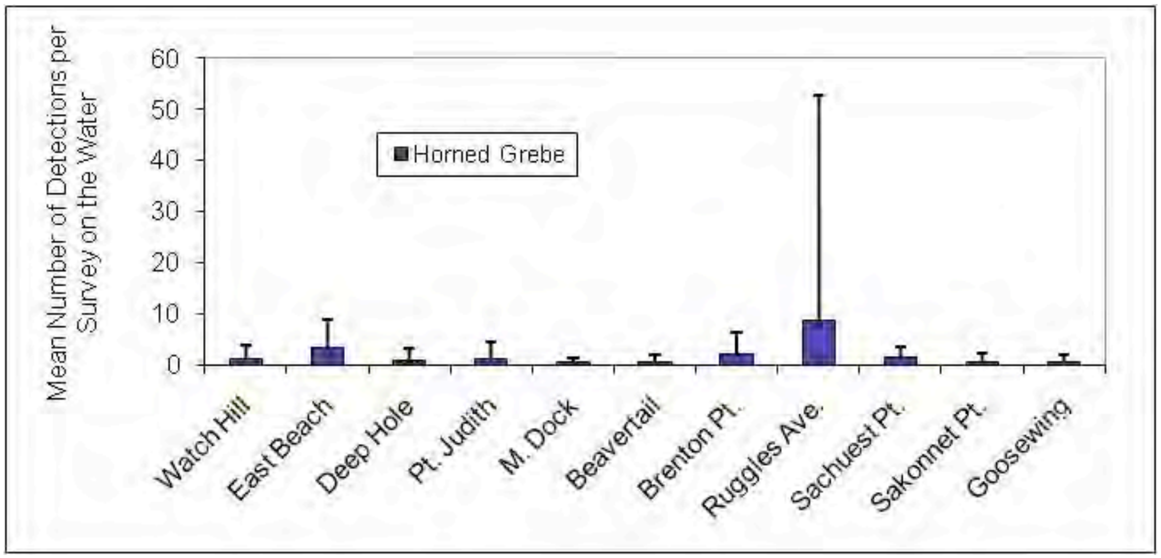


Fig. 48. Mean (SD) number of Horned Grebes detected per survey at 11 land-based seawatch stations (see Fig. 21 for locations of stations).

3.5 Shearwaters

We detected four species of shearwaters (Procellariidae) in the Ocean SAMP study area: Manx, Cory's, Greater, and Sooty Shearwater. Cory's Shearwater and Greater Shearwater are seasonally abundant and the most common species of shearwater in the SAMP study area, with Manx and Sooty Shearwaters relatively common but found in relatively low numbers.

Seasonal changes in abundance – Shearwaters are pelagic species that are found in the Ocean SAMP area during the summer months (Appendices B and C). During land-based surveys, Cory's Shearwater, was detected only during mid-summer during land-based surveys (July; Fig. 49). Greater, Cory's, and Sooty Shearwaters breed in the southern hemisphere and so reside in Rhode Island waters during the nonbreeding "winter" period of their annual cycle.

Flight altitude of birds - Shearwaters are almost always observed flying low over the water as they take advantage of small wind currents near the ocean surface to efficiently search for food near the ocean surface. All shearwaters that we observed flew at altitudes of <10 m (N = 665 detections).

Spatial patterns in abundance in nearshore waters – Cory's Shearwater the only species of shearwater that were detected regularly during land-based seawatches (>2400 detections; Table 13), where they were most common at East Beach, Deep Hole, Brenton Pt. and Ruggles Ave (Fig. 50). Greater (14 detections), Sooty (7 detections), and Manx Shearwaters (five detections) were rarely detected during land-based seawatches (Table 13). See Appendices B and C for data on shearwater abundance at each of the land-based seawatch stations for each month surveyed.

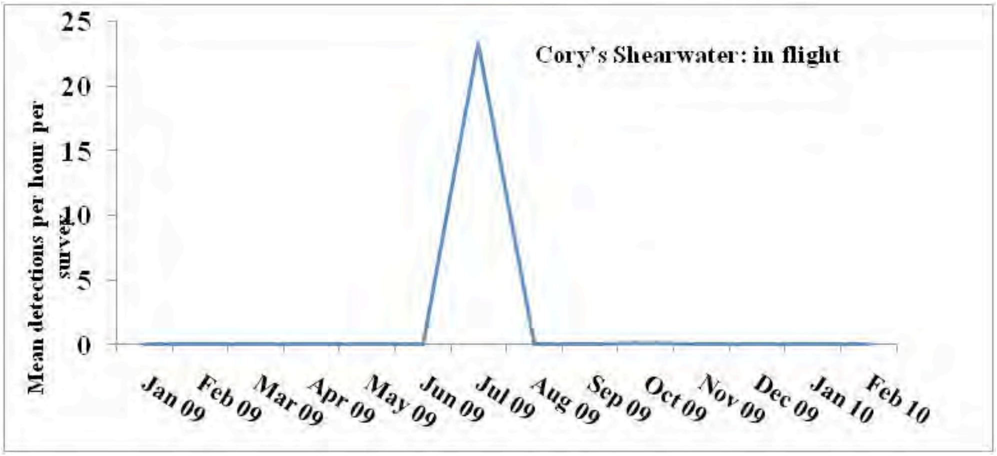


Fig. 49. Mean number of Cory's Shearwaters detected in flight per survey per month at 11 land-based seawatch stations along the Rhode Island coastline

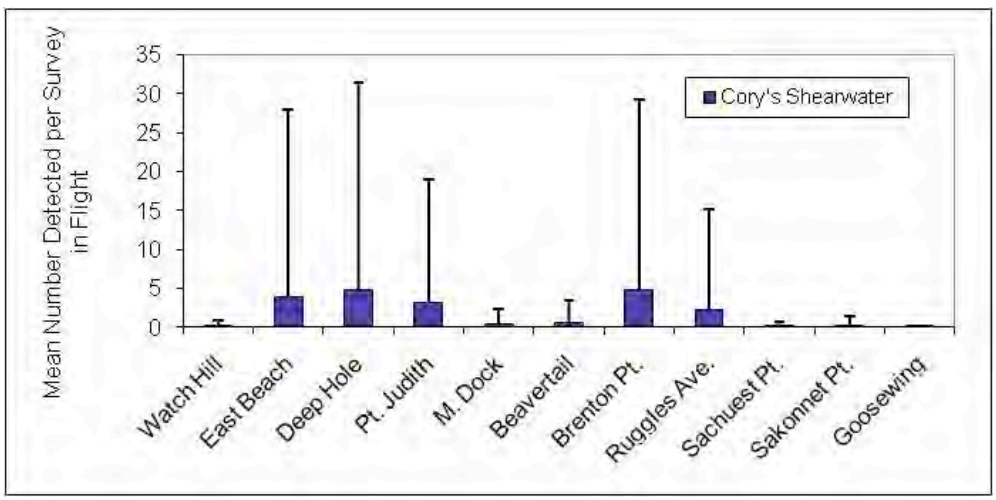


Fig. 50. Mean (SD) number of Cory's Shearwaters detected per survey at 11 land-based seawatch stations (see Fig. 21 for locations of stations).

Spatial patterns in abundance in nearshore and offshore waters –The best-fit Density Surface Model (DSM) for Cory's and Greater Shearwaters in summer explained 26.3% and 50.8% of the spatial variation in observed abundance, respectively (Appendix H for full model results). Cory's Shearwater density during summer was lowest in nearshore areas at the north end of the Ocean SAMP area and highest in south, central Rhode Island Sound and the Inner Continental Shelf (Fig. 51). In general, the spatial distribution of Greater Shearwater during summer was similar to that for Cory's Shearwater, although Greater Shearwater was less common closer to the coast than Cory's Shearwater (Fig. 51). Cory's Shearwater densities (over 5 detections per km^2) were on average higher than Greater Shearwater peak densities (2.5 detections per km^2; Fig. 51). The greatest uncertainty in shearwater density estimates occurred in the southern, central sections of Rhode Island Sound and the Inner Continental Shelf (Fig. 52).

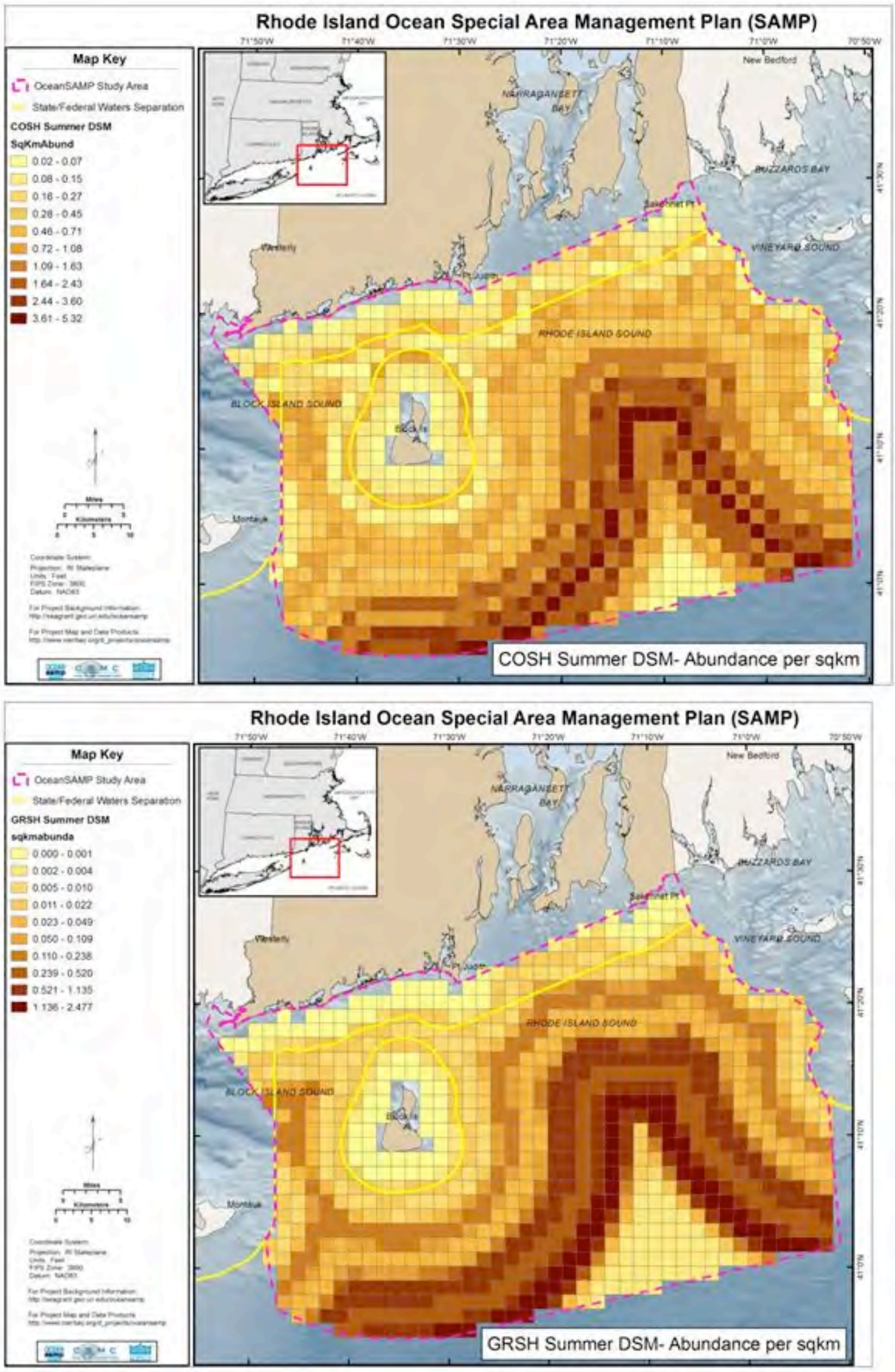
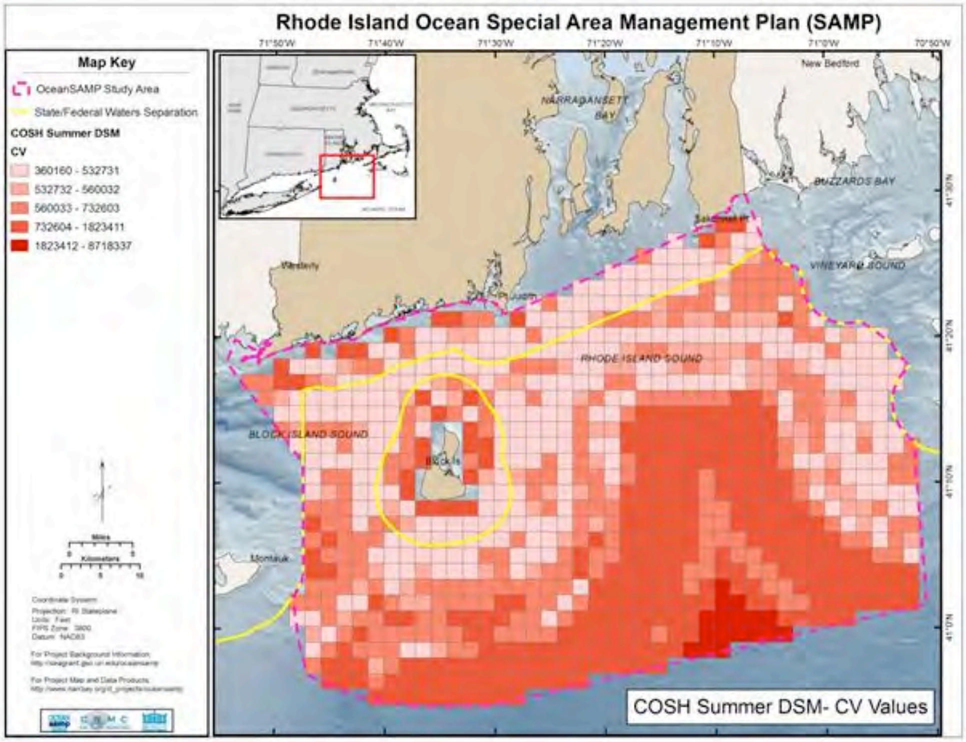


Fig. 51. DSM estimates of the spatial distribution and density of Cory's Shearwaters (upper) and Greater Shearwater (lower) in summer in the Ocean SAMP study area based on ship line-transect surveys.



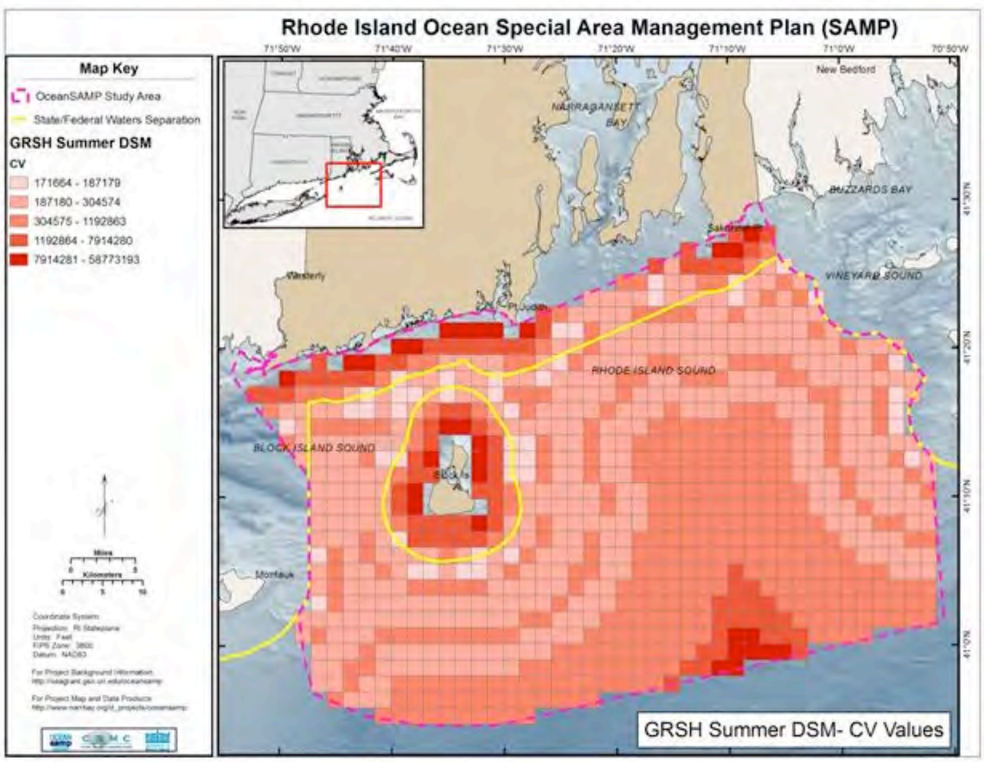


Fig. 52. Coefficient of Variation for DSM modeled density estimates for Cory's Shearwater (upper) and Greater Shearwater (lower) based on ship line transect surveys shown in Fig. 51.

Population size in the Ocean SAMP area – Based on the DSM models (Appendix H), we estimated that during summer 2009 there were 2,643 (95% CI: 1,979 to 3,530) Cory's Shearwaters and 3,350 (95% CI: 3,005 to 3,712) Greater Shearwaters in the Ocean SAMP study area (Appendix I). This is a conservative estimate of shearwater population for both species because it assumes no turnover of individuals. However, shearwaters travel great distances as they move from their southern hemisphere breeding areas to northern hemisphere nonbreeding areas including the Rhode Island Ocean SAMP study area. Thus, these population estimates likely greatly underestimate the actual number of shearwaters that inhabit the study area from June to August.

3.6 Storm-petrels

We detected two species of storm-petrels (Hydrobatidae) in the Ocean SAMP area, Wilson's Storm-Petrel and Leach's Storm-Petrel. Wilson's Storm-Petrels are common and seasonally abundant in the SAMP study area, while Leach's Storm-Petrels are uncommon. Wilson's Storm-Petrels breed in the southern hemisphere and so reside in Rhode Island waters during the nonbreeding "winter" period of their annual cycle.

Seasonal changes in abundance – Storm-petrels are pelagic species that are most common in the Ocean SAMP area during the summer months (Fig. 53).

Flight altitude of birds - Storm-Petrels are like shearwaters in that they are almost always observed flying low over the water as they take advantage of small wind currents near the ocean surface to efficiently search for food near the ocean surface. All storm-petrels were detected in flight and always at altitudes <10 m during land-based seawatches and ship-based surveys (N = 2,001 detections; Tables 15 and 19).

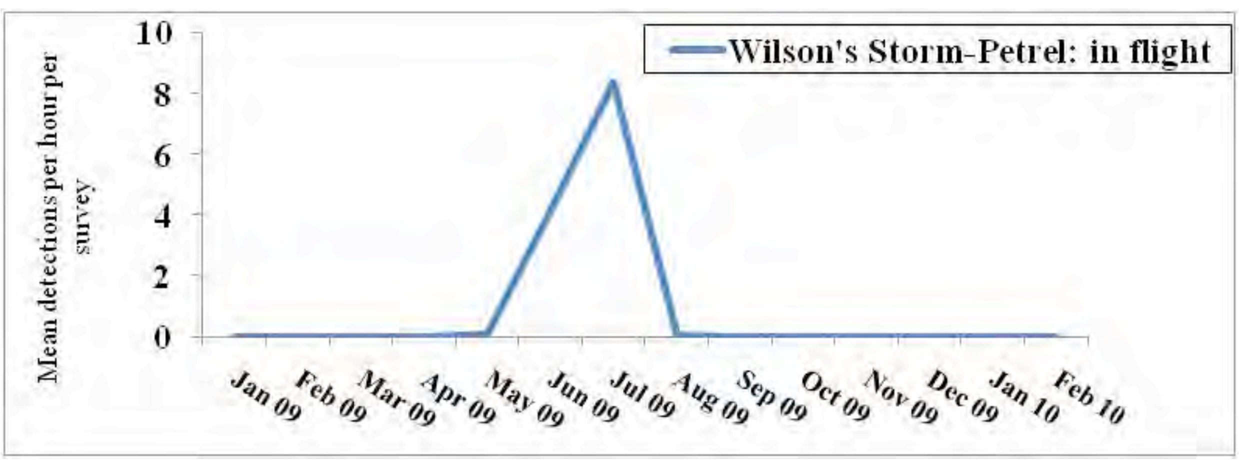


Fig. 53. Mean number of Wilson's Storm-Petrels detected in flight per survey per month at 11 land-based seawatch stations along the Rhode Island coastline

Spatial patterns in abundance in nearshore waters – We detected Wilson's Storm-Petrels from seawatch stations on both Block Island and Rhode Island Sound, with concentrations at East Beach, Deep Hole, and Pt. Judith (Fig. 54). In contrast, Leach's Storm-Petrels were only detected once during land-based seawatches, at Deep Hole (Table 13). See Appendices B and C for data on storm-petrel abundance at each of the land-based seawatch stations for each month surveyed.

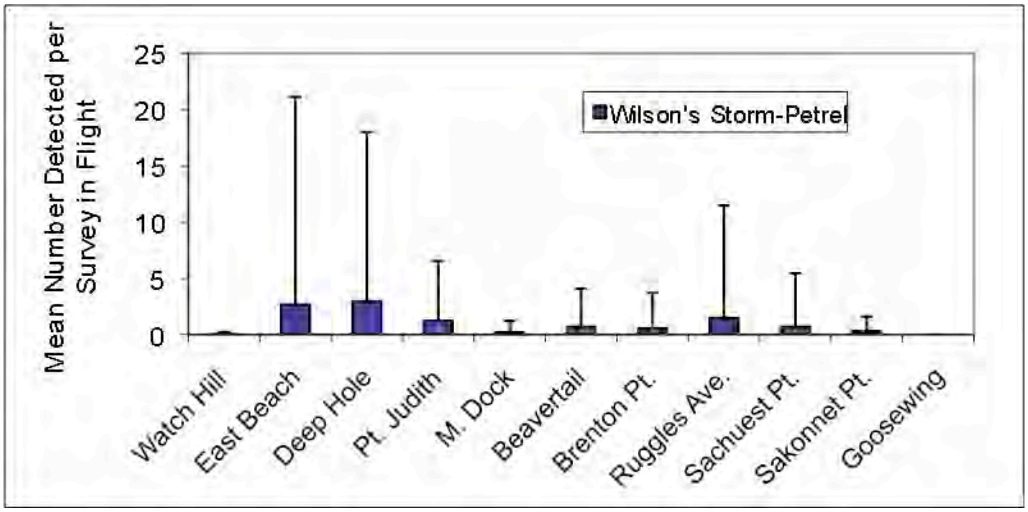


Fig. 54. Mean (SD) number of Wilson's Storm-Petrels detected per survey at 11 land-based seawatch stations (see Fig. 21 for locations of stations).

Spatial patterns in abundance in nearshore and offshore waters – We present the GAM plot that was derived from the observed abundance of Wilson's Storm -Petrels in flight from ship-based surveys during summer in Appendix J. The best-fit Density Surface Model (DSM) explained 33.5% of the spatial variation in observed abundance of Wilson's Storm Petrels in summer (see Appendix H for full model results). Wilson's Storm-Petrel density during summer was unique compared to other species (e.g., shearwater spp.) in that they were relatively abundant in a band about 3 miles offshore in Block Island Sound and Rhode Island Sound and were most densely concentrated over the Inner Continental Shelf (22 individuals per km^2; Fig. 55). The greatest uncertainty in Wilson's Storm Petrel density estimates occurred along the southern boundary of Rhode Island Sound and along the moderately deep sections of the Inner Continental Shelf (Fig. 56).

Population size in the Ocean SAMP area – Based on the DSM models (Appendix H), we estimated that during summer 2009 there were 16,335 (95% CI: 10,879 to 24,527) Wilson's Storm-Petrels in the Ocean SAMP study area (Appendix I), which made this species among the most abundant in offshore waters of the Ocean SAMP study area. This is a conservative estimate of Wilson's Storm-Petrel population because it assumes minimal turnover of individuals. However, Wilson's Storm-Petrel travel great distances as they move from their southern hemisphere breeding areas to northern hemisphere nonbreeding areas including the Rhode Island Ocean SAMP study area. Thus, this population estimate likely greatly underestimates the actual number of Wilson's Storm-Petrel that inhabit the study area from June to August.

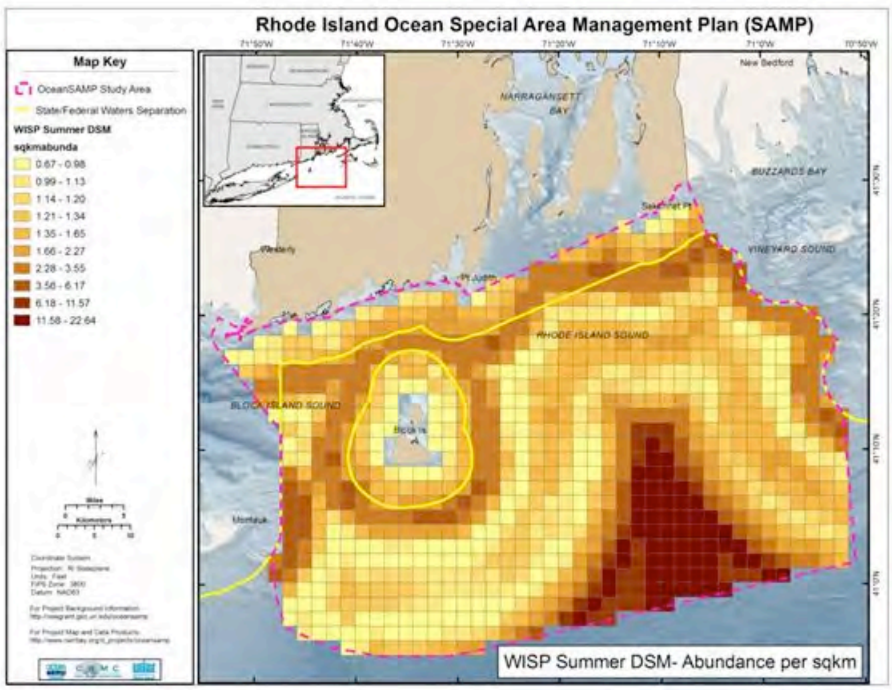


Fig. 55. DSM estimates of the spatial distribution and density of Wilson's Storm-Petrels in summer in the Ocean SAMP study area based on ship line-transect surveys.

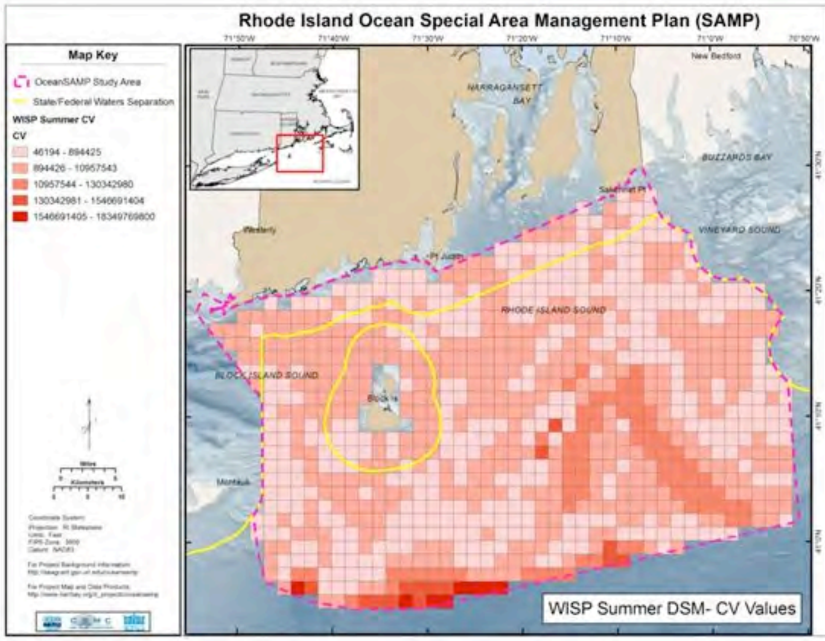


Fig. 56. Coefficient of Variation for Wilson's Storm-Petrel density estimates based on ship line transect surveys shown in Fig. 55.

Spatial patterns in abundance in relation to bathymetry – We did not detect storm-petrels during aerial surveys because flights were conducted too late in the season for storm-petrels. Thus, in our final report produced during 2011, we will estimate a bathymetric profile for storm-petrels as we did for other taxa.

3.7 Gannets

Northern Gannets are the only member of the family Sulidae that are found in the SAMP area. Northern Gannets are common and seasonally abundant during migration from their breeding grounds in Canada to wintering areas along the southern Atlantic Coast and into the Gulf of Mexico (Sibley 2000).

Seasonal changes in abundance – Northern Gannets are a common migrant and winter resident in nearshore and offshore waters of the Ocean SAMP area. Peak passage rates in the spring occur during April and May, whereas gannets during fall migration are most abundant in November and December (Fig. 57).

Flight altitude of birds – Gannets observed during land-based and ship-based surveys flew at a broad range of altitudes in part because they plunge-dive from an altitude of 10-40 m for fish that can be up to 20 m below the ocean surface . Most flying birds (54%) were at altitudes <10 m, with 36% flying between 10-25 m altitude, and 10% between 25-125 m (Fig. 58).

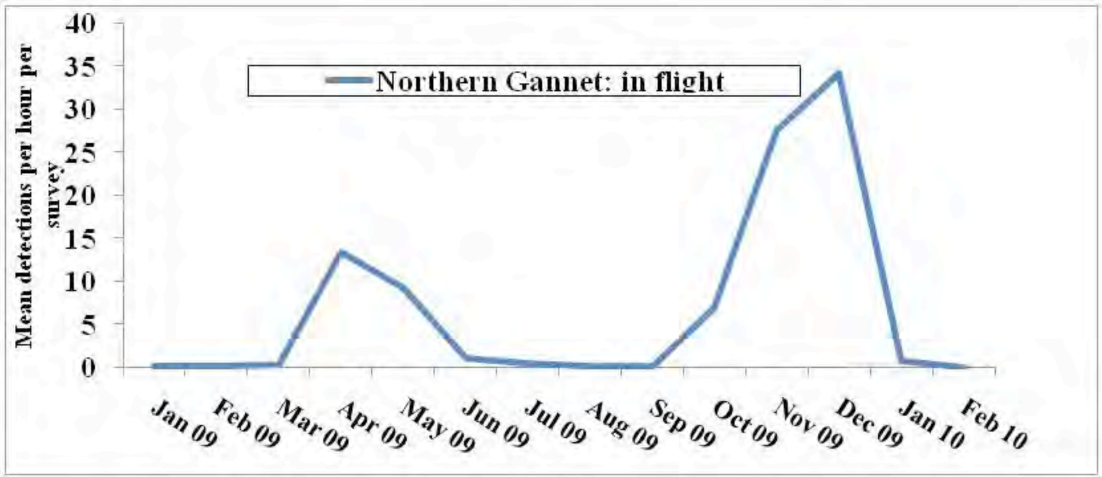


Fig. 57. Mean number of Northern Gannets detected in flight per survey per month at 11 land-based seawatch stations along the Rhode Island coastline.

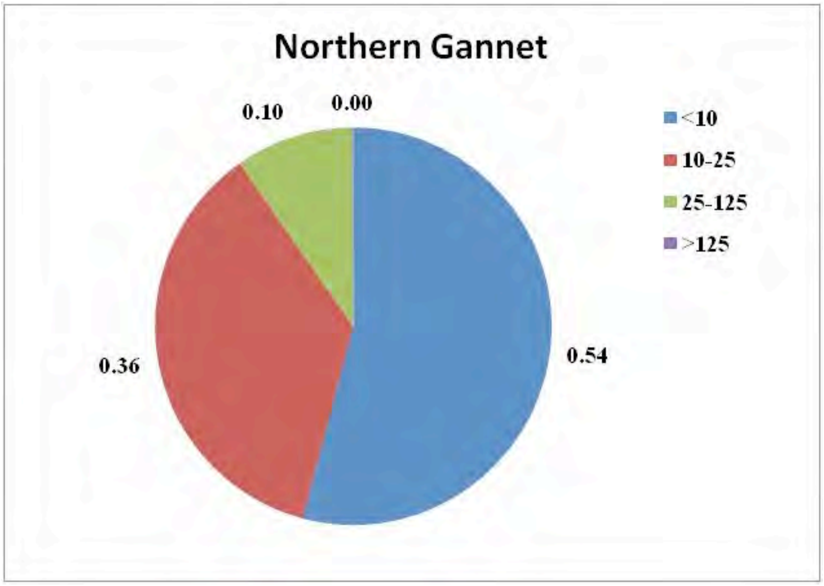


Fig. 58. Flight altitude of Northern Gannets (m above sea level: N = 9724) based estimates during land-based seawatches and ship-based line transects. Shown are proportion of birds in four altitude categories.

Spatial patterns in abundance in nearshore waters - In nearshore areas, gannets were common in Block Island Sound and Rhode Island Sound, with the greatest detection rates at Pt. Judith (Fig. 59). See Appendices B and C for data on Northern Gannet abundance at each of the land-based seawatch stations for each month surveyed.

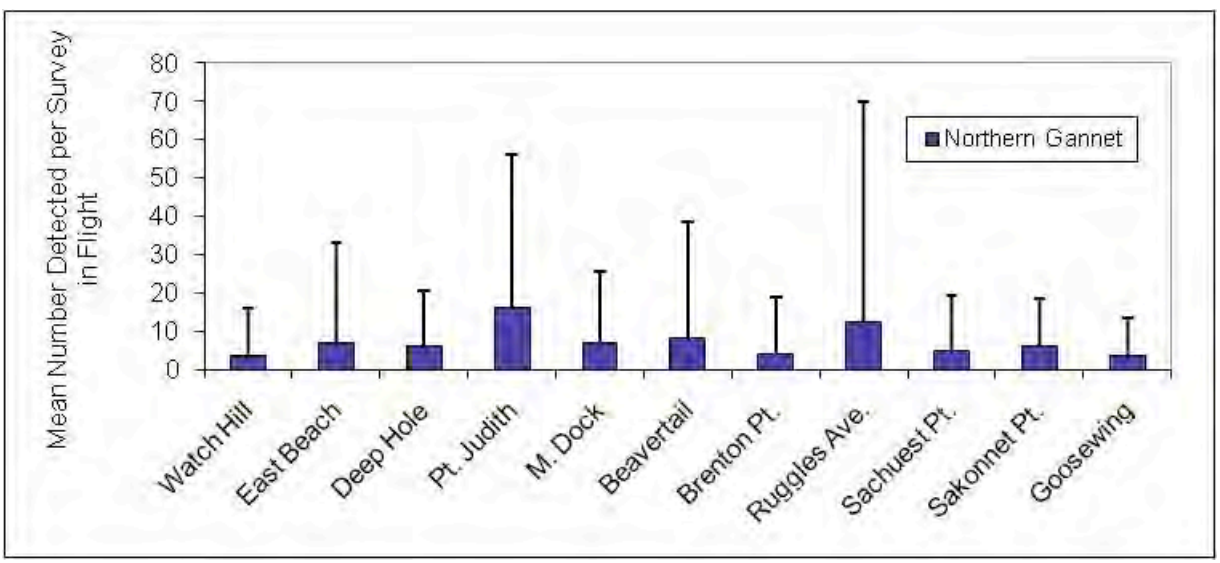


Fig. 59. Mean (SD) number of Northern Gannets detected per survey at 11 land-based seawatch stations (see Fig. 21 for locations of stations).

Spatial patterns in abundance in nearshore and offshore waters – We present the GAM plot that was derived from the observed abundance of Northern Gannets in flight from ship-based surveys during fall and winter in Appendix J. The best-fit Density Surface Models (DSM) for fall and winter explained 34.8% and 36.6% of the spatial variation, respectively (see Appendix H for full model results). Northern Gannet densities during fall were highest about 4 km off the south shore of mainland Rhode Island and around Block Island, as well as from the edge of Block Canyon extending SW to the Inner Continental Shelf (Fig. 60). Spatial patterns of gannet densities during the winter were generally similar to that during fall, although gannets were on average higher in density during winter (up to 51 birds per km^2 in winter and 33 birds per km^2 in fall; Fig. 60). The greatest uncertainty in gannet density estimates occurred along coast and in deeper sections of Rhode Island Sound in the fall and in a band of center of Rhode Island Sound in the winter (Fig. 61).

Population size in the Ocean SAMP area – Based on the Northern Gannett DSM (Appendix H), we estimated that during the fall there were 3,987 (95% CI = 3,336 to 4,764) Northern Gannets and during winter there were 4,373 (3,688 to 5,187) Northern Gannets within the Ocean SAMP area (Appendix I). In North America, gannets breed in only six colonies, three in the Gulf of St. Lawrence and three off of Newfoundland, with birds wintering as far south as Florida and into the Gulf of Mexico. Thus, these population estimates are likely conservative because it assumes minimal turnover of individuals and we know gannets migrate through Rhode Island waters during both spring and fall.

Spatial patterns in abundance in relation to bathymetry – The distribution and abundance of gannets detected during aerial surveys were generally consistent with the estimated densities from the Northern Gannet DSM (Fig. 62). During aerial surveys it was obvious that Northern Gannet distribution was often associated with commercial fishing boats, and we often observed Gannets plunge-diving for fish bycatch by trawlers (K. Winiarski, pers. obs.). The depth profile of gannets was similar to the depth profile of the study area, with peak abundance in ocean waters that were 30-45 m deep (Fig. 63).

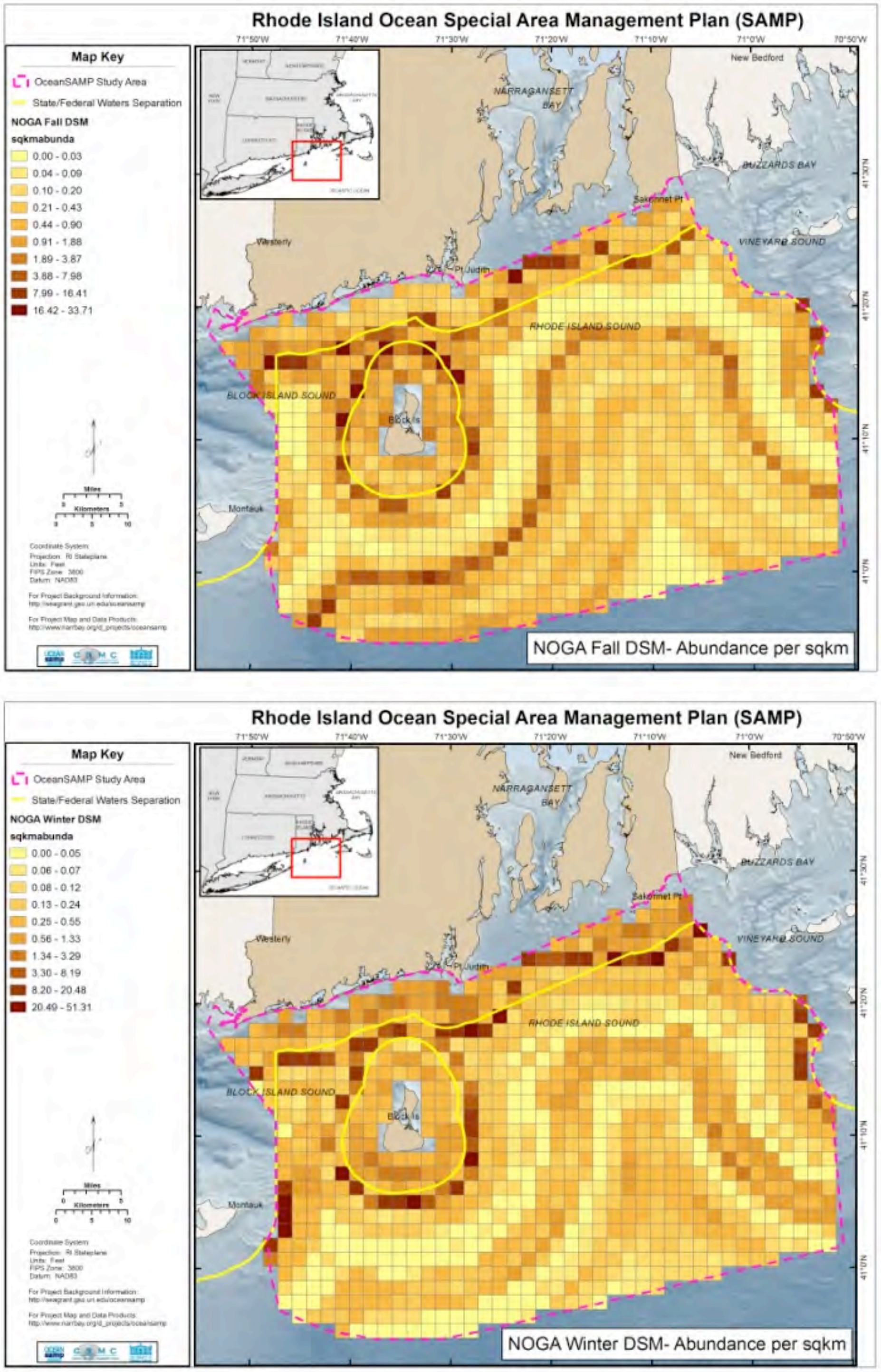
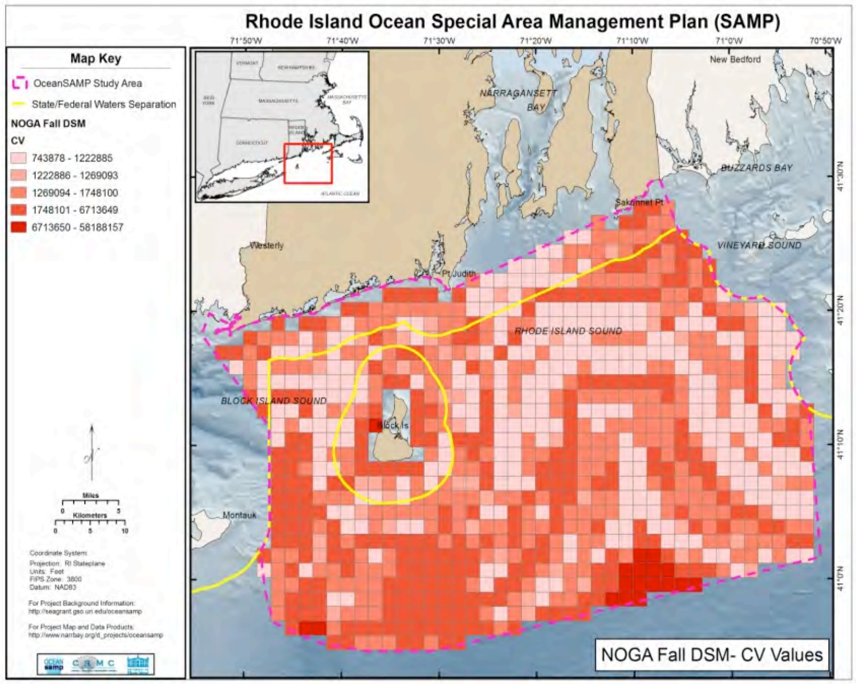


Fig. 60. DSM estimates of the spatial distribution and density of Northern Gannets in fall (upper) and winter (lower) in the Ocean SAMP study area based on ship line-transect surveys.



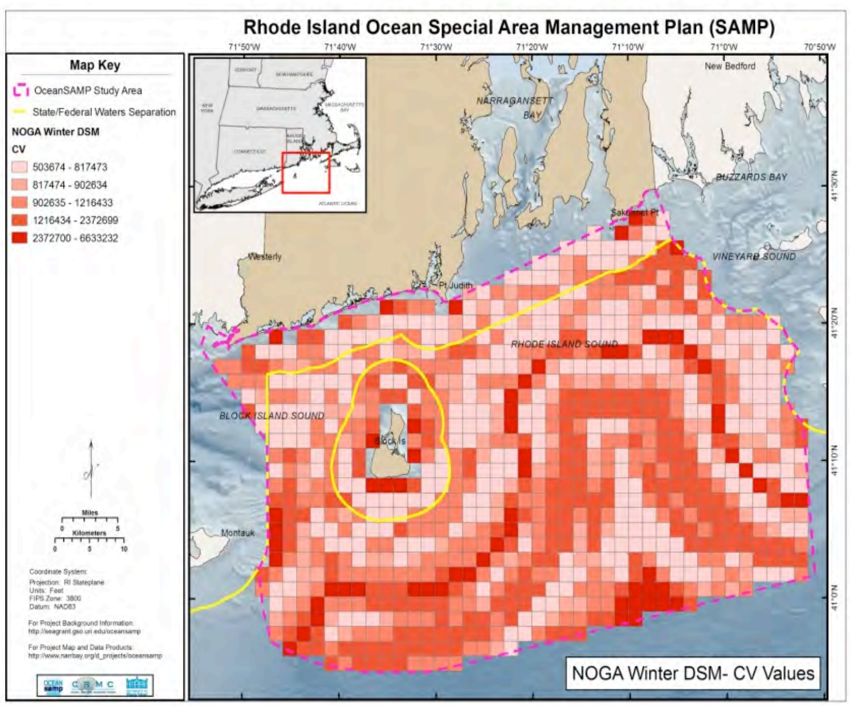


Fig. 61. Coefficient of Variation for DSM modeled gannet density estimates based on ship line transect surveys in fall (upper) and winter (lower) shown in Fig. 60.

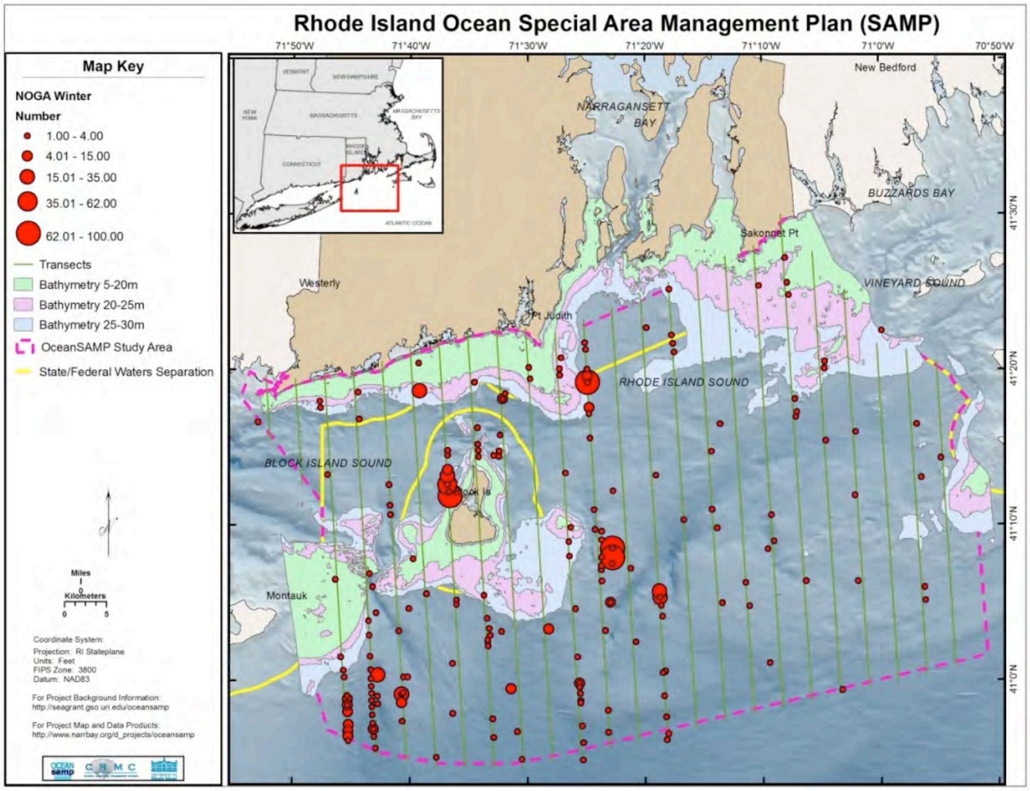


Fig. 62. Distribution of Northern Gannet flocks during aerial surveys in winter 2009-10. Large flocks were often trailing commercial fishing vessels.

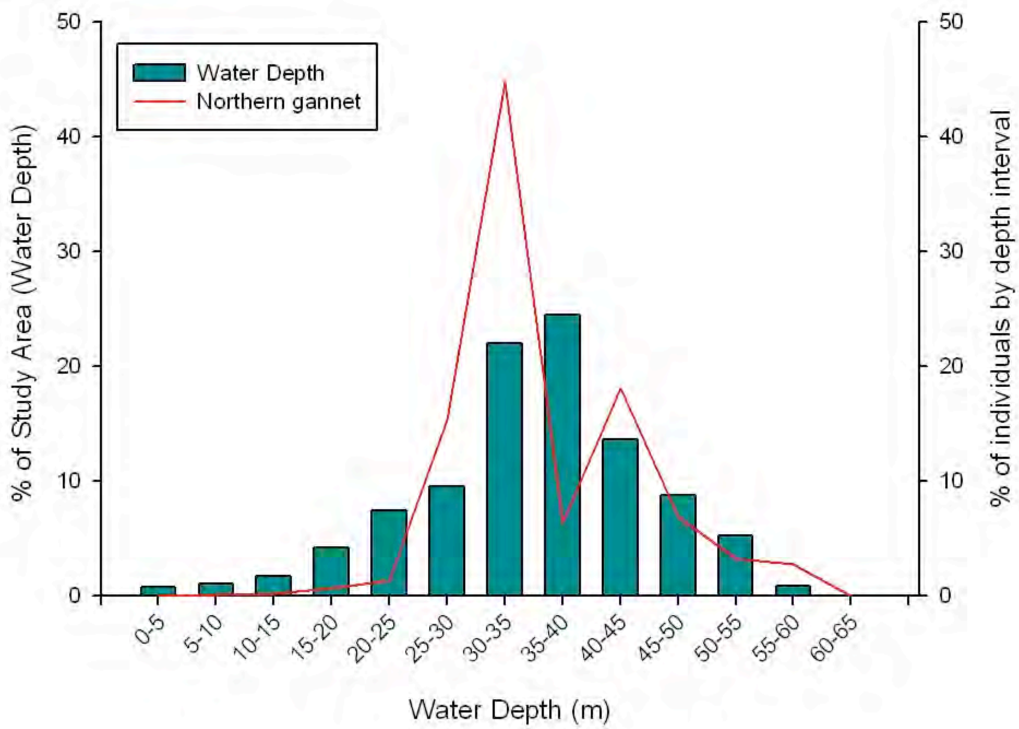


Fig. 63. Bathymetry of Ocean SAMP study area (green histogram) compared to depths where gannets were detected during aerial surveys (red line) (Fig. 62)

3.8 Cormorants

We detected two species of cormorants (Phalacrocoracidae) in the Ocean SAMP study area: Double-crested Cormorant and Great Cormorant. Double-crested Cormorants were the most abundant species of cormorant in the Ocean SAMP area, and this species had 10 times more detections than Great Cormorants during land-based seawatches; >25,000 detections vs. >2,200 detections, respectively (Table 13).

Seasonal changes in abundance - Cormorants are breeders, winter residents and migrants in the Ocean SAMP area. Around 2,000 pairs of Double-crested Cormorants nest on islands in Narragansett Bay (C. Raithel, unpublished data 2009; Ferren and Myers 1998). Hence, they occur in large numbers in the Ocean SAMP area from April through October (Fig. 64). Double-crested Cormorants migrate through Rhode Island waters during their fall migration mostly in September and October, and then peak again in May and June during spring migration (Fig. 64). Great Cormorants breed in a few colonies from Maine to Greenland, and only spend the winter months (Nov through March) in the Ocean SAMP study area (Fig. 64). Great Cormorants migrate winter in Rhode Island from November through March, with a possible peak influx of birds into the region in December (Fig. 64).

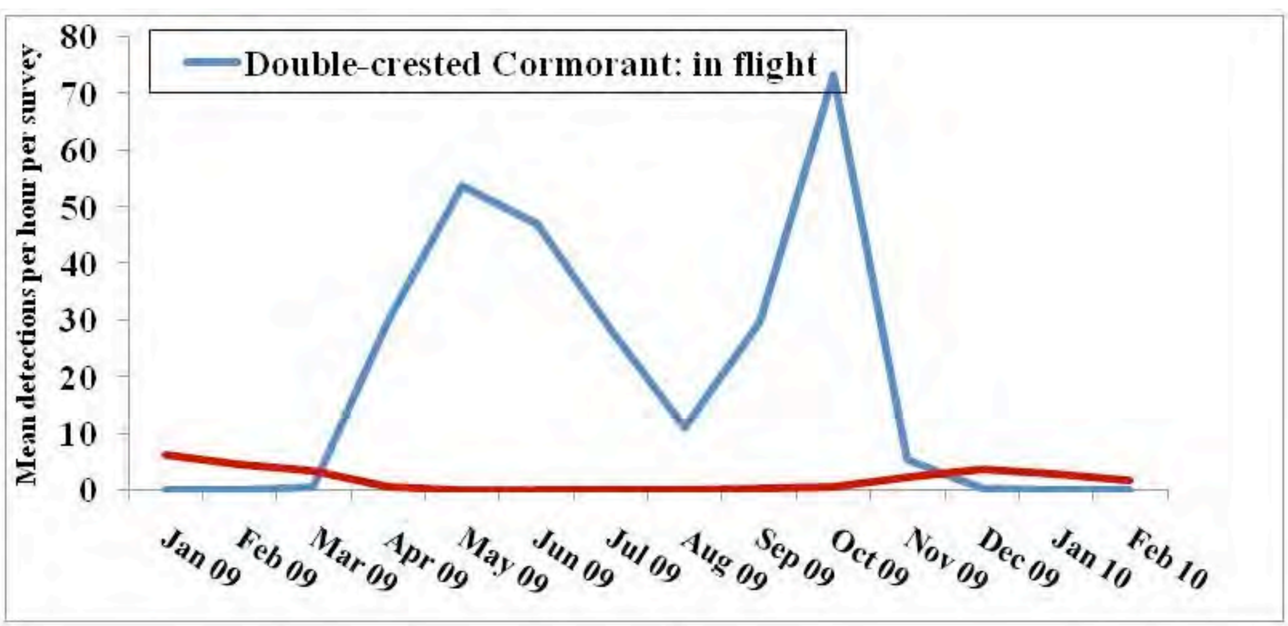


Fig. 64. Mean number of Double-crested and Great Cormorants detected in flight per survey per month at 11 land-based seawatch stations along the Rhode Island coastline

Flight altitude of birds - Flight altitudes of cormorants were variable. In the majority of our observations, cormorants were flying at <10 m altitude (81% of observations; Fig. 65). Of the birds flying higher than 10 m, approximately equal percentages were flying between 10-25 m (10%), and 25-125 m (8%) elevation, while about 1% were flying over 125 m in altitude. Birds flying this high were generally migratory flocks of Double-crested Cormorants flying near the mainland coast.

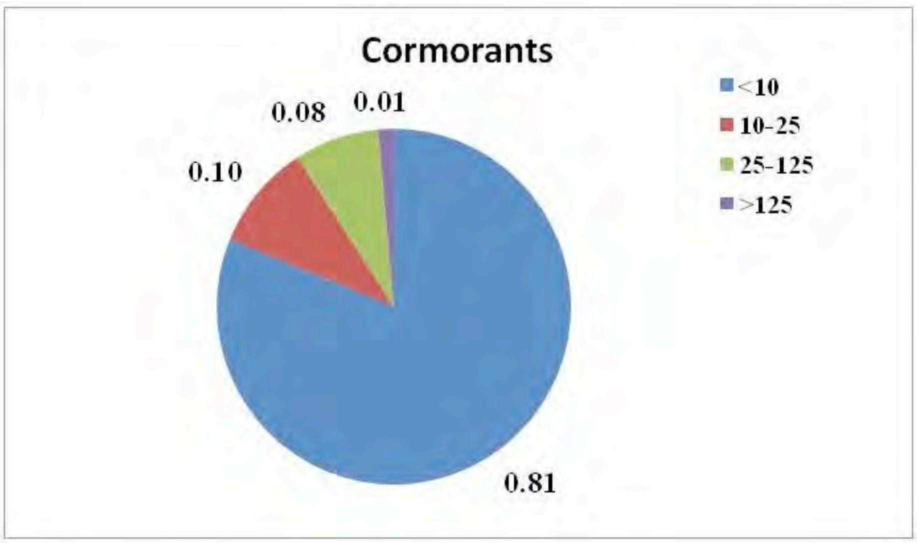


Fig. 65. Flight altitude of cormorants (m above sea level; N = 24,362 detections) based estimates during land-based seawatches and ship-based line transects. Proportion of birds in four altitude categories are shown.

Spatial patterns in abundance in nearshore waters - In nearshore areas, Double-crested Cormorants tend to be more abundant off of Deep Hole, Brenton Pt, Sachuest NWR, and Sakonnet Pt, in part due to the location of nearby breeding sites (Fig. 66). Great Cormorants are uniformly distributed across the study area (Fig. 66). See Appendices B and C for data on cormorant abundance at each of the land-based seawatch stations for each month surveyed.

Spatial patterns in abundance in nearshore and offshore waters – We had too few detections of Double-crested and Great Cormorants during ship-based line transects to model their density or spatial distribution (Table 17). However, a comparison of cormorant detections during land-based versus ship-based surveys clearly shows that they are almost exclusively found in nearshore habitats. For example, Double-crested Cormorants were only detected five times and Great Cormorants were only detected once during offshore ship-based surveys (Table 17), while we had over 25,000 detections of Double-created Cormorants and over 2,000 detections of Great Cormorants during land-based seawatches (Table 13).

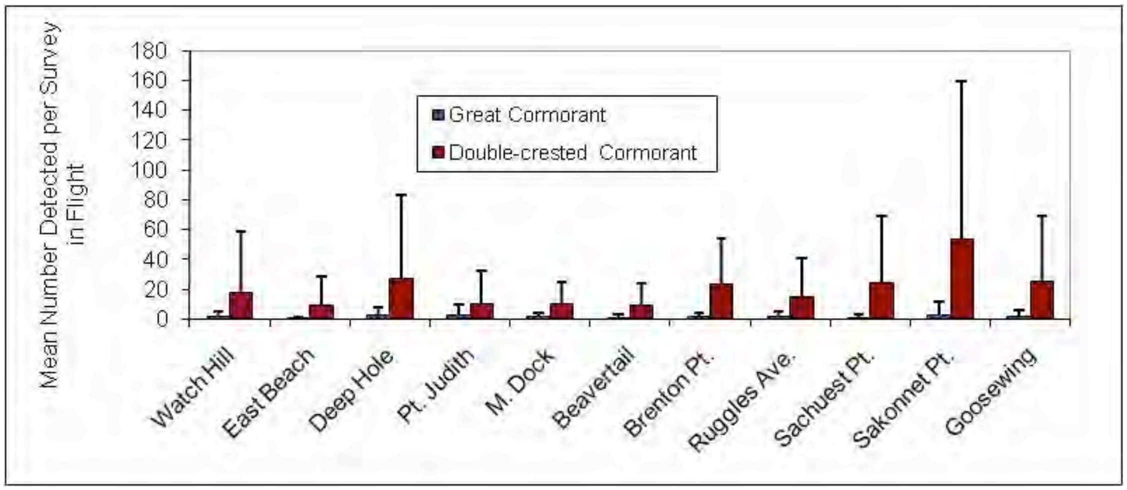


Fig. 66. Mean (SD) number of Double-crested and Great Cormorants detected per survey at 11 land-based seawatch stations (see Fig. 21 for locations of stations).

Population size in the Ocean SAMP area - We had too few detections of Double-crested and Great Cormorants during ship-based line transects to estimate their population size in the study area.

Spatial patterns in abundance in relation to bathymetry – We did not have any detections of cormorants sitting on the water during winter aerial surveys (Table 21), thus we did not explore cormorant abundance in relation to water depth in the SAMP study area. 3.9 Wading Birds

We detected seven species of wading birds (Herons and egrets; Ardeidae, Ibises; Threskiornithidae) in the Ocean SAMP area: Great Blue Heron, Great Egret, Snowy Egret, Cattle Egret, Green Heron, Black-crowned Night-Heron, and Glossy Ibis.

Seasonal changes in abundance - Wading birds breed in Rhode Island on islands throughout Narragansett Bay and small numbers of three species (Great Egret, Snowy Egret, and Black-crowned Night-Heron) nest on Block Island (C. Raithel, unpublished data 2009; Ferren and Myers 1998). Hence, they are most common in the Ocean SAMP are from May through September (Appendices B and C). All wading birds that nest in Rhode Island are migrants, with the exception of Great Blue Heron. Thus there is probably some migration by wading birds along the coast during migratory events, but the primary migratory routes are probably restricted to nearshore areas or over the land.

Flight altitude of birds - Flight altitudes of wading birds were variable. In the majority of our observations, 30% of wading birds were flying at <10 m altitude, 37% were at 10-25 m altitude, 32% at 25-125 m, and <1% >125 m (N = 134 detections;Table 15).

Spatial patterns in abundance in nearshore waters - In nearshore areas, wading birds tended to be sparse everywhere during land-based seawatches, since most species of wading birds appear to avoid flying out over the ocean. See Appendices B and C for data on wading bird abundance at each of the land-based seawatch stations for each month surveyed.

Spatial patterns in abundance in nearshore and offshore waters – We had too few detections of wading birds during ship-based line transects to model their density or spatial distribution.

Population size in the Ocean SAMP area - We had too few detections of wading birds during ship-based line transects to estimate their population size in the study area.

3.9 Waterfowl

We detected 18 species of waterfowl (Anatidae) in the Ocean SAMP study area: two species of swans (Mute and Tundra Swan), two species of geese (Canada and Brant Geese), seven species of dabbling ducks (Mallard, Black Duck,Wood Duck, Gadwall, Northern Pintail, American Widgeon and Green-winged Teal), one species of bay duck (Greater Scaup) and six species of seaducks (Common Eider, King Eider, Black Scoter, Surf Scoter, White-winged Scoter and Long-tailed Duck). Swans are common year round residents in Rhode Island, but found in relatively small numbers in the Ocean SAMP area. Geese and dabbling ducks are seasonally abundant and common migrants, but found in relatively small numbers in the Ocean SAMP area. Seaducks are common migrants and winter residents and abundant in the Ocean SAMP area.

Swans: We detected two species, Mute Swan (111 detections during land-based seawatches; Table 13) and Tundra Swan (2 detections during land-based seawatches; Table 13). No swans were detected offshore during ship-based line transects (Table 17) or during aerial surveys (Table 21). Both species primarily use coastal ponds in Rhode Island [e.g., Trustom (Table 8) and Ninigret Pond (Table 9)], although they are occasionally detected flying over nearshore areas along the mainland coast of Rhode Island. Due to low detection rates, we could not model the movement ecology or spatial distribution of swans.

Geese: We detected two species during fieldwork: Brant and Canada Goose. We often detected Brant during land-based seawatches (mean = 1.8 detections per survey), as well as Canada Geese (mean = 3.2 detections per survey; Table 13). We detected Brant offshore on Grid F (NW of Harbor of Refuge; Table 18) during ship-based line transects and during aerial surveys (Table 21). Both species are restricted to nearshore habitats or inland areas. Brant are common in Narragansett Bay (Tables 4 and 5) and along the coast at Napatree Point (Table 7). Due to low detection rates, we could not model the movement ecology or spatial distribution of geese.

Dabbling ducks (Genus *Anas*): We detected seven species of dabbling ducks during land-based seawatches of birds flying over the ocean or birds resting/foraging on the surface. Species we recorded included Wood Duck (10 detections), Mallard (74 detections), American Black Duck (700 detections), Gadwall (22 detections), Northern Pintail (7 detections), American Wigeon (14 detections) and Green-winged Teal (38 detections). American Black Ducks were the only species that was relatively common along the coastline (mean = 0.9 detections per survey; Table 13) because they regularly foraging in the intertidal zone on algae that is exposed at low tide (pers. obs.) Gadwalls and Mallards also will occasionally forage in the intertidal zone, however dabbling ducks are more common found in coastal ponds (Tables 8 and 9) or freshwater lakes inland. We rarely detected dabbling ducks during ship-based surveys (Table 17). Due to low detection rates, we could not model the movement ecology or spatial distribution of dabbling ducks.

Diving Ducks: We detected one species of bay duck during land-based seawatches, Greater Scaup, with an average of 1.3 detections per survey (Table 13). We also detected large numbers of Red-breasted Mergansers, Common Goldeneye, and Buffhead.

Seasonal changes in abundance- Diving ducks were most abundant during the winter months (Nov through May; Fig. 67).

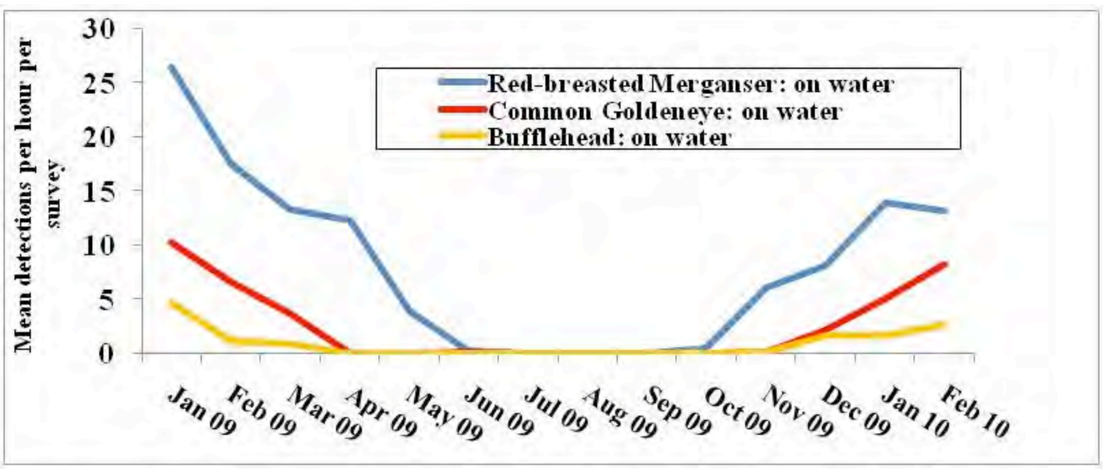


Fig. 67. Mean number of diving ducks detected per survey per month during land-based seawatches.

Flight altitude of birds.- Diving ducks were usually detected flying <10 m altitude (Table 15).

Spatial patterns in abundance in nearshore waters. – Diving ducks, in particular Red-breasted Mergansers, were most abundant at Deep Hole, Pt. Judith, and Brenton Pt, while Common Goldeneye were most abundant at Brenton Pt. (Fig. 68, see also Appendices B and C).

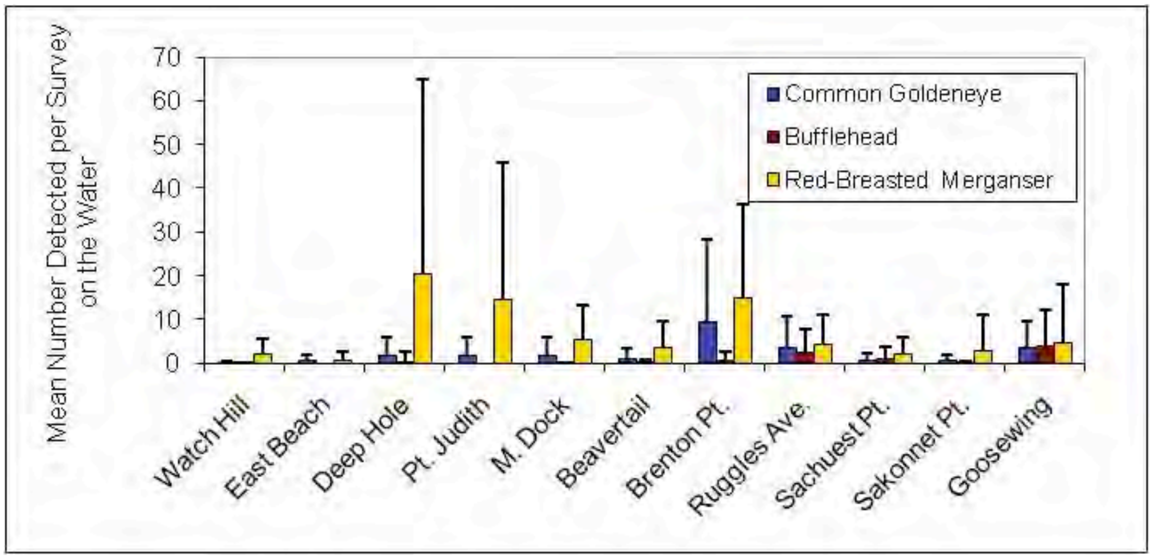


Fig. 68. Mean (SD) number of diving ducks detected per survey at 11 land-based seawatch stations (see Fig. 21 for locations of stations).

Spatial patterns in abundance in nearshore and offshore waters. – Diving ducks were rarely detected during ship-based line transects, or aerial surveys so we could not model their movement ecology or spatial distribution patterns. During ship-based line transects, scaup were detected in flight, once each on Grid C and Grid F (Table 18). Bay ducks are more abundant in Narragansett Bay (Tables 4 and 5) and in coastal ponds (Tables 8 and 9) than in the Ocean SAMP study area.

Population size in the Ocean SAMP area. – We had too few detections during ship-based line transect to estimate the population size of diving ducks in the Ocean SAMP study area.

Seaducks: Seaducks include eiders, scoters, and related species and are the most abundant species we detected in nearshore habitats in winter. We detected two species of eider, Common Eider, a very common species in nearshore areas with an average of 101 detections per survey (> 80,000 detections overall) during land-based seawatches and King Eider (26 total detections; Table 13). Long-tailed Ducks are uncommon in the Ocean SAMP study area, with 470 detections during land-based seawatches (0.6 detections per survey; Table 13). We detected all three species of scoters, Surf, Black, and White-winged Scoter, which were among the most abundant species in nearshore habitats in the Ocean SAMP study area.

Seasonal changes in abundance. – Seaducks primarily winter in Rhode Island, although large numbers also migrate through the region to winter farther south (Sibley 2000). During fall migration, birds start to move into the Ocean SAMP area from October through November. During spring migration, there appears to be a influx of birds starting February and peaking in March (Fig. 69). We noticed considerable interannual variation in numbers of birds in the study area between 2009 and 2010.

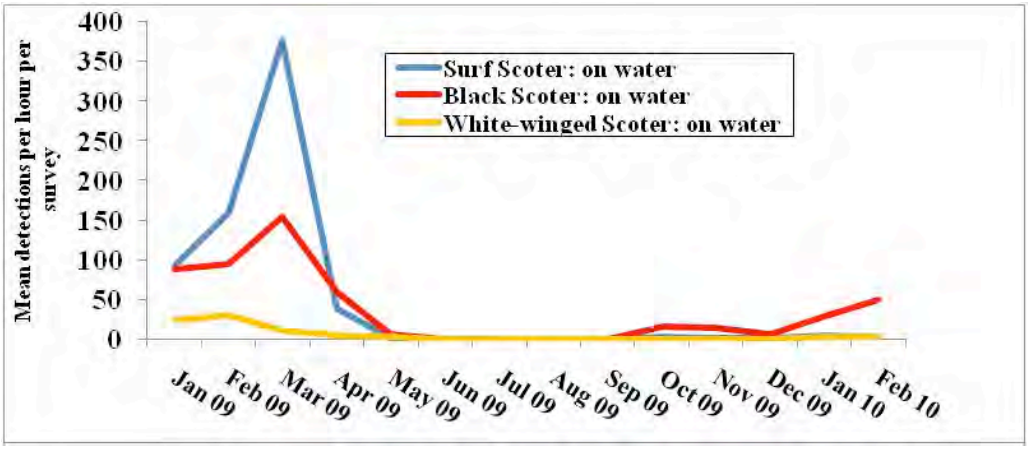


Fig. 69. Mean number of scoter detections per survey per month at 11 land-based seawatch stations.

Flight altitude of birds. –Most (91%) seaducks flew <10 m high, although 8% flew beween 10-25 m (Fig. 70)

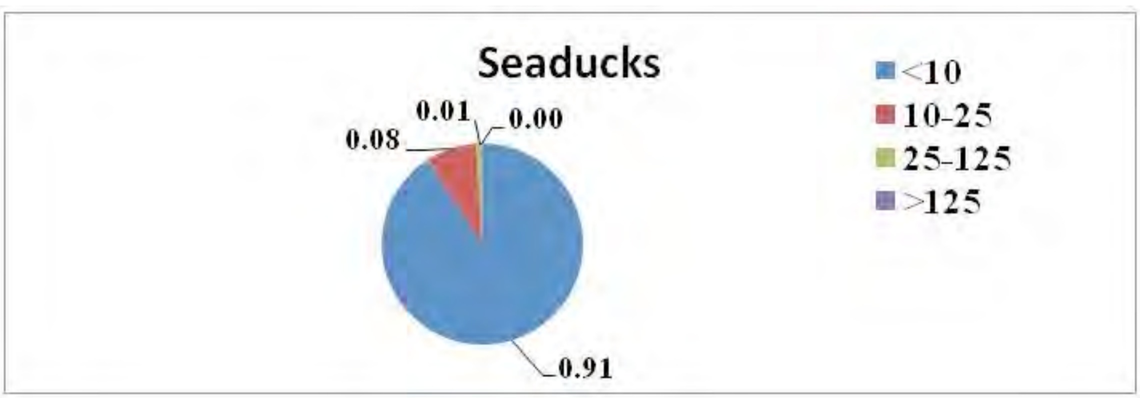


Fig. 70. Flight altitude of seaducks (m above sea level; N = 79,209 detections; eiders, scoters, and mergansers) based estimates during land-based seawatches and ship-based line transects. Shown are proportion of birds in four altitude categories.

Spatial patterns in abundance in nearshore waters. – The largest concentrations of scoters and eider were observed at Brenton Point, although we had relatively high numbers of scoter at Watch Hill, East Beach, Ruggles Ave, and Sakonnet Point (Figs. 71 and 72).

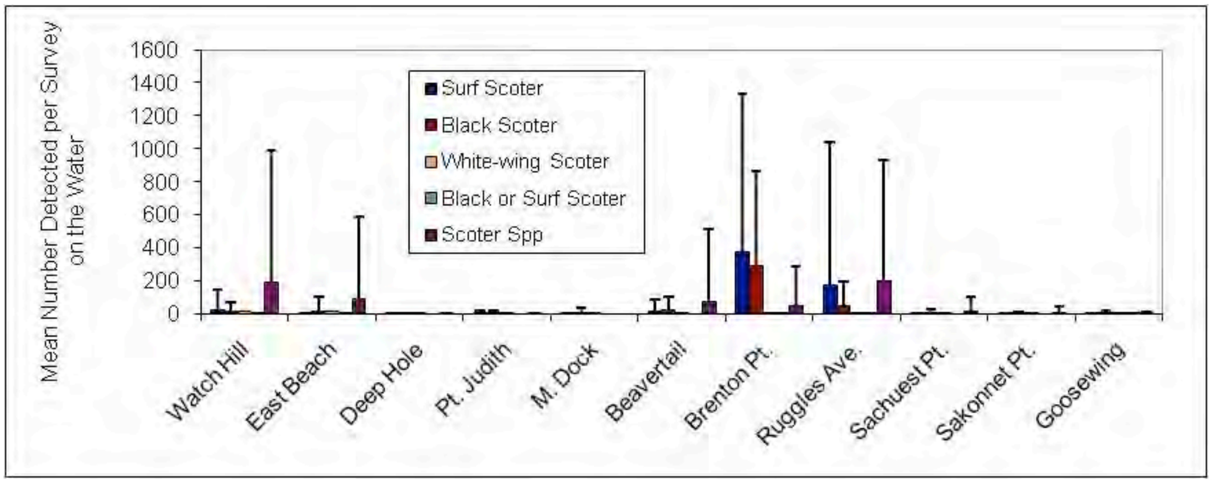


Fig. 71. Mean (SD) number of scoters detected per survey at 11 land-based seawatch stations (see Fig. 21 for locations of stations).

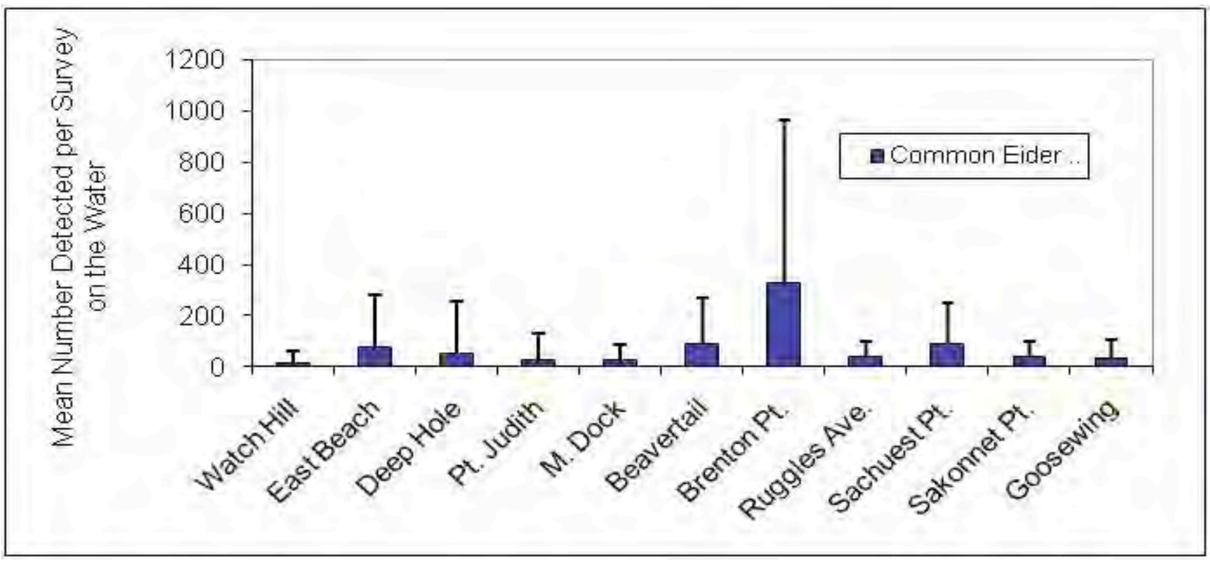


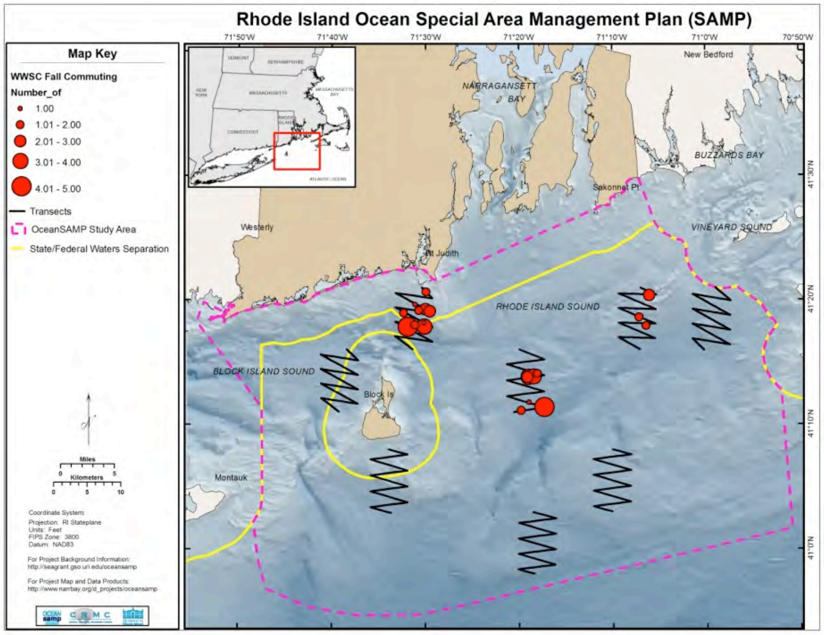
Fig. 72. Mean (SD) number of Common Eider detected per survey at 11 land-based seawatch stations (see Fig. 21 for locations of stations).

Spatial patterns in abundance in nearshore and offshore waters.- We had too few detections of seaducks during ship-based line transects in all seasons to model their density or spatial distribution. We believe limited detections of seaducks which are abundant in the Ocean SAMP area are a result of both (a) limited ship-based survey effort in waters shallow enough for seaduck foraging (waters <25 m), and (b) seaducks are more sensitive to the presence of the survey ship compared to other avian species. Seaducks routinely flush 700 m to 1000 m ahead of the ship making on-the-water detections difficult (K. Winiarski, pers. obs.). We plan on developing Density Surfact Models of their distribution and density based on aerial survey data (collected both in the winter of 2009-10 and winter of 2010-11) for a future Ocean SAMP report.

Athough we did not detected Surf or Black Scoters away from nearshore areas, we occasionally observed White-winged Scoters commuting throughout offshore sections of Rhode Island and Block Island Sounds and even as far out as the Inner Continental Shelf (Fig. 73). This suggests that land-based seawatches may underestimate the number of White-winged Scoters in the Ocean SAMP area.

Population size in the Ocean SAMP area - We had too few detections of seaducks during ship-based line transects in all seasons to estimate their population size in the study area.

Spatial patterns in abundance in relation to bathymetry – We often detected seaducks (eider and scoter) during our winter aerial surveys, however the number of seaducks in the area was relatively low during the winter of 2009-2010 compared to the previous year (Fig. 69). During aerial surveys, seaducks tended to be found in nearshore areas in the NW and NE corners of the Ocean SAMP study area, as well as S of Block Island and between Block Island and Montauk, Long Island (Fig. 74). Based on the bathymetry at locations where seaducks were detected during aerial surveys, scoter and eider seem to select shallow waters < 25 m deep (Fig. 75). There was some indication that scoter selected areas in the transition zone at about 20 m depth, but more detailed research is needed to determine the exact bathymetry requirements of scoters or eiders in the Ocean SAMP area.



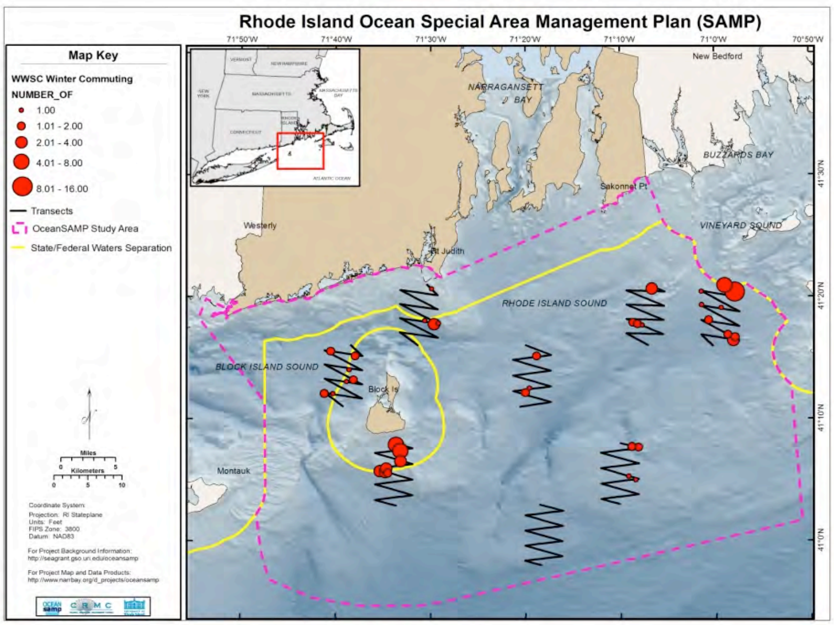
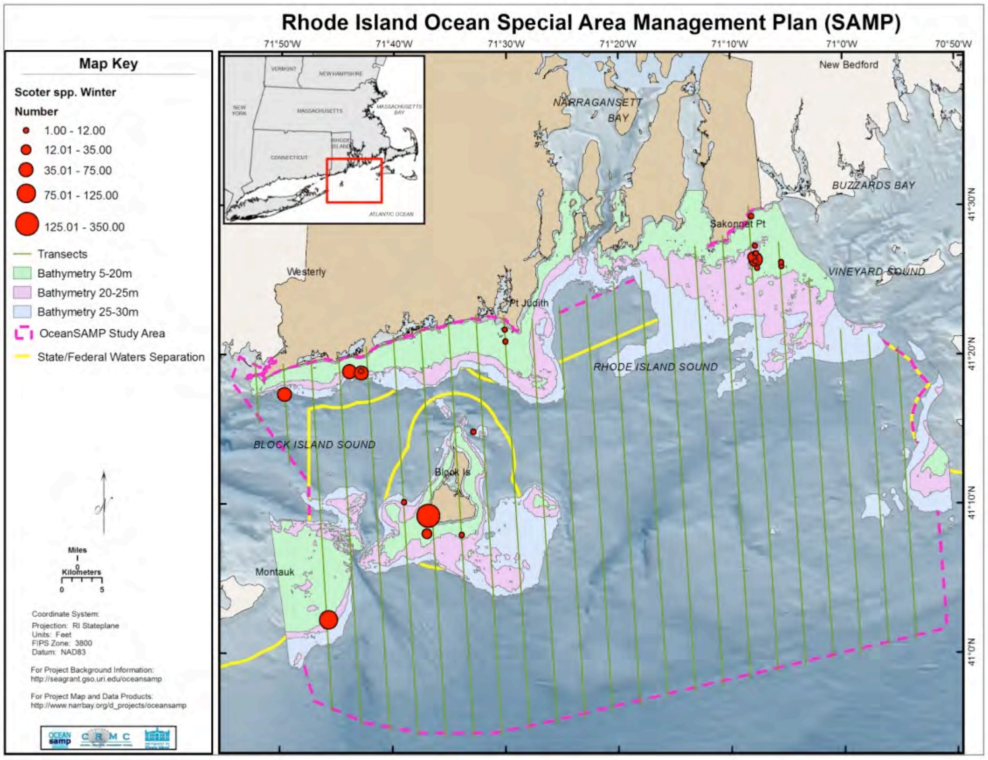


Fig. 73. Distribution of White-winged Scoter flocks in flight in fall (upper) and winter (lower) in the Ocean SAMP study area based on ship line-transect surveys.



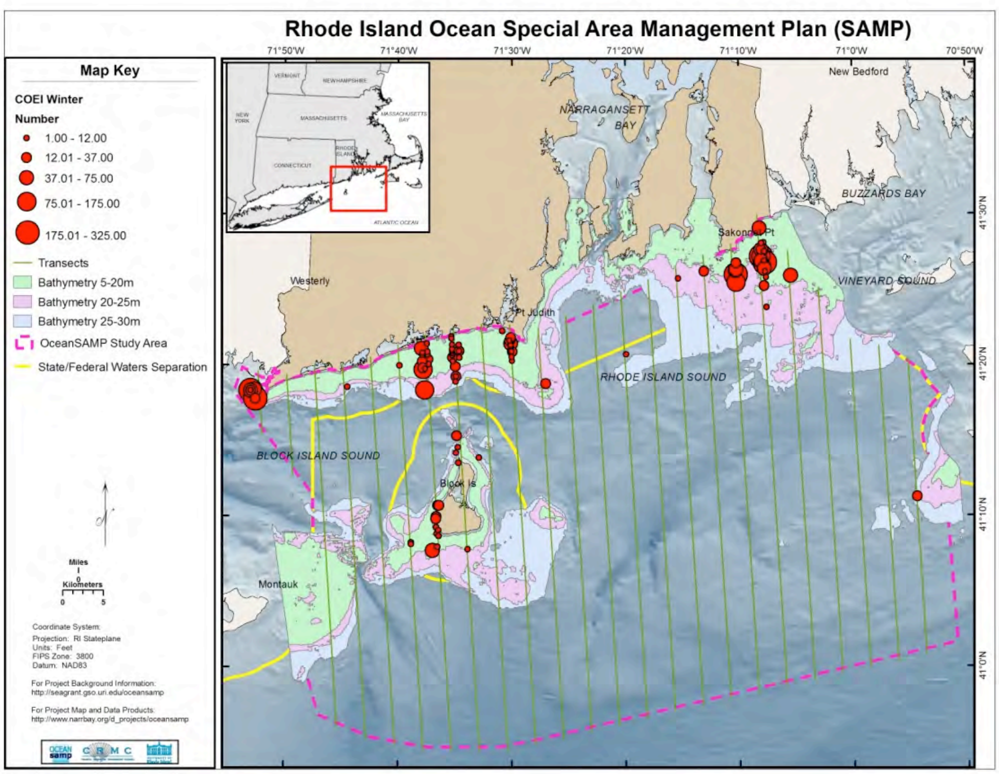
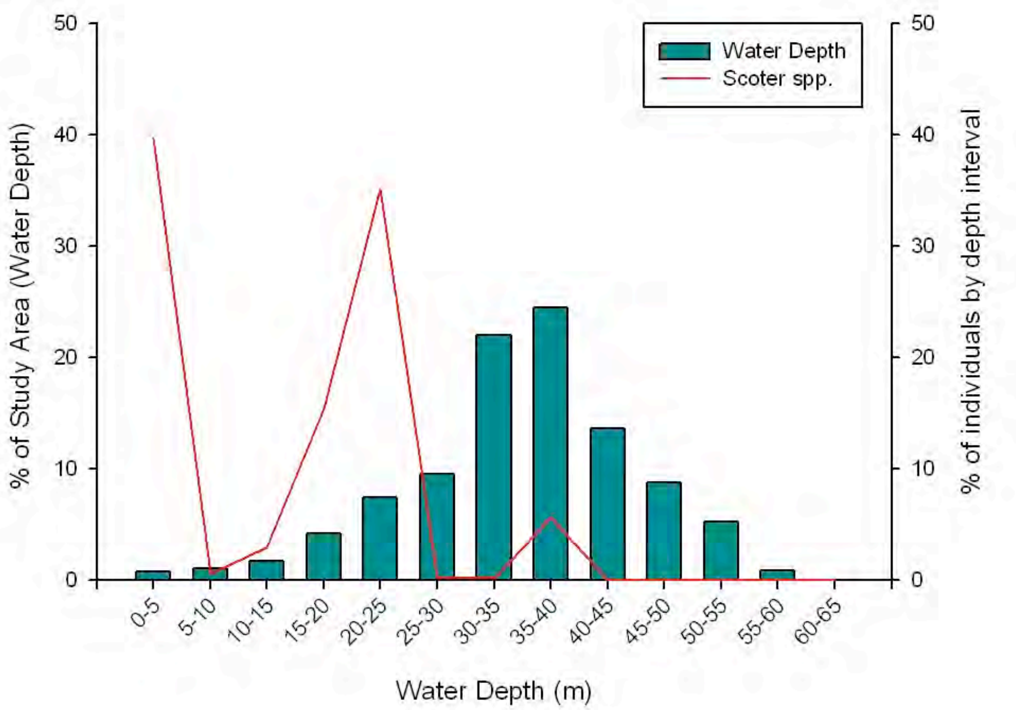


Fig. 74. Distribution of seaducks, scoter (upper) and Common Eider (lower) flocks during aerial surveys in winter 2009-10 in the Ocean SAMP study area.



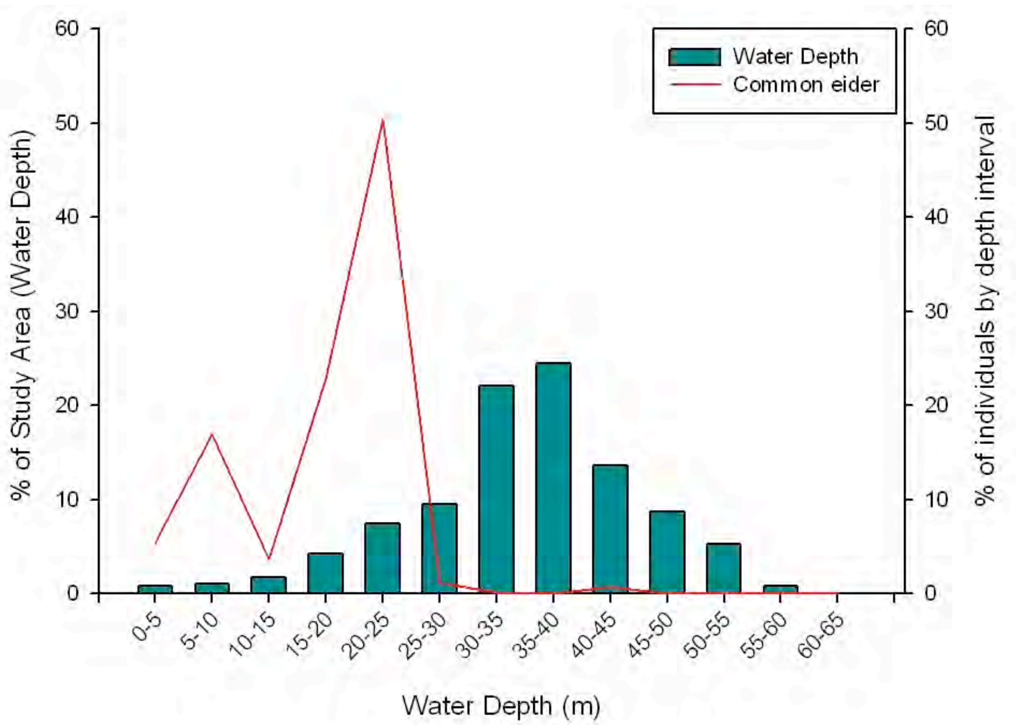


Fig. 75. Bathymetry of Ocean SAMP study area (green histogram) compared to depths where scoters (upper) and eiders (lower) were detected during aerial surveys (red line) (Fig. 74)

3.10 Shorebirds

We detected 19 species of shorebirds (Scolopacidae) in the Ocean SAMP area: four species of plovers (Black-bellied Plover, Piping Plover, Semipalmated Plover and Killdeer), one oystercatcher (American Oystercatcher), 13 species of sandpipers (Greater and Lesser Yellowlegs, Spotted Sandpiper, Whimbrel, Ruddy Turnstone, Purple Sandpiper, Sanderling, Dunlin, White-rumped Sandpiper, Semipalmated Sandpiper, Least Sandpiper, and Short-billed Dowitcher) and one species of phalarope (Red-necked phalarope). Shorebirds are common to the study area but found in relatively low numbers in the Ocean SAMP area, although Semipalmated Plovers, Ruddy Turnstone, Purple Sandpipers, Sanderlings, Dunlin, Semipalmated Sandpipesr and Short-billed Dowitcher were detected fairly often during land-based seawatches (Table 13).

Seasonal changes in abundance - Shorebirds are breeders, winter residents and migrants in the Ocean SAMP area. Most shorebirds migrate through Rhode Island waters during their fall migration mostly in August through September, and then peak again in May and June during spring migration. Around 80 pairs of Piping Plovers nest on the beaches of southern Rhode Island and Block Island (W. Edwards, USFWS, pers. comm.). Some shorebirds winter in Rhode Island (Purple Sandpiper, Sanderling, and Dunlin) which is why they had relatively high detection rates.

Spatial patterns in abundance in nearshore waters - In nearshore areas, shorebirds tend to be occasionally detected throughout the study area during land-based seawatches. See Appendices B and C for data on shorebird abundance at each of the land-based seawatch stations for each month surveyed.

Flight altitude of birds - Flight altitudes of shorbirds were variable. In the majority of our observations, 87% of shorebirds were flying at <10 m altitude, with 9% flying 10-25 m, and 4% flying 25-125 m (N = 6512 detections; Table 15).

Spatial patterns in abundance in nearshore and offshore waters – We had too few detections of shorebirds during ship-based line transects in all seasons to model their density or spatial distribution. We had few detections of shorebirds away from nearshore areas. During ship-based line transects we detected 6 species (Short-billed Dowitcher, Semipalmated Plover, Purple Sandpiper, Lesser Yellowlegs, Whimbrel, and Red-necked Phalarope on a variety of grids; Table 18). Red-necked Phalarope, a pelagic specialist, was only detected on Grid H over the Inner continental Shelf.

Population size in the Ocean SAMP area - We had too few detections of shorebirds during ship-based line transects to estimate their population size in the study area.

Spatial patterns in abundance in relation to bathymetry – With the exception of phalaropes, shorebirds generally only use water <10 cm deep. We only had a small number of detections of shorebirds during winter aerial surveys, thus we did not explore shorebird abundance in relation to water depth in the Ocean SAMP study area. All detections were of birds in flight likely migrating through the Ocean SAMP area.

3.11 Jaegers

We detected three species of jaegers (Stercorariidae) in the Ocean SAMP study area: Long-tailed, Parasitic and Pomarine Jaeger. All three species are relatively uncommon in the SAMP area; Parasitic Jaeger was the most regularly detected jaeger species during land-based seawatches.

Seasonal changes in abundance - Jaegers breed in the Arctic tundra and migrate through the Ocean SAMP area during spring and fall migration from May through October (Fig. 76; Appendix B and C).

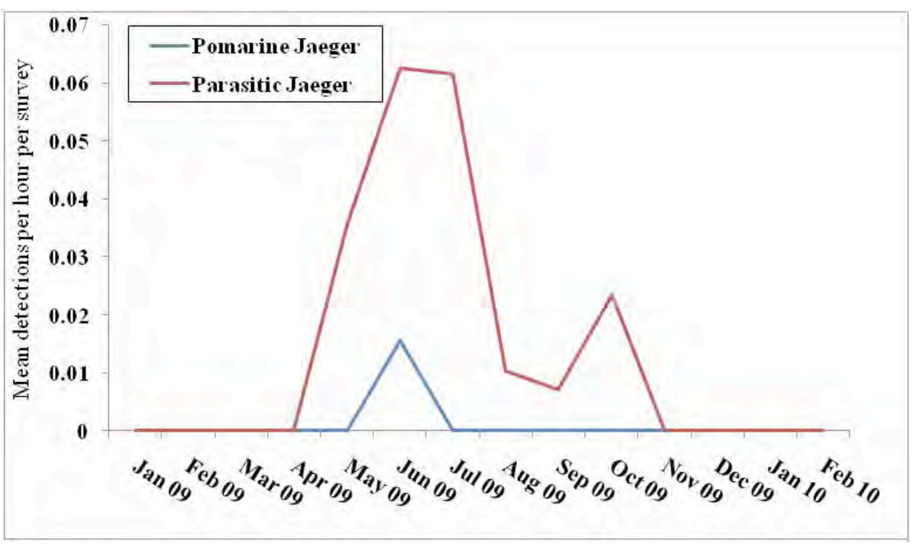


Fig. 76. Monthly differences in average number of Pomarine and Parasitic Jaegers detected in flight per survey at 11 land-based seawatch stations along the Rhode Island coastline

Flight altitude of birds - Flight altitudes of jaegers were similar to gulls. In the majority of our observations, 70% of jaegers were flying at <10 m altitude, 13% at 10-25 m, and 17% at 25-125 m (N = 24 detections; Table 15).

Spatial patterns in abundance in nearshore waters - In nearshore areas, jaegers tend to be more abundant off of Deep Hole, Pt. Judith, and Goosewing; Fig. 77). Parasitic Jaeger was the most common jaeger detected during land-based seawatches with 19 detections, while Pomarine Jaeger was detected only twice (Table 13). This is probably because Parasitic Jaegers specialize in kleptoparasitism of terns, which tend to be concentrated in nearshore areas during the post-breeding season. See Appendices B and C for data on jaeger abundance at each of the land-based seawatch stations for each month surveyed.

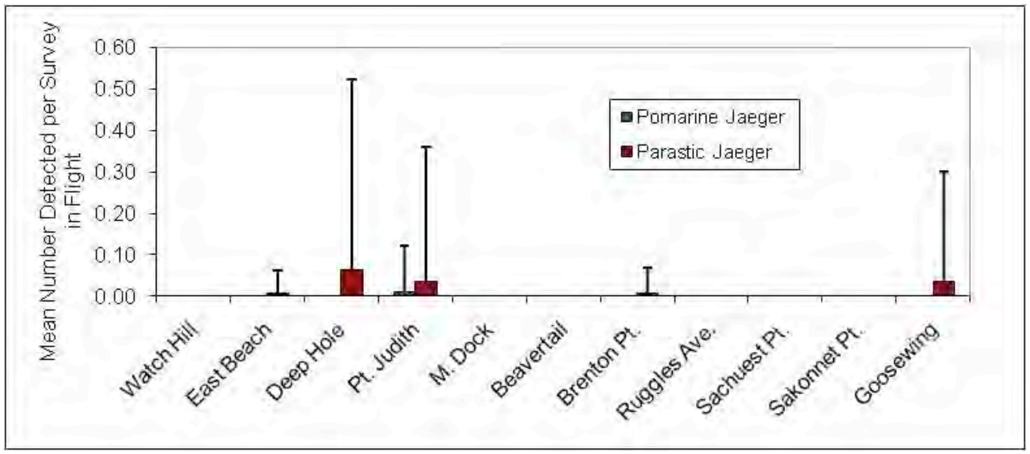


Fig. 77. Mean (SD) number of Pomarine and Parasitic Jaegers detected per survey at 11 land-based seawatch stations (see Fig. 21 for locations of stations).

Spatial patterns in abundance in nearshore and offshore waters – We had too few detections of jaegers during ship-based line transects in all seasons to model their density or spatial distribution. Jaegers were rarely detected during ship-based line transect surveys, with only one detection of Long-tailed Jaeger on Grid H (at the edge between Rhode Island Sound and Block Island Sound), one detection of Parasitic Jaeger on Grid F (SW of Harbor of Refuge in a nearshore area) and one detection of Pomarine Jaeger on Grid A (S of Block Island; Table 18).

Population size in the Ocean SAMP area - We had too few detections of jaegers during ship-based line transects in all seasons to estimate their population size in the study area.

Spatial patterns in abundance in relation to bathymetry – We had no detections of jaegers during winter aerial surveys, thus we did not explore jaeger abundance in relation to water depth in the Ocean SAMP study area.

3.12 Gulls

We detected six species of gulls (Laridae) in the Ocean SAMP study area: Bonaparte's, Laughing, Ring-billed, Herring, Iceland, and Great Black-backed Gull. Ring-billed Gull, Laughing Gull, Herring Gull, and Great Black-backed Gull were among the most abundant species detected in the Ocean SAMP area (Table 13). Bonaparte's Gulls are common during the winter months but found in relatively low numbers in the Ocean SAMP area. Iceland Gulls are rare in the study area, and we had just one detection during our surveys.

Seasonal changes in abundance - Herring Gulls and Great Black-backed Gulls nest in Rhode Island and are year-round residents, thus were detected throughout the year during our surveys. Herring Gull and Great Black-backed Gull numbers in flight peak in March when they are moving to their breeding colonies along the coast (Fig. 78). Bonaparte's, Ring-billed, and Laughing Gulls are common migrants and winter residents in the SAMP area that breed outside of Rhode Island, with their detection rates peaking in October (Fig. 79; see also Appendix D).

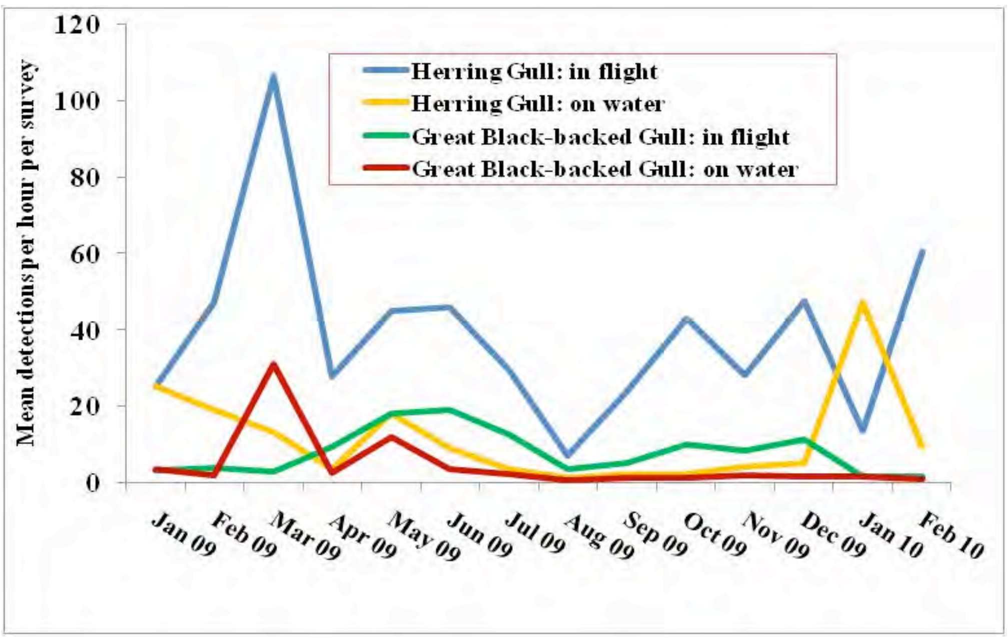


Fig. 78. Mean number of Herring and Great Black-backed Gulls detected on the water and in flight per survey per month at 11 land-based seawatch stations along the Rhode Island coastline.

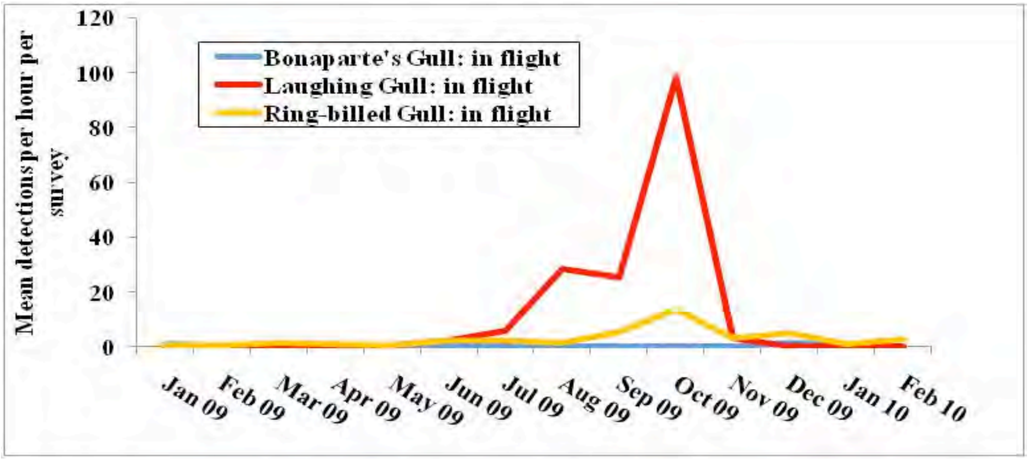


Fig. 79. Mean number of Bonaparte's, Laughing, and Ring-billed Gulls detected in flight per survey per month at 11 land-based seawatch stations along the Rhode Island coastline

Spatial patterns in abundance in nearshore waters - In nearshore areas, large gulls (Herring and Great Black-backed Gulls) tend to be widely dispersed in the study area. However, Herring Gulls detection rates peak near Goosewing, which is near both a nesting colony and a winter roost (Fig. 80). All three of the common small gulls (Bonaparte's, Laughing, and Ring-billed Gull) tend to be uniformly distributed throughout the study area (Fig. 81). See Appendices B and C for data on gull abundance at each of the land-based seawatch stations for each month surveyed.

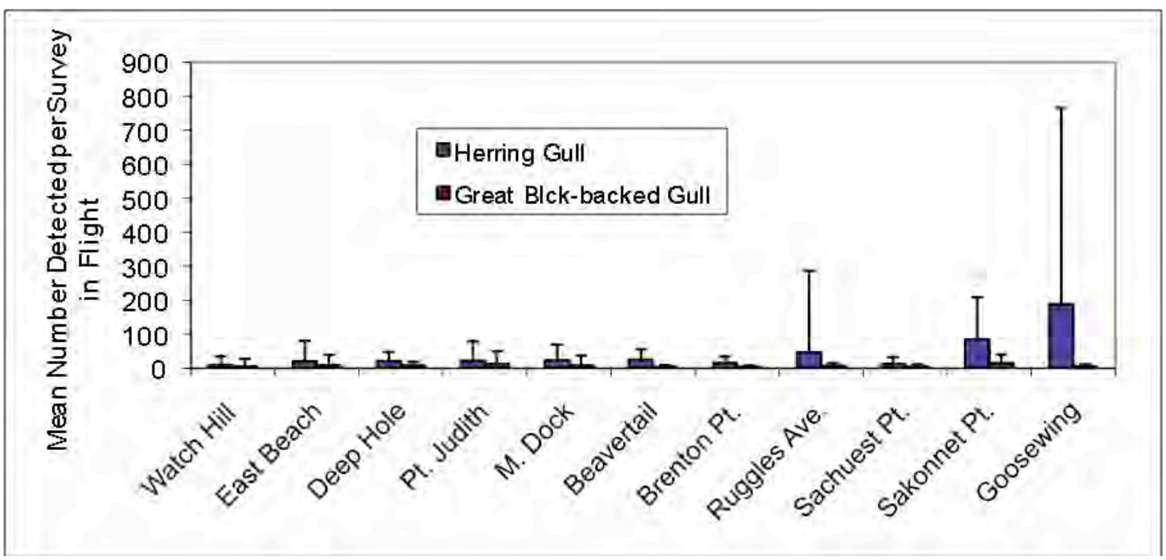


Fig. 80. Mean (SD) number of Herring and Great Black-backed Gulls detected per survey at 11 land-based seawatch stations (see Fig. 21 for locations of stations).

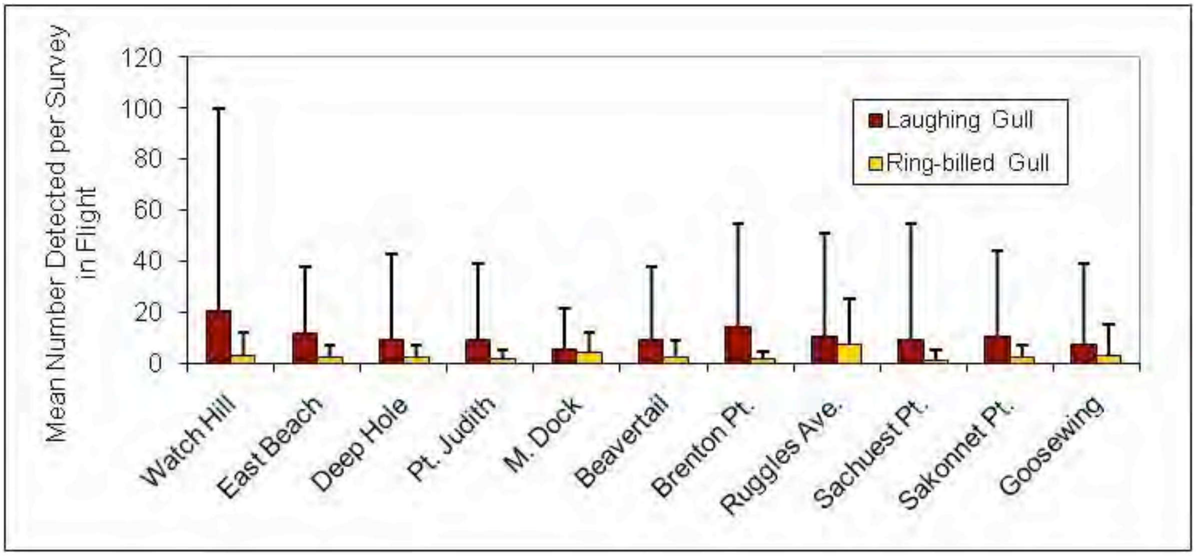


Fig. 81. Mean (SD) number of Laughing and Ring-billed Gulls detected per survey at 11 land-based seawatch stations (see Fig. 21 for locations of stations).

Flight altitude of birds - Gulls exhibit a broad range of flight altitudes (Fig. 82). During our surveys, most (58%) gulls were flying <10 m altitude, with substantial numbers flying between 10-25 m (30%), moderate numbers (12%) flying between 25-125 m, and <1% flying >125 m high.

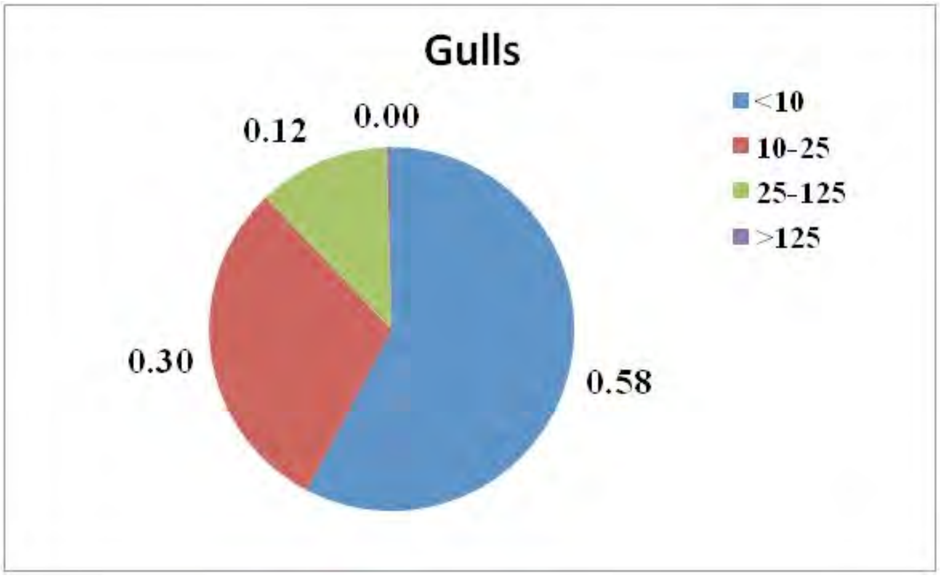
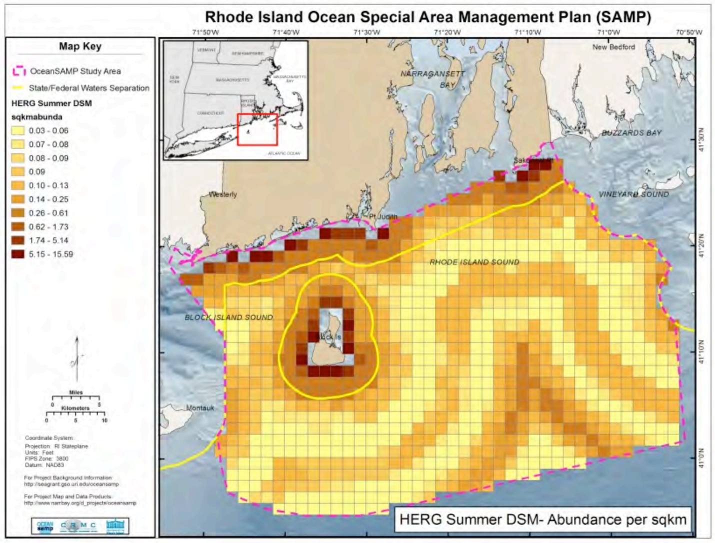
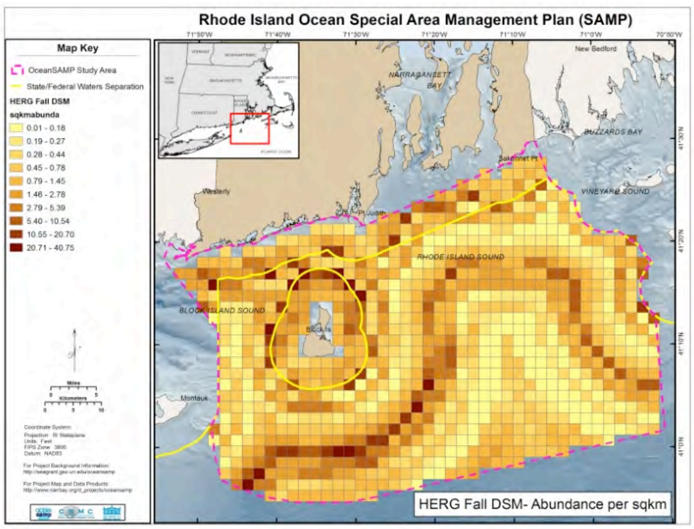


Fig. 82. Flight altitude of gulls (m above sea level; N = 100,031 detections) based estimates during land-based seawatches and ship-based line transects. Shown are the proportion of birds in four altitude categories.

Spatial patterns in abundance in nearshore and offshore waters –The best-fit Density Surface Model (DSM) for Herring Gulls explained 27.1%, 32.3% and 8.6% of the spatial variation in observed abundance during summer, fall and winter, respectively (see Appendix H for full model results). The best-fit DSM for Great Black-backed Gulls explained 19.1%, 43.9% and 7.5% of the spatial variation in observed abundance of Great Black-backed Gulls during summer, fall and winter, respectively (see Appendix H for full model results).

Herring Gulls were concentrated in nearshore areas adjacent to breeding colonies in the summer. During fall, densities increased to up to 40 birds per km^2 and gulls moved to offshore areas in Rhode Island Sound and the Inner Continental Shelf. During winter, Herring Gull densities declined (peak densities of 1.7 birds per km^2), and birds appeared to be more restricted to nearshore habitats, although some birds were using offshore areas (Fig. 83). In all three seasons, most of the variation in density estimates of Herring Gulls occurred in offshore areas (Fig. 84).


Rhode Island Ocean Special Area Management Plan (SAMP)
Map Key
OceanSAMP Study Area
State/Federal Waters Separation
HERG Summer DSM
sqkmabunda
0.03 - 0.06
0.07 - 0.08
0.08 - 0.09
0.09
0.10 - 0.13
0.14 - 0.25
0.26 - 0.61
0.62 - 1.73
1.74 - 5.14
5.15 - 15.59
NARRAGANSETT BAY
BUZZARDS BAY
VINEYARD SOUND
RHODE ISLAND SOUND
BLOCK ISLAND SOUND
New Bedford
Westerly
Montauk
HERG Summer DSM- Abundance per sqkm


Rhode Island Ocean Special Area Management Plan (SAMP)
Map Key
OceanSAMP Study Area
State/Federal Waters Separation
HERG Fall DSM
sqkmabunda
0.01 - 0.18
0.19 - 0.27
0.28 - 0.44
0.45 - 0.78
0.79 - 1.45
1.46 - 2.78
2.79 - 5.39
5.40 - 10.54
10.55 - 20.70
20.71 - 40.75
NARRAGANSETT BAY
BUZZARDS BAY
VINEYARD SOUND
RHODE ISLAND SOUND
BLOCK ISLAND SOUND
New Bedford
Westerly
Montauk
HERG Fall DSM- Abundance per sqkm

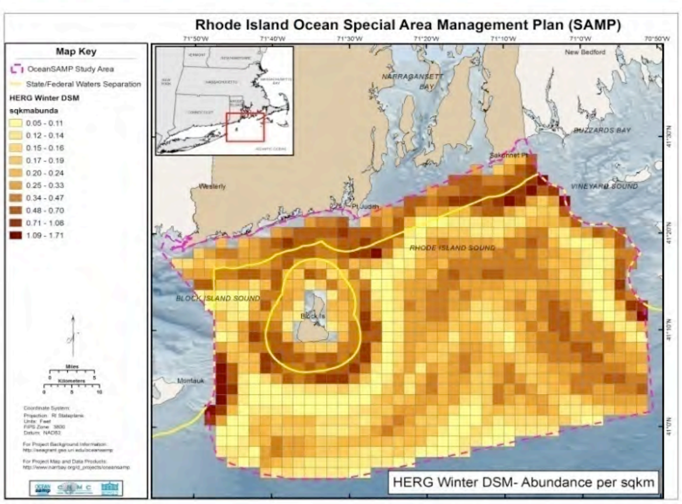

Rhode Island Ocean Special Area Management Plan (SAMP)
Map Key
OceanSAMP Study Area
State/Federal Waters Separation
HERG Winter DSM
sqkmabunda
0.05 - 0.11
0.12 - 0.14
0.15 - 0.16
0.17 - 0.19
0.20 - 0.24
0.25 - 0.33
0.34 - 0.47
0.48 - 0.70
0.71 - 1.08
1.09 - 1.71
NARRAGANSETT BAY
BUZZARDS BAY
VINEYARD SOUND
RHODE ISLAND SOUND
BLOCK ISLAND SOUND
New Bedford
Westerly
Montauk
HERG Winter DSM- Abundance per sqkm

Fig. 83. DSM estimates of the spatial distribution and density of Herring Gulls in summer (upper), fall (middle), and winter (lower) in the Ocean SAMP study area based on ship line-transect surveys.

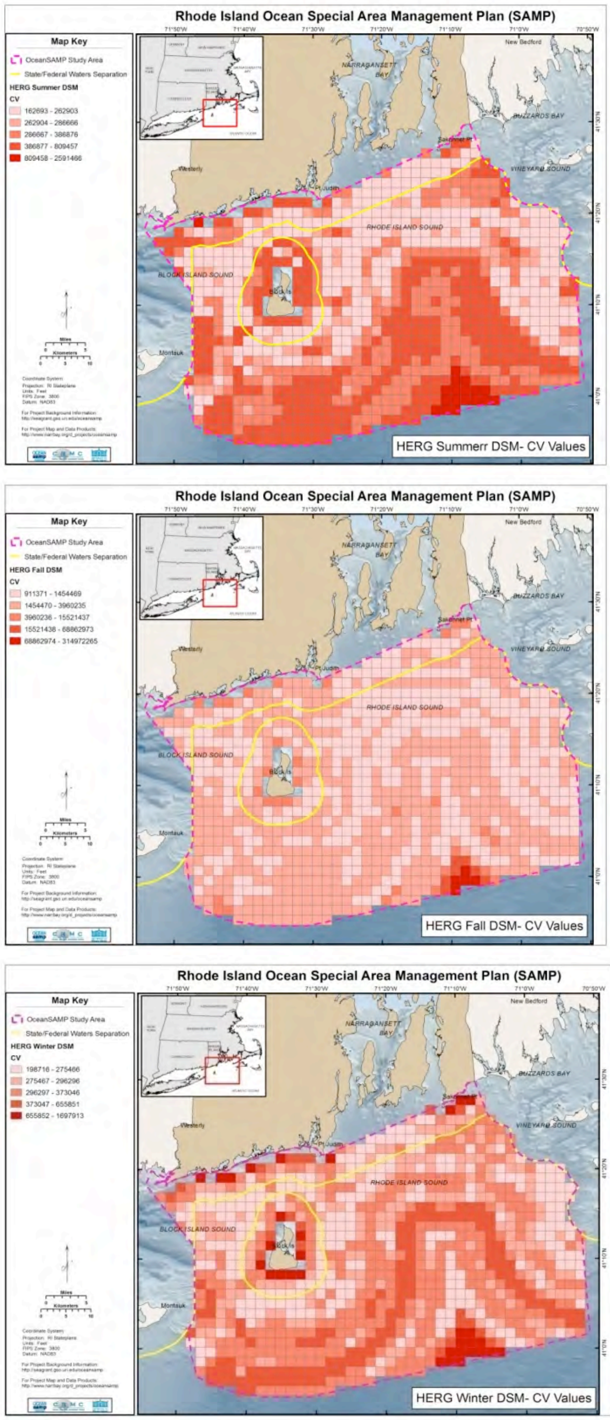


Fig. 84. Coefficient of Variation for DSM modeled Herring Gull density estimates in summer (upper), fall (middle), and winter (lower) density estimates based on ship line transect surveys shown in Fig. 83.

Great Black-backed gulls were concentrated, similar to Herring Gulls in nearshore areas, adjacent to breeding colonies in the summer (Fig. 85). In the fall, Great Black-backed Gulls dispersed to offshore areas in Block Island and Rhode Island Sounds, although estimated densities were very low in deeper, central, offshore sections of Rhode Island Sound and the Inner Continental Shelf (Fig. 85). During the fall, densities peaked at 36 individuals per km^2. During the winter, numbers of Great Black-backed Gulls in the Ocean SAMP area apparently declined substantially to only 3.6 individuals per km^2. In all three seasons, most of the variation in density estimates of Great Black-backed Gulls occurred in offshore areas (Fig. 86).

Population size in the Ocean SAMP area – Based on the DSM models (Appendix H), we estimated that during summer 2009 there were 1,454 Herring Gulls in the Ocean SAMP area (95% CI = 1,246 to 1,697), an increase to 7,332 individuals (6,000 to 8,961) in fall, and a dramatic decline to 1,082 individuals (1,042 to 1,124) during the winter season (Appendix I). In summer, we estimated 1,869 Great Black-backed Gulls in the Ocean SAMP area (95% CI = 1,255 to 2,786), an increase to 2,680 individuals (2,366 to 3,036) in fall, and a dramatic decline to 682 individuals (627 to 743) during the winter season (Appendix I).

Spatial patterns in abundance in relation to bathymetry – The distribution and abundance of gulls detected during aerial surveys were generally consistent with the estimated densities from the Herring Gull and Great Black-backed Gull winter DSM (Fig. 87). During aerial surveys it was obvious that Herring and Great Black-backed Gull distribution was often associated with commercial fishing boats, and we often observed gulls feeding behind boats (K. Winiarski, pers. obs.). The depth profile of Gulls was similar to the depth profile of the study area, with peak abundance in ocean waters that were 30-45 m deep (Fig. 88).

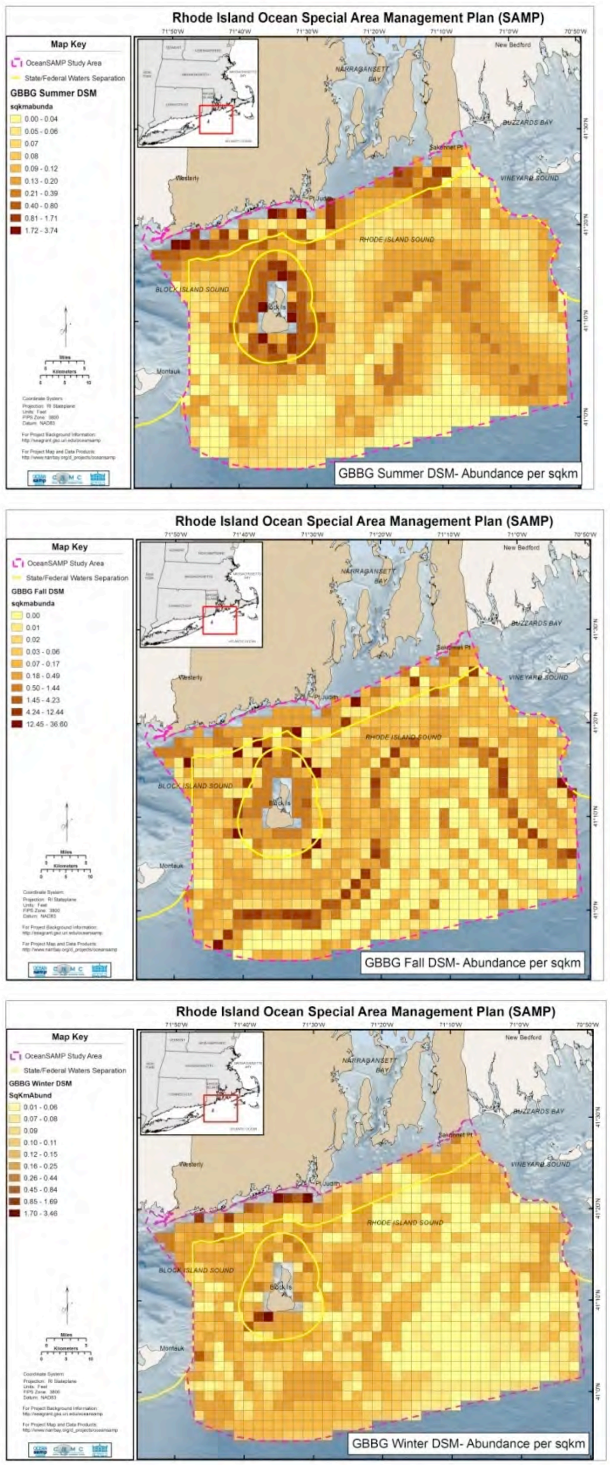


Fig. 85. DSM estimates of the spatial distribution and density of Great Black-backed Gulls in summer (upper), fall (middle) and winter (lower) in the Ocean SAMP study area based on ship line-transects.

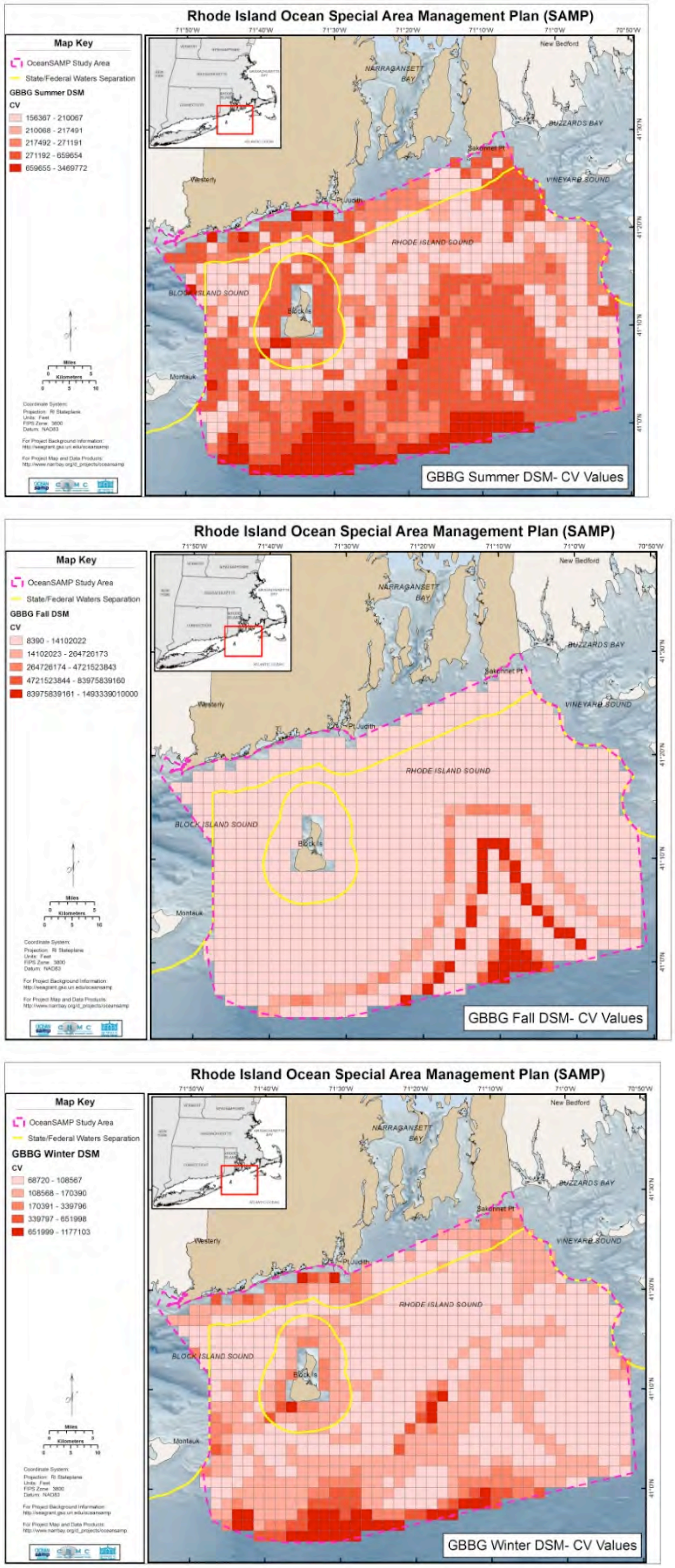


Fig. 86. Coefficient of Variation for DSM modeled Great Black-backed Gulls density estimates in summer (upper), fall (middle) and winter (lower) based on ship line transect surveys shown in Fig. 85. Density estimates exhibit more variation in areas in bright red.

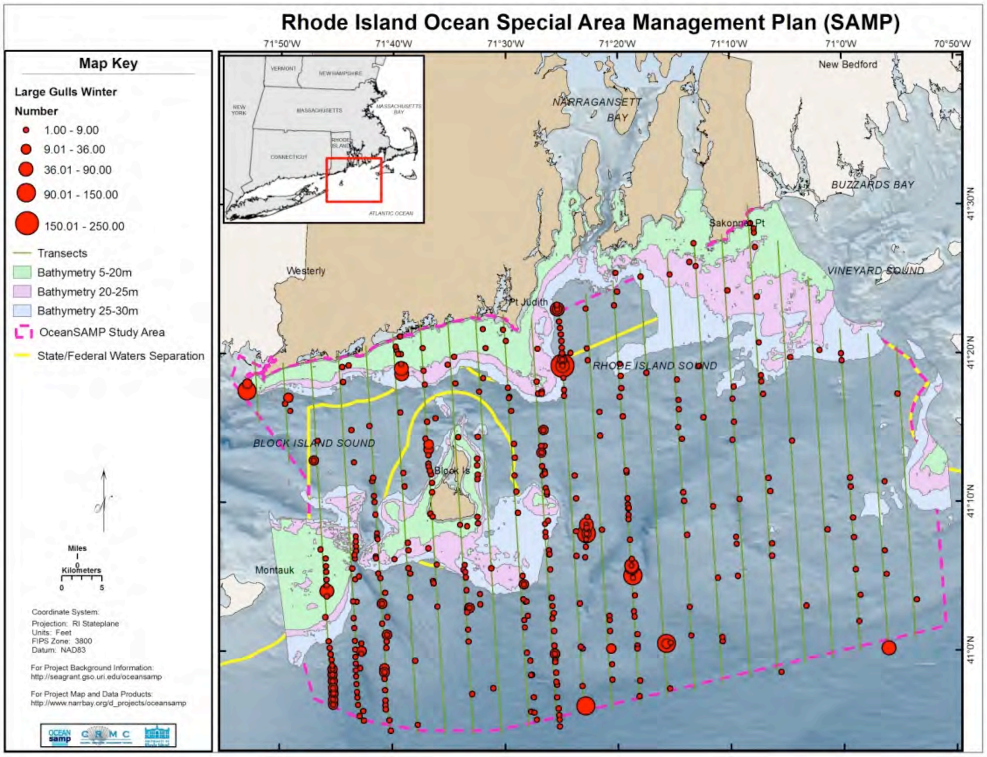


Fig. 87. Distribution of gulls detected during aerial surveys in the winter of 2009-2010. Large flocks tended to be associated with fishing vessels.

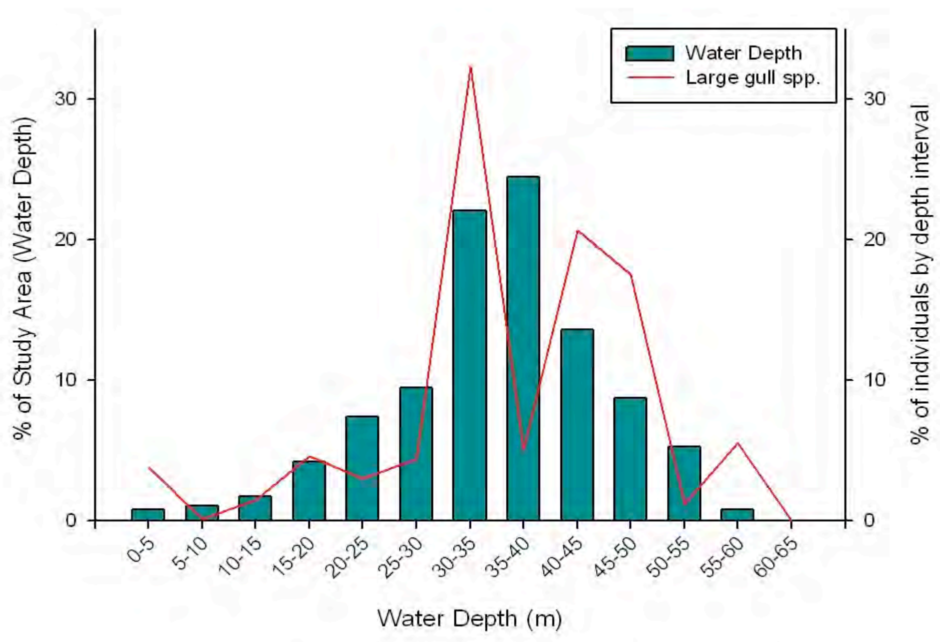


Fig. 88. Bathymetry of Ocean SAMP study area (green histogram) compared to depths where Herring and Great Black-backed Gulls were detected during aerial surveys (red line) (Fig. 87).

3.13 Kittiwakes

We detected one species of kittiwake (Laridae) in the Ocean SAMP study area, the Black-legged Kittiwake. The Black-legged Kittiwake is an offshore specialist that is not commonly found close to shore.

Seasonal changes in abundance – Black-legged Kittiwakes are winter residents and migrants in the Ocean SAMP area most commonly found from November through March (Fig. 89).

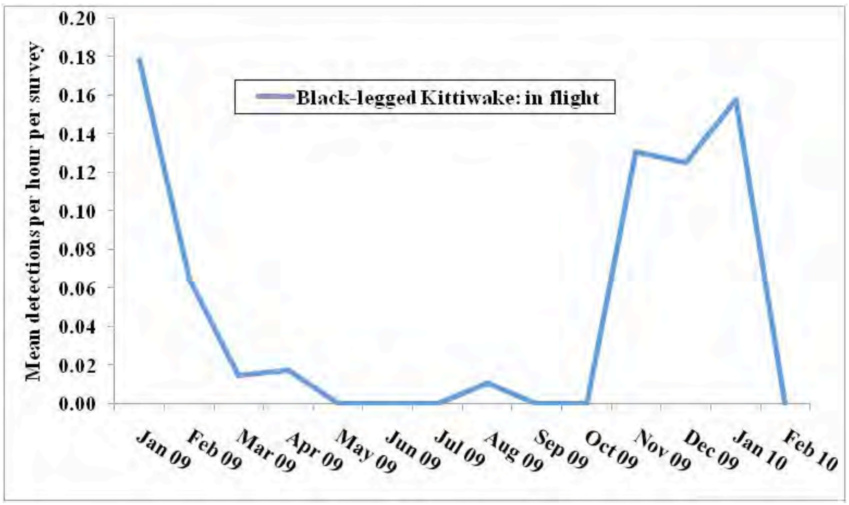


Fig. 89. Mean number of Black-legged Kittiwakes detected in flight per survey per month at 11 land-based seawatch stations along the Rhode Island coastline

Flight altitude of birds - Kittiwakes fly at similar altitudes as other gulls, with 58% of detections flying at altitudes <10 m high, 37% between 10-25 m, and about 6% flying over 25 m high (Fig. 90).

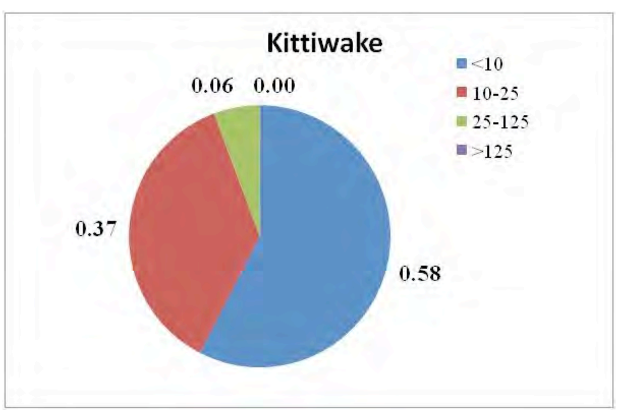


Fig. 90. Flight altitude of kittiwakes (m above sea level; N = 106 detections) based estimates during land-based seawatches and ship-based line transects. Shown are proportion of birds in four altitude categories.

Spatial patterns in abundance in nearshore waters - The only nearshore locations where kittiwakes were seen fairly regularly were Point Judith, Beavertail, Brenton Pt., and Ruggles Ave. (Fig. 91). See Appendices B and C for data on kittiwake abundance at each of the land-based seawatch stations for each month surveyed.

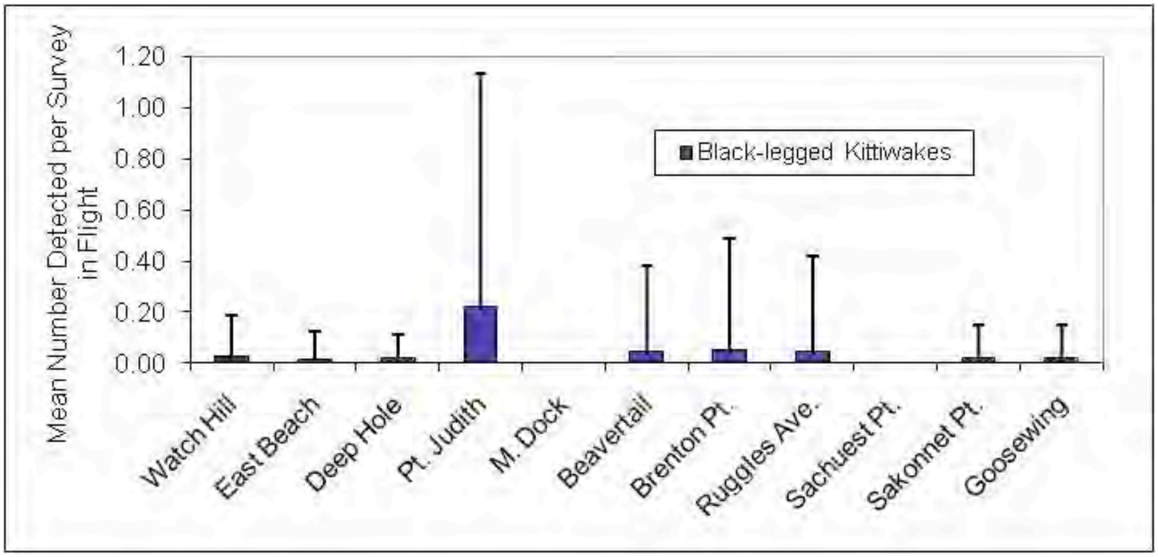
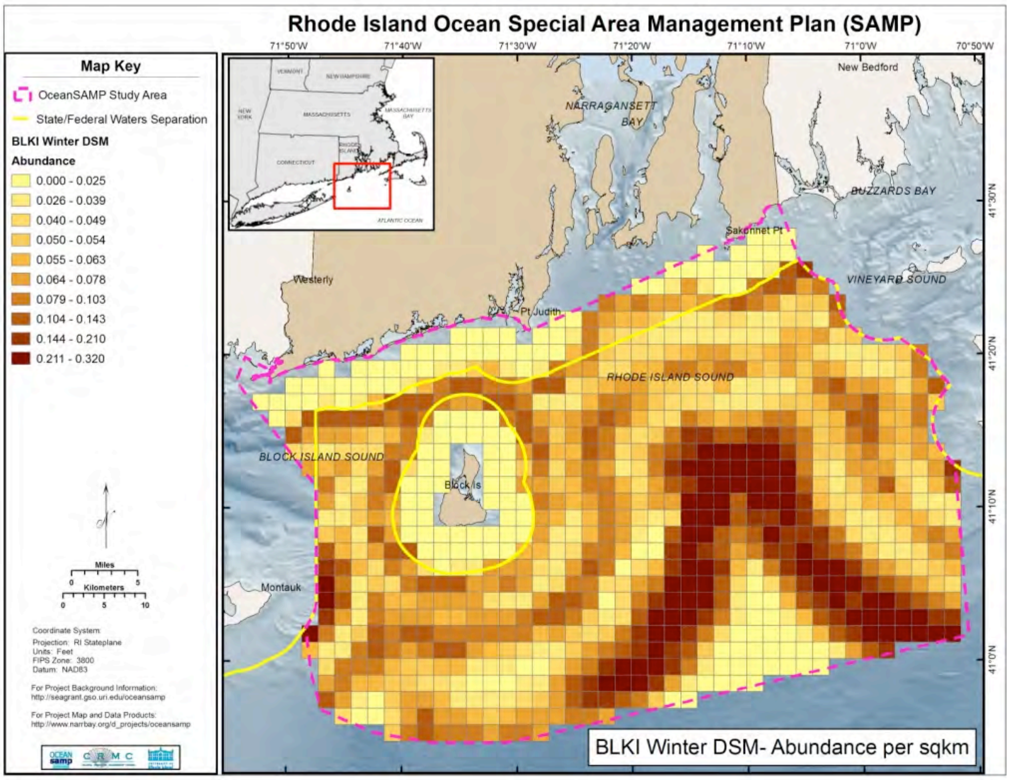


Fig. 91. Mean (SD) number of Black-legged Kittiwakes detected per survey at 11 land-based seawatch stations (see Fig. 21 for locations of stations).

Spatial patterns in abundance in nearshore and offshore waters –The best-fit Density Surface Model (DSM) explained 9.7% of the spatial variation in observed abundance of Black-legged Kittiwakes (see Appendix H for full model results). Black-legged Kittiwake densities during winter were greatest in the deeper waters of central Rhode Island Sound and the Inner Continental Shelf (Fig. 92). Densities were also high in a band about 3 miles south of the mainland coast and off of Block Island. However, there was considerable uncertainty about kittiwake use of nearshore habitats off of mainland Rhode Island and Block Island. The scarcity of kittiwake observations at land-based seawatch stations suggests the DSM model is fairly accurate concerning the paucity of kittiwakes using nearshore habitats. CVs for these density estimates are shown in Fig. 92.

Population size in the Ocean SAMP area - Based on the Black-legged Kittiwake DSM (Appendix H), we estimated that during the winter of 2009-2010, there were 291Black-legged Kittiwake (95% CI = 283 to 299) in the Ocean SAMP study area (Appendix I). This is a daily estimate during winter. Since kittiwakes are actively migrating through the area, we have no accurate estimates concerning their turnover rates in the study area, and so cannot determine how many kittiwakes use the area overall.



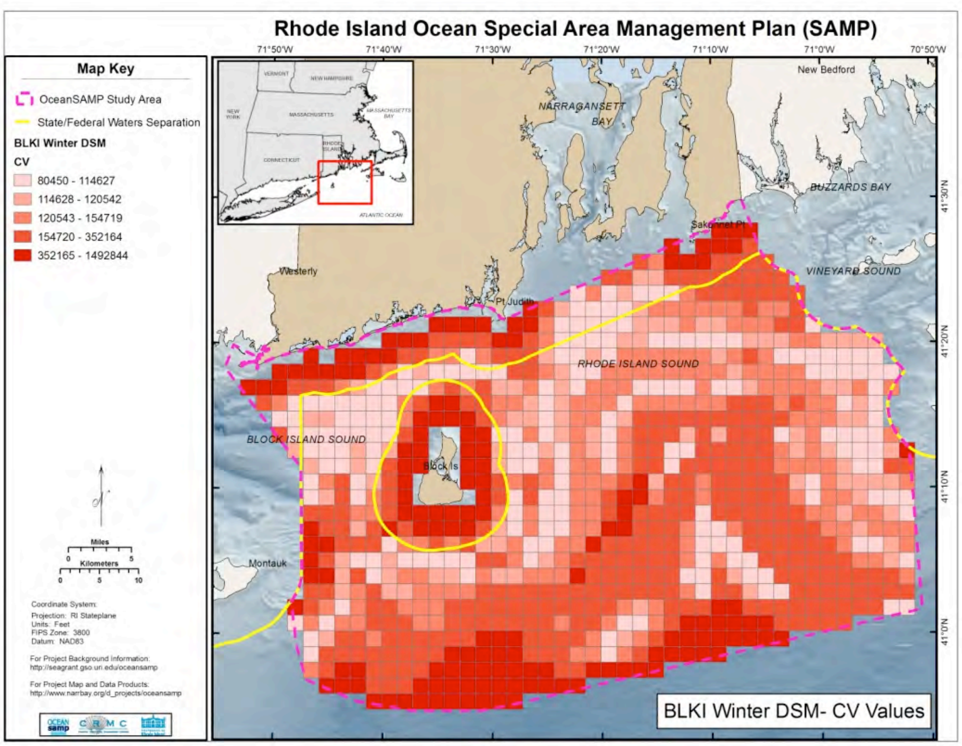


Fig. 92. DSM estimates of the spatial distribution and density of Black-legged Kittiwakes (upper) and CV estimates (lower) in winter in the Ocean SAMP study area based on ship line-transect surveys.

Spatial patterns in abundance in relation to bathymetry – The distribution and abundance of Black-legged Kittiwakes detected during aerial surveys were consistent with the estimated densities from the Black-legged Kittiwake DSM (Fig. 93). Most observations of kittiwakes during aerial surveys were on the Inner Continental Shelf and in southern sections of Rhode Island Sound (Fig. 93). Kittiwakes were primarily found in deeper waters of the Ocean SAMP area, with peak detections in waters that were 50-55 m deep (Fig. 94).

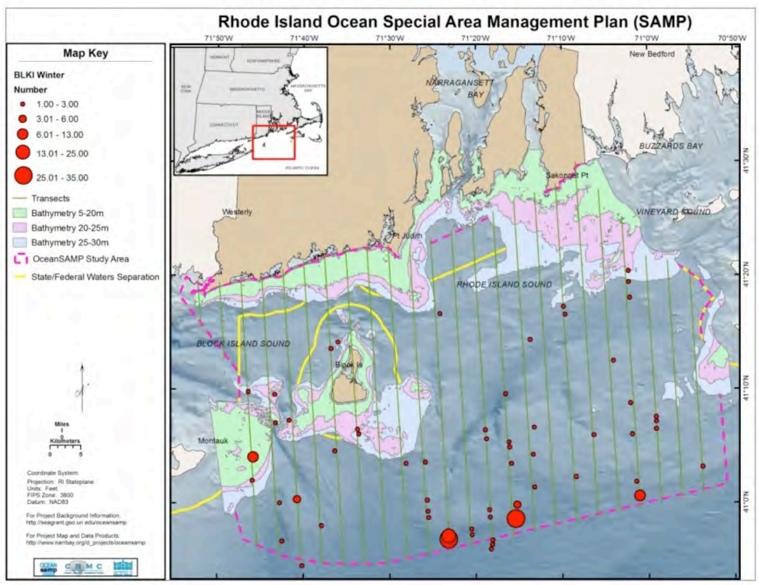


Fig. 93. Distribution of Black-legged Kittiwakes detected during aerial surveys in winter in the Ocean SAMP study area

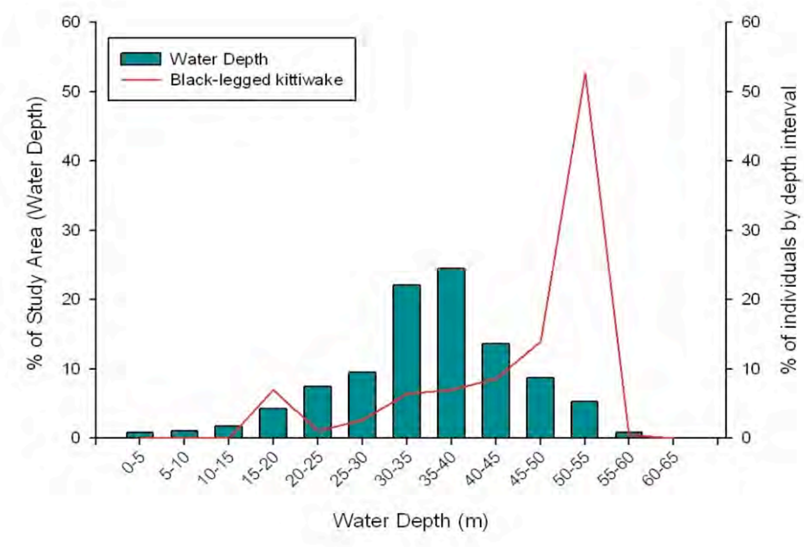


Fig. 94. Depth profile of Ocean SAMP study area (green histogram) compared to depths where Black-legged Kittiwakes were detected during aerial surveys (red line) (Fig. 93).

3.14 Terns and skimmers

We detected seven species of terns (Sternidae) and one species of skimmer (Rynchopidae) in the Ocean SAMP study area: Caspian, Royal, Common, Forster's, Roseate, Least, Black Tern and Black Skimmer. Common, Least and Roseate are the most abundant tern species detected in the Ocean SAMP area. Caspian Tern, Royal Tern, Forster's Tern, Black Tern and Black Skimmer are relatively uncommon in the SAMP area.

Seasonal changes in abundance - Terns are breeders and migrants in the Ocean SAMP area. Common and Least Terns are both species that breed locally in Rhode Island (C. Raithel unpublished data 2009; Ferren and Meyers 1998), which explains in part their high detection rates from May to September (Fig. 95). Roseate Terns breed in colonies near Rhode Island, and are primarily post-breeding migrants into the area from mid-July to early September (a detailed summary of Roseate Terns using the Ocean SAMP area is provided in section 3.2 above). All species of terns and skimmer spend only a maximum of six months in Rhode Island waters. For example, Common Terns are in the region from May through October (Fig 95), which is slightly longer than other migratory terns that only pass through the area to and from their breeding grounds (Royal, Caspian, Forster's, and Black Terns).

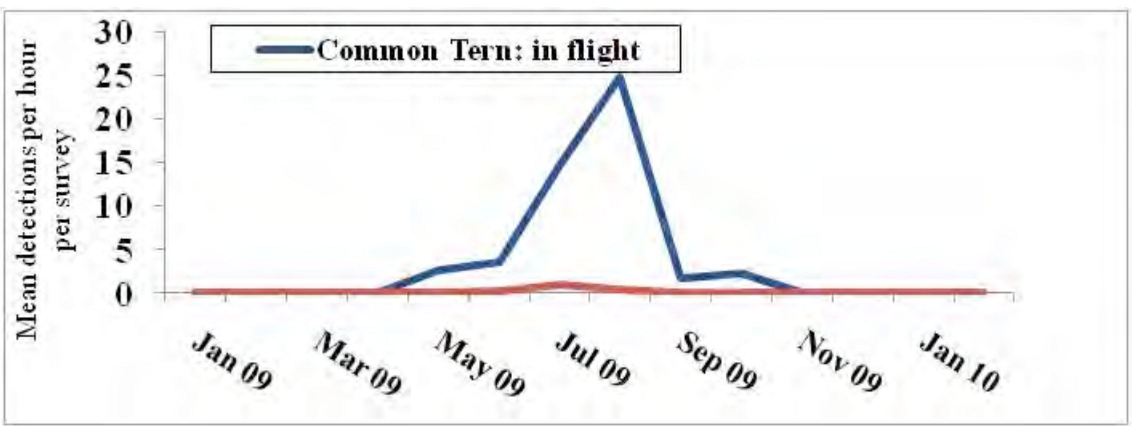


Fig. 95. Mean number of Common (blue line) and Roseate Terns (red line) detected in flight per survey per month at 11 land-based seawatch stations along the Rhode Island coastline.

Flight altitude of birds - Most terns (94%) were flying at altitudes of <25 m when we observed them during land-based seawatches and ship-based line-transect surveys (Fig. 96).

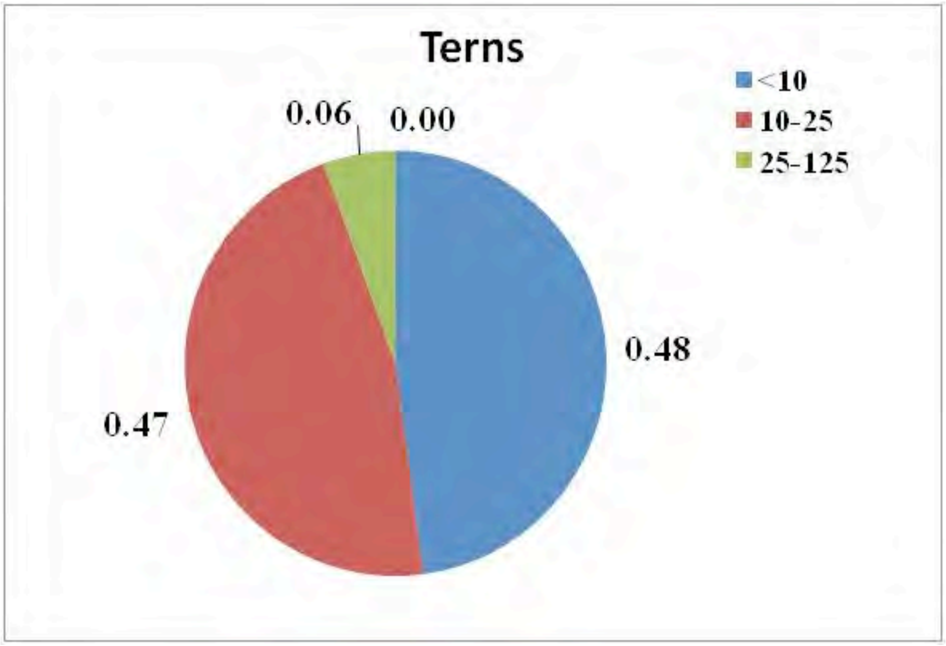


Fig. 96. Flight altitude of terns (m above sea level; N = 5,592 detections) based estimates during land-based seawatches and ship-based line transects. Shown are proportion of birds in four altitude categories.

Spatial patterns in abundance in nearshore waters – Common Terns tend to be detected throughout nearshore waters in the Ocean SAMP study area, while Least Terns tend to be more abundant in Block Island Sound and near Goosewing (Fig. 97). The distribution of Roseate Terns is discussed in detail in section 3.2 above. See Appendices B and C for data on tern and skinner abundance at each of the land-based seawatch stations for each month surveyed.

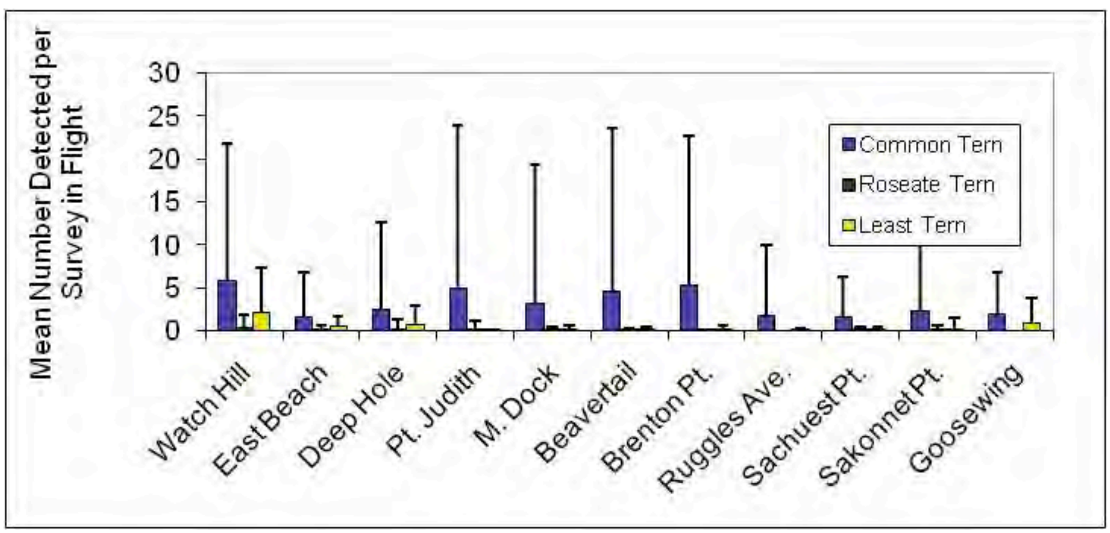


Fig. 97. Mean (SD) number of Common, Roseate, and Least Terns detected per survey at 11 land-based seawatch stations (see Fig. 21 for locations of stations).

Spatial patterns in abundance in nearshore and offshore waters –We detected a small number of commuting terns in offshore areas during ship-based surveys but not enough to confidently model the distribution and density of terns in the SAMP area (Fig. 98).

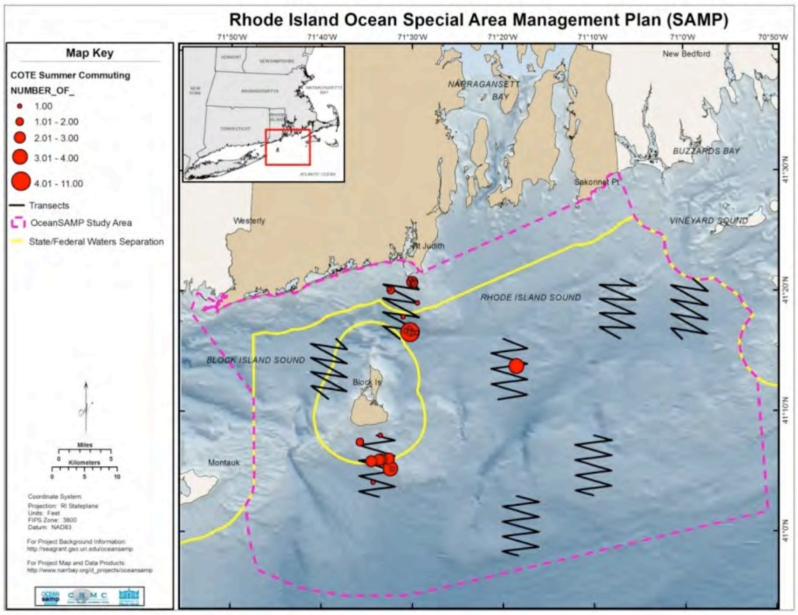


Fig. 98. Distribution of Common Tern flocks detected during ship line-transects in the summer in the Ocean SAMP study area

Population size in the Ocean SAMP area - We had too few detections of terns and skimmers during ship-based line transects in to estimate their population size in the study area.

Spatial patterns in abundance in relation to bathymetry – We had no detections of terns or skimmers during winter aerial surveys, thus we did not explore tern abundance in relation to water depth in the Ocean SAMP study area.

3.15 Alcids

We detected six species of alcids (Alcidae) in the Ocean SAMP study area: Razorbill, Common Murre, Thick-billed Murre, Dovekie, Black Guillemot, and Atlantic Puffin. Razorbills, Common Murre and Dovekies are common and abundant in the SAMP area. Thick-billed Murre, Black Guillemot and Atlantic Puffin are common but found in relatively low numbers in the Ocean SAMP study area.

Seasonal changes in abundance - Alcids are winter residents and migrants in the Ocean SAMP area. Based on land-based seawatch data of Razorbills, alcids start to appear Rhode Island in

December, their numbers peak in January, and most have departed by mid-March (Fig. 99; see also Appendix D).

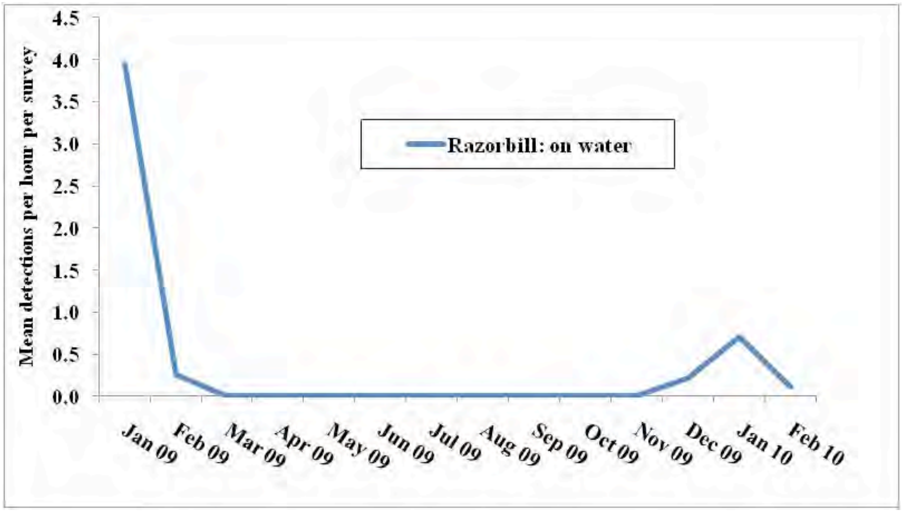


Fig. 99. Mean number of Razorbills detected on the water per survey per month at 11 land-based seawatch stations along the Rhode Island coastline

Flight altitude of birds - As with most pelagic species, alcids remain near the ocean surface when in flight; all birds observed were flying at altitudes <10 m (N = 401 detections; see also Tables 15 and 19).

Spatial patterns in abundance in nearshore waters - Razorbills were detected most often at rocky promontories (Pt. Judith, Beavertail; Fig. 100.). See Appendices B and C for data on alcid abundance at each of the land-based seawatch stations for each month surveyed.

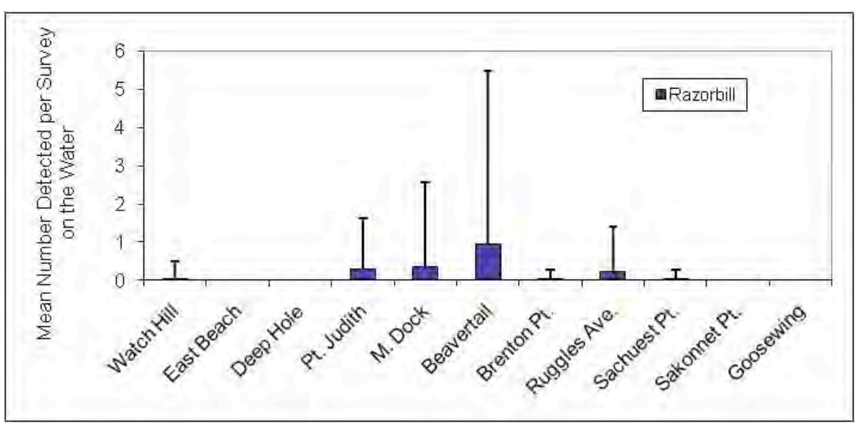


Fig. 100. Mean (SD) number Razorbills detected per survey at 11 land-based seawatch stations (see Fig. 21 for locations of stations).

Spatial patterns in abundance in nearshore and offshore waters – We present the detection function plots that were derived from the observed abundance of alcids on the water from ship-based surveys, and the associated GAM plot (Appendix J). The best-fit Density Surface Model (DSM) for Razorbills, Common Murres and Dovekies explained 11.3%, 23.5% and 34.6% of the spatial variation in observed abundance, respectively (see Appendix H for full model results). DSM models revealed a clear pattern of spatial segregation among these three species within the Ocean SAMP area. Razorbills tend to have their greatest density estimates (up to 1.5 birds per km^2) in the northern edge of the study area and south of Block Island in shallower waters (Fig. 101). Common Murres tend to be concentrated in the middle of the Ocean SAMP study area, in areas with slightly deeper water (Fig 101). High densities of Common Murres (up to 2.2 birds per km^2) occur north of Block Island and across the middle sections of Rhode Island Sound. Finally, Dovekies tended to occur in the deeper water sections of Rhode Island Sound and the Inner Continental Shelf, where densities can be much higher (up to 36.8 individuals per km^2) than any of the other alcids in the region (Fig. 101). We were unable to model the densities or distribution of the other three alcids due to their low detection rates. For all three alcids we modeled, we had the greatest uncertainty about density estimates in southern sections of Rhode Island Sound (Fig. 102).

Population size in the Ocean SAMP area - Based on the alcid DSMs (Appendix H), we estimated that during the winter of 2009-2010, Dovekies were the most abundant species, with 5,771 individuals (95% CI = 4,222 to 7,888), Razorbills the second most common, with 1,390 individuals (95% CI: 996 to1,940) and Common Murres the least abundant, with 623 individuals (95% CI: 548 to 707: Appendix I).

Spatial patterns in abundance in relation to bathymetry – The distribution and abundance of alcids detected during aerial surveys were consistent with the estimated densities from the alcid DSMs (Figure 103). When you compare the depth at alcid detections during aerial surveys compared to the depth profile of the Ocean SAMP area, it is apparent that alcids prefer deeper water (>30 m deep; Fig. 104).

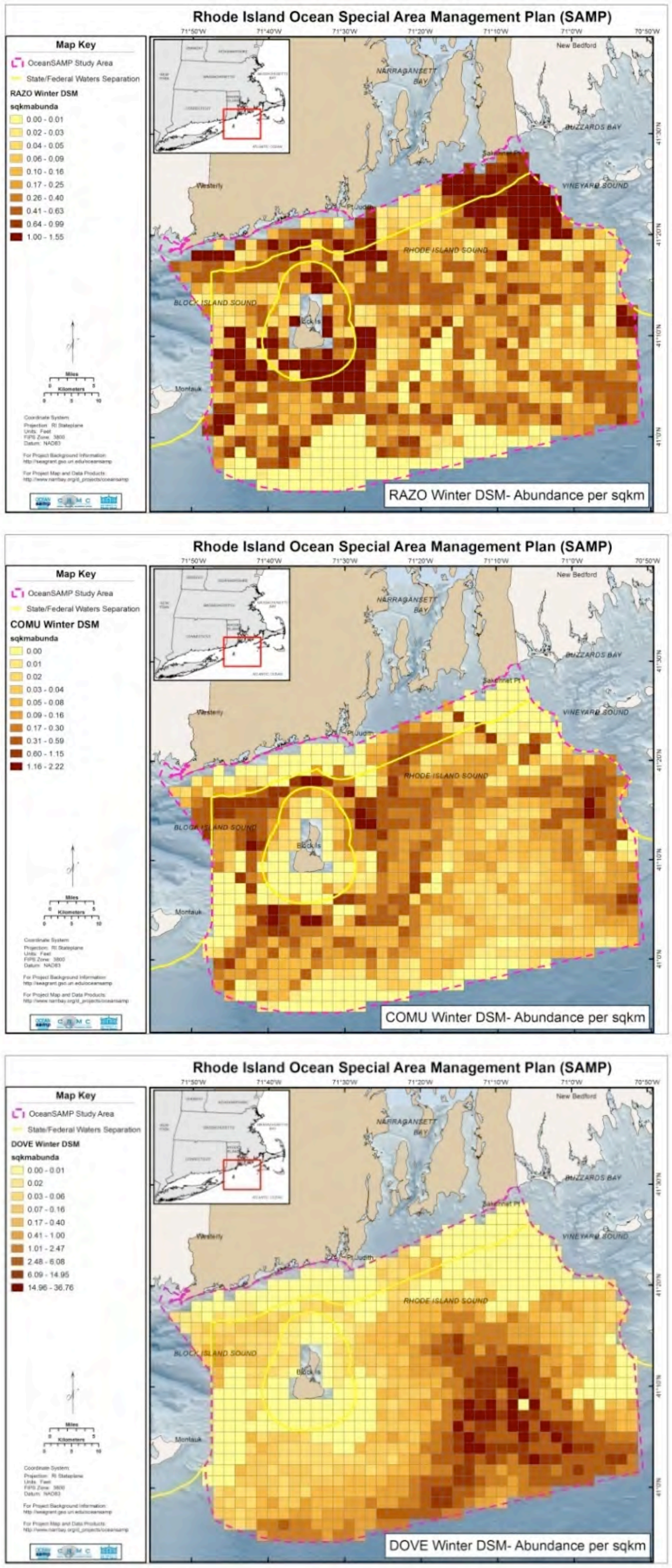


Fig. 101. DSM estimates of the spatial distribution and density of Razorbills (upper), Common Murre (middle) and Dovekie (lower) in winter in the Ocean SAMP study area based on ship line-transect surveys.

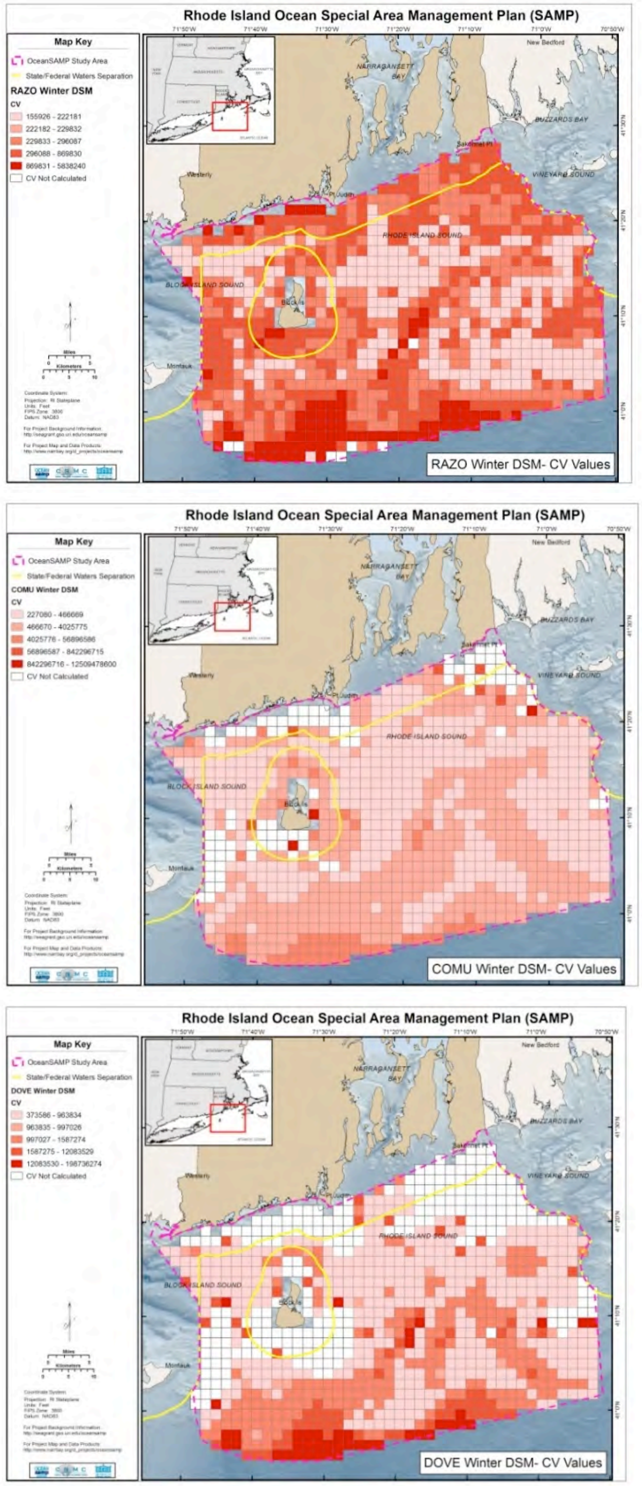


Fig. 102. Coefficient of Variation for DSM density estimates for Razorbills (upper), Common Murre (middle) and Dovekie (lower) based on ship line transect surveys shown in Fig. 101.

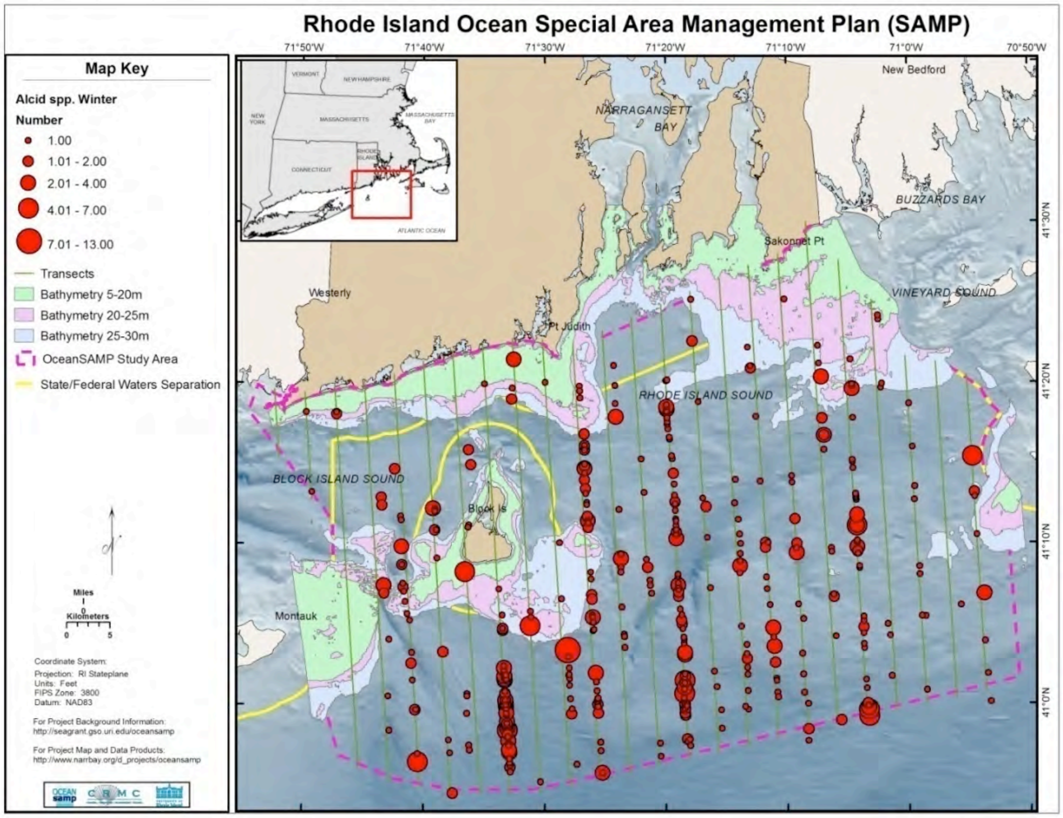


Fig. 103. Distribution of alcid flocks (e.g., Razorbills Common Murre, and Dovekie) based on aerial surveys in winter in the Ocean SAMP study area. We could not identify species during flights.

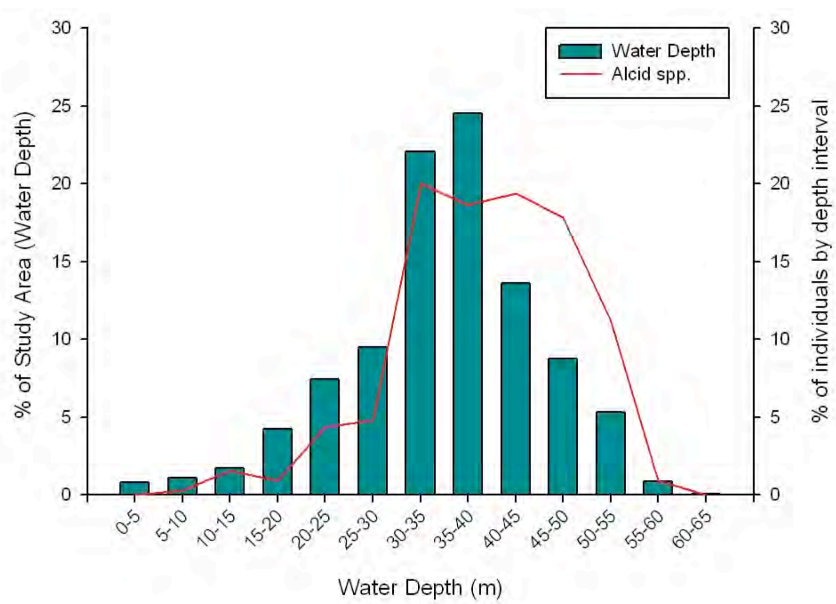


Fig. 104. Depth profile of Ocean SAMP study area (green histogram) compared to depths where alcids were detected during aerial surveys (red line) (Fig. 103).

3.16 Landbirds

We detected seven species of raptors (Accipitidae, Pandonidae and Falconidae), a dove species (Columbidae), an owl species (Strigidae), a swift (Apodidae), a hummingbird (Trochilidae), a kingfisher (Cerylidae), a flycatcher (Muscicapidae), three species of corvids (Corvidae), a lark (Alauidae), six species of swallows (Hirundinidae), a thrush (Turdidae), a pipit (Motacillidiae), a waxing (Bombycillidae), three warblers (Parulidae), a bunting (Emberizidae), a finch (Fringillidiae) , a junco (Emberizidae), three icterids (Icteridae) and a sparrow (Passeridae). Landbirds are relatively uncommon in the Ocean SAMP area (excluding Block Island) since they are generally associated with terrestrial habitats. The only raptor we detected regularly was Osprey, which is not surprising given that they often forage in nearshore habitats and regularly migrate along the coast. All other raptors were detected <10 times. Most raptors, with the exception of falcons, avoid crossing large water bodies, thus are rarely observed on Block Island.

Seasonal changes in abundance – Landbirds were recorded during land-based seawatches year round. Tree Swallows were among the most abundant landbirds and found in large numbers in the fall during migration (Appendices B-D).

Flight altitude of birds - Of the passerines we observed, 99% were flying at altitudes <25 m (Fig. 105). However, this is likely a biased estimate of flight altitudes and is not representative of flight altitudes of passerines because birds flying at higher elevations are unlikely to have been detected with our survey methods. A more quantitative unbiased sample of passerine flight altitudes is obtained from data collected by radar, which are available in Appendix K.

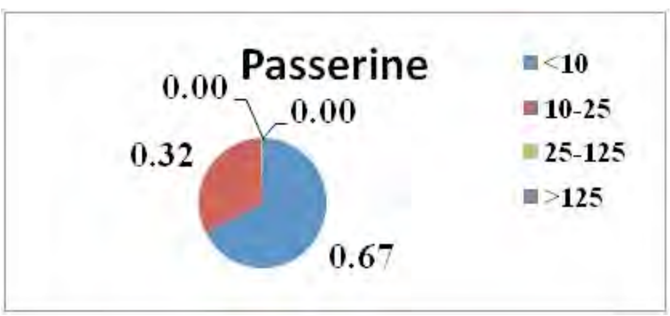


Fig. 105. Flight altitude of songbirds (m above sea level; N = 2,881) based on ocular estimates during land-based seawatches and ship-based line transects. Proportion of birds in four altitude categories is shown.

Spatial patterns in abundance in nearshore waters –Landbirds were distributed throughout seawatch stations (Appendices B and C).

Spatial patterns in abundance in nearshore and offshore waters – We had too few detections of landbirds during ship-based line transects in all seasons to model their density or spatial distribution. During ship-based line transects, we did detect a Mourning Dove and 7 species of songbirds (Bank and Tree Swallow; Blackpoll and Yellow-rumped Warbler; Dark-eyed Junco, Savannah Sparrow, and Snow Bunting; Table 18). The farthest offshore we detected a passerine was a Savannah Sparrow on Grid G.

Population size in the Ocean SAMP area **-** As expected, we had too few detections of landbirds during ship-based surveys to estimate their population size in the study area. This study was not designed to estimate the population size of landbirds migrating over Ocean SAMP study area.
Spatial patterns in abundance in relation to bathymetry – We had no detections of landbirds during aerial surveys, thus we did not explore Landbird abundance in relation to water depth in the SAMP study area.

4 Discussion

This interim report for the Rhode Island Special Area Management Plan (SAMP) summarizes our research conducted from January 2009 through mid-February 2010. This study represents the first attempt to quantify the spatial distribution and abundance of birds using the offshore waters of Rhode Island. However, our research is ongoing with ship-based and land-based surveys continuing through at least July 2010 and aerial surveys continuing until at least May 2011. Results from this ongoing research will be presented in another technical report published in 2011, along with a more comprehensive discussion of those final results. We provide here some discussion of the results presented in this interim report.

Previous Studies of Birds That Inhabit Rhode Island Waters

We compiled and summarized in this report the results from systematic surveys conducted in the Ocean SAMP study area in the late 1970s and throughout the 1980s. The largest historical offshore survey in the region was the Cetacean and Seabird Assessment Program surveys conducted from 1980-1988. This was a large-scale research program focused on investigating cetacean and seabird distribution and abundance from Cape Hatteras, North Carolina to Nova Scotia, Canada (MBO 1988). They surveyed within all shelf and shelf-edge waters < 183m (100 fathoms) deep in the Gulf of Maine, Georges Bank, southern New England waters, and the mid-Atlantic Bight (MBO 1988). They conducted a total of 1690 15-min long transects in the Inner Continental Shelf of the southern New England region from 1980 -1987, but only 101 transects were conducted within the Ocean SAMP study area boundaries over this 8-year study. Therefore, these surveys were too sparse over space and time to quantify baseline density or spatial distribution for birds within the Ocean SAMP boundaries. However, at larger spatial scales, these surveys summarize valuable information on avian distribution and abundance in this large-scale Atlantic offshore region (Power et al. 1980, Powers 1983).

We also summarized in this report the considerable historical information on avian abundance and distribution in Narragansett Bay, nearshore habitats along the southern Rhode Island coast (e.g., Sachuest Point NWR and Napatree Spit), and some coastal ponds. This summary makes it clear that a different suite of bird species uses Narragansett Bay and the coastal ponds than most of the Ocean SAMP study area that we surveyed. For example, although a diversity of dabbling ducks, geese, swans, and bay ducks are found in Narragansett Bay and the coastal ponds, those guilds occur only in low densities or are absent from the Ocean SAMP study area. Given this lack of historical baseline surveys, the results we present in this report provide the first quantitative estimates of the spatial distribution and abundance of birds inhabiting the offshore waters of Rhode Island.

Species Richness and Abundance of Birds in the Ocean SAMP Area

Importance of Nearshore Habitats

Our avian surveys along with historical avian surveys in Rhode Island nearshore waters, as well as bird surveys conducted in Nantucket Sound by Massachusetts Audubon as part of the Cape Wind research project, show the importance of nearshore, shallow waters for a wide range of avian species including seaducks, loons, grebes, cormorants, geese, gulls, gannets and one species of alcid (Razorbill). Of the 796 1-2 hr land-based surveys that we conducted, we detected 465,039 individuals of 121 different avian species. During the summer, nearshore waters were important for terns (including the federally endangered Roseate Tern), gulls, and shorebirds. During winter, seaducks and loons (both Common and Red-throated Loons) were also abundant throughout the Ocean SAMP study area. In Nantucket Sound, large numbers of loons (2,200 and 4,600 were detected in the winters of 2003-04 and 2004-05, respectively) and Razorbills (2,600 and 2,800, respectively) inhabited nearshore, shallow waters (Perkins et al. 2005). Thus, these nearshore, shallow water habitats in southern New England provide vital habitat for many avian species and possibly millions of migratory birds inhabit these nearshore waters in the Ocean SAMP study area during some portion of their annual life cycle.

Common Loons deserve mention because a significant portion of the population that nests in New England freshwater lakes spends the winter in Rhode Island waters. Common Loons primarily utilize nearshore areas in the SAMP area during December and January, though there is some indication that they move farther offshore as the winter progresses, potentially during their flightless molt period. Kenow et al. (2009), in a satellite telemetry study of 17 Common Loons, found that 95% of locations were within 10.5 km of a coastal land mass, with a maximum distance from shore of 26.6 km. Mean water depth at loon telemetry locations was <20 m for loons monitored by Kenow et al. (2009), and averaged 13 m. Kenow et al. (2009) documented winter home ranges of adult Common Loons from 43 to 1,159 km^2, indicating loons ranged widely during winter. This telemetry study documented movement of loons between Rhode Island Sound and Buzzards Bay, Massachusetts. Another adult spent 3 months in Cape Cod Bay and then moved 87 km to Narragansett Bay in early February. However, the local movement patterns of resident wintering loons in the Ocean SAMP study area are still poorly understood and need further investigation. We estimated a surprisingly large population of Common Loons (2,901 individuals (95% CI = 2535-3321) during winter within the Ocean SAMP study area. Given that New York, Vermont, New Hampshire, Massachusetts, and Maine had 5,400 adults nesting during 2009 (NE Loon Study Group, pers. comm.), the Ocean SAMP area supports the equivalent of 54% of the Northeast loon breeding population during the winter. Thus, the nearshore waters within the Ocean SAMP area provide critical wintering habitat for significant numbers of loons that inhabit New England.

Importance of Offshore Habitats

Offshore areas in Rhode Island Sound and the Inner Continental Shelf provide important habitat for a different suite of birds than nearshore areas. On the 54 ship-based line transects (conducted from Jun 2009 to Feb 2010) we detected 13,170 individuals of 56 species. In contrast to avian species that use the ocean for part of their annual cycle (e.g., Loons [Gaviiformes], Grebes [Podicipiformes], and waterfowl [Anseriformes]), three orders of seabirds (Charadriiformes, Procellariiformes, and Pelecaniiformes) have specific adaptations that make them dependent throughout the year on the ocean for their food resources (Durant et al. 2004) and many of these seabirds primarily inhabit offshore waters. In the summer, thousands of shearwaters and storm-petrels use the southern sections of Rhode Island Sound and the Inner Continental Shelf during their large-scale movements throughout the Atlantic Ocean (Powers et al. 1983). In the fall and spring, Northern Gannets migrate through the SAMP area, taking advantage of abundant schools of sandlance (*Ammodytes* spp.) and mackerel (*Scomber scombrus*) (MBO 1988). Recent investigations of gannet migration from their breeding grounds in NE Canada to wintering sites off of SE North America document large-scale movements of gannets from nearer shore areas to pelagic waters hundreds of kilometers offshore (Montevecchi 2010).

During the winter, large numbers of alcids (Common and Thick-billed Murre, Dovekie) move into southern New England to feed on krill (e.g., euphausiids), decapods, fish and squid (Brown 1988, Huettmann et al. 2005) and they inhabit the deeper, offshore waters of the Ocean SAMP study area. These movements of alcids can be quite episodic. For example, Huettmann et al. (2005) conducted systematic boat-based surveys for alcids off Grand Manan Island, New Brunswick, and detected an average of 3,327 ± 4,058 (CV = 123; min = 160) large alcids between 3 Jan to 3 April 1998. However, on one survey in the middle of this survey period they detected 45,278 large alcids. In Jan 2010, we observed a similar influx of alcids during aerial surveys (average number of alcids from 18 Nov to 22 Feb = 70 ± 129; CV = 184; Table 26). In sum, these offshore, deeper water habitats in the Ocean SAMP study area provide vital habitat for many avian species and it is likely that millions of migratory birds inhabit these offshore waters during some portion of their annual life cycle.

Endangered Species (Roseate Terns)

Roseate Terns are the only federally-listed endangered species of bird found in the Ocean SAMP study area. Our land-based and ship-based surveys that specifically focused on Roseate Terns (e.g., small boat tern surveys) revealed that Roseate Terns reside in the SAMP area only during mid-July to late-August (post-breeding) and this species is relatively uncommon. We observed most Roseate Terns in nearshore waters during seawatches, although we detected eight Roseate Terns during ship-based surveys in August. An ornithologist working for New Jersey Audubon Society on Block Island consistently observed up to 100 Roseate Terns on the island on any given day during August. This suggests that Roseate Terns are commuting through offshore waters during this post-breeding period before they eventually reach Cape Cod prior to fall migration.

Bathymetry as an Important Driver of Avian Species Composition: A Comparison with Nantucket Sound

We found water depth to be an important physical variable driving spatial distribution and abundance of avian species within the SAMP study area, and this is a relatively unique aspect of the Ocean SAMP study area. For example, the bathymetry of Nantucket Sound is much shallower (primarily <20 m deep) than the Ocean SAMP study area (<8% of the Ocean SAMP study area is <20 m deep) and avian community composition between Nantucket Sound and the RI Ocean SAMP study area was strikingly dissimilar. We found that seaducks in the Ocean SAMP area were mostly restricted to waters <25 m deep (Fig. 75), which is a relatively small portion of the study area, and we detected far fewer seaducks in the Ocean SAMP study area during the winter of 2009-2010 than in Nantucket Sound in the mid-2000s.

Perkins et al. (2005) estimated 280,000 and 204,000 Common Eider; 83,000 and 277,000 scoter in the winters of 2004-04 and 2004-05, respectively, in Nantucket Sound. Seaduck abundance within Nantucket Sound reflects the availability of benthic prey for scoters and eiders that typically utilize shallow habitats <20 m deep for feeding (Ydenberg and Guillemetter 1991, Lewis 2005, Kaiser 2006, NERI 2006). In contrast, thousands of shearwaters and storm-petrels use the deeper southern sections of the SAMP area during summer and large numbers of alcids (Razorbill, Common and Thick-billed Murre, Dovekie) move into the SAMP area to feed on krill (e.g., euphausiids), decapods, fish and squid (Brown 1988, Huettmann et al. 2005) during the winter. These species are much less common in Nantucket Sound because deepwater foraging habitat is not available. The bathymetry of Rhode Island Sound and Block Island Sound provides seaducks and seabirds with a much broader spectrum of water depth choices, including much deeper areas, than in Nantucket Sound. Consequently, water depth is an important determinant of the distribution, abundance, and species composition of birds in the Ocean SAMP study area.

Review of Survey Methodology

The survey methods that we used provide an accurate assessment of the distribution and abundance of birds in the Ocean SAMP study area on mostly fair-weather days during the diurnal portion of the study period. The 800 land-based seawatch surveys that were conducted throughout the year for this report allowed us to quantify migration phenology and spatial variation in use of nearshore habitats. In addition, compared to ship-based and aerial surveys, land-based seawatches were relatively inexpensive to conduct. However, land-based seawatches only provide information about bird distribution and abundance relatively close to the coast (<3 km from shore). In addition, it is extremely difficult to standardize protocols among stations (e.g., elevation of the observer above the ocean surface, area sampled at each station, habitat characteristics vary among stations); thus, these point count data are too complex to analyze in a DISTANCE framework (Buckland et al. 2001) to estimate density patterns among stations.

One of the primary methods we used to accurately assess the spatial distribution, abundance, and behavior of birds in the Ocean SAMP study area was ship-based surveys, which have been used by ornithologists for almost 100 years (Jespersen 1924), with standardized protocols in place for 25 years (Tasker 1984, Camphuysen et al. 2004). However, because standardized survey protocols recommend the vessels moves at 10 km/hr, many hours (multiple days) of survey effort are needed to adequately cover a study area as large as the Ocean SAMP area. Yet, recent advances in line transect methods allowed us to model the spatial distribution and abundance of bird density across the entire study area from these restricted surveys (Ronconi and Burger 2009).

We also used aerial strip transect surveys along with the land-based and ship-based surveys to document distribution and abundance of birds in the Ocean SAMP study area. Aerial surveys allowed observers to cover portions of the entire Ocean SAMP study area in one day (approximately 3 hrs to survey every third transect; Fig. 26). Disadvantages of aerial surveys include identification of all birds to species is not possible (e.g., diving loons, small alcids, dark scoters) and flight altitude and flight direction of flying birds cannot be recorded. Despite these limitations, aerial transect surveys remain the primary method of choice for large-scale studies of nearshore and offshore birds especially in relation to offshore development projects (e.g., Camphuysen et al. 2004). After we complete at least one year of aerial surveys, we will use the DISTANCE framework (Buckland et al. 2001) and the data from both the aerial and ship-based surveys to estimate density of birds throughout the Ocean SAMP study area.

Importance of Long Term Avian Research: Inter-annual Variation in Avian Abundance

We documented considerable inter-annual variation in spatial distribution and abundance of birds during our surveys from Jan 2009 to Feb 2010, which is consistent with other longer-term studies of seabirds and seaducks. Seaducks were relatively more abundant during land-based seawatches in the winter of 2008-2009 compared to the winter of 2009-2010. For example, at Brenton Point (a primary foraging spot for seaducks) from 27 Jan to 25 March 2009, we counted on average 5,730 ± 4,250 (SD) scoters and eiders during each survey on the water (max = 16,055 on 6 March 2009). In contrast, from 2 Nov 2009 to 18 Feb 2010, we only detected on average 412 ± 192 (max = 1,107) scoters and eiders on the water. Thus, although we detected relatively few seaducks during aerial and ship based surveys during 2009-2010, it was likely a reflection of the relatively low numbers of seaducks in Rhode Island that winter. Locally, Perkins et al. (2004, 2005) documented substantial annual variation in the spatial distribution and abundance of seaduck flocks in Nantucket Sound. This inter-annual variation in abundance of birds makes it necessary to conduct avian surveys over an extended time period so that an accurate baseline assessment of the distribution and abundance of birds is available for comparison with data collected before, during, and after proposed development projects.

Daily Movement Patterns of Birds

Our surveys were designed to reliably estimate bird distribution and abundance throughout the year, but such surveys do not provide direct information about local daily movement patterns of seaducks in the Ocean SAMP study area. Near Nantucket Island, Long-tailed Ducks commute daily from nocturnal roosting sites in Nantucket Sound to Nantucket Shoals, up to 70 km offshore where they forage for pelagic amphipods in waters <20 m deep (White et al. 2009). We detected very few Long-tailed Ducks during our fieldwork. However, we did observe large numbers of scoters (primarily Surf and Black Scoter) emigrating south of the Sakonnet River into Rhode Island Sound every evening and then large numbers of birds immigrating north back up the Sakonnet River in the evening from January through March 2010. Documenting such regular daily movements of large numbers of birds within the Ocean SAMP study area would help delineate commuting corridors and help determine nocturnal roosting sites of seaducks, important information to consider when determining the location of offshore development projects. During 2011-2012, we will monitor the local movements of Surf Scoters implanted with satellite transmitters so that commuting corridors and frequently used nocturnal roosting sites can be delineated.

Summary

This report provides the first quantitative estimates of the spatial distribution and abundance of birds in the nearshore and offshore waters of Rhode Island. We have documented substantial avian use of nearshore habitats throughout the year. During winter, these nearshore waters are especially vital to a variety of species including seaducks, loons, grebes, gannets and cormorants. During summer, these nearshore waters become important for terns, gulls, and shorebirds. In contrast, offshore areas in Rhode Island Sound and the Inner Continental Shelf provide important wintering habitat for alcids, kittiwakes, gannets, gulls, and other species. During summer, these offshore areas provide critical habitat for a variety of seabirds that migrate long distances to reach Rhode Island waters. Storm-Petrels, from breeding colonies in Antarctica, and shearwaters, from breeding colonies in the southern central Atlantic Ocean, pass through Rhode Island during their annual migration around the perimeter of the Atlantic Ocean. These long-distance migrants are among the most numerous birds in the Ocean SAMP study area during this time. The distribution, abundance, and species composition of birds that we have documented in the Ocean SAMP study area are in part the product of the broad spectrum of water depths in Rhode Island Sound and Block Island Sound, its associated effects on many aspects of the ecosystem (e.g., water temperature, circulation, productivity), and the geographic location of Rhode Island waters with respect to one of the major bird migration corridors in North America.

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APPENDICES

Appendix A. List of birds that could occur in Ocean SAMP study area. Given are common name, scientific name, Status (A= abundant, C = Common, U = uncommon, O = occasional, V = vagrant; based on Conway 1979), and whether the species was detected during any Ocean SAMP survey from Jan 2009 through mid-Feb 2010 (either land-based seawatch, ship-based grid, or aerial survey).

Common Name	Scientific Name	Status	On SAMP Surveys?
Red-throated Loon	*Gavia stellata*	A	Yes
Pacific Loon	*Gavia pacifica*	V	Yes
Common Loon	*Gavia immer*	A	Yes
Pied-billed Grebe	*Podilymbus podiceps*	U	
Horned Grebe	*Podiceps auritus*	C	Yes
Red-necked Grebe	*Podiceps grisegena*	U	Yes
Yellow-nosed Albatross	*Thalassarche chlororhynchos*	V	
Northern Fulmar	*Fulmarus glacialis*	U	Yes
Cory's Shearwater	*Calonectris diomedea*	A	Yes
Greater Shearwater	*Puffinus gravis*	A	Yes
Sooty Shearwater	*Puffinus griseus*	C	Yes
Manx Shearwater	*Puffinus puffinus*	C	Yes
Audubon's Shearwater	*Puffinus lherminieri*	V	
Wilson's Storm-Petrel	*Oceanites oceanicus*	A	Yes
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	U	Yes
Red-billed Tropicbird	*Phaethon aethereus*	V	
Northern Gannet	*Morus bassanus*	A	Yes
American White Pelican	*Pelecanus erythrorhynchos*	V	
Brown Pelican	*Pelecanus occidentalis*	V	
Double-crested Cormorant	*Phalacrocorax auritus*	A	Yes
Great Cormorant	*Phalacrocorax carbo*	C	Yes
Magnificent Frigatebird	*Fregata magnificens*	V	
American Bittern	*Botaurus lentiginosus*	U	
Least Bittern	*Ixobrychus exilis*	O	
Great Blue Heron	*Ardea herodias*	C	Yes
Great Egret	*Ardea alba*	C	Yes
Snowy Egret	*Egretta thula*	C	Yes
Little Blue Heron	*Egretta caerulea*	U	
Tricolored Heron	*Egretta tricolor*	U	
Cattle Egret	*Bubulcus ibis*	U	Yes

Green Heron	*Butorides virescens*	C	Yes
Black-crowned Night-Heron	*Nycticorax nycticorax*	C	Yes
Yellow-crowned Night-Heron	*Nyctanassa violacea*	U	
White Ibis	*Eudocimus albus*	V	
Glossy Ibis	*Plegadis falcinellus*	C	Yes
Mute Swan	*Cygnus olor*	C	Yes
Tundra Swan	*Cygnus columbianus*	V	Yes
Greater White-fronted Goose	*Anser albifrons*	V	
Snow Goose	*Chen caerulescens*	U	
Brant	*Branta bernicla*	C	Yes
Cackling Goose	*Branta hutchinsii*	O	
Canada Goose	*Branta canadensis*	A	Yes
Wood Duck	*Aix sponsa*	C	Yes
Gadwall	*Anas strepera*	C	Yes
Eurasian Wigeon	*Anas penelope*	V	
American Wigeon	*Anas americana*	A	Yes
American Black Duck	*Anas rubripes*	A	Yes
Mallard	*Anas platyrhynchos*	A	Yes
Blue-winged Teal	*Anas discors*	C	
Northern Shoveler	*Anas clypeata*	O	
Northern Pintail	*Anas acuta*	C	
Green-winged Teal	*Anas crecca*	C	Yes
Canvasback	*Aythya valisineria*	U	
Redhead	*Aythya americana*	C	Yes
Ring-necked Duck	*Aythya collaris*	C	Yes
Tufted Duck	*Aythya fuligula*	V	
Greater Scaup	*Aythya marila*	A	Yes
Lesser Scaup	*Aythya affinis*	C	Yes
King Eider	*Somateria spectabilis*	V	Yes
Common Eider	*Somateria mollissima*	A	Yes
Harlequin Duck	*Histrionicus histrionicus*	C	Yes
Surf Scoter	*Melanitta perspicillata*	A	Yes
White-winged Scoter	*Melanitta fusca*	A	Yes
Black Scoter	*Melanitta nigra*	A	Yes
Long-tailed Duck	*Clangula hyemalis*	U	Yes
Bufflehead	*Bucephala albeola*	C	Yes
Common Goldeneye	*Bucephala clangula*	C	Yes
Barrow's Goldeneye	*Bucephala islandica*	V	
Smew	*Mergellus albellus*	V	
Hooded Merganser	*Lophodytes cucullatus*	C	Yes
Common Merganser	*Mergus merganser*	U	Yes

Red-breasted Merganser	*Mergus serrator*	A	Yes
Ruddy Duck	*Oxyura jamaicensis*	A	Yes
Black Vulture	*Coragyps atratus*	U	
Turkey Vulture	*Cathartes aura*	C	
Osprey	*Pandion haliaetus*	C	Yes
Swallow-tailed Kite	*Elanoides forficatus*	V	
Bald Eagle	*Haliaeetus leucocephalus*	U	
Northern Harrier	*Circus cyaneus*	C	Yes
Sharp-shinned Hawk	*Accipiter striatus*	C	Yes
Cooper's Hawk	*Accipiter cooperii*	C	Yes
Northern Goshawk	*Accipiter gentilis*	U	
Red-shouldered Hawk	*Buteo lineatus*	U	
Broad-winged Hawk	*Buteo platypterus*	C	Yes
Red-tailed Hawk	*Buteo jamaicensis*	C	
Rough-legged Hawk	*Buteo lagopus*	U	
American Kestrel	*Falco sparverius*	U	Yes
Merlin	*Falco columbarius*	C	Yes
Peregrine Falcon	*Falco peregrinus*	C	Yes
Clapper Rail	*Rallus longirostris*	U	
King Rail	*Rallus elegans*	U	
Virginia Rail	*Rallus limicola*	C	
Sora	*Porzana carolina*	C	
Common Moorhen	*Gallinula chloropus*	U	
American Coot	*Fulica americana*	C	
Sandhill Crane	*Grus canadensis*	O	
Black-bellied Plover	*Pluvialis squatarola*	C	Yes
American Golden-Plover	*Pluvialis dominica*	O	
Semipalmated Plover	*Charadrius semipalmatus*	C	Yes
Piping Plover	*Charadrius melodus*	U	Yes
Killdeer	*Charadrius vociferus*	C	Yes
American Oystercatcher	*Haematopus palliatus*	U	Yes
Black-necked Stilt	*Himantopus mexicanus*	V	
American Avocet	*Recurvirostra americana*	V	
Spotted Sandpiper	*Actitis macularius*	O	Yes
Solitary Sandpiper	*Tringa solitaria*	U	
Greater Yellowlegs	*Tringa melanoleuca*	C	Yes
Willet	*Tringa semipalmata*	C	Yes
Lesser Yellowlegs	*Tringa flavipes*	U	Yes
Upland Sandpiper	*Bartramia longicauda*	O	
Whimbrel	*Numenius phaeopus*	O	Yes
Hudsonian Godwit	*Limosa haemastica*	O	

Ruddy Turnstone	*Arenaria interpres*	A	Yes
Red Knot	*Calidris canutus*	U	
Sanderling	*Calidris alba*	C	
Semipalmated Sandpiper	*Calidris pusilla*	C	Yes
Western Sandpiper	*Calidris mauri*	O	
Least Sandpiper	*Calidris minutilla*	C	Yes
White-rumped Sandpiper	*Calidris fuscicollis*	O	Yes
Baird's Sandpiper	*Calidris bairdii*	O	
Pectoral Sandpiper	*Calidris melanotos*	O	
Purple Sandpiper	*Calidris maritima*	C	Yes
Dunlin	*Calidris alpina*	A	Yes
Ruff	*Philomachus pugnax*	V	
Short-billed Dowitcher	*Limnodromus griseus*	C	Yes
Long-billed Dowitcher	*Limnodromus scolopaceus*	O	
Wilson's Snipe	*Gallinago delicata*	U	
American Woodcock	*Scolopax minor*	C	
Wilson's Phalarope	*Phalaropus tricolor*	O	
Red-necked Phalarope	*Phalaropus lobatus*	O	Yes
Red Phalarope	*Phalaropus fulicarius*	O	
Black-legged Kittiwake	*Rissa tridactyla*	C	Yes
Sabine's Gull	*Xema sabini*	V	
Bonaparte's Gull	*Chroicocephalus philadelphia*	U	Yes
Little Gull	*Hydrocoloeus minutus*	V	Yes
Laughing Gull	*Leucophaeus atricilla*	A	Yes
Franklin's Gull	*Leucophaeus pipixcan*	V	
Black-tailed Gull	*Larus crassirostris*	V	
Ring-billed Gull	*Larus delawarensis*	C	Yes
Herring Gull	*Larus argentatus*	A	Yes
Iceland Gull	*Larus glaucoides*	O	Yes
Lesser Black-backed Gull	*Larus fuscus*	O	
Glaucous Gull	*Larus hyperboreus*	O	
Great Black-backed Gull	*Larus marinus*	A	Yes
Sooty Tern	*Onychoprion fuscatus*	V	
Least Tern	*Sternula antillarum*	C	Yes
Gull-billed Tern	*Gelochelidon nilotica*	V	
Caspian Tern	*Hydroprogne caspia*	O	Yes
Black Tern	*Chlidonias niger*	U	Yes
Roseate Tern	*Sterna dougallii*	C	Yes
Common Tern	*Sterna hirundo*	A	Yes
Arctic Tern	*Sterna paradisaea*	O	
Forster's Tern	*Sterna forsteri*	U	

Royal Tern	*Thalasseus maximus*	O	Yes
Sandwich Tern	*Thalasseus sandvicensis*	V	
Black Skimmer	*Rynchops niger*	O	Yes
Pomarine Jaeger	*Stercorarius pomarinus*	C	Yes
Parasitic Jaeger	*Stercorarius parasiticus*	U	Yes
Long-tailed Jaeger	*Stercorarius longicaudus*	O	Yes
Dovekie	*Alle alle*	A	Yes
Common Murre	*Uria aalge*	C	Yes
Thick-billed Murre	*Uria lomvia*	U	Yes
Razorbill	*Alca torda*	A	Yes
Black Guillemot	*Cepphus grylle*	U	Yes
Long-billed Murrelet	*Brachyramphus perdix*	V	
Atlantic Puffin	*Fratercula arctica*	O	Yes
Rock Pigeon	*Columba livia*	A	Yes
Mourning Dove	*Zenaida macroura*	A	Yes
Yellow-billed Cuckoo	*Coccyzus americanus*	O	
Black-billed Cuckoo	*Coccyzus erythropthalmus*	O	
Barn Owl	*Tyto alba*	O	
Eastern Screech-Owl	*Megascops asio*	U	
Great Horned Owl	*Bubo virginianus*	C	
Snowy Owl	*Bubo scandiacus*	O	
Barred Owl	*Strix varia*	O	
Great Gray Owl	*Strix nebulosa*	V	
Long-eared Owl	*Asio otus*	O	
Short-eared Owl	*Asio flammeus*	O	Yes
Northern Saw-whet Owl	*Aegolius acadicus*	C	
Common Nighthawk	*Chordeiles minor*	U	
Whip-poor-will	*Caprimulgus vociferus*	C	
Chimney Swift	*Chaetura pelagica*	C	Yes
Ruby-throated Hummingbird	*Archilochus colubris*	C	Yes
Belted Kingfisher	*Megaceryle alcyon*	C	Yes
Yellow-bellied Sapsucker	*Sphyrapicus varius*	U	
Downy Woodpecker	*Picoides pubescens*	A	
Hairy Woodpecker	*Picoides villosus*	U	
Northern Flicker	*Colaptes auratus*	A	Yes
Pileated Woodpecker	*Dryocopus pileatus*	O	
Eastern Wood-Pewee	*Contopus virens*	C	
Acadian Flycatcher	*Empidonax virescens*	O	
Alder Flycatcher	*Empidonax alnorum*	O	
Willow Flycatcher	*Empidonax traillii*	O	
Least Flycatcher	*Empidonax minimus*	O	

Eastern Phoebe	*Sayornis phoebe*	C	
Say's Phoebe	*Sayornis saya*	V	
Great Crested Flycatcher	*Myiarchus crinitus*	C	
Eastern Kingbird	*Tyrannus tyrannus*	C	Yes
Scissor-tailed Flycatcher	*Tyrannus forficatus*	V	
Northern Shrike	*Lanius excubitor*	U	
White-eyed Vireo	*Vireo griseus*	O	
Yellow-throated Vireo	*Vireo flavifrons*	O	
Blue-headed Vireo	*Vireo solitarius*	O	
Philadelphia Vireo	*Vireo philadelphicus*	O	
Red-eyed Vireo	*Vireo olivaceus*	C	
Blue Jay	*Cyanocitta cristata*	A	Yes
American Crow	*Corvus brachyrhynchos*	C	Yes
Fish Crow	*Corvus ossifragus*	C	Yes
Common Raven	*Corvus corax*	O	
Horned Lark	*Eremophila alpestris*	U	Yes
Purple Martin	*Progne subis*	U	Yes
Tree Swallow	*Tachycineta bicolor*	A	Yes
N. Rough-winged Swallow	*Stelgidopteryx serripennis*	O	Yes
Bank Swallow	*Riparia riparia*	U	Yes
Cliff Swallow	*Petrochelidon pyrrhonota*	O	Yes
Cave Swallow	*Petrochelidon fulva*	V	
Barn Swallow	*Hirundo rustica*	C	Yes
Black-capped Chickadee	*Poecile atricapillus*	A	
Tufted Titmouse	*Baeolophus bicolor*	A	
Red-breasted Nuthatch	*Sitta canadensis*	C	
Brown Creeper	*Certhia americana*	C	
Carolina Wren	*Thryothorus ludovicianus*	C	
House Wren	*Troglodytes aedon*	C	
Winter Wren	*Troglodytes troglodytes*	O	
Sedge Wren	*Cistothorus platensis*	O	
Marsh Wren	*Cistothorus palustris*	O	
Golden-crowned Kinglet	*Regulus satrapa*	C	
Ruby-crowned Kinglet	*Regulus calendula*	C	
Blue-gray Gnatcatcher	*Polioptila caerulea*	O	
Northern Wheatear	*Oenanthe oenanthe*	V	
Eastern Bluebird	*Sialia sialis*	U	
Veery	*Catharus fuscescens*	C	
Gray-cheeked Thrush	*Catharus minimus*	O	
Bicknell's Thrush	*Catharus bicknelli*	O	
Swainson's Thrush	*Catharus ustulatus*	O	

Hermit Thrush	*Catharus guttatus*	O	
Wood Thrush	*Hylocichla mustelina*	C	
American Robin	*Turdus migratorius*	A	Yes
Varied Thrush	*Ixoreus naevius*	V	
Gray Catbird	*Dumetella carolinensis*	A	
Northern Mockingbird	*Mimus polyglottos*	C	
Brown Thrasher	*Toxostoma rufum*	U	
European Starling	*Sturnus vulgaris*	A	
American Pipit	*Anthus rubescens*	U	
Bohemian Waxwing	*Bombycilla garrulus*	U	
Cedar Waxwing	*Bombycilla cedrorum*	A	Yes
Blue-winged Warbler	*Vermivora pinus*	C	
Golden-winged Warbler	*Vermivora chrysoptera*	O	
Tennessee Warbler	*Vermivora peregrina*	O	
Orange-crowned Warbler	*Vermivora celata*	O	
Nashville Warbler	*Vermivora ruficapilla*	O	
Northern Parula	*Parula americana*	U	
Cape May Warbler	*Dendroica tigrina*	O	
Black-throated Blue Warbler	*Dendroica caerulescens*	U	
Yellow-rumped Warbler	*Dendroica coronata*	A	Yes
Black-throated Green Warbler	*Dendroica virens*	C	
Blackburnian Warbler	*Dendroica fusca*	U	
Yellow Warbler	*Dendroica petechia*	C	Yes
Chestnut-sided Warbler	*Dendroica pensylvanica*	C	
Magnolia Warbler	*Dendroica magnolia*	U	
Yellow-throated Warbler	*Dendroica dominica*	O	
Pine Warbler	*Dendroica pinus*	C	
Prairie Warbler	*Dendroica discolor*	C	
Palm Warbler	*Dendroica palmarum*	U	Yes
Bay-breasted Warbler	*Dendroica castanea*	O	
Blackpoll Warbler	*Dendroica striata*	C	Yes
Cerulean Warbler	*Dendroica cerulea*	O	
Black-and-white Warbler	*Mniotilta varia*	C	
American Redstart	*Setophaga ruticilla*	C	
Prothonotary Warbler	*Protonotaria citrea*	O	
Worm-eating Warbler	*Helmitheros vermivorum*	O	
Ovenbird	*Seiurus aurocapilla*	C	
Northern Waterthrush	*Seiurus noveboracensis*	O	
Louisiana Waterthrush	*Seiurus motacilla*	O	
Kentucky Warbler	*Oporornis formosus*	O	
Connecticut Warbler	*Oporornis agilis*	O	

Mourning Warbler	*Oporornis philadelphia*	O	
Common Yellowthroat	*Geothlypis trichas*	C	
Hooded Warbler	*Wilsonia citrina*	U	
Wilson's Warbler	*Wilsonia pusilla*	O	
Canada Warbler	*Wilsonia canadensis*	U	
Yellow-breasted Chat	*Icteria virens*	O	
Green-tailed Towhee	*Pipilo chlorurus*	V	
Eastern Towhee	*Pipilo erythrophthalmus*	C	
American Tree Sparrow	*Spizella arborea*	C	
Chipping Sparrow	*Spizella passerina*	C	
Clay-colored Sparrow	*Spizella pallida*	O	
Field Sparrow	*Spizella pusilla*	C	
Vesper Sparrow	*Pooecetes gramineus*	O	
Lark Sparrow	*Chondestes grammacus*	O	
Savannah Sparrow	*Passerculus sandwichensis*	U	Yes
Grasshopper Sparrow	*Ammodramus savannarum*	O	
Nelson's Sparrow	*Ammodramus nelsoni*	U	
Saltmarsh Sparrow	*Ammodramus caudacutus*	C	
Seaside Sparrow	*Ammodramus maritimus*	U	
Fox Sparrow	*Passerella iliaca*	U	
Song Sparrow	*Melospiza melodia*	A	
Lincoln's Sparrow	*Melospiza lincolnii*	U	
Swamp Sparrow	*Melospiza georgiana*	U	
White-throated Sparrow	*Zonotrichia albicollis*	A	
White-crowned Sparrow	*Zonotrichia leucophrys*	U	
Dark-eyed Junco	*Junco hyemalis*	A	Yes
Lapland Longspur	*Calcarius lapponicus*	U	
Snow Bunting	*Plectrophenax nivalis*	U	Yes
Summer Tanager	*Piranga rubra*	O	
Scarlet Tanager	*Piranga olivacea*	U	
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	U	
Blue Grosbeak	*Passerina caerulea*	O	
Indigo Bunting	*Passerina cyanea*	U	
Dickcissel	*Spiza americana*	O	
Bobolink	*Dolichonyx oryzivorus*	U	Yes
Red-winged Blackbird	*Agelaius phoeniceus*	C	
Eastern Meadowlark	*Sturnella magna*	O	
Yellow-headed Blackbird	*X. xanthocephalus*	O	
Rusty Blackbird	*Euphagus carolinus*	O	
Common Grackle	*Quiscalus quiscula*	C	Yes
Brown-headed Cowbird	*Molothrus ater*	A	Yes

Orchard Oriole	*Icterus spurius*	O	
Baltimore Oriole	*Icterus galbula*	U	
Purple Finch	*Carpodacus purpureus*	U	
House Finch	*Carpodacus mexicanus*	C	
Red Crossbill	*Loxia curvirostra*	U	
White-winged Crossbill	*Loxia leucoptera*	O	
Common Redpoll	*Acanthis flammea*	O	
Pine Siskin	*Spinus pinus*	U	
American Goldfinch	*Spinus tristis*	C	Yes
House Sparrow	*Passer domesticus*	A	

Appendix B. Mean (SD) number of detections of birds **on the water** at 11 land-based seawatch stations along coastal Rhode Island at northern edge of Ocean SAMP study area from Jan 2009 through mid-Feb 2010. N = total number of detections at that station (Watch Hill to Pt. Judith).

	Watch Hill			East Beach			Deep Hole			Pt Judith		
	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
Red-throated Loon	0.43	1.15	33	3.38	12.30	264	1.18	3.18	94	1.36	3.47	116
Pacific Loon	0.01	0.11	1	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Common Loon	7.40	12.22	570	9.81	14.53	765	6.29	9.47	503	4.21	6.09	358
Loon spp.	0.21	1.23	16	0.26	2.26	20	0.03	0.22	2	0.01	0.11	1
Red-necked Grebe	0.00	0.00	0	0.03	0.16	2	0.01	0.11	1	0.13	0.43	11
Horned Grebe	1.16	2.66	89	3.22	5.59	251	0.93	2.12	74	1.14	3.14	97
Cory's Shearwater	0.00	0.00	0	0.10	0.91	8	0.00	0.00	0	0.79	7.27	67
Wilson's Storm-Petrel	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.01	0.11	1
Great Cormorant	0.27	1.10	21	0.03	0.16	2	0.01	0.11	1	0.55	1.28	47
Double-c. Cormorant	7.10	15.71	547	1.19	2.93	93	2.19	10.73	175	2.98	6.76	253
Northern Gannet	0.04	0.25	3	0.37	2.74	29	0.20	1.58	16	0.44	2.85	37
Snowy Egret	0.00	0.00	0	0.01	0.11	1	0.00	0.00	0	0.00	0.00	0
Mute Swan	0.04	0.34	3	0.01	0.11	1	0.05	0.35	4	0.04	0.24	3
Canada Goose	0.00	0.00	0	0.64	5.66	50	0.00	0.00	0	0.00	0.00	0
Atlantic Brant	1.45	10.53	112	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Am. Black Duck	0.05	0.32	4	0.05	0.32	4	0.08	0.38	6	0.02	0.22	2
Greater Scaup	0.00	0.00	0	0.00	0.00	0	4.33	22.75	346	0.00	0.00	0
Common Eider	16.47	44.56	1268	73.83	209.27	5759	54.11	198.47	4329	27.59	100.51	2345
Long-tailed Duck	0.16	0.67	12	0.24	1.06	19	0.16	1.14	13	0.48	2.06	41
Surf Scoter	23.62	123.13	1819	0.73	3.98	57	0.04	0.19	3	2.72	13.11	231
Black Scoter	12.73	55.11	980	13.90	91.01	1084	0.88	5.35	70	2.99	13.79	254
Surf or Black Scoter	1.23	10.83	95	0.38	3.40	30	0.00	0.00	0	0.00	0.00	0
White-winged Scoter	16.29	73.09	1254	13.13	60.84	1024	0.03	0.16	2	0.01	0.11	1
Scoter spp.	192.3	799.87	14808	91.54	492.64	7140	0.14	1.23	11	0.15	0.87	13
Common Goldeneye	0.08	0.31	6	0.49	1.47	38	1.58	4.32	126	1.65	4.33	140

Appendix B. continued.

	Watch Hill			East Beach			Deep Hole			Pt Judith		
	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
Bufflehead	0.03	0.16	2	0.00	0.00	0	0.41	2.30	33	0.00	0.00	0
Red-brd Merganser	1.96	3.44	151	0.77	2.00	60	20.46	44.28	1637	14.61	31.14	1242
Seaduck spp.	0.00	0.00	0	38.46	251.87	3000	0.00	0.00	0	0.00	0.00	0
Ruddy Duck	0.00	0.00	0	0.21	1.27	16	0.00	0.00	0	0.00	0.00	0
Purple Sandpiper	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.11	0.98	9
Sanderling	0.00	0.00	0	3.14	20.40	245	0.00	0.00	0	0.00	0.00	0
Semipal. Sandpiper	0.00	0.00	0	0.01	0.11	1	0.00	0.00	0	0.00	0.00	0
Bonaparte's Gull	0.01	0.11	1	0.00	0.00	0	0.01	0.11	1	0.02	0.15	2
Laughing Gull	1.12	4.14	86	0.91	3.75	71	0.19	0.75	15	0.39	2.87	33
Ring-billed Gull	0.05	0.22	4	0.55	2.43	43	0.61	2.76	49	0.04	0.19	3
Herring Gull	3.16	7.12	243	9.68	32.09	755	5.51	14.16	441	3.15	6.84	268
Great Black-bd. Gull	1.01	1.93	78	5.26	20.66	410	2.16	5.05	173	3.05	5.64	259
Black-ld. Kittiwake	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.01	0.11	1
Gull spp.	0.58	3.80	45	2.69	18.21	210	0.10	0.89	8	0.12	1.08	10
Common Tern	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.01	0.11	1
Thick-billed Murre	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.01	0.11	1
Razorbill	0.05	0.46	4	0.00	0.00	0	0.00	0.00	0	0.28	1.35	24
Dovekie	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.01	0.11	1
Black Guillemot	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.01	0.11	1
Alcid spp.	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.04	0.33	3
Common Grackle	0.00	0.00	0	0.00	0.00	0	0.03	0.22	2	0.00	0.00	0
Overall	289.0	839.84	22255	275.03	681.75	21452	101.69	212.50	8135	69.13	132.14	5876

Appendix B continued. Birds detected on the water during land-based seawatches (Monahan's Dock to Ruggles Ave)

	M. Dock			Beavertail			Brenton Point			Ruggles		
	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
Red-throated Loon	2.93	8.14	264	0.42	1.22	34	0.17	0.45	11	4.15	13.55	270
Common Loon	4.61	8.23	415	1.63	2.65	132	5.06	6.90	329	7.29	13.30	474
Loon spp.	0.04	0.30	4	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Red-necked Grebe	0.07	0.25	6	0.07	0.31	6	0.06	0.35	4	0.32	1.54	21
Horned Grebe	0.36	0.83	32	0.49	1.34	40	2.15	4.10	140	8.65	44.18	562
Cory's Shearwater	0.14	1.37	13	0.00	0.00	0	0.85	6.82	55	0.43	3.12	28
Shearwater spp.	0.00	0.00	0	0.00	0.00	0	0.02	0.12	1	0.00	0.00	0
Great Cormorant	0.22	0.99	20	0.67	1.57	54	0.28	1.53	18	0.71	1.85	46
Double-c. Cormorant	3.74	12.97	337	2.17	3.48	176	6.63	11.79	431	2.66	4.62	173
Northern Gannet	0.34	2.10	31	0.00	0.00	0	0.18	0.85	12	0.20	0.83	13
Great Egret	0.01	0.11	1	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Mute Swan	0.06	0.27	5	0.00	0.00	0	0.00	0.00	0	0.02	0.12	1
Canada Goose	0.47	3.11	42	0.01	0.11	1	0.00	0.00	0	5.08	19.60	330
Atlantic Brant	0.08	0.46	7	1.05	8.79	85	0.80	2.77	52	0.00	0.00	0
Mallard	0.03	0.32	3	0.02	0.22	2	0.03	0.17	2	0.00	0.00	0
Am. Black Duck	0.14	0.63	13	0.11	0.50	9	0.18	0.85	12	0.18	0.63	12
Gadwall	0.00	0.00	0	0.02	0.22	2	0.06	0.50	4	0.00	0.00	0
American Wigeon	0.00	0.00	0	0.02	0.22	2	0.03	0.25	2	0.00	0.00	0
Green-winged Teal	0.00	0.00	0	0.00	0.00	0	0.02	0.12	1	0.00	0.00	0
Greater Scaup	0.02	0.21	2	0.04	0.33	3	0.05	0.28	3	0.03	0.25	2
Common Eider	24.08	63.48	2167	87.48	182.16	7086	327.09	638.37	21261	37.88	62.75	2462
King Eider	0.00	0.00	0	0.02	0.16	2	0.35	0.96	23	0.00	0.00	0
Harlequin Duck	0.00	0.00	0	6.78	9.99	549	0.02	0.12	1	0.46	1.43	30
Long-tailed Duck	0.00	0.00	0	0.05	0.22	4	1.86	7.27	121	0.00	0.00	0
Surf Scoter	0.08	0.40	7	16.10	65.77	1304	376.00	959.43	24440	172.55	864.2	11216
Black Scoter	6.99	27.50	629	22.25	78.61	1802	291.71	572.49	18961	45.29	150.7	2944
Surf or Black Scoter	0.00	0.00	0	0.00	0.00	0	5.40	28.37	351	1.62	10.35	105

Appendix B. Continued.

	M. Dock			Beavertail			Brenton Point			Ruggles		
	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
White-winged Scoter	0.01	0.11	1	0.52	1.18	42	5.51	18.87	358	6.68	20.61	434
Scoter spp.	0.00	0.00	0	74.69	434.46	6050	51.18	232.78	3327	196.52	730.6	12774
Common Goldeneye	1.57	4.53	141	0.98	2.31	79	9.32	19.01	606	3.43	7.20	223
Barrow's Goldeneye	0.00	0.00	0	0.00	0.00	0	0.02	0.12	1	0.00	0.00	0
Bufflehead	0.01	0.11	1	0.12	0.75	10	0.51	2.05	33	2.58	5.32	168
Red-brd Merganser	5.53	7.69	498	3.69	5.81	299	14.94	21.39	971	4.20	7.04	273
Semipalmated Plover	0.00	0.00	0	0.00	0.00	0	0.06	0.39	4	0.00	0.00	0
Spotted Sandpiper	0.00	0.00	0	0.00	0.00	0	0.02	0.12	1	0.00	0.00	0
Purple Sandpiper	0.40	3.22	36	0.00	0.00	0	4.77	24.11	310	0.95	6.36	62
Sanderling	0.00	0.00	0	0.00	0.00	0	0.02	0.12	1	0.00	0.00	0
Bonaparte's Gull	0.60	2.49	54	0.23	1.19	19	0.03	0.17	2	0.00	0.00	0
Laughing Gull	1.17	9.01	105	0.53	2.33	43	1.42	9.11	92	2.48	11.77	161
Ring-billed Gull	1.76	9.28	158	0.47	2.10	38	0.29	1.54	19	0.22	0.78	14
Herring Gull	8.26	23.09	743	7.80	17.66	632	11.83	21.67	769	3.43	7.25	223
Great Black-bd. Gull	1.66	5.03	149	1.57	4.34	127	33.46	248.79	2175	1.63	3.11	106
Black-ld Kittiwake	0.01	0.11	1	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Gull spp.	1.33	12.65	120	0.62	3.98	50	0.03	0.25	2	1.55	8.95	101
Sterna spp.	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.37	2.98	24
Thick-billed Murre	0.01	0.11	1	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Razorbill	0.36	2.21	32	0.95	4.54	77	0.03	0.25	2	0.22	1.18	14
Alcid spp.	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.02	0.12	1
Tree Swallow	0.09	0.84	8	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Overall	67.18	90.09	6046	231.59	611.50	18759	1152.43	2244.00	74908	511.80	1236.4	33267

Appendix B continued. Birds detected on the water during land-based seawatches (Sachuest to Goosewing).

	Sachuest			Sakonnet			Goosewing		
Species	Mean	SD	N	Mean	SD	N	Mean	SD	N
Red-throated Loon	0.89	2.01	55	0.29	0.85	16	1.58	4.62	90
Common Loon	2.94	3.80	182	2.64	2.77	148	2.32	3.17	132
Loon spp.	0.03	0.18	2	0.00	0.00	0	0.02	0.13	1
Red-necked Grebe	0.11	0.55	7	0.00	0.00	0	0.00	0.00	0
Horned Grebe	1.26	2.19	78	0.61	1.51	34	0.58	1.28	33
Cory's Shearwater	0.02	0.13	1	0.00	0.00	0	0.00	0.00	0
Great Cormorant	0.11	0.41	7	0.05	0.30	3	0.18	0.63	10
Double-crested Cormorant	2.71	6.10	168	7.75	18.61	434	8.84	45.97	504
Northern Gannet	0.16	0.85	10	0.02	0.13	1	0.05	0.40	3
Great Egret	0.00	0.00	0	0.07	0.37	4	0.00	0.00	0
Mute Swan	0.00	0.00	0	0.00	0.00	0	0.19	1.33	11
Canada Goose	0.00	0.00	0	0.63	4.54	35	0.60	3.99	34
Atlantic Brant	0.50	2.55	31	0.30	1.91	17	0.14	1.06	8
Mallard	0.00	0.00	0	0.00	0.00	0	0.05	0.23	3
American Black Duck	0.89	3.62	55	0.27	0.88	15	4.28	14.16	244
Gadwall	0.00	0.00	0	0.00	0.00	0	0.07	0.53	4
American Wigeon	0.02	0.13	1	0.00	0.00	0	0.05	0.29	3
Greater Scaup	0.66	2.62	41	0.00	0.00	0	8.07	34.19	460
Scaup spp.	0.00	0.00	0	0.07	0.53	4	3.96	20.98	226
Common Eider	86.79	162.01	5381	39.91	61.13	2235	34.26	72.45	1953
Harlequin Duck	5.84	8.36	362	1.27	3.01	71	0.00	0.00	0
Long-tailed Duck	0.00	0.00	0	0.00	0.00	0	0.02	0.13	1
Surf Scoter	0.82	3.37	51	0.70	2.26	39	0.68	2.38	39
Black Scoter	5.55	21.28	344	2.14	11.09	120	5.79	11.57	330
Surf or Black Scoter	0.00	0.00	0	0.00	0.00	0	0.09	0.66	5
White-winged Scoter	3.27	8.63	203	2.89	9.13	162	5.19	10.09	296
Scoter spp.	15.69	83.81	973	7.20	34.41	403	2.77	11.27	158

Appendix B. Continued.

	Sachuest			Sakonnet			Goosewing		
Species	Mean	SD	N	Mean	SD	N	Mean	SD	N
Common Goldeneye	0.60	1.77	37	0.55	1.55	31	3.56	6.14	203
Barrow's Goldeneye	0.00	0.00	0	0.00	0.00	0	0.02	0.13	1
Bufflehead	0.98	2.61	61	0.05	0.30	3	3.77	8.26	215
Red-breasted Merganser	1.98	3.89	123	2.82	8.35	158	4.70	13.27	268
Seaduck spp.	0.00	0.00	0	0.00	0.00	0	1.32	9.93	75
Peregrine Falcon	0.00	0.00	0	0.02	0.13	1	0.00	0.00	0
Piping Plover	0.00	0.00	0	0.00	0.00	0	0.05	0.29	3
Semipalmated Plover	0.00	0.00	0	0.00	0.00	0	0.18	1.32	10
Spotted Sandpiper	0.03	0.25	2	0.00	0.00	0	0.00	0.00	0
Purple Sandpiper	0.24	1.91	15	0.05	0.40	3	0.00	0.00	0
Sanderling	0.00	0.00	0	0.00	0.00	0	0.88	6.62	50
Dunlin	0.19	1.52	12	0.00	0.00	0	0.00	0.00	0
Semipalmated Sandpiper	0.00	0.00	0	0.00	0.00	0	0.02	0.13	1
Laughing Gull	0.47	1.91	29	0.61	2.81	34	0.89	5.01	51
Ring-billed Gull	0.18	1.05	11	0.41	2.15	23	2.25	10.32	128
Herring Gull	1.65	4.25	102	12.93	40.43	724	63.58	331.64	3624
Iceland Gull	0.00	0.00	0	0.00	0.00	0	0.02	0.13	1
Great Black-backed Gull	0.48	0.94	30	5.46	15.22	306	2.77	5.50	158
Gull spp.	0.00	0.00	0	0.00	0.00	0	8.88	47.35	506
Common Tern	0.00	0.00	0	0.02	0.13	1	0.00	0.00	0
Razorbill	0.03	0.25	2	0.00	0.00	0	0.00	0.00	0
Overall	135.10	205.44	8376	89.73	91.16	5025	172.67	365.05	9842

Appendix C. Mean (SD) number of birds detected per hour **in flight** at 11 land-based seawatch stations along coastal Rhode Island from Jan 2009 to mid-Feb 2010. N = total number detections at that station (Watch Hill to Pt. Judith).

	Watch Hill			East Beach			Deep Hole			Point Judith		
Species	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
Red-throated Loon	0.9	2.6	66	0.57	2.33	45	0.98	3.57	79	2.80	5.98	238
Pacific Loon	0.0	0.0	0	0.00	0.00	0	0.01	0.11	1	0.01	0.05	1
Common Loon	1.8	4.7	137	2.39	6.26	187	3.91	12.32	313	3.99	13.61	339
Loon spp.	0.3	1.5	25	0.95	6.20	74	0.61	1.96	49	0.29	1.30	25
Red-necked Grebe	0.0	0.1	1	0.01	0.11	1	0.04	0.25	3	0.06	0.21	5
Horned Grebe	0.2	1.1	14	0.01	0.11	1	0.03	0.16	3	0.07	0.29	6
Cory's Shearwater	0.1	0.8	9	3.81	24.21	297	4.79	26.61	383	3.12	15.92	266
Greater Shearwater	0.0	0.0	0	0.02	0.13	2	0.00	0.00	0	0.01	0.05	1
Manx Shearwater	0.0	0.0	0	0.00	0.00	0	0.00	0.00	0	0.01	0.11	1
Sooty Shearwater	0.0	0.0	0	0.00	0.00	0	0.01	0.11	1	0.00	0.00	0
Shearwater spp.	0.0	0.0	0	1.04	8.51	82	3.79	33.54	304	0.25	1.20	22
Wilson's St.-Petrel	0.0	0.2	3	2.68	18.44	209	2.96	15.03	237	1.22	5.32	104
Leach's Storm-Petrel	0.0	0.0	0	0.00	0.00	0	0.01	0.06	1	0.00	0.00	0
Storm-Petrel spp.	0.0	0.0	0	0.00	0.00	0	0.01	0.11	1	0.00	0.00	0
Great Cormorant	1.9	3.3	143	0.47	0.95	37	2.23	5.26	179	3.00	6.34	255
Double-c Cormorant	17.8	40.9	1370	9.04	19.37	706	26.84	56.64	2148	10.42	21.40	886
Northern Gannet	3.8	12.3	290	6.90	26.27	538	5.89	14.69	472	16.04	40.17	1363
Great Blue Heron	0.0	0.0	0	0.03	0.16	2	0.09	0.73	8	0.02	0.12	2
Great Egret	0.0	0.2	2	0.02	0.13	2	0.01	0.06	1	0.01	0.05	1
Snowy Egret	0.0	0.1	1	0.03	0.16	2	0.04	0.24	3	0.00	0.00	0
Cattle Egret	0.0	0.0	0	0.00	0.00	0	0.00	0.00	0	0.01	0.05	1
Green Heron	0.0	0.0	0	0.00	0.00	0	0.04	0.34	3	0.00	0.00	0
Blk-c N-Heron	0.0	0.0	0	0.00	0.00	0	0.01	0.06	1	0.00	0.00	0
Glossy Ibis	0.0	0.0	0	0.18	1.42	14	0.00	0.00	0	0.00	0.00	0
Mute Swan	0.0	0.1	1	0.08	0.36	6	0.04	0.19	3	0.04	0.25	4
Canada Goose	0.9	3.8	71	0.35	1.46	27	0.63	2.84	50	1.14	4.26	97

Appendix C Continued.

	Watch Hill			East Beach			Deep Hole			Point Judith		
Species	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
Atlantic Brant	0.4	1.6	31	0.37	1.42	29	0.37	1.40	30	1.38	4.39	117
Wood Duck	0.1	0.5	4	0.00	0.00	0	0.04	0.34	3	0.00	0.00	0
Mallard	0.0	0.1	1	0.06	0.30	5	0.21	1.28	17	0.05	0.35	5
Am Black Duck	0.1	0.4	7	0.12	0.66	9	0.16	0.50	13	0.05	0.49	5
Gadwall	0.0	0.2	2	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Northern Pintail	0.0	0.0	0	0.00	0.00	0	0.00	0.00	0	0.01	0.05	1
American Wigeon	0.0	0.2	2	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Green-winged Teal	0.0	0.0	0	0.03	0.23	2	0.06	0.50	5	0.16	1.52	14
Teal spp.	0.0	0.0	0	0.00	0.00	0	0.01	0.06	1	0.00	0.00	0
Anas spp.	0.0	0.0	0	0.13	1.13	10	0.04	0.24	3	0.01	0.11	1
Greater Scaup	0.0	0.0	0	0.02	0.17	2	0.18	1.36	14	0.19	1.79	17
Scaup spp.	0.0	0.0	0	0.05	0.45	4	0.01	0.11	1	0.04	0.27	4
Aythya Spp.	0.0	0.0	0	0.03	0.23	2	0.21	1.11	17	0.00	0.00	0
Common Eider	38.7	191.4	2983	9.71	42.93	757	14.37	46.21	1150	23.94	85.50	2035
Long-tailed Duck	0.5	1.5	35	0.41	2.34	32	0.11	0.36	9	0.40	1.29	34
Surf Scoter	6.3	45.5	484	0.88	2.23	69	1.24	5.60	100	7.92	34.91	674
Black Scoter	7.4	36.8	571	1.63	5.43	128	1.26	6.34	101	15.11	73.64	1284
Surf or Black Scoter	0.6	2.3	44	1.44	4.72	112	1.99	7.16	160	3.39	11.96	288
White-winged Scoter	6.3	21.9	489	4.87	16.03	380	0.74	1.97	60	2.51	5.96	213
Scoter spp.	10.3	28.3	795	65.06	315.6	5075	4.98	8.85	398	18.79	78.74	1597
Common Goldeneye	0.0	0.2	3	0.05	0.27	4	0.16	0.67	13	0.30	1.28	26
Bufflehead	0.0	0.3	3	0.00	0.00	0	0.12	0.67	10	0.00	0.00	0
Hooded Merganser	0.0	0.0	0	0.00	0.00	0	0.02	0.17	2	0.00	0.00	0
Red-bd Merganser	1.3	2.5	100	0.85	2.08	67	1.62	2.87	130	4.45	9.88	379
Common Merganser	0.0	0.0	0	0.00	0.00	0	0.01	0.06	1	0.00	0.00	0
Seaduck spp.	0.0	0.0	0	8.65	58.92	675	0.83	3.79	66	0.11	0.98	9
Northern Harrier	0.0	0.1	1	0.01	0.11	1	0.00	0.00	0	0.00	0.00	0

Appendix C continued.

	Watch Hill			East Beach			Deep Hole			Point Judith		
Species	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
Osprey	0.1	0.2	5	0.05	0.21	4	0.09	0.33	8	0.01	0.11	1
Merlin	0.0	0.2	2	0.01	0.06	1	0.00	0.00	0	0.01	0.08	1
American Kestrel	0.0	0.2	3	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Peregrine Falcon	0.0	0.0	0	0.00	0.00	0	0.00	0.00	0	0.02	0.12	2
Black-bellied Plover	0.0	0.1	1	0.02	0.13	2	0.01	0.11	1	0.00	0.00	0
Piping Plover	0.0	0.0	0	0.04	0.34	3	0.01	0.06	1	0.00	0.00	0
Semipal. Plover	0.1	0.4	5	0.40	2.47	32	0.19	0.73	16	0.01	0.11	1
Killdeer	0.0	0.0	0	0.00	0.00	0	0.00	0.00	0	0.02	0.12	2
Am. Oystercatcher	0.0	0.1	1	0.00	0.00	0	0.00	0.00	0	0.02	0.12	2
Greater Yellowlegs	0.0	0.0	0	0.01	0.11	1	0.01	0.06	1	0.00	0.00	0
Lesser Yellowlegs	0.0	0.0	0	0.04	0.26	4	0.01	0.11	1	0.08	0.76	7
Willet	0.1	0.6	5	0.06	0.37	5	0.00	0.00	0	0.01	0.05	1
Spotted Sandpiper	0.0	0.1	1	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Whimbrel	0.0	0.2	4	0.12	0.91	9	0.00	0.00	0	0.08	0.58	7
Ruddy Turnstone	0.2	1.3	14	0.11	0.70	9	0.05	0.35	4	0.09	0.58	8
Purple Sandpiper	0.3	1.4	24	0.11	0.68	9	0.26	2.24	21	0.98	4.91	84
Sanderling	3.1	18.6	236	7.63	26.85	595	0.74	3.02	60	1.41	8.28	120
Dunlin	0.0	0.0	0	0.10	0.71	8	0.18	1.14	15	0.00	0.00	0
Semipal. Sandpiper	3.4	26.8	260	0.51	2.76	40	0.76	3.49	61	3.47	28.19	295
Peep spp.	0.7	3.4	53	1.72	8.31	134	0.53	3.19	43	1.22	5.43	104
Least Sandpiper	0.1	0.8	10	0.00	0.00	0	0.00	0.00	0	0.03	0.19	3
Short-bd Dowitcher	0.5	3.0	40	0.26	1.95	20	0.29	2.52	24	0.42	2.18	36
Shorebird Spp.	1.2	5.6	91	1.40	6.96	109	0.45	1.90	36	1.42	6.24	121
Pomarine Jaeger	0.0	0.0	0	0.00	0.00	0	0.00	0.00	0	0.01	0.11	1
Parasitic Jaeger	0.0	0.0	0	0.01	0.06	1	0.06	0.46	5	0.04	0.33	3
Jaeger spp.	0.0	0.0	0	0.00	0.00	0	0.01	0.06	1	0.00	0.00	0
Bonaparte's Gull	0.1	0.3	5	0.38	1.80	30	0.24	0.94	19	0.58	2.01	49

Appendix C Continued.

	Watch Hill			East Beach			Deep Hole			Point Judith		
Species	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
Laughing Gull	20.6	78.9	1587	11.31	26.60	882	9.24	33.43	739	8.85	30.27	752
Ring-billed Gull	3.0	8.8	232	1.99	4.63	155	1.97	4.68	157	1.63	3.56	138
Herring Gull	9.8	25.2	751	20.41	60.20	1592	21.28	26.87	1702	22.58	56.93	1919
Great Black-bd Gull	5.9	21.5	454	9.59	30.18	748	8.37	10.84	670	12.48	37.45	1061
Black-l. Kittiwake	0.0	0.2	2	0.01	0.11	1	0.02	0.10	2	0.22	0.91	19
Gull spp.	16.1	60.5	1236	32.66	141.19	2548	66.76	160.67	5341	6.13	31.69	521
Caspian Tern	0.0	0.0	0	0.01	0.11	1	0.00	0.00	0	0.00	0.00	0
Royal Tern	0.0	0.0	0	0.03	0.23	2	0.00	0.00	0	0.01	0.05	1
Common Tern	5.9	15.9	455	1.65	5.11	129	2.51	10.19	201	4.98	19.00	424
Forster's Tern	0.1	0.3	5	0.01	0.11	1	0.00	0.00	0	0.01	0.11	1
Roseate Tern	0.3	1.5	26	0.11	0.57	9	0.20	1.06	16	0.25	0.91	21
Least Tern	2.2	5.2	168	0.45	1.20	35	0.65	2.22	52	0.02	0.12	2
Black Tern	0.0	0.2	2	0.04	0.34	3	0.01	0.06	1	0.01	0.05	1
Sterna spp.	1.3	10.5	98	2.42	12.62	189	0.51	1.94	41	1.35	10.86	115
Black Skimmer	0.0	0.0	0	0.02	0.17	2	0.00	0.00	0	0.00	0.00	0
Murre spp.	0.0	0.0	0	0.00	0.00	0	0.00	0.00	0	0.01	0.05	1
Razorbill	0.1	0.5	5	0.01	0.11	1	0.03	0.22	2	0.64	2.08	54
Black Guillemot	0.0	0.0	0	0.00	0.00	0	0.00	0.00	0	0.01	0.05	1
Alcid spp.	0.0	0.1	1	0.06	0.46	5	0.01	0.08	1	0.47	2.10	40
Mourning Dove	0.0	0.1	1	0.00	0.00	0	0.00	0.00	0	0.01	0.11	1
Chimney Swift	0.0	0.1	1	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Ruby-t Hummbird	0.0	0.0	0	0.01	0.11	1	0.00	0.00	0	0.01	0.11	1
Belted Kingfisher	0.0	0.1	1	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Northern Flicker	0.0	0.0	0	0.00	0.00	0	0.00	0.00	0	0.01	0.05	1
Eastern Kingbird	0.0	0.0	0	0.01	0.06	1	0.00	0.00	0	0.00	0.00	0
Blue Jay	0.2	1.4	12	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Fish Crow	0.1	0.6	5	0.06	0.57	5	0.00	0.00	0	0.00	0.00	0

	Watch Hill			East Beach			Deep Hole			Point Judith		
Species	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
Horned Lark	0.0	0.1	1	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Purple Martin	0.0	0.0	0	0.02	0.13	2	0.02	0.12	2	0.01	0.05	1
N Rough-w Swallow	0.0	0.2	2	0.05	0.45	4	0.00	0.00	0	0.15	0.75	13
Bank Swallow	0.0	0.0	0	0.00	0.00	0	0.00	0.00	0	0.08	0.45	7
Tree Swallow	130.6	1144.6	10058	1.67	11.41	130	1.13	8.91	91	0.36	2.79	31
Cliff Swallow	0.0	0.0	0	0.01	0.11	1	0.00	0.00	0	0.00	0.00	0
Barn Swallow	0.4	2.0	34	0.21	0.97	17	0.11	0.45	9	0.08	0.41	7
American Pipit	0.0	0.0	0	0.00	0.00	0	0.01	0.06	1	0.00	0.00	0
Cedar Waxwing	0.0	0.0	0	0.00	0.00	0	0.00	0.00	0	0.01	0.11	1
Yellow Warbler	0.0	0.2	3	0.00	0.00	0	0.01	0.11	1	0.02	0.12	2
Palm Warbler	0.0	0.0	0	0.00	0.00	0	0.00	0.00	0	0.01	0.05	1
Snow Bunting	0.1	0.6	6	0.01	0.11	1	0.00	0.00	0	0.00	0.00	0
Brown-hd Cowbird	0.0	0.0	0	0.00	0.00	0	0.00	0.00	0	0.08	0.48	7
Common Grackle	0.0	0.0	0	0.00	0.00	0	0.00	0.00	0	0.04	0.24	3
Total	306.3	1184.5	23586	218.84	373.75	17069	199.22	245.34	15938	191.94	252.55	16315

Appendix C continued. Birds detected **in flight** during land-based seawatches (Monahan’s Dock to Ruggles Ave).

	Monahan's Dock			Beavertail			Brenton Point			Ruggles		
Species	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
Red-throated Loon	0.9	2.1	82	0.6	1.5	50	0.8	3.7	53	0.8	2.1	49
Common Loon	2.1	6.1	191	1.4	4.2	110	1.3	2.8	87	3.6	16.4	233
Loon spp.	0.8	4.3	74	0.3	1.0	26	0.2	1.1	12	0.5	2.8	32
Red-necked Grebe	0.0	0.1	1	0.0	0.1	1	0.0	0.1	1	0.0	0.1	2
Horned Grebe	0.0	0.1	1	0.0	0.2	4	0.3	2.5	22	0.1	0.6	8
Cory's Shearwater	0.4	2.0	33	0.6	2.8	51	4.8	24.5	312	2.3	12.8	151
Greater Shearwater	0.0	0.0	0	0.0	0.1	1	0.1	0.5	4	0.0	0.1	1
Manx Shearwater	0.0	0.2	3	0.0	0.1	1	0.0	0.0	0	0.0	0.0	0
Sooty Shearwater	0.0	0.1	1	0.0	0.0	0	0.0	0.1	1	0.0	0.1	1

Appendix C. Continued.

	Monahan's Dock			Beavertail			Brenton Point			Ruggles		
Species	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
Shearwater spp.	0.2	0.9	17	0.4	2.7	29	5.6	44.3	361	0.3	2.4	22
Wilson's Storm-Petrel	0.2	1.0	18	0.7	3.4	57	0.6	3.2	36	1.5	10.0	97
Great Cormorant	1.4	2.9	125	0.9	1.7	76	1.3	2.5	87	1.5	3.4	100
Double-cd Cormorant	9.9	15.3	888	9.5	13.8	770	23.0	31.1	1492	14.9	25.7	968
Northern Gannet	7.1	18.3	636	8.0	30.4	645	4.2	14.7	271	12.2	57.6	796
Great Blue Heron	0.0	0.1	1	0.1	0.4	5	0.0	0.1	1	0.0	0.2	2
Great Egret	0.2	0.7	17	0.0	0.0	0	0.0	0.0	0	0.0	0.2	3
Snowy Egret	0.0	0.1	1	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Cattle Egret	0.0	0.0	0	0.0	0.0	0	0.0	0.1	1	0.0	0.0	0
Black-crd Night-Heron	0.0	0.1	1	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Glossy Ibis	0.0	0.2	2	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Mute Swan	0.1	0.5	10	0.0	0.1	1	0.0	0.1	1	0.0	0.2	2
Canada Goose	5.1	12.8	456	1.4	10.1	114	0.7	3.5	43	7.0	24.1	456
Atlantic Brant	1.6	5.7	143	2.2	7.3	180	0.9	3.9	59	1.8	9.7	116
Mallard	0.1	0.4	6	0.0	0.1	2	0.1	0.4	6	0.0	0.1	1
American Black Duck	0.1	0.5	12	0.0	0.2	3	0.3	1.7	20	0.3	1.1	17
Gadwall	0.0	0.1	1	0.0	0.0	0	0.1	0.3	5	0.0	0.0	0
American Wigeon	0.0	0.0	0	0.0	0.2	2	0.0	0.0	0	0.0	0.0	0
Green-winged Teal	0.0	0.0	0	0.1	1.3	12	0.0	0.0	0	0.0	0.0	0
Anas spp.	0.1	0.7	7	0.0	0.3	4	0.0	0.1	1	0.0	0.2	3
Greater Scaup	0.0	0.3	4	0.0	0.2	2	0.0	0.0	0	0.0	0.2	2
Scaup spp.	0.0	0.2	3	0.3	2.3	28	0.0	0.0	0	0.0	0.0	0
Aythya Spp.	0.1	0.5	5	0.0	0.2	2	0.0	0.0	0	0.0	0.0	0
Common Eider	11.7	39.4	1054	18.2	43.1	1475	40.8	122.4	2650	15.8	32.8	1029
King Eider	0.0	0.0	0	0.0	0.0	0	0.0	0.1	1	0.0	0.0	0
Harlequin Duck	0.0	0.1	1	0.7	2.6	58	0.5	1.7	30	0.1	0.6	9
Long-tailed Duck	0.1	0.3	7	0.2	0.5	14	0.2	1.1	16	0.1	0.5	5

Appendix C. Continued.

	Monahan's Dock			Beavertail			Brenton Point			Ruggles		
Species	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
Surf Scoter	0.7	4.0	59	0.9	2.0	70	0.9	3.4	58	3.3	10.7	213
Black Scoter	2.0	13.6	178	3.2	10.2	256	4.4	15.1	283	1.9	4.8	120
Surf or Black Scoter	2.2	15.9	196	1.8	9.1	148	0.7	3.0	46	3.2	8.6	208
White-winged Scoter	0.9	5.3	84	0.6	1.7	48	4.7	35.3	304	1.4	4.9	93
Scoter spp.	8.5	56.3	763	5.9	32.6	477	14.3	70.4	931	64.6	301.8	4197
Common Goldeneye	0.3	1.5	27	0.1	0.3	6	0.3	1.1	18	0.8	4.0	54
Bufflehead	0.0	0.4	4	0.0	0.0	0	0.0	0.1	1	0.1	0.3	5
Red-breasted Merganser	1.6	3.4	147	1.1	2.7	90	1.9	4.5	122	2.9	6.7	188
Common Merganser	0.0	0.0	0	0.0	0.0	0	0.0	0.1	1	0.0	0.0	0
Seaduck spp.	0.0	0.0	0	0.0	0.1	1	0.0	0.0	0	0.7	4.0	47
Northern Harrier	0.0	0.1	1	0.0	0.0	0	0.0	0.0	0	0.0	0.2	3
Osprey	0.1	0.2	5	0.0	0.1	1	0.0	0.3	3	0.0	0.2	3
American Kestrel	0.0	0.0	0	0.0	0.0	0	0.0	0.1	1	0.0	0.0	0
Peregrine Falcon	0.0	0.0	0	0.0	0.2	2	0.0	0.0	0	0.0	0.0	0
Falcon spp.	0.0	0.0	0	0.0	0.1	1	0.0	0.0	0	0.0	0.0	0
Black-bellied Plover	0.0	0.0	0	0.0	0.0	0	0.0	0.2	3	0.0	0.0	0
Semipalmated Plover	0.0	0.2	3	0.1	0.6	9	0.3	1.0	18	0.0	0.1	1
American Oystercatcher	0.0	0.1	1	0.0	0.1	2	0.0	0.0	0	0.0	0.0	0
Willet	0.0	0.1	1	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Spotted Sandpiper	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.1	1
Ruddy Turnstone	0.0	0.3	3	0.0	0.0	0	0.5	2.2	31	0.1	0.6	7
Purple Sandpiper	2.0	9.0	178	1.0	5.3	81	3.1	9.5	201	2.0	5.8	132
Sanderling	2.5	7.2	227	0.6	2.9	45	0.2	1.5	12	0.5	3.0	34
Dunlin	0.2	1.3	17	0.0	0.1	1	0.0	0.0	0	0.0	0.0	0
Semipalmated Sandpiper	0.3	1.9	24	0.1	0.6	7	0.3	1.1	17	0.2	1.5	12
Peep spp.	1.1	6.5	103	0.4	2.7	35	0.1	0.4	6	0.3	2.1	17
Least Sandpiper	0.1	0.4	5	0.0	0.1	1	0.2	0.7	12	0.0	0.0	0

Appendix C. Continued.

	Monahan's Dock			Beavertail			Brenton Point			Ruggles		
Species	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
Short-billed Dowitcher	0.0	0.1	1	0.1	0.8	9	0.0	0.4	3	0.0	0.0	0
Shorebird Spp.	1.3	5.8	119	0.7	4.1	55	0.6	2.1	39	0.0	0.1	1
Parasitic Jaeger	0.0	0.0	0	0.0	0.0	0	0.0	0.1	1	0.0	0.0	0
Jaeger spp.	0.0	0.0	0	0.0	0.1	1	0.0	0.0	0	0.0	0.0	0
Bonaparte's Gull	0.6	2.0	54	0.7	2.0	60	0.1	0.5	5	0.1	0.3	5
Laughing Gull	5.4	15.9	483	9.2	28.3	743	13.9	40.6	904	10.1	40.5	659
Ring-billed Gull	4.2	7.8	378	2.2	6.9	178	1.4	3.0	93	7.1	18.0	465
Herring Gull	23.7	46.1	2135	25.3	30.8	2049	15.7	18.8	1020	46.7	240.3	3039
Great Black-backed Gull	8.6	28.6	777	4.3	5.0	348	3.7	4.5	242	7.4	8.1	480
Black-legged Kittiwake	0.0	0.0	0	0.0	0.3	4	0.1	0.4	4	0.0	0.4	3
Gull spp.	20.9	83.1	1883	9.4	34.1	759	1.1	5.3	75	4.7	14.6	305
Royal Tern	0.0	0.1	1	0.0	0.1	1	0.0	0.0	0	0.0	0.0	0
Common Tern	3.1	16.2	281	4.6	19.1	370	5.3	17.3	347	1.7	8.2	110
Forster's Tern	0.0	0.0	0	0.0	0.1	1	0.0	0.0	0	0.0	0.0	0
Roseate Tern	0.1	0.3	5	0.0	0.2	3	0.0	0.1	1	0.0	0.0	0
Least Tern	0.1	0.5	13	0.1	0.4	6	0.1	0.5	6	0.1	0.2	4
Black Tern	0.0	0.1	1	0.0	0.1	2	0.0	0.0	0	0.0	0.0	0
Sterna spp.	0.2	0.8	17	0.3	1.4	26	0.3	1.6	17	3.1	22.8	204
Razorbill	0.1	0.3	6	0.2	0.6	13	0.0	0.1	1	0.0	0.1	2
Alcid spp.	0.1	0.2	5	0.1	0.5	9	0.0	0.2	2	0.0	0.2	2
Chimney Swift	0.0	0.1	1	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Belted Kingfisher	0.0	0.1	1	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
American Crow	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.4	1.4	23
Fish Crow	0.0	0.1	1	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Corvid spp.	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.2	0.9	11
Horned Lark	0.0	0.1	1	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
N Rough-wd Swallow	0.1	0.7	12	0.0	0.2	2	0.0	0.0	0	0.4	1.7	25

Appendix C. Continued

	Monahan's Dock			Beavertail			Brenton Point			Ruggles		
Species	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
Bank Swallow	0.0	0.0	0	0.0	0.3	3	0.0	0.0	0	0.0	0.0	0
Tree Swallow	2.3	12.1	205	0.0	0.3	4	0.0	0.3	3	0.2	1.6	13
Barn Swallow	0.4	1.2	40	0.1	0.7	12	0.5	1.9	34	0.2	0.6	11
Swallow spp.	0.2	0.8	18	0.0	0.2	3	0.0	0.2	3	0.0	0.3	3
American Robin	0.0	0.0	0	0.0	0.0	0	0.0	0.2	2	0.0	0.0	0
American Pipit	0.0	0.0	0	0.0	0.0	0	0.0	0.1	1	0.0	0.1	1
Yellow Warbler	0.0	0.3	3	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Common Grackle	0.0	0.1	1	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Passerine spp.	0.0	0.1	1	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Total	136.2	150.6	12255	119.2	106.2	9655	160.5	199.8	10433	227.6	420.8	14795

Appendix C. Continued. Birds detected **in flight** during land-based seawatches (Sachuest and Goosewing).

	Sachuest			Sakonnet			Goosewing		
Species	Mean	SD	N	Mean	SD	N	Mean	SD	N
Red-throated Loon	1.63	3.51	101	0.70	2.11	39	0.46	1.85	26
Common Loon	1.42	3.10	88	1.13	2.10	64	1.75	7.87	100
Loon spp.	0.19	1.08	12	0.57	1.98	32	1.43	5.27	82
Red-necked Grebe	0.01	0.10	1	0.02	0.13	1	0.00	0.00	0
Horned Grebe	0.06	0.31	4	0.04	0.16	2	0.01	0.07	1
Cory's Shearwater	0.10	0.56	6	0.20	1.13	11	0.01	0.07	1
Manx Shearwater	0.00	0.00	0	0.00	0.00	0	0.01	0.07	1
Shearwater spp.	0.00	0.00	0	0.01	0.07	1	0.00	0.00	0
Wilson's Storm-Petrel	0.69	4.75	43	0.30	1.29	17	0.00	0.00	0
Great Cormorant	1.05	1.88	65	2.93	8.59	164	1.43	4.22	82
Double-crested Cormorant	24.60	44.26	1525	53.01	106.24	2969	24.97	44.34	1424
Northern Gannet	4.71	14.62	292	6.26	12.35	351	3.71	9.71	212
Appendix C. Continued									

	Sachuest			Sakonnet			Goosewing		
Species	Mean	SD	N	Mean	SD	N	Mean	SD	N
Great Blue Heron	0.05	0.28	3	0.02	0.13	1	0.00	0.00	0
Great Egret	0.01	0.06	1	0.04	0.27	3	0.02	0.13	1
Green Heron	0.00	0.00	0	0.04	0.27	2	0.00	0.00	0
Black-crowned Night-Heron	0.00	0.00	0	0.03	0.15	2	0.00	0.00	0
Glossy Ibis	0.00	0.00	0	0.00	0.00	0	0.07	0.53	4
Mute Swan	0.02	0.13	1	0.05	0.23	3	0.35	1.01	20
Tundra Swan	0.00	0.00	0	0.00	0.00	0	0.04	0.26	2
Canada Goose	0.43	2.60	27	0.55	2.67	31	1.34	5.02	77
Atlantic Brant	0.79	3.62	49	0.53	1.97	30	0.15	1.06	9
Wood Duck	0.00	0.00	0	0.00	0.00	0	0.03	0.20	2
Mallard	0.00	0.00	0	0.06	0.23	4	0.07	0.42	4
American Black Duck	0.24	0.67	15	0.40	0.81	23	1.65	7.52	94
Gadwall	0.00	0.00	0	0.04	0.27	2	0.00	0.00	0
Northern Pintail	0.00	0.00	0	0.05	0.34	3	0.00	0.00	0
Anas spp.	0.00	0.00	0	0.10	0.67	6	0.05	0.29	3
Greater Scaup	0.08	0.64	5	0.01	0.07	1	0.75	4.52	43
Scaup spp.	0.00	0.00	0	0.19	1.40	11	1.76	12.91	101
Common Eider	18.02	56.76	1117	14.00	32.68	784	5.93	10.99	338
Harlequin Duck	1.04	2.75	65	0.22	0.65	13	0.04	0.19	2
Long-tailed Duck	0.14	0.39	9	0.24	1.00	14	0.00	0.00	0
Surf Scoter	6.46	17.28	401	2.96	11.30	166	0.11	0.79	6
Black Scoter	4.21	9.60	261	3.74	10.97	210	0.32	0.95	18
Surf or Black Scoter	5.11	23.10	317	2.60	8.46	146	1.93	11.93	110
White-winged Scoter	2.56	4.35	159	4.34	9.35	243	0.59	1.89	34
Scoter spp.	53.35	205.24	3308	32.17	143.00	1802	4.87	11.39	278
Common Goldeneye	0.76	3.27	47	0.23	0.61	13	0.38	1.13	22
Bufflehead	0.88	3.04	55	0.04	0.24	3	0.18	0.86	11

Appendix C. Continued.

	Sachuest			Sakonnet			Goosewing		
Species	Mean	SD	N	Mean	SD	N	Mean	SD	N
Hooded Merganser	0.07	0.57	5	0.00	0.00	0	0.00	0.00	0
Red-breasted Merganser	1.71	3.61	106	1.40	2.41	78	1.01	2.15	58
Seaduck spp.	7.07	53.17	439	0.98	7.35	55	1.22	8.94	70
Northern Harrier	0.00	0.00	0	0.01	0.07	1	0.00	0.00	0
Sharp-shinned Hawk	0.01	0.06	1	0.02	0.13	1	0.00	0.00	0
Cooper's Hawk	0.00	0.00	0	0.01	0.07	1	0.00	0.00	0
Osprey	0.02	0.13	1	0.03	0.15	2	0.06	0.27	4
Merlin	0.02	0.13	1	0.00	0.00	0	0.00	0.00	0
American Kestrel	0.01	0.06	1	0.01	0.07	1	0.00	0.00	0
Peregrine Falcon	0.02	0.13	1	0.00	0.00	0	0.03	0.15	2
Falcon spp.	0.00	0.00	0	0.00	0.00	0	0.01	0.07	1
Black-bellied Plover	0.00	0.00	0	0.05	0.40	3	0.07	0.53	4
Piping Plover	0.00	0.00	0	0.01	0.07	1	0.02	0.13	1
Semipalmated Plover	0.00	0.00	0	0.12	0.60	7	0.17	0.61	10
Killdeer	0.00	0.00	0	0.00	0.00	0	0.03	0.15	2
American Oystercatcher	0.00	0.00	0	0.08	0.33	5	0.00	0.00	0
Greater Yellowlegs	0.00	0.00	0	0.36	2.54	20	0.00	0.00	0
Yellowlegs spp.	0.00	0.00	0	0.02	0.13	1	0.00	0.00	0
Willet	0.00	0.00	0	0.00	0.00	0	0.01	0.07	1
Spotted Sandpiper	0.02	0.14	2	0.00	0.00	0	0.00	0.00	0
Ruddy Turnstone	0.06	0.29	4	0.09	0.36	5	0.02	0.13	1
Purple Sandpiper	3.60	11.93	223	2.43	6.34	136	0.00	0.00	0
Sanderling	0.87	3.74	54	0.00	0.00	0	2.73	9.20	156
Dunlin	0.03	0.25	2	0.00	0.00	0	0.32	1.90	19
White-rumped Sandpiper	0.02	0.13	1	0.00	0.00	0	0.00	0.00	0
Semipalmated Sandpiper	0.01	0.06	1	0.04	0.16	2	0.10	0.55	6
Peep spp.	0.06	0.29	4	0.94	6.43	53	0.32	2.38	18
Appendix C. Continued.									

	Sachuest			Sakonnet			Goosewing		
Species	Mean	SD	N	Mean	SD	N	Mean	SD	N
Least Sandpiper	0.04	0.32	3	0.04	0.16	2	0.00	0.00	0
Short-billed Dowitcher	0.04	0.32	3	0.00	0.00	0	0.00	0.00	0
Shorebird Spp.	0.69	3.84	43	0.46	1.84	26	1.03	6.64	59
Parasitic Jaeger	0.00	0.00	0	0.00	0.00	0	0.04	0.26	2
Jaeger spp.	0.01	0.06	1	0.00	0.00	0	0.00	0.00	0
Bonaparte's Gull	0.00	0.00	0	0.32	1.68	18	0.02	0.13	1
Laughing Gull	9.26	45.13	574	10.18	33.50	570	7.42	31.21	423
Ring-billed Gull	1.02	3.98	64	2.26	4.47	127	2.96	12.04	169
Herring Gull	12.64	20.41	784	84.89	124.19	4754	188.98	576.08	10772
Great Black-backed Gull	4.64	7.08	288	15.22	25.36	853	4.78	7.09	272
Black-legged Kittiwake	0.00	0.00	0	0.02	0.13	1	0.02	0.13	1
Gull spp.	4.35	11.79	270	10.55	44.19	591	40.27	133.35	2296
Royal Tern	0.00	0.00	0	0.02	0.13	1	0.00	0.00	0
Common Tern	1.55	4.63	96	2.30	9.42	129	1.91	4.96	109
Roseate Tern	0.06	0.40	4	0.07	0.53	4	0.00	0.00	0
Least Tern	0.06	0.40	4	0.22	1.30	13	0.91	2.88	52
Black Tern	0.00	0.00	0	0.04	0.27	2	0.00	0.00	0
Sterna spp.	1.10	5.79	69	2.70	19.11	151	0.73	2.77	42
Razorbill	0.07	0.40	5	0.02	0.13	1	0.00	0.00	0
Alcid spp.	0.05	0.38	3	0.00	0.00	0	0.00	0.00	0
Mourning Dove	0.00	0.00	0	0.00	0.00	0	0.03	0.15	2
Short-eared Owl	0.00	0.00	0	0.01	0.07	1	0.00	0.00	0
American Crow	0.02	0.13	1	0.01	0.10	1	0.00	0.00	0
Crows	0.00	0.00	0	0.01	0.07	1	0.00	0.00	0
Purple Martin	0.00	0.00	0	0.00	0.00	0	0.02	0.13	1
N. Rough-winged Swallow	0.00	0.00	0	0.45	3.34	25	0.02	0.09	1
Bank Swallow	0.03	0.25	2	0.00	0.00	0	0.01	0.07	1

Appendix C. Continued.

	Sachuest			Sakonnet			Goosewing		
Species	Mean	SD	N	Mean	SD	N	Mean	SD	N
Tree Swallow	11.67	61.86	724	4.50	22.22	252	18.56	77.52	1058
Barn Swallow	0.08	0.34	5	0.21	1.34	12	0.07	0.36	4
Swallow spp.	0.09	0.54	6	0.34	2.04	19	0.39	1.83	22
American Robin	0.06	0.44	4	0.00	0.00	0	0.00	0.00	0
American Pipit	0.00	0.00	0	0.01	0.07	1	0.00	0.00	0
Cedar Waxwing	0.01	0.06	1	0.00	0.00	0	0.00	0.00	0
Yellow Warbler	0.01	0.06	1	0.00	0.00	0	0.00	0.00	0
Yellow-rumped Warbler	0.29	2.16	18	0.00	0.00	0	0.02	0.13	1
Warbler spp.	0.01	0.06	1	0.04	0.27	2	0.00	0.00	0
Snow Bunting	0.00	0.00	0	0.39	2.94	22	0.00	0.00	0
Bobolink	0.01	0.06	1	0.00	0.00	0	0.00	0.00	0
American Goldfinch	0.26	1.67	16	0.00	0.00	0	0.00	0.00	0
Passerine spp.	0.06	0.51	4	0.00	0.00	0	0.05	0.40	3
Total	190.38	252.71	11804	269.68	301.32	15102	328.70	593.97	18736

Appendix D. Mean number of detections (±1 SD) per survey for each month from 23 January 2009 to 21 February 2010 for 121 species of birds detected during 796 land-based seawatches at 11 stations along the Rhode Island coast. Note: One and two hour surveys, birds in flight and birds on the water have been pooled.

	Jan 2009		Feb 2009		Mar 2009		Apr 2009	
Species	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Red-throated Loon	3.76	6.25	0.72	1.09	3.47	8.06	5.43	11.42
Pacific Loon	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Common Loon	13.62	11.12	7.48	5.92	5.93	4.59	24.16	43.14
Loon spp.	0.14	0.36	0.09	0.29	0.07	0.31	0.72	2.74
Red-necked Grebe	0.19	0.51	0.13	0.39	0.25	1.48	0.12	0.42
Horned Grebe	5.71	4.56	4.56	4.78	9.21	42.93	2.00	5.08
Cory's Shearwater	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Greater Shearwater	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manx Shearwater	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sooty Shearwater	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shearwater spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wilson's Storm-Petrel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leach's Storm-Petrel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Storm-petrel spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Great Cormorant	12.86	21.11	7.52	11.68	5.50	8.96	0.79	2.67
Double-cd Cormorant	0.00	0.00	0.00	0.00	2.24	13.37	51.24	155.05
Northern Gannet	0.33	0.97	0.11	0.50	0.50	1.67	24.31	107.42
Great Blue Heron	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.13
Great Egret	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.32
Snowy Egret	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.22
Cattle Egret	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Green Heron	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blk-crd Night-Heron	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Glossy Ibis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mute Swan	0.33	1.53	0.35	0.87	0.13	1.09	0.00	0.00
Tundra Swan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Canada Goose	10.24	24.39	5.76	17.31	4.12	11.94	0.88	2.06
Atlantic Brant	5.05	9.98	6.52	15.80	6.25	16.81	1.21	5.06
Wood Duck	0.00	0.00	0.00	0.00	0.04	0.36	0.00	0.00
Mallard	0.05	0.22	0.00	0.00	0.06	0.34	0.09	0.39
Am Black Duck	8.29	18.73	2.74	10.51	1.10	2.29	0.05	0.29
Gadwall	0.43	1.03	0.04	0.27	0.03	0.24	0.00	0.00
Northern Pintail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
American Wigeon	0.33	1.32	0.04	0.27	0.01	0.12	0.00	0.00
Green-winged Teal	0.00	0.00	0.00	0.00	0.01	0.12	0.00	0.00
Teal spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Anas spp.	0.00	0.00	0.00	0.00	0.06	0.49	0.00	0.00
Greater Scaup	11.43	51.46	2.59	10.82	1.31	10.31	0.12	0.70
Scaup spp.	14.57	52.48	0.09	0.49	0.00	0.00	0.07	0.53
Athya Spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.66
Common Eider	273.05	674.14	214.00	564.17	165.72	395.14	38.26	91.30
King Eider	0.00	0.00	0.07	0.54	0.12	0.68	0.10	0.45

Appendix D continued.

	Jan 2009		Feb 2009		Mar 2009		Apr 2009	
Species	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Harlequin Duck	1.67	3.64	4.63	11.66	3.63	7.70	1.52	3.50
Long-tailed Duck	2.05	2.69	2.93	9.42	1.01	3.11	0.62	2.59
Surf Scoter	99.00	305.62	167.94	670.81	379.49	1103.53	66.64	148.08
Black Scoter	94.19	221.56	101.15	340.12	160.07	501.31	75.22	186.36
Black or Surf Scoter	0.00	0.00	0.00	0.00	0.00	0.00	0.14	1.05
White-winged Scoter	28.52	59.30	36.28	122.88	17.65	28.93	12.57	22.47
Scoter spp.	814.62	1646.0	408.89	892.60	183.03	574.49	337.0	1037.5
Common Goldeneye	14.43	14.10	8.44	10.49	4.78	7.00	0.33	1.57
Barrow's Goldeneye	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bufflehead	6.29	10.99	1.35	3.51	0.88	2.58	0.00	0.00
Hooded Merganser	0.00	0.00	0.06	0.41	0.00	0.00	0.00	0.00
Red-brd Merganser	31.14	60.40	23.30	39.62	16.90	22.40	18.05	19.56
Common Merganser	0.00	0.00	0.04	0.19	0.00	0.00	0.00	0.00
Seaduck spp.	9.90	22.54	66.72	309.35	21.10	126.17	0.00	0.00
Ruddy Duck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northern Harrier	0.00	0.00	0.00	0.00	0.01	0.12	0.02	0.13
Sharp-shinned Hawk	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cooper's Hawk	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Osprey	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.13
Merlin	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.18
American Kestrel	0.05	0.22	0.00	0.00	0.01	0.12	0.03	0.18
Peregrine Falcon	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Falcon spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Black-bellied Plover	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Piping Plover	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Semipalmated Plover	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Killdeer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Am Oystercatcher	0.00	0.00	0.00	0.00	0.03	0.17	0.02	0.13
Greater Yellowlegs	0.00	0.00	0.00	0.00	0.00	0.00	0.34	2.50
Lesser Yellowlegs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yellowlegs spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Willet	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Spotted Sandpiper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Whimbrel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ruddy Turnstone	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Purple Sandpiper	10.05	22.55	9.80	28.84	4.12	13.67	5.62	15.12
Sanderling	0.71	2.85	0.37	2.34	1.41	6.25	0.00	0.00
Dunlin	0.00	0.00	0.50	2.59	0.21	1.70	0.00	0.00
White-rpd Sandpiper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Semipalm.Sandpiper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peep spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Least Sandpiper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Short-bd Dowitcher	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shorebird Spp.	0.05	0.22	0.52	3.41	1.40	7.11	2.07	7.85

Appendix D continued.

	Jan 2009		Feb 2009		Mar 2009		Apr 2009	
Species	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pomarine Jaeger	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Parasitic Jaeger	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jaeger spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bonaparte's Gull	2.33	4.89	0.76	2.77	0.03	0.17	0.00	0.00
Laughing Gull	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.43
Ring-billed Gull	0.71	1.01	1.17	3.66	2.62	9.48	1.71	4.56
Herring Gull	69.10	61.17	97.65	259.84	216.85	1052.51	45.34	78.42
Iceland Gull	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Great Bk-backed Gull	8.29	9.27	7.56	15.43	34.94	243.08	14.86	25.21
Black-ld Kittiwake	0.43	1.33	0.07	0.33	0.01	0.12	0.02	0.13
Gull spp.	48.33	125.94	34.07	73.08	38.71	188.16	3.19	18.66
Caspian Tern	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Royal Tern	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Common Tern	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forster's Tern	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Roseate Tern	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Least Tern	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Black Tern	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sterna spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Black Skimmer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thick-billed Murre	0.05	0.22	0.02	0.14	0.00	0.00	0.00	0.00
Murre spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Razorbill	5.19	8.46	0.89	2.51	0.21	0.94	0.12	0.70
Dovekie	0.05	0.22	0.00	0.00	0.00	0.00	0.00	0.00
Black Guillemot	0.05	0.22	0.00	0.00	0.00	0.00	0.02	0.13
Alcid spp.	1.00	3.92	0.26	0.85	0.26	1.25	0.09	0.66
Mourning Dove	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Short-eared Owl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chimney Swift	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ruby-t Hummingbird	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Belted Kingfisher	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.13
Northern Flicker	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.13
Eastern Kingbird	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blue Jay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
American Crow	0.05	0.22	0.17	1.09	0.00	0.00	0.00	0.00
Fish Crow	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.93
Corvid spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.22
Horned Lark	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Purple Martin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N Rough-w. Swallow	0.00	0.00	0.00	0.00	0.00	0.00	0.43	1.49
Bank Swallow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tree Swallow	0.00	0.00	0.00	0.00	0.01	0.12	0.00	0.00
Cliff Swallow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barn Swallow	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.55

Appendix D continued.

	Jan 2009		Feb 2009		Mar 2009		Apr 2009	
Species	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Swallow spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.26
American Robin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
American Pipit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cedar Waxwing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yellow Warbler	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yellow-rd Warbler	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Palm Warbler	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Warbler spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Snow Bunting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bobolink	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Brown-hd Cowbird	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.74
Common Grackle	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.37
American Goldfinch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Passerine spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	1608.6	1973.2	1228.3	1860.3	1295.5	2182.4	736.6	1215.8

Appendix D continued (May-June)

	May		Jun		Jul		Aug	
Species	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Red-throated Loon	2.66	5.83	0.03	0.18	0.02	0.12	0.00	0.00
Pacific Loon	0.02	0.13	0.00	0.00	0.00	0.00	0.00	0.00
Common Loon	17.95	31.52	2.28	3.96	0.78	1.87	0.23	0.83
Loon spp.	3.41	11.65	0.00	0.00	0.00	0.00	0.00	0.00
Red-necked Grebe	0.02	0.13	0.02	0.13	0.00	0.00	0.00	0.00
Horned Grebe	0.02	0.13	0.00	0.00	0.00	0.00	0.00	0.00
Cory's Shearwater	0.00	0.00	0.00	0.00	36.88	84.65	0.00	0.00
Greater Shearwater	0.00	0.00	0.00	0.00	0.20	1.03	0.00	0.00
Manx Shearwater	0.13	0.38	0.00	0.00	0.00	0.00	0.00	0.00
Sooty Shearwater	0.02	0.13	0.03	0.25	0.03	0.17	0.00	0.00
Shearwater spp.	0.02	0.13	0.05	0.38	23.38	114.77	0.00	0.00
Wilson's Storm-Petrel	0.09	0.67	6.47	23.88	12.62	43.51	0.04	0.29
Leach's Storm-Petrel	0.00	0.00	0.00	0.00	0.02	0.12	0.00	0.00
Storm-petrel spp.	0.00	0.00	0.02	0.13	0.00	0.00	0.00	0.00
Great Cormorant	0.02	0.13	0.00	0.00	0.00	0.00	0.00	0.00
Double-cd Cormorant	78.05	96.60	72.50	101.31	46.60	53.47	17.06	21.49
Northern Gannet	11.00	16.76	1.33	2.05	0.51	1.37	0.08	0.35
Great Blue Heron	0.00	0.00	0.00	0.00	0.20	0.94	0.00	0.00
Great Egret	0.25	1.05	0.28	0.70	0.08	0.41	0.00	0.00
Snowy Egret	0.00	0.00	0.05	0.28	0.05	0.37	0.06	0.43
Cattle Egret	0.00	0.00	0.00	0.00	0.02	0.12	0.00	0.00
Green Heron	0.00	0.00	0.03	0.25	0.05	0.37	0.00	0.00
Black-c Night-Heron	0.00	0.00	0.06	0.24	0.00	0.00	0.00	0.00
Glossy Ibis	0.07	0.53	0.08	0.45	0.38	3.10	0.00	0.00
Mute Swan	0.07	0.37	0.38	1.56	0.12	0.67	0.00	0.00
Tundra Swan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Canada Goose	0.61	2.22	0.69	4.26	0.00	0.00	0.00	0.00
Atlantic Brant	0.00	0.00	0.02	0.13	0.00	0.00	0.00	0.00
Wood Duck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mallard	0.23	0.76	0.14	0.47	0.17	0.67	0.00	0.00
Am. Black Duck	0.04	0.27	0.00	0.00	0.00	0.00	0.00	0.00
Gadwall	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northern Pintail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
American Wigeon	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Green-winged Teal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Teal spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Anas spp.	0.36	2.67	0.00	0.00	0.02	0.12	0.00	0.00
Greater Scaup	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scaup spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Athya Spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Common Eider	6.52	15.63	1.80	4.43	1.15	3.56	2.98	8.73
King Eider	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Harlequin Duck	0.02	0.13	0.00	0.00	0.00	0.00	0.00	0.00
Long-tailed Duck	0.05	0.23	0.00	0.00	0.00	0.00	0.00	0.00
Surf Scoter	5.93	14.40	0.08	0.32	0.00	0.00	0.00	0.00
Black Scoter	8.02	22.17	0.03	0.18	0.05	0.28	0.33	1.89
Black or Surf Scoter	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.29
White-winged Scoter	21.05	59.65	0.16	0.54	0.15	0.89	0.02	0.14
Scoter spp.	31.20	113.43	0.11	0.76	0.03	0.25	0.00	0.00
Common Goldeneye	0.00	0.00	0.05	0.38	0.00	0.00	0.00	0.00
Barrow's Goldeneye	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bufflehead	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hooded Merganser	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Red-bd Merganser	5.89	16.36	0.23	0.79	0.02	0.12	0.00	0.00
Common Merganser	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Seaduck spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ruddy Duck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northern Harrier	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sharp-shinned Hawk	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cooper's Hawk	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Osprey	0.13	0.47	0.23	0.50	0.20	0.54	0.04	0.20
Merlin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
American Kestrel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peregrine Falcon	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Falcon spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Black-bellied Plover	0.00	0.00	0.03	0.25	0.02	0.12	0.19	0.67
Piping Plover	0.11	0.49	0.03	0.18	0.02	0.12	0.00	0.00
Semipalmated Plover	0.00	0.00	0.00	0.00	0.42	1.45	1.63	5.77
Killdeer	0.02	0.13	0.00	0.00	0.02	0.12	0.00	0.00
Am. Oystercatcher	0.05	0.30	0.05	0.28	0.08	0.37	0.00	0.00
Greater Yellowlegs	0.02	0.13	0.00	0.00	0.00	0.00	0.00	0.00
Lesser Yellowlegs	0.00	0.00	0.00	0.00	0.12	0.88	0.02	0.14
Yellowlegs spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.14
Willet	0.11	0.80	0.06	0.30	0.18	1.25	0.00	0.00
Spotted Sandpiper	0.00	0.00	0.00	0.00	0.06	0.39	0.08	0.35

	May		Jun		Jul		Aug	
Species	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Whimbrel	0.00	0.00	0.00	0.00	0.38	1.35	0.02	0.14
Ruddy Turnstone	0.07	0.53	0.00	0.00	0.74	3.05	1.71	4.99
Purple Sandpiper	1.48	7.24	0.02	0.13	0.00	0.00	0.00	0.00
Sanderling	0.00	0.00	0.03	0.25	14.54	48.50	1.25	5.86
Dunlin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
White-rd Sandpiper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Semipalm. Sandpiper	0.02	0.13	0.09	0.75	17.25	85.98	3.58	8.45
Peep spp.	0.00	0.00	0.00	0.00	7.49	15.42	5.31	14.14
Least Sandpiper	0.00	0.00	0.00	0.00	0.26	0.91	0.40	1.27
Short-bd. Dowitcher	0.00	0.00	0.00	0.00	2.77	7.65	1.06	6.53
Shorebird Spp.	0.41	1.57	0.06	0.35	7.68	18.78	1.75	3.82
Pomarine Jaeger	0.00	0.00	0.03	0.25	0.00	0.00	0.00	0.00
Parasitic Jaeger	0.04	0.27	0.13	1.00	0.11	0.75	0.02	0.14
Jaeger spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bonaparte's Gull	0.25	1.61	0.09	0.64	0.02	0.12	0.00	0.00
Laughing Gull	0.80	1.80	2.92	4.29	9.69	15.85	41.25	78.32
Ring-billed Gull	1.14	2.60	4.22	16.81	4.52	10.82	3.46	10.94
Herring Gull	82.68	124.95	69.89	102.78	42.38	71.58	12.90	27.82
Iceland Gull	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Great Bk-backed Gull	36.21	43.61	29.08	50.99	17.11	31.71	5.98	8.38
Black-ld Kittiwake	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.14
Gull spp.	6.89	25.53	24.91	75.17	9.06	25.91	9.83	58.03
Caspian Tern	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Royal Tern	0.00	0.00	0.02	0.13	0.06	0.30	0.02	0.14
Common Tern	3.34	7.59	4.80	9.62	20.45	33.61	35.10	54.57
Forster's Tern	0.00	0.00	0.00	0.00	0.02	0.12	0.17	0.60
Roseate Tern	0.00	0.00	0.20	0.96	1.40	3.24	0.44	1.27
Least Tern	1.91	5.03	3.45	8.22	1.94	4.29	0.65	2.29
Black Tern	0.00	0.00	0.00	0.00	0.06	0.30	0.23	0.69
Sterna spp.	0.84	3.68	0.33	1.14	3.03	9.07	18.83	59.27
Black Skimmer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thick-billed Murre	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Murre spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Razorbill	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dovekie	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Black Guillemot	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Alcid spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mourning Dove	0.00	0.00	0.00	0.00	0.02	0.12	0.04	0.29
Short-eared Owl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chimney Swift	0.02	0.13	0.02	0.13	0.02	0.12	0.00	0.00
Ruby-t Hummingbird	0.02	0.13	0.00	0.00	0.00	0.00	0.02	0.14
Belted Kingfisher	0.00	0.00	0.00	0.00	0.02	0.12	0.00	0.00
Northern Flicker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eastern Kingbird	0.00	0.00	0.02	0.13	0.00	0.00	0.00	0.00
Blue Jay	0.43	3.21	0.00	0.00	0.00	0.00	0.00	0.00
American Crow	0.00	0.00	0.02	0.13	0.00	0.00	0.00	0.00
Fish Crow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	May		Jun		Jul		Aug	
Species	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Corvid spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Horned Lark	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Purple Martin	0.00	0.00	0.05	0.21	0.03	0.25	0.02	0.14
N Rough-w Swallow	0.75	3.70	0.19	0.83	0.35	1.32	0.00	0.00
Bank Swallow	0.04	0.19	0.02	0.13	0.17	1.05	0.08	0.35
Tree Swallow	0.00	0.00	0.02	0.13	0.49	1.34	5.75	28.26
Cliff Swallow	0.00	0.00	0.00	0.00	0.02	0.12	0.00	0.00
Barn Swallow	1.02	2.35	0.48	1.28	0.78	1.87	1.38	3.56
Swallow spp.	0.70	3.25	0.02	0.13	0.40	1.04	2.44	7.25
American Robin	0.04	0.27	0.00	0.00	0.00	0.00	0.00	0.00
American Pipit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cedar Waxwing	0.00	0.00	0.02	0.13	0.00	0.00	0.00	0.00
Yellow Warbler	0.13	0.00	0.00	0.12	0.57	0.06	0.32	0.13
Yellow-rd. Warbler	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Palm Warbler	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Warbler spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Snow Bunting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bobolink	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Brown-hd Cowbird	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Common Grackle	0.53	0.03	0.25	0.00	0.00	0.00	0.00	0.53
American Goldfinch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Passerine spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	272.0	228.4	252.4	288.0	287.7	176.6	171.2	272.0

Appendix D continued. (Sept – Dec 2009)

	Sep		Oct		Nov		Dec	
Species	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Red-throated Loon	0.03	0.17	3.00	9.23	7.99	10.61	12.10	19.93
Pacific Loon	0.00	0.00	0.00	0.00	0.01	0.12	0.00	0.00
Common Loon	0.79	2.03	6.67	8.72	16.22	19.51	14.72	18.25
Loon spp.	0.00	0.00	0.43	1.72	4.00	9.50	1.40	3.09
Red-necked Grebe	0.00	0.00	0.09	0.34	0.26	0.80	0.12	0.32
Horned Grebe	0.00	0.00	0.02	0.13	0.10	0.35	0.85	1.84
Cory's Shearwater	0.04	0.20	0.02	0.13	0.00	0.00	0.00	0.00
Greater Shearwater	0.01	0.12	0.00	0.00	0.00	0.00	0.00	0.00
Manx Shearwater	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sooty Shearwater	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shearwater spp.	0.03	0.17	0.00	0.00	0.00	0.00	0.00	0.00
Wilson's Storm-Petrel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leach's Storm-Petrel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Storm-petrel spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Great Cormorant	0.34	1.37	0.60	1.76	3.71	4.97	7.13	16.20
Double-cd Cormorant	53.39	91.37	88.36	124.47	9.93	22.89	0.67	1.49
Northern Gannet	0.15	0.79	11.78	30.68	40.07	58.26	49.73	91.63
Great Blue Heron	0.08	0.37	0.24	1.71	0.00	0.00	0.07	0.41
Great Egret	0.01	0.12	0.05	0.29	0.00	0.00	0.00	0.00
Snowy Egret	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Cattle Egret	0.00	0.00	0.02	0.13	0.00	0.00	0.00	0.00
Green Heron	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Black-cd N-Heron	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Glossy Ibis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mute Swan	0.01	0.12	0.26	0.83	0.10	0.39	0.08	0.38
Tundra Swan	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.26
Canada Goose	0.65	5.46	0.02	0.13	1.25	6.75	13.93	32.16
Atlantic Brant	0.00	0.00	4.24	11.49	1.65	5.98	0.15	1.04
Wood Duck	0.04	0.36	0.00	0.00	0.06	0.48	0.00	0.00
Mallard	0.03	0.24	0.10	0.48	0.09	0.61	0.27	1.47
Am Black Duck	0.07	0.49	0.12	0.59	0.20	0.80	3.45	12.13
Gadwall	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northern Pintail	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.18
American Wigeon	0.00	0.00	0.00	0.00	0.03	0.24	0.00	0.00
Green-winged Teal	0.00	0.00	0.60	2.65	0.03	0.24	0.00	0.00
Teal spp.	0.00	0.00	0.02	0.13	0.00	0.00	0.00	0.00
Anas spp.	0.01	0.12	0.17	0.60	0.00	0.00	0.47	1.92
Greater Scaup	0.00	0.00	0.00	0.00	0.29	1.55	1.43	8.76
Scaup spp.	0.00	0.00	2.10	15.23	0.12	0.74	0.15	1.04
Athya Spp.	0.00	0.00	0.00	0.00	0.36	2.24	0.32	1.47
Common Eider	5.69	12.77	282.40	403.57	172.49	230.11	77.63	90.06
King Eider	0.00	0.00	0.02	0.13	0.00	0.00	0.00	0.00
Harlequin Duck	0.00	0.00	0.16	0.72	2.09	5.87	2.20	5.36
Long-tailed Duck	0.00	0.00	0.43	1.51	0.67	1.36	0.58	2.73
Surf Scoter	0.14	0.64	8.84	22.13	2.78	11.19	2.38	5.66
Black Scoter	0.37	2.02	40.38	123.76	19.09	57.70	10.50	25.84
Black or Surf Scoter	0.55	1.87	18.22	46.06	8.54	29.39	6.20	14.86
White-winged Scoter	0.54	1.76	4.00	8.39	2.45	2.94	1.43	3.35
Scoter spp.	0.38	1.86	4.59	11.18	6.81	17.46	2.40	6.18
Common Goldeneye	0.00	0.00	0.00	0.00	0.16	0.74	2.42	6.35
Barrow's Goldeneye	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.13
Bufflehead	0.00	0.00	0.00	0.00	0.88	4.33	1.70	5.06
Hooded Merganser	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Red-bd Merganser	0.03	0.24	2.19	4.06	12.74	22.86	12.97	15.38
Common Merganser	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Seaduck spp.	0.00	0.00	0.95	7.22	0.00	0.00	0.03	0.26
Ruddy Duck	0.00	0.00	0.28	1.47	0.00	0.00	0.00	0.00
Northern Harrier	0.01	0.12	0.00	0.00	0.03	0.17	0.02	0.13
Sharp-shinned Hawk	0.04	0.26	0.00	0.00	0.00	0.00	0.00	0.00
Cooper's Hawk	0.01	0.12	0.00	0.00	0.00	0.00	0.00	0.00
Osprey	0.11	0.36	0.03	0.18	0.00	0.00	0.00	0.00
Merlin	0.04	0.20	0.02	0.13	0.00	0.00	0.00	0.00
American Kestrel	0.00	0.00	0.03	0.18	0.00	0.00	0.00	0.00
Peregrine Falcon	0.10	0.30	0.02	0.13	0.00	0.00	0.00	0.00
Falcon spp.	0.03	0.17	0.00	0.00	0.00	0.00	0.00	0.00
Black-bellied Plover	0.01	0.12	0.00	0.00	0.09	0.72	0.00	0.00
Piping Plover	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Semipalmated Plover	0.49	1.80	0.31	0.88	0.00	0.00	0.00	0.00
Killdeer	0.01	0.12	0.00	0.00	0.01	0.12	0.00	0.00

	Sep		Oct		Nov		Dec	
Species	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Am. Oystercatcher	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Greater Yellowlegs	0.01	0.12	0.00	0.00	0.00	0.00	0.00	0.00
Lesser Yellowlegs	0.06	0.33	0.00	0.00	0.00	0.00	0.00	0.00
Yellowlegs spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Willet	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Spotted Sandpiper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Whimbrel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ruddy Turnstone	0.01	0.12	0.03	0.26	0.00	0.00	0.00	0.00
Purple Sandpiper	0.00	0.00	0.10	0.79	2.20	7.58	4.65	13.46
Sanderling	9.51	38.18	9.17	29.58	1.51	4.20	0.72	3.70
Dunlin	0.13	0.79	0.26	1.22	0.22	1.69	0.12	0.90
White-rd Sandpiper	0.00	0.00	0.02	0.13	0.00	0.00	0.00	0.00
Semipalm. Sandpiper	0.24	0.90	0.02	0.13	0.00	0.00	0.00	0.00
Peep spp.	0.80	5.94	0.00	0.00	0.00	0.00	0.00	0.00
Least Sandpiper	0.20	0.90	0.00	0.00	0.00	0.00	0.00	0.00
Short-bd Dowitcher	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shorebird Spp.	1.32	4.38	0.71	2.93	0.12	0.85	0.00	0.00
Pomarine Jaeger	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Parasitic Jaeger	0.01	0.12	0.00	0.00	0.00	0.00	0.00	0.00
Jaeger spp.	0.01	0.12	0.03	0.18	0.00	0.00	0.00	0.00
Bonaparte's Gull	0.00	0.00	0.22	0.82	0.38	1.59	3.15	7.34
Laughing Gull	37.69	41.13	108.52	144.32	4.04	8.60	0.02	0.13
Ring-billed Gull	7.86	13.90	13.83	28.95	4.26	5.55	8.12	18.51
Herring Gull	40.69	93.16	24.86	45.68	48.29	140.61	89.08	194.58
Iceland Gull	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Great Bl-backed Gull	8.34	8.99	5.93	5.94	11.74	26.42	22.57	88.35
Black-ld Kittiwake	0.00	0.00	0.00	0.00	0.19	0.93	0.25	1.81
Gull spp.	18.49	43.46	116.21	293.59	44.71	174.31	64.42	221.58
Caspian Tern	0.03	0.24	0.00	0.00	0.00	0.00	0.00	0.00
Royal Tern	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Common Tern	1.96	9.38	0.00	0.00	0.00	0.00	0.00	0.00
Forster's Tern	0.00	0.00	0.03	0.26	0.00	0.00	0.00	0.00
Roseate Tern	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Least Tern	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Black Tern	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sterna spp.	2.06	11.37	0.03	0.26	0.00	0.00	0.00	0.00
Black Skimmer	0.04	0.36	0.00	0.00	0.00	0.00	0.00	0.00
Thick-billed Murre	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Murre spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.13
Razorbill	0.00	0.00	0.00	0.00	0.00	0.00	0.53	1.64
Dovekie	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Black Guillemot	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Alcid spp.	0.00	0.00	0.02	0.13	0.04	0.27	0.33	1.63
Mourning Dove	0.01	0.12	0.02	0.13	0.00	0.00	0.00	0.00
Short-eared Owl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chimney Swift	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ruby-t Hummingbird	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	Sep		Oct		Nov		Dec	
Species	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Belted Kingfisher	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northern Flicker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eastern Kingbird	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blue Jay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
American Crow	0.03	0.24	0.00	0.00	0.00	0.00	0.03	0.26
Fish Crow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corvid spp.	0.00	0.00	0.26	1.84	0.01	0.12	0.03	0.26
Horned Lark	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.13
Purple Martin	0.01	0.12	0.00	0.00	0.00	0.00	0.00	0.00
N. Rough-w Swallow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bank Swallow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tree Swallow	25.94	78.75	204.71	1322.9	0.00	0.00	0.00	0.00
Cliff Swallow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barn Swallow	0.24	1.15	0.03	0.26	0.00	0.00	0.00	0.00
Swallow spp.	0.13	0.53	0.03	0.18	0.00	0.00	0.00	0.00
American Robin	0.10	0.83	0.00	0.00	0.00	0.00	0.00	0.00
American Pipit	0.01	0.12	0.03	0.18	0.03	0.24	0.00	0.00
Cedar Waxwing	0.01	0.12	0.00	0.00	0.00	0.00	0.00	0.00
Yellow Warbler	0.01	0.12	0.00	0.00	0.00	0.00	0.00	0.00
Yellow-rd Warbler	0.01	0.12	0.02	0.13	0.00	0.00	0.00	0.00
Palm Warbler	0.01	0.12	0.00	0.00	0.00	0.00	0.00	0.00
Warbler spp.	0.10	0.54	0.03	0.26	0.00	0.00	0.00	0.00
Snow Bunting	0.00	0.00	0.03	0.26	0.41	2.71	0.00	0.00
Bobolink	0.01	0.12	0.00	0.00	0.00	0.00	0.00	0.00
Brown-hd Cowbird	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Common Grackle	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
American Goldfinch	0.03	0.24	0.24	1.71	0.00	0.00	0.00	0.00
Passerine spp.	0.06	0.37	0.10	0.55	0.13	0.75	0.00	0.00
Grand Total	220.5	214.6	967.3	1440.3	433.6	405.2	421.6	469.6

Appendix D continued.

	Jan 2010		Feb 2010	
Species	Mean	SD	Mean	SD
Red-throated Loon	2.95	4.19	0.66	1.26
Pacific Loon	0.02	0.13	0.00	0.00
Common Loon	6.75	6.37	4.96	6.12
Loon spp.	0.51	1.57	0.02	0.15
Red-necked Grebe	0.26	0.58	0.00	0.00
Horned Grebe	3.98	7.75	2.55	2.54
Cory's Shearwater	0.00	0.00	0.00	0.00
Greater Shearwater	0.00	0.00	0.00	0.00
Manx Shearwater	0.00	0.00	0.00	0.00
Sooty Shearwater	0.00	0.00	0.00	0.00
Shearwater spp.	0.00	0.00	0.00	0.00
Wilson's Storm-Petrel	0.00	0.00	0.00	0.00
Leach's Storm-Petrel	0.00	0.00	0.00	0.00
Storm-petrel spp.	0.00	0.00	0.00	0.00
Great Cormorant	4.96	5.40	2.55	3.18
Double-cd Cormorant	0.02	0.13	0.02	0.15
Northern Gannet	1.37	3.98	0.04	0.29
Great Blue Heron	0.00	0.00	0.00	0.00
Great Egret	0.00	0.00	0.00	0.00
Snowy Egret	0.00	0.00	0.00	0.00
Cattle Egret	0.00	0.00	0.00	0.00
Green Heron	0.00	0.00	0.00	0.00
Black-cd N-Heron	0.00	0.00	0.00	0.00
Glossy Ibis	0.00	0.00	0.00	0.00
Mute Swan	0.07	0.42	0.17	0.64
Tundra Swan	0.00	0.00	0.00	0.00
Canada Goose	9.95	39.34	0.89	2.55
Atlantic Brant	1.65	4.97	1.00	2.71
Wood Duck	0.00	0.00	0.00	0.00
Mallard	0.02	0.13	0.00	0.00
Am Black Duck	0.63	1.76	0.62	1.29
Gadwall	0.05	0.40	0.13	0.65
Northern Pintail	0.00	0.00	0.11	0.73
American Wigeon	0.00	0.00	0.04	0.29
Green-winged Teal	0.00	0.00	0.00	0.00
Teal spp.	0.00	0.00	0.00	0.00
Anas spp.	0.00	0.00	0.02	0.15
Greater Scaup	3.04	14.87	5.21	25.14
Scaup spp.	0.00	0.00	0.00	0.00
Athya Spp.	0.00	0.00	0.00	0.00
Common Eider	103.23	142.71	207.28	490.58
King Eider	0.09	0.34	0.04	0.20
Harlequin Duck	4.02	7.73	3.62	8.28
Long-tailed Duck	0.63	1.62	0.40	0.92
Surf Scoter	7.00	16.50	6.21	15.39
Black Scoter	36.77	64.72	57.55	107.83

Appendix D continued.

	Jan 2010		Feb 2010	
Species	Mean	SD	Mean	SD
Black or Surf Scoter	13.81	29.73	10.55	51.47
White-winged Scoter	5.58	12.43	4.68	9.57
Scoter spp.	92.04	360.64	19.98	78.31
Common Goldeneye	5.28	7.31	8.57	19.47
Barrow's Goldeneye	0.02	0.13	0.00	0.00
Bufflehead	2.04	5.20	2.64	5.41
Hooded Merganser	0.16	1.19	0.00	0.00
Red-bd Merganser	17.19	25.06	15.02	38.34
Common Merganser	0.00	0.00	0.00	0.00
Seaduck spp.	0.00	0.00	0.00	0.00
Ruddy Duck	0.00	0.00	0.00	0.00
Northern Harrier	0.00	0.00	0.02	0.15
Sharp-shinned Hawk	0.00	0.00	0.00	0.00
Cooper's Hawk	0.00	0.00	0.00	0.00
Osprey	0.00	0.00	0.00	0.00
Merlin	0.00	0.00	0.00	0.00
American Kestrel	0.00	0.00	0.00	0.00
Peregrine Falcon	0.00	0.00	0.00	0.00
Falcon spp.	0.00	0.00	0.00	0.00
Black-bellied Plover	0.00	0.00	0.00	0.00
Piping Plover	0.00	0.00	0.00	0.00
Semipalmated Plover	0.00	0.00	0.00	0.00
Killdeer	0.00	0.00	0.00	0.00
Am Oystercatcher	0.00	0.00	0.00	0.00
Greater Yellowlegs	0.00	0.00	0.00	0.00
Lesser Yellowlegs	0.00	0.00	0.00	0.00
Yellowlegs spp.	0.00	0.00	0.00	0.00
Willet	0.00	0.00	0.00	0.00
Spotted Sandpiper	0.00	0.00	0.00	0.00
Whimbrel	0.00	0.00	0.00	0.00
Ruddy Turnstone	0.02	0.13	0.00	0.00
Purple Sandpiper	2.77	6.86	0.09	0.58
Sanderling	0.28	1.62	1.06	7.29
Dunlin	0.00	0.00	0.00	0.00
White-rd Sandpiper	0.00	0.00	0.00	0.00
Semipalm Sandpiper	0.00	0.00	0.00	0.00
Peep spp.	0.00	0.00	0.00	0.00
Least Sandpiper	0.00	0.00	0.00	0.00
Short-bd Dowitcher	0.00	0.00	0.00	0.00
Shorebird Spp.	0.05	0.40	0.00	0.00
Pomarine Jaeger	0.00	0.00	0.00	0.00
Parasitic Jaeger	0.00	0.00	0.00	0.00
Jaeger spp.	0.00	0.00	0.00	0.00
Bonaparte's Gull	1.58	4.08	0.11	0.73

Appendix D continued.

	Jan 2010		Feb 2010	
Species	Mean	SD	Mean	SD
Laughing Gull	0.00	0.00	0.00	0.00
Ring-billed Gull	1.51	3.86	7.38	33.21
Herring Gull	70.58	334.85	127.79	577.65
Iceland Gull	0.02	0.13	0.00	0.00
Great Black-bd Gull	3.72	4.79	3.47	6.35
Black-ld Kittiwake	0.25	0.93	0.00	0.00
Gull spp.	2.53	15.94	0.00	0.00
Caspian Tern	0.00	0.00	0.00	0.00
Royal Tern	0.00	0.00	0.00	0.00
Common Tern	0.00	0.00	0.00	0.00
Forster's Tern	0.00	0.00	0.00	0.00
Roseate Tern	0.00	0.00	0.00	0.00
Least Tern	0.00	0.00	0.00	0.00
Black Tern	0.00	0.00	0.00	0.00
Sterna spp.	0.00	0.00	0.00	0.00
Black Skimmer	0.00	0.00	0.00	0.00
Thick-billed Murre	0.00	0.00	0.00	0.00
Murre spp.	0.00	0.00	0.00	0.00
Razorbill	1.28	4.30	0.15	0.66
Dovekie	0.00	0.00	0.00	0.00
Black Guillemot	0.00	0.00	0.00	0.00
Alcid spp.	0.46	2.67	0.04	0.29
Mourning Dove	0.00	0.00	0.00	0.00
Short-eared Owl	0.00	0.00	0.02	0.15
Chimney Swift	0.00	0.00	0.00	0.00
Ruby-t Hummingbird	0.00	0.00	0.00	0.00
Belted Kingfisher	0.00	0.00	0.00	0.00
Northern Flicker	0.00	0.00	0.00	0.00
Eastern Kingbird	0.00	0.00	0.00	0.00
Blue Jay	0.00	0.00	0.00	0.00
American Crow	0.07	0.53	0.15	1.02
Fish Crow	0.00	0.00	0.00	0.00
Corvid spp.	0.00	0.00	0.00	0.00
Horned Lark	0.00	0.00	0.02	0.15
Purple Martin	0.00	0.00	0.00	0.00
N Rough-w Swallow	0.00	0.00	0.00	0.00
Bank Swallow	0.00	0.00	0.00	0.00
Tree Swallow	0.00	0.00	0.00	0.00
Cliff Swallow	0.00	0.00	0.00	0.00
Barn Swallow	0.00	0.00	0.00	0.00
Swallow spp.	0.00	0.00	0.00	0.00
American Robin	0.00	0.00	0.00	0.00
American Pipit	0.00	0.00	0.00	0.00
Cedar Waxwing	0.00	0.00	0.00	0.00

Appendix D continued.

	Jan 2010		Feb 2010	
Species	Mean	SD	Mean	SD
Yellow Warbler	0.00	0.00	0.00	0.00
Yellow-rd Warbler	0.60	4.50	0.00	0.00
Palm Warbler	0.00	0.00	0.00	0.00
Warbler spp.	0.00	0.00	0.00	0.00
Snow Bunting	0.00	0.00	0.00	0.00
Bobolink	0.00	0.00	0.00	0.00
Brown-headed Cowbird	0.00	0.00	0.00	0.00
Common Grackle	0.00	0.00	0.00	0.00
American Goldfinch	0.00	0.00	0.00	0.00
Passerine spp.	0.00	0.00	0.00	0.00
Grand Total	409.8	515.1	495.9	823.1

Appendix E. Mean (SD) number of detections per grid, CV of detection rate, total number of detections, and % of surveys (n = 16) with a detection within a grid) during ship-based line transect surveys for data pooled across all 8 grids (see Fig. 24) conducted in the summer of 2009 (10 June thru 25 Aug 2009).

Species	Mean	SD	CV	Total detections	% of surveys
Common Loon	0.38	0.72	191.7	6	25.00
Red-throated Loon	0.06	0.25	400.0	1	6.25
Shearwater unidentified	1.69	3.40	201.5	27	43.75
Small shearwater	0.13	0.50	400.0	2	6.25
Manx Shearwater	0.13	0.34	273.3	2	12.50
Greater Shearwater	12.06	21.84	181.1	193	62.50
Cory's Shearwater	30.94	36.59	118.3	495	75.00
Sooty Shearwater	1.00	2.03	203.3	16	25.00
Wilson's Storm-Petrel	82.00	112.96	137.8	1,312	93.75
Leach's Storm-Petrel	0.13	0.50	400.0	2	6.25
Northern Gannet	2.13	3.24	152.6	34	56.25
Double-crd. Cormorant	0.31	0.70	225.3	5	18.75
Great Cormorant	0.06	0.25	400.0	1	6.25
Great Blue Heron	0.06	0.25	400.0	1	6.25
Mallard	0.06	0.25	400.0	1	6.25
Shorebird unidentified	0.13	0.50	400.0	2	6.25
Semipalmated Plover	0.13	0.50	400.0	2	6.25
Whimbrel	0.25	1.00	400.0	4	6.25
Short-billed Dowitcher	0.31	1.25	400.0	5	6.25
Phalarope unidentified	0.06	0.25	400.0	1	6.25
Pomarine Jaeger	0.06	0.25	400.0	1	6.25
Long-tailed Jaeger	0.06	0.25	400.0	1	6.25
Parasitic Jaeger	0.06	0.25	400.0	1	6.25
Gull spp.	0.06	0.25	400.0	1	6.25
Laughing Gull	6.81	24.62	361.4	109	31.25
Herring Gull	8.94	13.80	154.4	143	93.75
Great Black-bd. Gull	11.38	13.23	116.3	182	100.00
Tern unidentified	0.69	1.01	147.6	11	37.50
Common Tern	3.69	9.14	247.9	59	31.25
Roseate Tern	0.50	1.21	242.2	8	18.75
Grand Total	**165.06**	**132.36**	**80.2**	**2,628**	

Appendix F. Mean (SD) number of detections per grid, CV of detection rate, total number of detections, and % of surveys (n = 18) with a detection within a grid) during ship-based line transect surveys for data pooled across all 8 grids (see Fig. 24) conducted during fall (8 Sept thru 19 Nov 2009).

Species	Mean	SD	CV	Total	% of surveys
Common Loon	2.94	6.82	231.7	53	50.0
Red-throated Loon	1.33	4.09	306.5	24	22.2
Loon spp.	0.17	0.71	424.3	3	5.6
Red-necked Grebe	0.06	0.24	424.3	1	5.6
Northern Fulmar	0.28	0.67	240.9	5	16.7
Greater Shearwater	2.56	5.26	205.8	46	38.9
Cory's Shearwater	1.39	2.91	209.8	25	33.3
Wilson's Storm-Petrel	11.06	32.21	291.4	199	11.1
Northern Gannet	36.44	104.90	287.8	656	72.2
Double-crd Cormorant	0.22	0.55	246.7	4	16.7
Bay duck unidentified	0.44	1.89	424.3	8	5.6
Green-winged Teal	0.56	2.36	424.3	10	5.6
Scaup unidentified	3.06	8.93	292.4	55	11.1
Common Eider	12.00	35.46	295.5	216	27.8
Scoter unidentified	0.22	0.94	424.3	4	5.6
Surf or Black Scoter	9.44	22.94	242.9	170	16.7
Surf Scoter	11.22	40.98	365.2	202	27.8
Black Scoter	14.17	31.22	220.4	255	27.8
White-winged Scoter	3.17	6.82	215.3	57	27.8
Long-tailed Duck	0.67	1.75	262.3	12	22.2
Merlin	0.06	0.24	424.3	1	5.6
Lesser Yellowlegs	0.22	0.94	424.3	4	5.6
Red-necked Phalarope	1.33	5.66	424.3	24	5.6
Purple Sandpiper	0.22	0.94	424.3	4	5.6
Whimbrel	0.06	0.24	424.3	1	5.6
Phalarope unidentified	0.06	0.24	424.3	1	5.6
Shorebird unidentified	0.06	0.24	424.3	1	5.6
Ring-billed Gull	0.89	2.11	237.5	16	38.9
Bonaparte's Gull	0.33	1.41	424.3	6	5.6
Laughing Gull	3.39	4.10	121.1	61	55.6
Herring Gull	72.50	185.23	255.5	1305	94.4
Great Black-backed Gull	39.33	122.38	311.1	708	83.3
Black-legged Kittiwake	0.56	1.65	297.5	10	11.1
Gull unidentified	1.67	7.07	424.3	30	5.6
Tern unidentified	0.06	0.24	424.3	1	5.6
Common Tern	0.11	0.47	424.3	2	5.6
Razorbill	0.22	0.43	192.5	4	22.2
Atlantic Puffin	0.28	1.18	424.3	5	5.6
Grand Total	**233.28**	**426.47**	**182.8**	**4199**	**100.0**

Appendix G. Mean (SD)) number of detections per grid, CV of detection rate, total number of detections, and % of surveys (n = 20) with a detection within a grid during ship-based line transect surveys for data pooled across all 8 grids (see Fig. 24) conducted during winter 2009-2010 (18 Dec 2009 through 13 Feb 2010).

Species	Mean	SD	CV	Total	% of surveys
Common Loon	11.65	7.40	63.5	233	95
Red-throated Loon	4.05	6.18	152.5	81	55
Loon spp.	0.10	0.31	307.8	2	10
Northern Gannet	29.40	81.35	276.7	588	75
Double-crd cormorant	0.05	0.22	447.2	1	5
Great Cormorant	0.70	1.45	207.8	14	25
Brant	0.85	3.80	447.2	17	5
Dabbling duck unidentified	0.55	2.46	447.2	11	5
Common Eider	3.90	6.11	156.7	78	45
Long-tailed Duck	0.45	0.89	197.1	9	25
White-winged Scoter	5.20	5.97	114.8	104	85
Surf or Black Scoter	3.40	9.70	285.2	68	30
Surf Scoter	0.35	0.75	212.9	7	20
Black Scoter	1.10	2.02	184.0	22	30
Red-breasted Merganser	0.10	0.31	307.8	2	10
Bonaparte's Gull	0.60	1.14	190.4	12	30
Ring-billed Gull	0.80	1.91	238.6	16	20
Herring Gull	10.20	7.74	75.9	204	95
Great Black-bd Gull	5.55	5.60	100.8	111	100
Black-legged Kittiwake	2.25	2.22	98.7	45	65
Gull unidentified	1.35	4.94	366.3	27	15
Razorbill	4.45	6.44	144.8	89	60
Murre unidentified	0.30	0.98	326.2	6	10
Common Murre	6.55	13.23	202.0	131	55
Thick-billed Murre	0.15	0.49	326.2	3	10
Dovekie	6.25	17.44	279.0	125	30
Alcid unidentified	4.15	10.30	248.1	83	55
Grand Total	**104.45**	**104.81**	**100.3**	**2089**	**100**

Appendix H. Model selection results for Density Surface Models (DSM) for various species of birds in the Ocean SAMP area.

Species	Season	Model	Deviance explained (%)	edf	CV (%)
Common Loon	Winter	s(depth T dis to land)	21.5	22.74	0.069
Northern Gannet	Fall	s(depth T dis to land)	34.8	18.82	0.091
Northern Gannet	Winter	s(depth T dis to land)	36.6	23.44	0.087
Cory's Shearwater	Summer	s(depth T dis to land)	26.3	22.07	0.054
Greater Shearwater	Summer	s(depth) + s(dis to land)	50.8	8.37	0.149
Wilson's Storm-Petrel	Summer	s(depth) + s(dis to land)	33.5	13.89	0.210
Herring Gull	Summer	s(depth T dis to land)	27.1	12.35	0.079
Herring Gull	Fall	s(depth T dis to land)	32.3	20.78	0.102
Herring Gull	Winter	s(depth T dis to land)	8.6	14.9	0.019
Great Black-backed Gull	Summer	s(depth) + s(dis to land)	19.1	11.12	0.206
Great Black-backed Gull	Fall	s(depth T dis to land)	43.9	27.61	0.064
Great Black-backed Gull	Winter	s(depth) + s(dis to land)	7.45	9.08	0.044
Black-legged Kittiwake	Winter	s(depth) + s(dis to land)	9.74	12.112	0.014
Razorbill	Winter	s(depth)	11.3	8.774	0.171
Common Murre	Winter	s(depth) + s(dis to land)	23.5	15.133	0.065
Dovekie	Winter	s(depth) + s(dis to land)	34.6	11.72	0.160

Appendix I. Estimated number of individuals (N) and 95% Confidence intervals for 11 species of birds in Ocean SAMP area during three seasons based on DSM models (Appendix H).

Species	Season	N	95% CI
Common Loon	Winter	2,901	2535-3321
Northern Gannet	Fall	3,987	3336-4764
Northern Gannet	Winter	4,373	3688-5187
Cory's Shearwater	Summer	3,340	3005-3712
Greater Shearwater	Summer	2,643	1979-3530
Wilson's Storm-Petrel	Summer	16,335	10879-24527
Herring Gull	Summer	1454	1246-1697
Herring Gull	Fall	7332	6000-8961
Herring Gull	Winter	1082	1042-1124
Great Black-bd. Gull	Summer	1869	1255-2786
Great Black-bd. Gull	Fall	2680	2366-3036
Great Black-bd. Gull	Winter	682	627-743
Black-legged Kittiwake	Winter	291	283-299
Razorbill	Winter	1390	996-1940
Common Murre	Winter	623	548-707
Dovekie	Winter	5771	4222-7888

Appendix J. Detection functions and Generalized Additive Model output used to develop Density Surface Models for 11 species of birds in the Ocean SAMP study area.

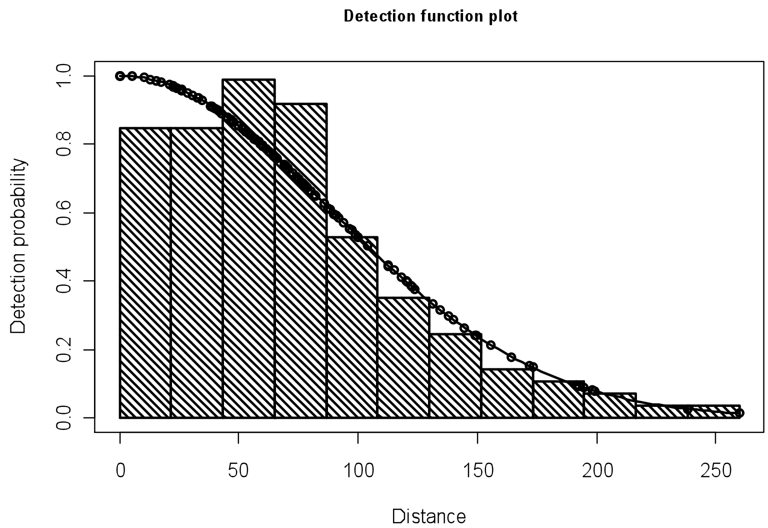


Figure J-1. Histogram of the distance data and the ‘best’ detection model (half-normal) for Common Loons in the study area during the winter season.

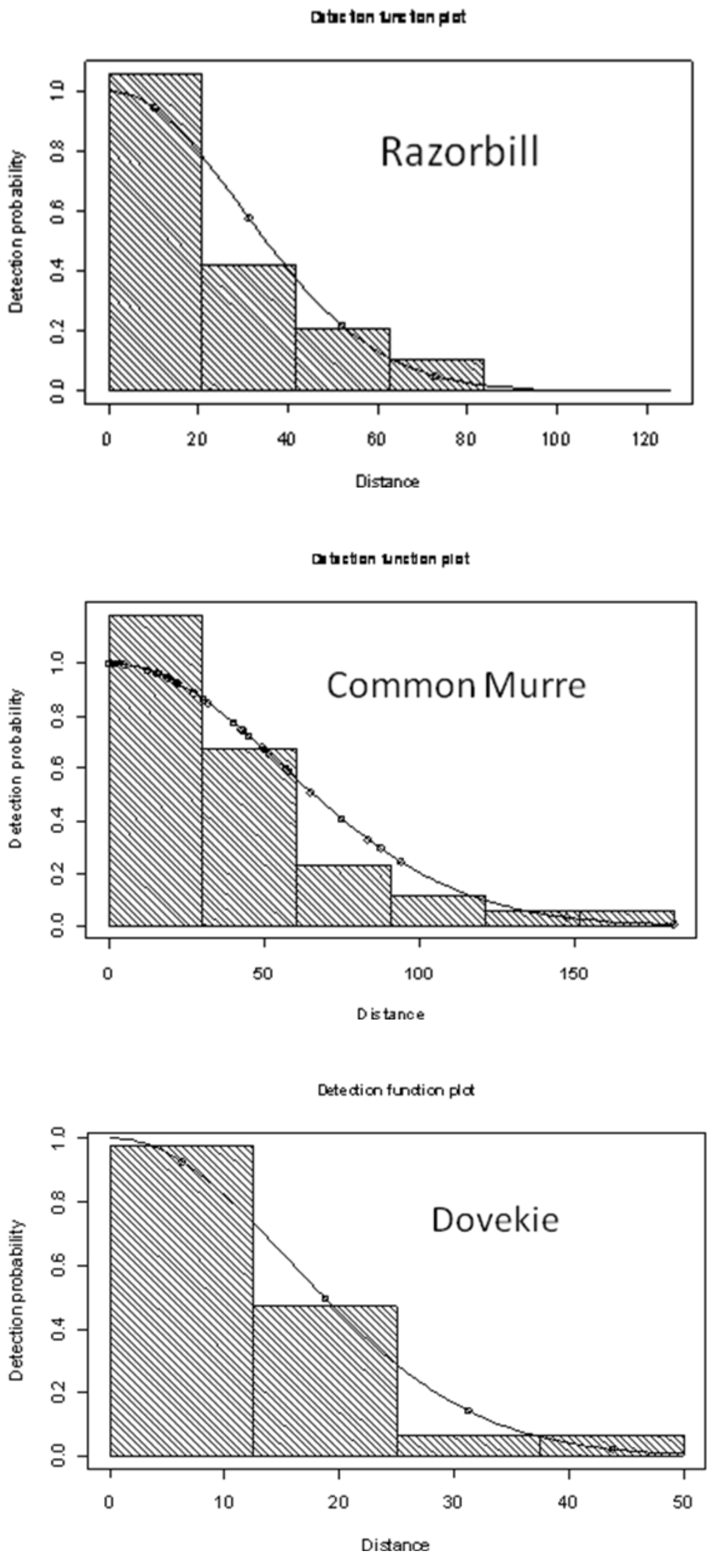


Fig. J-2.. Histogram of the distance data and the 'best' detection model (half-normal) for Razorbill, Common Murre and Dovekie in the study area during the winter season.

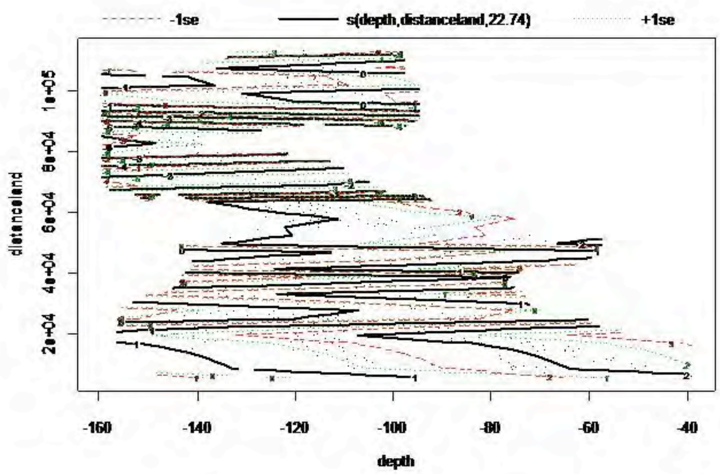


Fig. J-3. The output of the GAM model that best predicted Common Loon abundance in the study area during winter. The solid lines show the nature of the relationship as a contour plot (dotted lines are related to confidence intervals above and below the contour surface).

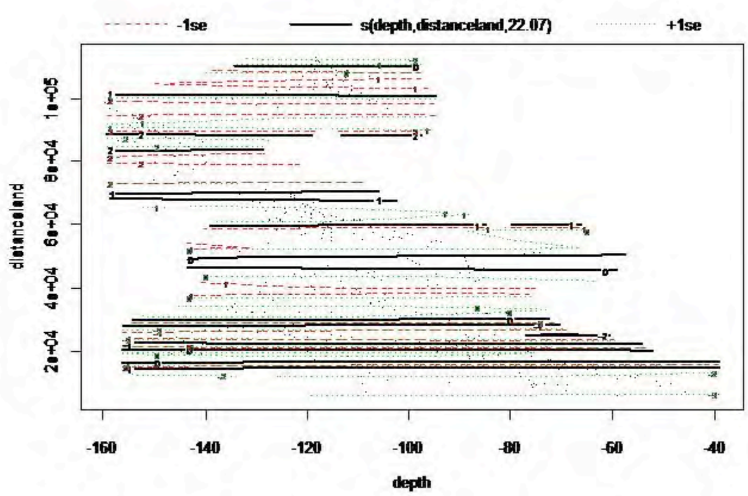


Fig. J-4. The output from the GAM model that best predicted Cory's Shearwater abundance in the study area during summer. The solid lines show the nature of the relationship as a contour plot (dotted lines are related to confidence intervals above and below the contour surface).

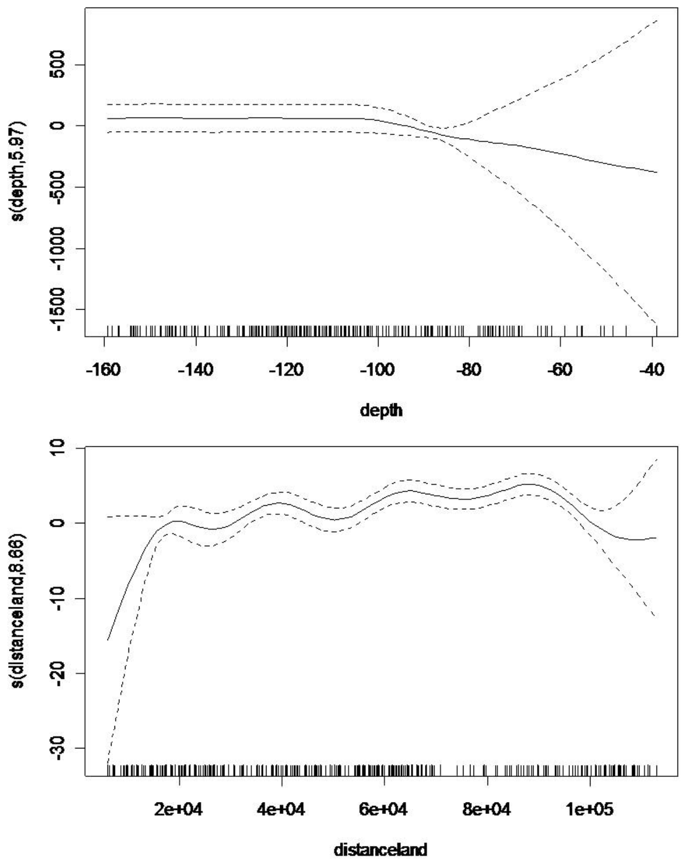


Figure J-5. The output from the GAM model that best predicted Greater Shearwater abundance in the study area during summer. The 95% confidence interval is represented with the dotted line and the distribution of data available to model (e.g. distribution of segments) is represented with the parallel lines on the x-axis.

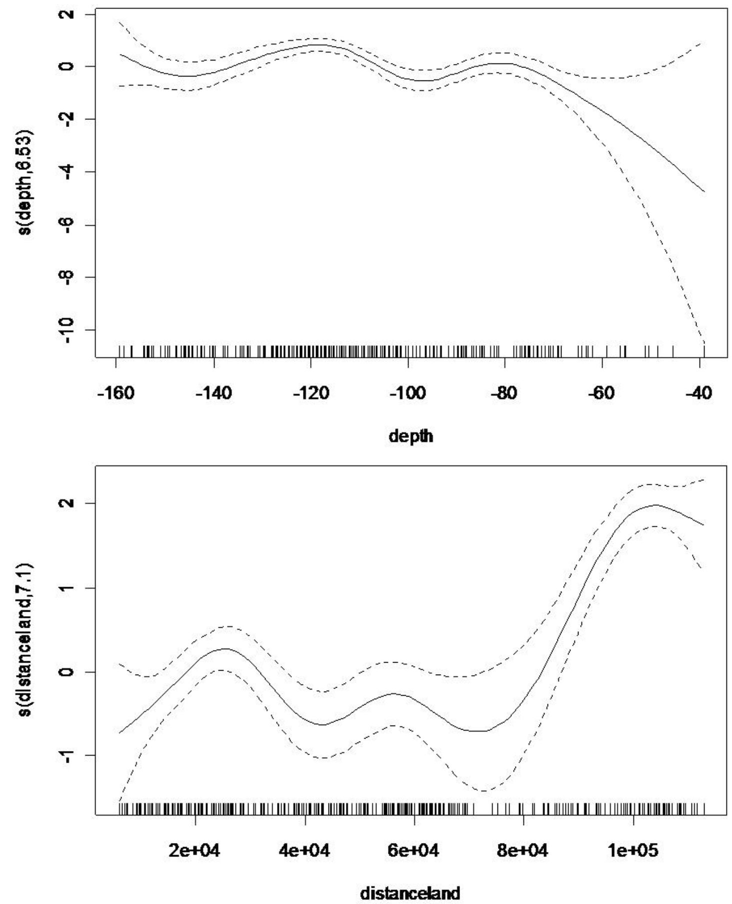
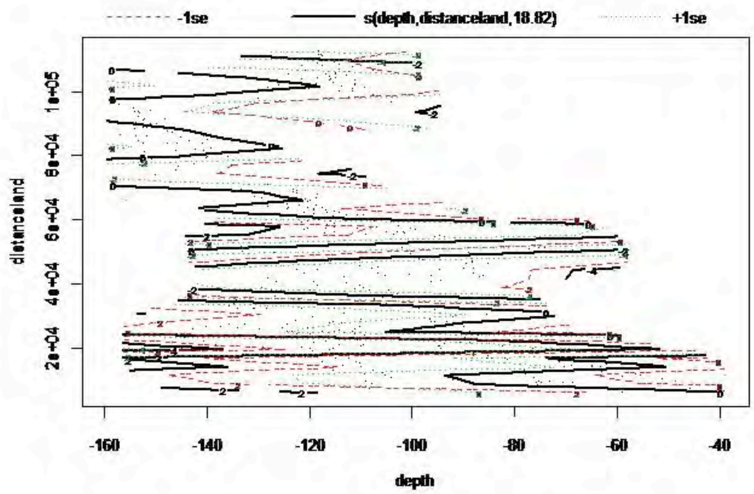


Fig. J-6. The output from the GAM model that best predicted Wilson Storm-Petrel abundance in the study area during summer. The 95% confidence interval is represented with the dotted line and the distribution of data available to model (e.g. distribution of segments) is represented with the parallel lines on the x-axis.



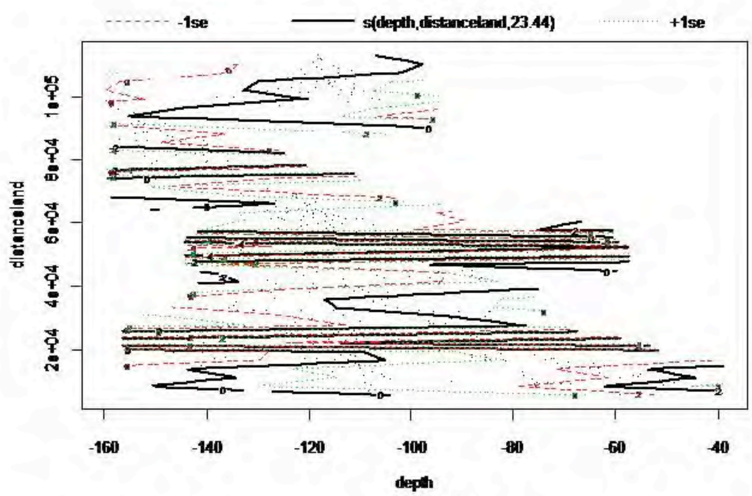
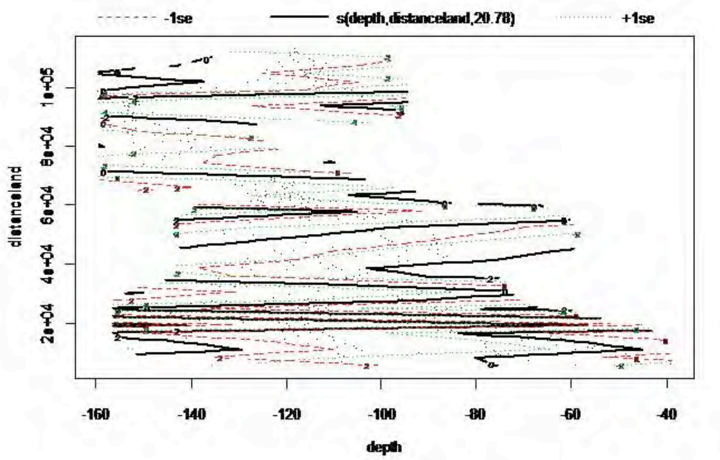


Fig. J-7. The output from the GAM model that best predicted Northern Gannet abundance in the study area during fall (top panel) and winter (bottom panel). The solid lines show the nature of the relationship as a contour plot (dotted lines are related to confidence intervals above and below the contour surface).



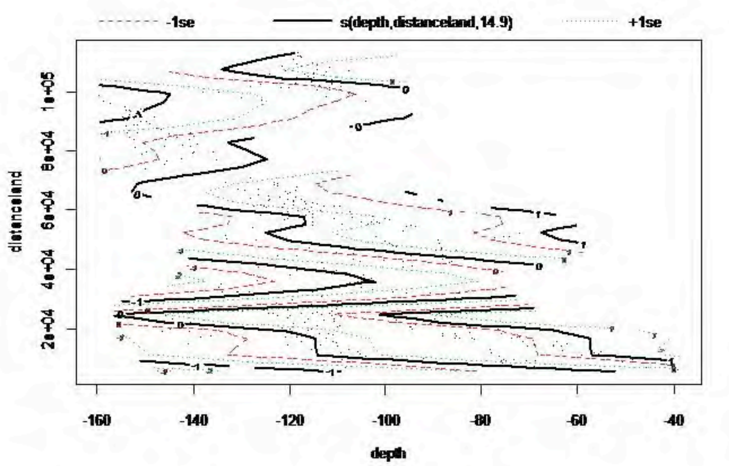


Fig. J-8. The output from the GAM model that best predicted Herring Gull abundance in the study area during summer (top panel), fall (middle panel) and winter (bottom panel). The solid lines show the nature of the relationship as a contour plot (dotted lines are related to confidence intervals above and below the contour surface).

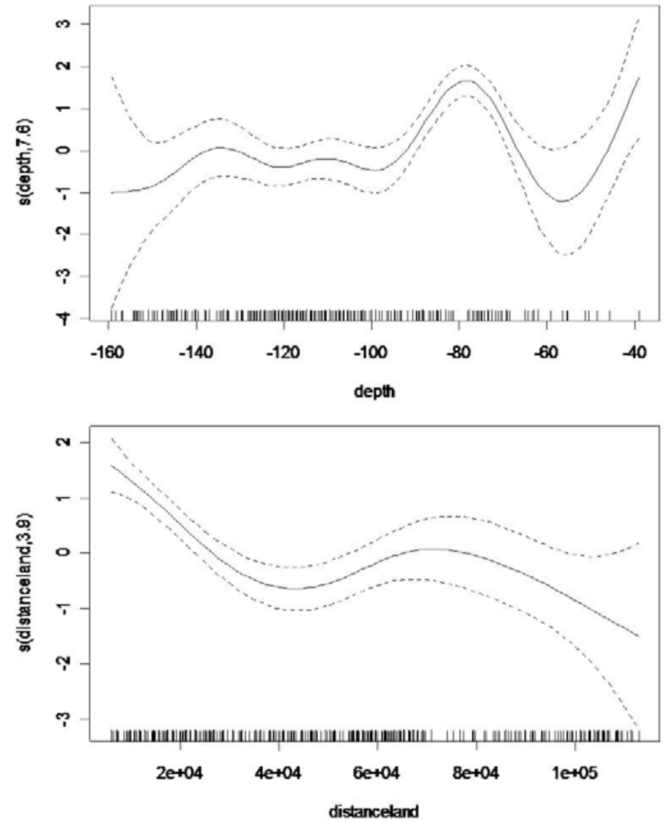


Fig. J-9. The output from the GAM model that best predicted Great Black-backed Gull in the study area during summer The 95% confidence interval is represented with the dotted line and the distribution of data available to model (e.g. distribution of segments) is represented with the parallel lines on the x-axis.

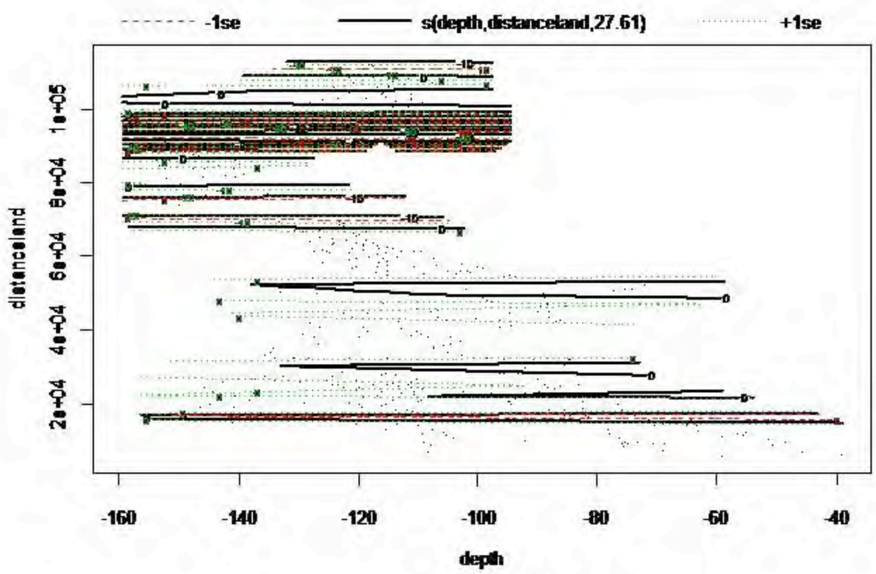


Fig. J-10. The output from the GAM model that best predicted Great Black-backed Gull abundance in the study area during fall. The solid lines show the nature of the relationship as a contour plot (dotted lines are related to confidence intervals above and below the contour surface).

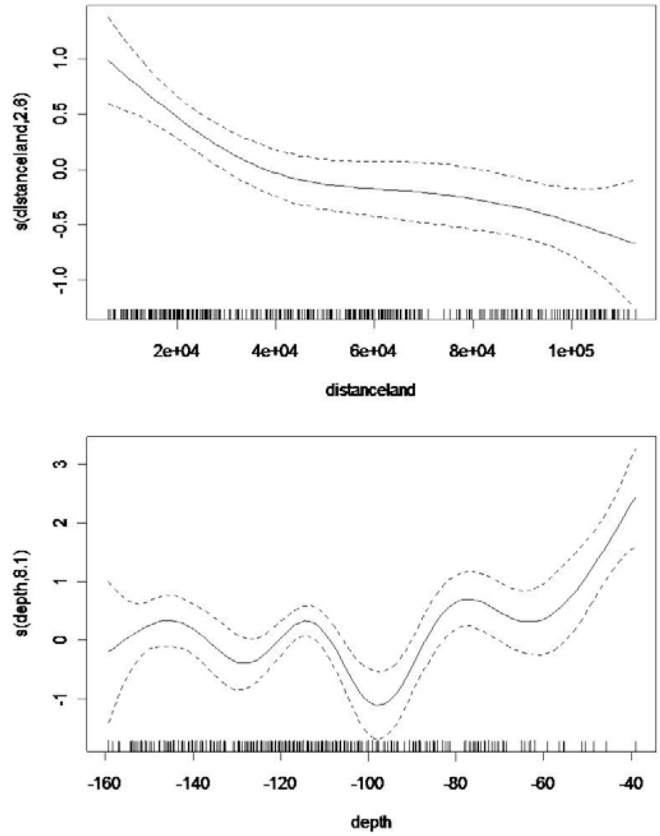


Fig. J-11. The output from the GAM model that best predicted Great Black-backed abundance in the study area during winter. The 95% confidence interval is represented with the dotted line and the distribution of data available to model (e.g. distribution of segments) is represented with the parallel lines on the x-axis.

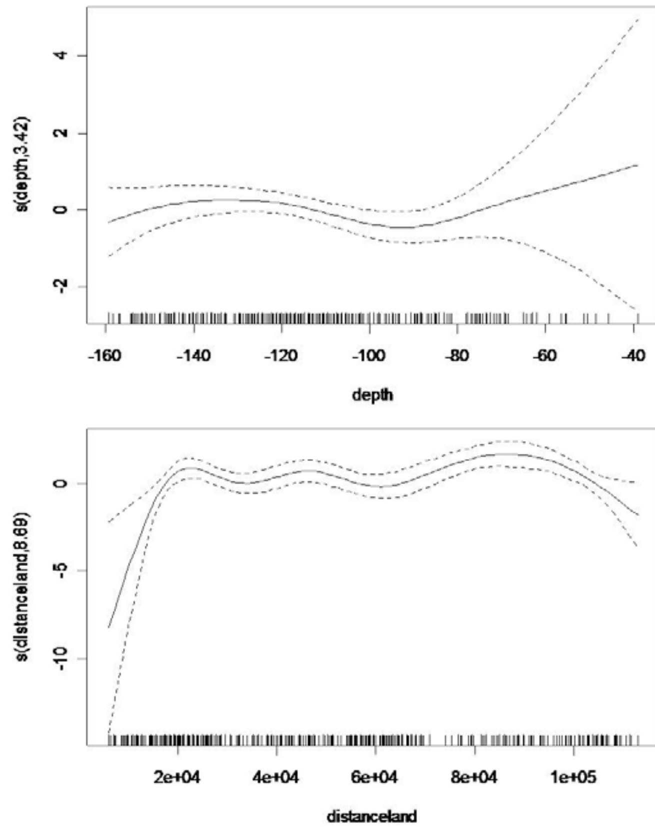


Fig. J-12. The output from the GAM model that best predicted Black-legged Kittiwake abundance in the study area during winter. The 95% confidence interval is represented with the dotted line and the distribution of data available to model (e.g. distribution of segments) is represented with the parallel lines on the x-axis.

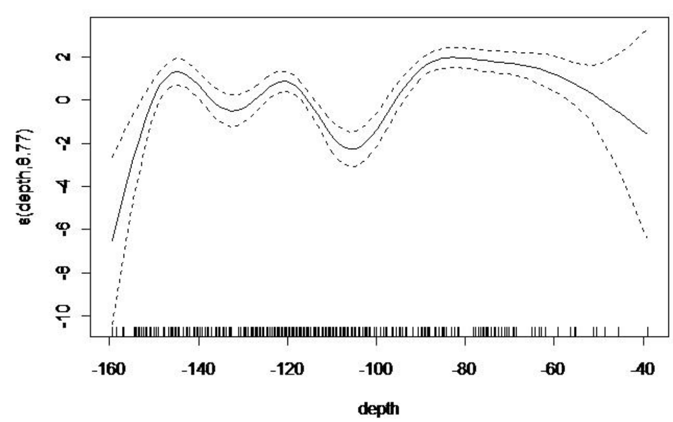


Fig. J-13. The output from the GAM model that best predicted Razorbill abundance in the study area during winter. The 95% confidence interval is represented with the dotted line and the distribution of data available to model (e.g. distribution of segments) is represented with the parallel lines on the x-axis.

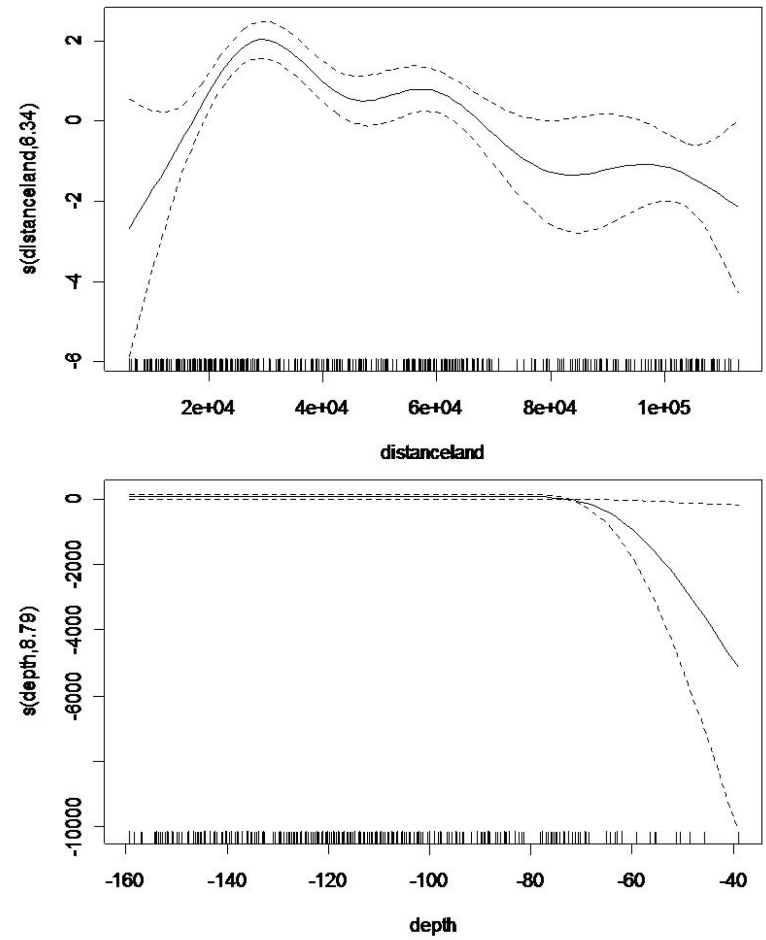


Fig. J-14. The output from the GAM model that best predicted Common Murre abundance in the study area during winter. The 95% confidence interval is represented with the dotted line and the distribution of data available to model (e.g. distribution of segments) is represented with the parallel lines on the x-axis.

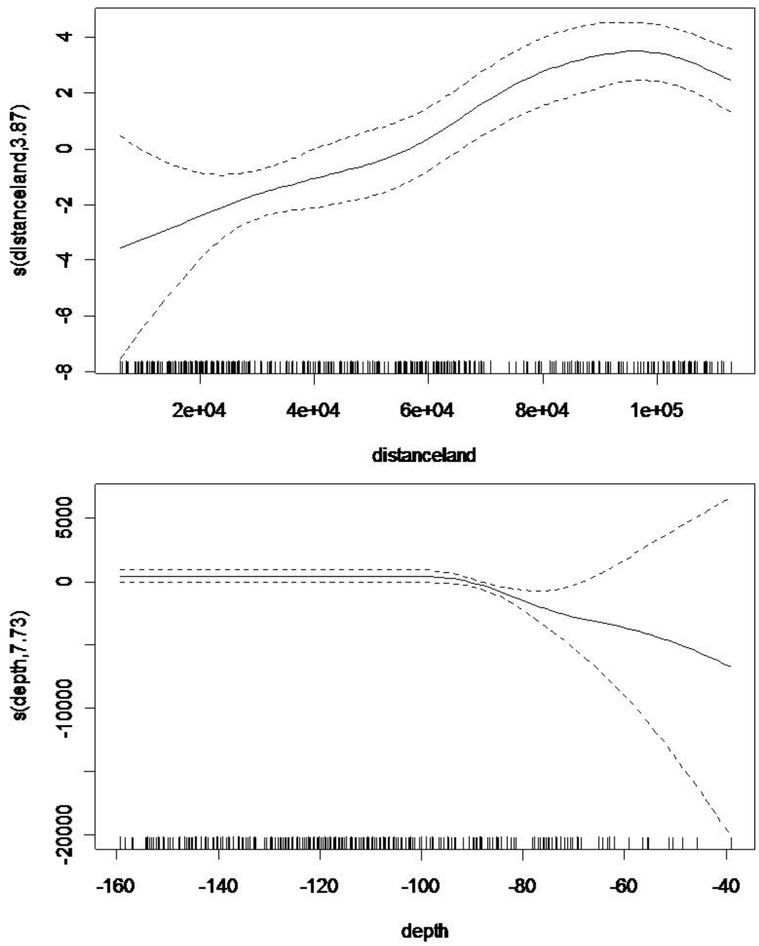


Fig. J-15. The output from the GAM model that best predicted Dovekie abundance in the study area during winter. The 95% confidence interval is represented with the dotted line and the distribution of data available to model (e.g. distribution of segments) is represented with the parallel lines on the x-axis.

Appendix K.

RADAR MONITORING OF BIRD AND BAT MOVEMENT PATTERNS ON BLOCK ISLAND AND ITS COASTAL WATERS

DRAFT INTERIM REPORT

Submitted to
University of Rhode Island
Department of Natural Resources Science

State of Rhode Island
Ocean Strategic Area Management Plan

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Department of Research and Monitoring

20 June 2010

GOALS AND OBJECTIVES

The goal of this task was to provide an improved understanding of bird and possibly bat movement patterns on Block Island, Rhode Island and in the local waters around the island. Specifically, our objectives were to (1) estimate nightly and seasonal passage patterns of aerial vertebrates (i.e., birds, bats) traversing Block Island and its coastal waters, (2) estimate altitudinal distributions of bird/bat movements and determine what proportion occurs at altitudes deemed a "risk" for collisions with wind turbines (3) determine flight directions and pathways of bird/bat "targets" in the study area and (4) investigate how meteorological conditions affect flight dynamics and behavior. This interim report will address Objectives 1-3. Results for Objective 4 and a discussion of all results relative to what is currently known about bird and bat movement patterns in other regions will be provided in a future report.

METHODS

Radar equipment and configuration

We used a dual mobile marine radar system to collect data on bird and bat flight dynamics and behavior. This system consists of two 25 kW Furuno X-band marine radars (frequency = 9410 GHz, wavelength = 3 cm, model # FAR2127BB, Furuno Electric Company, Nishinomiya, Japan) mounted to a trailer (12' long x 6' wide x 8' high, Fig. 1). The radars and all computer equipment connected to them were powered with a single Honda EU6500i fitted with a 15 gallon external gas tank to extend uninterrupted operating time.

The radars typically are fitted with standard 6.5' open array antennas (Fig. 1), which produce a fan-shaped electromagnetic beam 1.23° x 20°. The antennas rotate simultaneously to monitor various bird/bat flight dynamics and behavior patterns. In our system, one radar unit operates with the antenna rotating rotate in the vertical plane (i.e., "vertical radar"). This is accomplished by mounting the antenna turning unit perpendicular to the ground (Fig. 1). The antenna sweeps from horizon to horizon, describing a 180° arc above radar level (arl), 20° wide (Fig. 2). Data collected with the radar in this orientation were used to generate target (i.e., birds, bats) passage estimates and to quantify altitudinal distributions of targets (see Fig. 3 for data image example). During data collection at the southern end of the island (i.e., 19 March – 30 April), the vertical radar was positioned so that the antenna swept an arc from South to North. This was done to maximize the number of targets detected as waterbirds moved east to west along the southern coast of the island.

The second radar unit operates with the antenna rotating rotate in the horizontal plane (i.e., "horizontal radar"), describing a 360° arc every 2.5 seconds (Fig. 4). Data collected in this mode provided information on flight direction and in some cases, passage rates (see Fig. 5 for data image example). During the study we experienced persistent and often extensive backscatter of electromagnetic energy from wave action experienced at the southern site which dramatically affected the quality of data collected with the horizontal radar (Fig. 6 upper). On some days, this backscatter was extreme and it occluded the horizontal radar's entire view of the ocean sample area (Fig. 6 lower). Although, this is common problem when using radar in marine application, the southern site's elevation above sea level (i.e., ~45 m) exacerbated the problem. In an attempt to address this we experimented with a parabolic dish antenna (Fig. 7). This antenna produces a 4° conical-shaped electromagnetic beam and our mounting allowed it to be elevated in 2.5° above the scanning horizon. With the antenna elevated at 5° above the scanning horizon, we were able to eliminate detection of most wave-generated backscattered energy. Raising the antenna this far above the scanning horizon reduced our ability to sample low to the ocean surface, so we opted not to use the parabolic dish antenna at the southern site. We did, however, use this antenna at the northern radar site for the last 9 weeks of the study (8 October – 15 December) to reduce backscatter problems. We were able to do this by elevating the antenna only 2.5° above the scanning horizon, thereby maintaining the radar's view of areas close to the ocean's surface.

The radar's pulse length (i.e., rate that electromagnetic energy is transmitted) can be set from 0.07 - 1.2 μsec and detection ranges from 0.125 - 96 nautical miles (nm). For both radars, we used a 0.15 μsec pulse length. For monitoring the sunrise – sunset period (i.e., diurnal period) we set the horizontal radars' range to 2 nm as we expected to monitor the movements of larger waterbirds (e.g., loons, sea ducks, gulls) during the day. During the sunset – sunrise period (i.e., nocturnal period) we set the radars' range to 1 nm to increase the detection of small passerines and shorebirds that typically migrate at night. The range for the vertical radar was always set to 1.0 nm detection range regardless of the time of day.

Short pulse lengths provide better target resolution and more accurate location and distance estimates. Similarly, short detection ranges result in improved resolution of small passerine or bat-sized targets. The radars we use feature color-coded target representation that indicates return signal strength. This allows for discrimination and removal of weak reflectors that could be insects. The radar units also are equipped with an integrated global positioning system (GPS) and target tracking feature that allowed us to determine each target's coordinates and quantify target flight directions.

Each radar's processor unit is connected directly to a computer equipped with a PCI frame grabber circuit board. Using proprietary scheduling software developed by New Jersey Audubon Society (NJAS), we automatically captured five consecutive radar sweep images as bitmap files for any interval and for any period. Typically we collect images for five consecutive radar sweeps, every 10 minutes, from sunrise to sunset (~360 images/night/radar). We chose 10 minute intervals because we believe this insures total turnover of targets between samples.

Study sites and data collection time frame

From 19 March – April 30 2009, our radar system collected data on Audubon Society of Rhode Island property near the Lewis Farm, at the southern end of Block Island (i.e., "southern" site, 41°08.98' N, 71° 36.18' W, Fig. 8). The site is approximately 50 m above sea level and was selected because of its wide field of view to the south that would allow monitoring of migration of waterbirds (e.g., scoters, loons) that typically winter along the SE coast of Block Island. This location provided a view of the ocean from approximately 170-300° (i.e., S – NW or 130° of arc, Fig. 9) for the horizontal radar. The radar's view of the ocean between 90-170° (i.e., E – S, or 80° of arc) was occluded by a rise along the edge of the landform. Areas from approximately 300-90° (NW – E, or 150° of arc) were over land.

From 1 May – 15 October 2009, the NJAS radar system was located on Town of New Shoreham property, at the north end of the island, along the SW shore of Sachem Pond (i.e., "northern" site, 41°13.11' N, 71° 34.30' W, Fig. 8). The site was selected primarily to monitor northward and southward migration movements of passerines and other landbirds as well as waterbird (e.g., herons, egrets, terns) movements during the summer breeding season. The radar's view of the ocean was clear to the north, east and west. However backscatter of electromagnetic energy from trees and low-rising dunes occluded some of the radar's view of the surrounding landscape (Fig. 10). Unlike the southeastern study site, we experienced only minor problems in a limited area with backscatter of electromagnetic energy from wave action (i.e., from 15-40° or 25° of arc).

Although we anticipated moving the radar system back to the southern site on 1 Nov, (i.e., New Jersey Audubon Society, University of Rhode Island bird/bat monitoring principals) decided to leave the radar at the northern location through the end of the study period (i.e., 15 December). This was primarily because of issues related to extreme backscatter of radar energy from wave action experienced at the southern site (see above for description of problem).

To the extent possible, data were collected 24 hours/day, during the entire 272 day study period . The radar system was shut down approximately 30 min every two days to fill the generator's gas tank. From 9 – 14 July, the radar was offline for service.

Data Processing and Analysis

We collected approximately 1764 hours of data/radar during spring 2009 (74 days, mean = 23.83 hr/day) and reviewed approximately 52, 900 images/radar. For the summer period, we collected 934 hours of data per radar (39 days, mean = 23.97 hrs/day) and reviewed 28,900 images for each radar. From 9 – 14 July, the radar was offline for service. During the fall data collection period, we collected 3523 hours of data for each radar (147 days, mean = 23.97 hr/day) and reviewed approximately 105,600 images per radar. We experienced intermittent problems with the computer attached to the vertical radar on 6 – 8 December.

Image review was conducted to determine occurrences of bird/bat movement episodes and identify precipitation events, insect contamination or any other unwanted propagation. Precipitation and insects typically have distinct characteristics that allow trained observers to distinguish them from bird and bat targets. Data images with precipitation, insect contamination or any other unwanted propagation were removed from subsequent data analyses either using data processing software developed by NJAS or by manually removing images from data set before analyses. In extreme cases (e.g., continuous rain), we removed entire days or nights of data from analysis.

<u>Vertical radar</u>

Using image processing software developed by NJAS, we extracted target information from all data images collected with the vertical radar. The integrated image processing software:

1. Identifies the sample area and creates a template (Fig. 11) to remove stationary radar reflectors (i.e., ground clutter, sea clutter, main bang).
2. Removes targets with low signal strength likely to be insects (i.e., based on color value).
3. Smooths the data and locates and marks the centroid of each discrete target that remains
4. Exports a text file that includes information on every target's signal strength and its position (i.e., the distance of its centroid) in the *X*- and *Y*-planes relative to the radar's position

5. Outputs a bitmap image showing the transformed data with marked targets (Fig.12). This last feature allows us to review the data processing output to identify possible spurious targets and remove them from the data analysis step.

Using an analysis software program developed by NJAS staff, we summarized target counts, passage rates and altitudinal distribution (i.e., target position in the *Y*-plane relative to radar's position) for 10 min and hourly intervals. The software's output includes the total number of targets detected in each image and the mean number of targets detected in each five-image sample.

Our analysis software also quantifies the number of targets detected in discrete altitudinal bins (e.g., 100 m). Nineteen 100 m (approximately 1 nm) altitudinal bins were created from the data collected with the vertical radar. It also has a threshold feature that allows us to filter out data with unusually high target counts, typically indicating precipitation or insect contamination.

The results of analyses in this report are based on the average for each five-image sampling bout. These values are summed for the entire night's data collection (sum of the sample averages) to generate hourly, daily and nightly passage estimates. We believe using the sum of the sample averages is a more accurate assessment for the number of targets crossing through the study area because it minimizes the effect of enumerating the same targets multiple times during a single sampling bout. Analyses to quantify variation in target counts in successive images in a sampling bout indicated that coefficients of variation (CV) were very low (< 2%).

Horizontal radar

We used NJAS-developed software to calculate target directions from images collected with the horizontally radar. The program requires that the end of a target's trail and the target (in that order) be marked using the computer's mouse and cursor (Fig. 13). The program outputs the position of the trail's tail and the target and from these calculates the target's direction of movement. For day and night period, we analyzed one image for each hour of data collected on each sample day. Targets for each hour were compiled and we used Oriana© 3.0 circular statistical software (Kovach Computing 2006) to generate mean vectors (directional tendency), vector lengths (*r*, strength of directional tendency) and test statistical significance (i.e., Rayleigh's *Z* test, Zar 2003). We calculated second-order mean vectors (i.e., mean of mean vectors) for each season (i.e., day and night separately) and tested for statistical significance using Hotelling T^2 test (Mardia and Rupp 2000).

Statistical Analysis

We used General Linear Model procedures (GLM, Zar 1998) the effect of SEASON (i.e., SPRING migration: 19 Mar – 31 May, SUMMER: 1 June – 15 July, FALL migration: 16 July – 15 December) PERIOD (DAY: sunrise to sunset the same day, NIGHT: sunset to sunrise the following morning) and the interaction between the two variables on target passage and passage rates (i.e., targets/hr). We used the same statistical approach to investigate these factors on the proportion and number of targets detected in the two lowest altitudinal strata (i.e., ≤ 100 m, $100 < x \leq 200$ m). We used Bonferonni procedures to make *post hoc* pairwise comparisons when GLM procedures suggested significant affects of predictor variables (i.e., SEASON, PERIOD, SEASON*PERIOD interaction) on response variables.

We used Kolmogorov-Smirnoff two-sample tests (Corder and Foreman 2009) to compare altitudinal distributions among seasons and between periods and used GLM procedures to investigate relationships between targets detected and the proportion of targets detected in the two lowest altitudinal strata.

To estimate directional patterns of movement, we compiled hourly target azimuths generated by our software for each season and by period. We used circular statistical analysis procedures (Mardia and Rupp 2000) to generate mean vectors (directional tendency), vector lengths (r, strength of directional tendency) and test statistical significance (i.e., Rayleigh's Z test, Zar 2003) for each SEASON/PERIOD combination (e.g., spring/day, spring/night). Using means and circular variance output from Oriana, we calculated second-order mean vectors (i.e., mean of mean vectors) for each SEASON/PERIOD combination and tested for statistical significance using Hotelling T^2 test (Mardia and Rupp 2000).

Prior to statistical analyses, response and predictor variables were evaluated to determine if they met assumptions of parametric tests being employed. If assumptions were not met, data were transformed or non parametric tests were used. Based on these assessments we used arcsine transformations to normalize variables represented as proportions (e.g., proportion of targets detected in various altitudinal strata). We used the log transformation to normalize the response variable representing nightly number of targets detected, hourly rates of targets detected and targets detected within altitudinal strata. Although we present results of statistical analyses that used transformed variables, we present summary statistics (e.g., means, standard errors) for response variables in their untransformed state in textual, tabular and graphical accounts, unless otherwise indicated. All standard statistical analyses were performed using SAS® 9.2 (SAS Institute, Inc. 2004) and SYSTAT® 11.0 (SYSTAT Software, Inc. 2004). Statistical tests involving directional data (i.e., flight direction) were performed using Orianna 3.0© (Kovach Computing Services 2007). Results of statistical tests were considered significant at $\alpha \leq 0.05$.

RESULTS

Target passage and passage rates

Numbers of birds and bats detected during the study varied widely within and among seasons and between day and night periods (Tables 1 – 6, Figs. 14, 15, 16). Generally, sums of the 10-minute sample averages and hourly rates of targets detected raged 2-3 orders of magnitude within a single season or period and coefficients of variation were > 95%. These results indicate that seasonal bird/bat movements, especially during migration periods (i.e., both diurnal and nocturnal), were temporally episodic. The seasonal pattern in targets detection varied between day and night. Kolmogorov Smirnov two-sample tests suggested that day and night cumulative frequency distributions that characterized daily changes in target movements, were significantly different in spring (maximum difference = 0.402, $P < 0.001$, Fig. 17 upper) and summer (maximum difference = 0.605, $P < 0.001$, Fig. 17 center), but not in fall (maximum difference = 0.099, $P < 0.48$, Fig. 17 lower).

Despite large variability in indices of movement, we found statistically significant SEASON ($F_{2, 513} = 9.23$, $P = 0.0001$) and PERIOD (i.e., day, night, $F_{1, 514} = 10.38$, $P = 0.0014$) effects on the number of targets detected (i.e., sum of the sample averages). Targets detected during the fall (mean = 141.24 ± SE 1.08) were significantly greater ($P = 0.003$) than in spring (mean = 89.90 ± SE 1.19) and summer ($P = 0.001$, mean = 76.54 ± SE 1.17), while spring and summer were not significantly different from each other. Targets detected at night (mean = 123.70 ± SE 1.10) were significantly greater ($P < 0.001$) than those detected during the day (mean = 79.32 ± SE 1.10). We also found a significant SEASON*PERIOD interaction ($F_{2, 513} = 14.47$, $P < 0.0001$). *Post hoc* comparisons suggested that targets detected during fall/night were significantly greater than all other SEASON/PERIOD combinations (all *P*s < 0.0001, Fig. 18 upper) while none of the other combinations were statistically different from each other (Fig. 18 upper).

We found similar significant SEASON ($F_{2, 513} = 6.98$, $P = 0.001$) and PERIOD ($F_{1, 514} = 27.40$, $P < 0.0001$) effects on target detection rate (i.e., targets detected/hour). Again, fall target detection rate (mean = 14.95 ± SE 1.07) was significantly greater ($P = 0.01$) than spring (mean = 10.43 ± SE 1.11) and summer ($P = 0.008$, mean = 9.28 ± SE 1.15), while spring and summer were not significantly different from each other. Targets detection rates at night (mean = 15.68 ± SE 1.09) were also significantly greater ($P < 0.0001$) than those during the day (mean = 8.16 ± SE 1.09). We found a significant SEASON*PERIOD interaction ($F_{2, 513} = 14.47$, $P < 0.0001$). *Post hoc* comparisons indicated that target detection rate during fall/night was significantly greater than all other SEASON/PERIOD combinations (all *P*s < 0.0001, Fig. 18 lower) while none of the other combinations were statistically different from each other (Fig. 18 lower).

Bird/bat movements also varied with time relative to sunrise and sunset. The diurnal period (i.e., sunrise – sunset) appeared to be characterized by distinct peaks in movement 6-8 hours after sunrise (Fig. 19). Peak movement during the nocturnal period (i.e., sunset – sunrise the following morning) appeared to occur 1-3 hours after sunset (Fig. 20). However, Kolmogorov Smirnov two-sample tests suggested that day and night cumulative frequency distributions, which characterized hourly changes in target detections, were not significantly different among seasons for day (Fig. 21 upper, all *P*s > 0.60) or night (Fig. 21 lower, all *P*s > 0.80) data collection periods. Additionally, comparisons of season-specific cumulative frequency distributions for day and night data collections periods were not significantly different (all *P*s > 0.3, *cf* Fig. 21).

Target altitude

Results from Kolmogorov-Smirvov two-sample tests suggest that proportional distributions of targets detected in each 100 m strata (i.e., up to one nautical mile or approximately 1900 m) were not significantly different (all *P*s > 0.10) among seasons for the diurnal (Fig. 22, upper) or nocturnal periods (Fig. 22, lower). Regardless of season or period, altitudinal distributions of detected targets generally increased with altitude to peak between 200 and 400 m (Figs. 23, 24), except during the spring/diurnal period when the greatest proportion of detected targets occurred in the 0-100 m stratum. At altitudes greater than 500 m the proportion of detected targets decreased asymptotically.

<u>0-100 meter stratum</u>

Our data also suggest extensive within-season variation in the proportion of and number of targets detected in the lowest altitudinal strata we considered (i.e., targets ≤ 100 m, Tables 1 – 6, Figs. 25, 26, 27). Kolmogorov Smirnov two-sample tests suggested that cumulative frequency distributions that characterized daily changes in the proportion of target detected in the 0-100 m stratum, were significantly different between day and night data collection periods in spring (maximum difference = 0.402, $P < 0.001$, Fig. 28 upper), summer (maximum difference = 0.632, $P < 0.001$, Fig. 28, center) and fall (maximum difference = 0.160, $P < 0.05$, Fig. 28, lower). Additionally, Kolmogorov Smirnov two-sample tests suggested a significant difference in the cumulative frequency distributions among seasons for the day (*cf* Fig. 28, all *P*s < 0.005,) and night (*cf* Fig. 28, all *P*s < 0.0009,) data collection periods.

Although the proportional distributions of target altitudes were high day-to-day and night-to-night variability, we found significant SEASON ($F_{2, 513} = 4.49$, $P = 0.01$) and PERIOD ($F_{1, 514} = 36.19$, $P < 0.0001$) effects on the proportion of targets detected in the 0-100 m stratum. The proportion of targets detected in the 0-100 m stratum was significantly greater in summer ($P = 0.04$) during the (mean = 0.116 ± SE 0.000) compared to fall (0.086 ± SE 0.00) and nearly so compared to spring ($P = 0.08$, mean = 0.106 ± SE 0.000). Additionally, the proportion of targets detected in the 0-100 m stratum was significantly greater ($P < 0.0001$) during the day (mean = 0.132 ± SE 0.000) than at night (mean = 0.076 ± SE 0.00).

We found a significant SEASON*PERIOD interaction effect on the proportion of targets detected in the 0-100 m stratum ($F_{2, 513} = 3.98$, $P < 0.02$). *Post hoc* comparisons indicated that fall/night had a significantly smaller proportion (mean = 0.065 ± SE 0.005) than any other SEASON/PERIOD combination (all *P*s < 0.02) except summer/night (Fig. 29, upper). Summer/day had the greatest proportion of targets detected in the 0-100 m stratum (mean = 0.176 ± SE 0.018) and this was significantly greater than all SEASON/night combinations (all Ps < 0.02) but not greater than other SEASON/day combinations (Fig. 29, upper).

We found a significant SEASON effect on targets detected (i.e., sums of the 10-minute sample averages) in the 0-100 stratum ($F_{2, 513} = 3.49$, $P = 0.03$), but no significant PERIOD effect ($F_{1, 514} = 0.16$, $P = 0.69$). Targets detected in fall (mean = 10.43 ± SE 1.08) were significantly greater ($P = 0.05$) than in spring (mean = 7.70 ± SE 1.11) but not summer (mean = 7.66 ± SE 1.16). Targets we detected in spring and summer were not statistically different.

However, the SEASON*PERIOD interaction was significant. *Post hoc* comparisons indicated that targets detected in the 0-100 stratum for the fall/night combination (mean = 31.43 ± SE 3.86) were significantly greater (all *P*s < 0.004, Fig. 29, lower) than fall/day (mean = 16.68 ± SE 2.09), spring/night (mean = 11.68 ± SE 1.63) and summer night (mean = 14.40 ± SE 4.13). Other SEASON/PERIOD combinations were not statistically different from each other (Fig.29, lower).

The proportion and mean number of bird/bat targets detected in the 0-100 m altitudinal stratum showed extensive hour-to-hour variation during day and night data collection periods, regardless of season (spring: Figs. 30, summer: Fig. 31, fall: Fig. 32). Variation in the proportion and numbers of targets in the 0-100 m stratum appeared to follow patterns similar to those observed in the hourly proportion and total count of targets and patterns discussed in the previous section (*cf* Figs. 19, 20). That is, during the diurnal period (i.e., sunrise – sunset) distinct peaks in the mean proportion and number of targets detected in the lowest altitudinal strata occurred 6-8 hours after sunrise. During spring and summer nocturnal periods (i.e., sunset to sunrise the following morning), peak mean proportions and number of targets detected below 100 m appeared to occur 1-3 hours after sunset (Figs. 30, 31). In fall, however, the mean proportion of targets detected at or below 100 m was smallest at sunrise and gradually increased to the greatest values as sunrise approached (Fig. 32, upper right). Conversely, the mean number of targets detected in this stratum was greatest at sunset and decreased gradually to reach the smallest values of the night at sunrise (Fig. 32 lower right).

However, Kolmogorov Smirnov two-sample tests suggested that cumulative frequency distributions that characterized hourly changes in the proportion of target detected in the 0-100 m stratum were not significantly different between day and night data collection periods in spring, summer or fall (all Ps > 0.20, Fig. 33). Additionally, Kolmogorov Smirnov two-sample tests suggested that there was no statistical difference in the cumulative frequency distributions that characterize hourly variation among seasons for the day (all Ps > 0.80, *cf* Fig. 33) and night (all Ps > 0.60, *cf* Fig. 33) data collection periods.

<u>101-200 meter stratum</u>
Similar to our findings for the 0-100 m stratum, our data also suggest extensive within-season variation in the proportion of and number of targets detected in the 101-200 m stratum, Tables 1 – 6, Figs. 24, 25, 26). Kolmogorov Smirnov two-sample tests suggested that cumulative frequency distributions that characterized daily changes in the proportion of target detected in the 101-200 m stratum, were significantly different between day and night data collection periods in spring (maximum difference = 0.240, P = 0.03, Fig. 34 upper) and summer (maximum difference = 0.526, P < 0.0001, Fig. 34, center), but not in fall (maximum difference = 0.126, P < 0.19, Fig. 28, lower). Additionally, Kolmogorov Smirnov two-sample tests suggested the fall cumulative frequency distribution for the day data collection period was significantly different than spring and summer (all Ps ≤ 0.003 *cf* Fig. 34), for spring and fall were statistically different (P = 0.69).

We found a significant SEASON ($F_{2, 513}$ = 5.29, P = 0.005) and PERIOD ($F_{1, 514}$ = 32.63, P < 0.0001) effects on the proportion of targets detected in the 101-200 m stratum. The proportion of targets detected in the 101-200 m stratum was significantly greater in summer (mean = 0.175 ± SE 0.000) compared with fall (P = 0.01, mean = 0.138 ± SE 0.000) and spring (P = 0.006, mean = 0.133 ± SE 0.000), but fall and spring were statistically different from each other (Fig. 35, upper). "Day" had significantly greater proportion (P < 0.0001, mean = 0.177 ± SE 0.000) of targets in the 101-200 m stratum than "night" (mean = 0.122 ± SE 0.000). A SEASON*PEROID effect on the proportion of targets detected in the 101-200 m stratum was not evident from our analyses ($F_{2, 513}$ = 1.65, P = 0.19, Fig. 35, upper).

Similar to results from the 0-100 m stratum, we found a significant SEASON effect on targets detected in the 101-200 stratum ($F_{2, 513}$ = 8.61, P = 0.0002) and no significant PERIOD effect ($F_{1, 514}$ = 0.60, P = 0.44). We detected significantly greater numbers of targets in fall (mean = 18.41 ± SE 1.08) compared with spring (P = 0.0002, mean = 10.56 ± SE 1.12). However, targets detected in fall and summer (mean = 13.00 ± SE 1.17) were not statistically different, nor were they for spring and summer. We also found a significant SEASON*PERIOD effect ($F_{2, 513}$ = 12.46, P < 0.0001) on targets detected in the 101-200 m stratum. Significant more targets were detected during fall/night (mean = 65.66 ± SE 7.08, (Fig. 35, lower) than all other SEASON/PERIOD combinations (all Ps ≤ 0.0004) except for summer/day (P = 0.09, mean =

30.82 ± SE 5.55, Fig. 35, lower). None of the other SEASON/PERIOD combinations were significantly different from each other (Fig. 35, lower).

As was the case for the 0-100 m altitudinal stratum, the proportion and mean number of bird/bat targets detected in the 101-200 m altitudinal stratum showed extensive hour-to-hour variation during day and night data collection periods, regardless of season (spring: Figs. 30, summer: Fig. 31, fall: Fig. 32). Variation in the proportion and numbers of targets in the 101-200 m stratum appeared to follow patterns observed in the hourly proportion and total count of targets discussed in the previous section (*cf* Figs. 19, 20) and for the 0-100 m stratum (Figs. 30, 31, 32). Generally, peaks in the mean proportion and number of targets detected in the lowest altitudinal strata occurred approximately 6-8 hours after sunrise during the diurnal period (i.e., sunrise – sunset). During spring and summer nocturnal periods (i.e., sunset to sunrise the following morning) these peaks occurred approximately 1-3 hours after sunset (Figs. 30, 31). In contrast, the mean proportion of targets detected in the 101-200 m stratum was smallest at sunrise and gradually increased to the greatest values as sunrise approached during the fall nocturnal period (Fig. 32, upper right), while the mean number of targets detected in this stratum was greatest at sunset and decreased gradually to reach the smallest values of the night at sunrise (Fig. 32 lower right).

However, Kolmogorov Smirnov two-sample tests suggested that cumulative frequency distributions that characterized hourly changes in the proportion of target detected in the 101-200 m stratum were not significantly different between day and night data collection periods in spring, summer or fall (all *P*s > 0.15, Fig. 36). Additionally, Kolmogorov Smirnov two-sample tests suggested that there was no statistical difference in the cumulative frequency distributions that characterize hourly variation among seasons for the day (all *P*s > 0.60, *cf* Fig. 36) and night (all *P*s > 0.80, *cf* Fig. 36) data collection periods.

Relationships between target altitude and movement magnitude

<u>0-100 meter stratum</u>

Generally, we found a negative relationship between the proportion of targets detected (i.e., arsine transformed, see Methods section, Statistical Analysis) in the 0-100 m stratum and total targets detected (i.e., log transformed, see Methods section, Statistical Analysis) across all strata. That is, as total targets detected increased, the proportion of targets in the lowest altitudinal stratum decreased regardless of season or period (Figs. 37, 38, 39). However, these relationships were only statistically significant for the night periods and the fall/day period (all *P*s < 0.02, Table 7).

<u>101-200 meter stratum</u>

For the 101-200 m stratum, only spring/day, fall/day and fall night exhibited a negative relationship between the proportion of targets detected and total targets detected across all strata (Figs. 37, 39). All of these relationships were statistically significant (all, *P*s < 0.01, Table 7). For spring/night, summer/day and summer/night periods, relationships between the proportion of targets detected and total targets detected across all strata were positive (Figs. 37, 38). However, only the relationship for summer/night was significant (*P* = 0.02).

Target flight direction

We conducted second-order analyses (i.e., means of means) on mean vectors and vector lengths calculated for each season/period combination (e.g., spring/day, summer/night, fall/night). We found that second-order mean vectors were significantly different from random for each period in spring and summer (Fig. 40). However, neither fall/day nor fall/night second-order mean vectors were statistically different from random (fall/day: mean vector = 328°, $r = 0.14$, $F_{1,145} = 2.82$, $P = 0.06$, fall/night: mean vector = 265°, $r = 0.09$, $F_{1,145} = 1.16$, $P = 0.31$). After visual inspection of the data, we noticed that many of the first-order mean vectors during July and August were oriented toward the north, while many from September – December were oriented to the south. Given this, we split the fall data into four groups: July – August, day and night, September – December, day and night. Of these, all second-order mean vectors were statistically significant (all Ps < 0.003, Fig. 41) except for September – December/day ($P = 0.22$, Fig. 41). We found not statistical difference when we compared season-specific day and night second-order mean vectors for each season (all Ps > 0.20). A comparison between September – December/day and September – December/night was not possible because the second-order mean vector of the former was no statistically significant.

Table 1. Results of marine radar image analyses for data collected on 73 days (i.e., sunrise to sunset the same day) during the spring 2009 migration period (19 March - 31 May on Block Island, New Shoreham, Rhode Island. "Total targets detected" are the number of birds/bats detected in all images collected. "Sum of the sample averages" refers to the target count averaged over the five successive images that constitute a sample (i.e., every 10 minutes). These values are summed for the entire night's data collection to generate a passage estimate. "Target detection rate" represents the number of targets detected per nautical mile of passage front per hour. We also present the proportion and number of targets detected within the three lowest altitudinal strata (i.e., 100, 200, 300 m).

Date	Julian day	Total targets detected	Sum of the sample averages	Target detection rate	Proportion of targets <=100 m	Number of targets <=100 m	Proportion of targets 101-200 m	Number of targets 101-200 m	Proportion of targets 201-300 m	Number of targets 201-300 m
03/20/09	79	3836	760	87.69	0.0201	15.26	0.0250	19.02	0.0344	26.15
03/21/09	80	200	37	3.31	0.1500	5.55	0.1450	5.37	0.2050	7.59
03/22/09	81	515	102	11.55	0.0388	3.96	0.0641	6.54	0.0583	5.94
03/23/09	82	337	65	6.39	0.0267	1.74	0.1454	9.45	0.2136	13.89
03/24/09	83	643	126	11.63	0.2504	31.55	0.2084	26.26	0.1882	23.71
03/25/09	84	438	87	7.68	0.1667	14.50	0.1895	16.49	0.2169	18.87
03/26/09	85	740	145	16.42	0.0595	8.62	0.0297	4.31	0.0419	6.07
03/27/09	86	265	52	4.73	0.3623	18.84	0.1623	8.44	0.1019	5.30
03/28/09	87	100	20	2.40	0.2100	4.20	0.1600	3.20	0.0100	0.20
03/29/09	88	32	7	2.80	0.0000	0.00	0.0000	0.00	0.0000	0.00
03/30/09	89	909	181	22.16	0.4070	73.67	0.0792	14.34	0.1045	18.92
03/31/09	90	193	37	3.47	0.1917	7.09	0.2021	7.48	0.0466	1.73
04/01/09	91	658	112	13.18	0.0106	1.19	0.0198	2.21	0.0198	2.21
04/02/09	92	290	56	13.44	0.0759	4.25	0.3414	19.12	0.2414	13.52
04/03/09	93	1171	232	32.37	0.0598	13.87	0.0102	2.38	0.0248	5.75
04/04/09	94	1837	363	31.11	0.0332	12.05	0.0430	15.61	0.0697	25.29
04/05/09	95	1876	374	31.61	0.2377	88.91	0.0608	22.73	0.0810	30.30
04/06/09	96	1066	212	48.92	0.0722	15.31	0.0394	8.35	0.0366	7.76
04/07/09	97	7191	1422	118.50	0.2356	334.98	0.0419	59.52	0.0334	47.46
04/08/09	98	6911	1359	151.00	0.1399	190.15	0.0865	117.59	0.0291	39.53
04/09/09	99	700	136	11.33	0.1043	14.18	0.0786	10.69	0.0829	11.27
04/10/09	100	697	142	13.27	0.1707	24.24	0.1306	18.54	0.0631	8.96
04/11/09	101	146	31	14.31	0.5822	18.05	0.2055	6.37	0.1096	3.40
04/12/09	102	278	52	6.50	0.2014	10.47	0.2734	14.22	0.0971	5.05
04/13/09	103	383	72	6.00	0.0783	5.64	0.1619	11.66	0.0836	6.02
04/14/09	104	566	114	12.67	0.0230	2.62	0.1131	12.89	0.0442	5.04
04/15/09	105	1225	245	19.86	0.0237	5.80	0.0914	22.40	0.0278	6.80
04/16/09	106	515	100	8.00	0.1087	10.87	0.1417	14.17	0.2039	20.39
04/17/09	107	319	62	4.89	0.0627	3.89	0.2414	14.97	0.0878	5.44
04/18/09	108	1426	282	23.50	0.0196	5.54	0.0743	20.96	0.0912	25.71
04/19/09	109	648	130	10.68	0.1204	15.65	0.2207	28.69	0.1651	21.47
04/20/09	110	351	56	7.81	0.1054	5.90	0.1966	11.01	0.0484	2.71
04/21/09	111	637	124	14.88	0.0471	5.84	0.0534	6.62	0.0518	6.42
04/22/09	112	632	124	15.18	0.0617	7.65	0.1535	19.03	0.1962	24.33
04/23/09	113	703	141	13.22	0.0327	4.61	0.1465	20.66	0.0484	6.82
04/24/09	114	332	63	4.91	0.0512	3.23	0.2078	13.09	0.1325	8.35

Table 1. Continued

04/25/09	115	3125	624	47.39	0.0109	6.79	0.0522	32.55	0.0915	57.11
04/26/09	116	745	157	11.92	0.0255	4.00	0.1812	28.45	0.0966	15.17
04/27/09	117	823	161	12.23	0.0413	6.65	0.1397	22.50	0.1701	27.39
04/28/09	118	1041	204	15.90	0.0384	7.84	0.0768	15.68	0.0384	7.84
04/29/09	119	473	92	7.26	0.1078	9.92	0.2452	22.56	0.1776	16.34
04/30/09	120	499	102	7.75	0.0301	3.07	0.2285	23.30	0.0541	5.52
05/01/09	121	490	97	18.19	0.1694	16.43	0.1735	16.83	0.0592	5.74
05/02/09	122	275	51	5.56	0.0618	3.15	0.1127	5.75	0.1055	5.38
05/03/09	123	354	69	27.60	0.6017	41.52	0.2797	19.30	0.0311	2.14
05/04/09	124	291	55	9.71	0.1271	6.99	0.3162	17.39	0.2543	13.99
05/05/09	125	157	32	5.33	0.4459	14.27	0.0892	2.85	0.0000	0.00
05/06/09	126	752	146	12.17	0.2061	30.09	0.2566	37.47	0.1702	24.85
05/07/09	127	807	163	16.58	0.0310	5.05	0.0756	12.32	0.0496	8.08
05/08/09	128	423	81	6.23	0.1348	10.91	0.1820	14.74	0.1560	12.64
05/09/09	129	205	37	4.04	0.0585	2.17	0.1366	5.05	0.1073	3.97
05/10/09	130	203	34	2.49	0.0985	3.35	0.4384	14.91	0.0640	2.18
05/11/09	131	178	34	2.68	0.2303	7.83	0.3652	12.42	0.0562	1.91
05/12/09	132	880	175	13.29	0.1534	26.85	0.2318	40.57	0.2966	51.90
05/13/09	133	660	128	9.85	0.0818	10.47	0.3152	40.34	0.2364	30.25
05/14/09	134	1134	227	25.22	0.5273	119.71	0.0820	18.62	0.0097	2.20
05/15/09	135	391	82	8.04	0.2992	24.54	0.1841	15.10	0.0946	7.76
05/16/09	136	213	40	3.16	0.2723	10.89	0.1737	6.95	0.1268	5.07
05/17/09	137	142	27	3.12	0.0282	0.76	0.1197	3.23	0.1056	2.85
05/18/09	138	127	23	2.38	0.2441	5.61	0.1969	4.53	0.1654	3.80
05/19/09	139	667	130	9.40	0.3418	44.44	0.2204	28.65	0.1934	25.14
05/20/09	140	233	40	3.00	0.0773	3.09	0.2146	8.58	0.0858	3.43
05/21/09	141	184	34	2.52	0.0815	2.77	0.3641	12.38	0.1304	4.43
05/22/09	142	277	50	3.80	0.0830	4.15	0.1769	8.84	0.1227	6.14
05/23/09	143	404	83	6.47	0.1089	9.04	0.1559	12.94	0.1535	12.74
05/24/09	144	384	75	5.77	0.0391	2.93	0.1589	11.91	0.0964	7.23
05/25/09	145	937	181	13.24	0.1889	34.19	0.1366	24.73	0.2038	36.90
05/26/09	146	580	110	7.95	0.3603	39.64	0.1931	21.24	0.1534	16.88
05/27/09	147	79	11	1.18	0.0759	0.84	0.1646	1.81	0.0759	0.84
05/28/09	148	103	20	2.93	0.1553	3.11	0.3786	7.57	0.0388	0.78
05/29/09	149	246	44	3.89	0.0203	0.89	0.2114	9.30	0.1138	5.01
05/30/09	150	440	81	5.86	0.0455	3.68	0.3341	27.06	0.2068	16.75
05/31/09	151	691	139	11.58	0.0434	6.03	0.1679	23.33	0.1042	14.48
Totals	73 days	58379	11462			1524		1246.11		933.17
Means		800	157	16	0.14	21	0.17	17	0.11	13

Table 2. Results of marine radar image analyses for data collected on 74 nights (i.e., sunset to sunrise the following morning) during the spring 2009 migration period (19 March - 31 May on Block Island, New Shoreham, Rhode Island. "Total targets detected" are the number of birds/bats detected in all images collected. "Sum of the sample averages" refers to the target count averaged over the five successive images that constitute a sample (i.e., every 10 minutes). These values are summed for the entire night's data collection to generate a passage estimate. "Target detection rate" represents the number of targets detected per nautical mile of passage front per hour. We also present the proportion and number of targets detected within the three lowest altitudinal strata (i.e., 100, 200, 300 m).

Date	Julian day	Total targets detected	Sum of the sample averages	Target detection rate	Proportion of targets <=100 m	Number of targets <=100 m	Proportion of targets 101-200 m	Number of targets 101-200 m	Proportion of targets 201-300 m	Number of targets 201-300 m
03/19/09	78	221.00	43	3.91	0.13	5.45	0.19	7.98	0.29	12.26
03/20/09	79	363.00	71	6.00	0.08	5.87	0.04	2.93	0.06	4.50
03/21/09	80	325.00	61	5.15	0.03	1.88	0.06	3.57	0.08	4.88
03/22/09	81	70.00	12	1.01	0.19	2.23	0.14	1.71	0.04	0.51
03/23/09	82	60.00	9	0.77	0.07	0.60	0.05	0.45	0.00	0.00
03/24/09	83	34.00	6	0.51	0.32	1.94	0.09	0.53	0.18	1.06
03/25/09	84	306.00	59	5.06	0.09	5.21	0.08	4.82	0.07	4.05
03/26/09	85	71.00	14	3.23	0.37	5.13	0.00	0.00	0.11	1.58
03/27/09	86	107.00	19	2.15	0.01	0.18	0.06	1.07	0.00	0.00
03/28/09	87	331.00	65	16.96	0.08	5.11	0.02	1.37	0.02	1.18
03/29/09	88	141.00	27	5.06	0.46	12.45	0.00	0.00	0.00	0.00
03/30/09	89	99.00	16	1.41	0.11	1.78	0.18	2.91	0.08	1.29
03/31/09	90	259.00	48	4.24	0.12	5.56	0.10	4.82	0.04	1.85
04/01/09	91	95.00	17	3.64	0.49	8.41	0.01	0.18	0.00	0.00
04/02/09	92	443.00	86	7.59	0.02	1.36	0.01	0.58	0.00	0.19
04/03/09	93	843.00	169	15.13	0.05	9.02	0.10	17.24	0.13	22.25
04/04/09	94	391.00	74	6.63	0.04	2.65	0.03	2.27	0.05	3.79
04/05/09	95	1017.00	204	18.27	0.16	32.50	0.08	16.05	0.08	16.05
04/06/09	96	930.00	180	18.62	0.11	19.94	0.06	10.65	0.06	11.03
04/07/09	97	4125.00	824	100.90	0.11	93.89	0.08	63.12	0.05	37.75
04/08/09	98	967.00	191	17.91	0.04	6.72	0.08	14.81	0.05	8.69
04/09/09	99	1027.00	203	18.74	0.05	10.67	0.09	19.17	0.09	17.59
04/10/09	100	347.00	70	12.35	0.18	12.91	0.01	1.01	0.03	1.82
04/11/09	101	237.00	47	4.78	0.21	9.72	0.08	3.77	0.02	0.99
04/12/09	102	123.00	24	2.22	0.20	4.68	0.18	4.29	0.26	6.24
04/13/09	103	421.00	83	7.66	0.12	9.66	0.26	21.69	0.23	19.12
04/14/09	104	249.00	53	8.37	0.06	3.41	0.17	8.94	0.17	8.94
04/15/09	105	1743.00	348	32.63	0.02	8.59	0.08	29.55	0.09	30.95
04/16/09	106	396.00	78	7.43	0.15	11.42	0.30	23.64	0.12	9.06
04/17/09	107	532.00	106	10.10	0.14	14.94	0.18	19.33	0.17	18.13
04/18/09	108	476.00	89	9.37	0.08	7.48	0.16	14.58	0.08	6.92
04/19/09	109	181.00	36	3.43	0.09	3.18	0.35	12.53	0.22	7.76
04/20/09	110	282.00	57	68.40	0.06	3.23	0.06	3.64	0.09	5.26
04/21/09	111	395.00	77	85.77	0.06	4.87	0.06	4.48	0.06	4.68
04/22/09	112	133.00	26	5.57	0.08	1.95	0.16	4.11	0.07	1.76
04/23/09	113	167.00	31	3.05	0.08	2.41	0.38	11.69	0.28	8.54

Table 2. Continued

04/24/09	114	856.00	172	16.65	0.09	14.67	0.17	29.34	0.19	32.75
04/25/09	115	1829.00	369	36.90	0.03	10.89	0.18	66.58	0.19	68.39
04/26/09	116	975.00	192	28.76	0.05	10.44	0.19	36.82	0.15	28.95
04/27/09	117	1582.00	310	31.00	0.04	11.17	0.11	34.10	0.18	55.46
04/28/09	118	738.00	147	18.77	0.06	8.17	0.13	19.52	0.09	13.35
04/29/09	119	308.00	60	6.00	0.04	2.14	0.28	16.75	0.11	6.43
04/30/09	120	1912.00	385	39.83	0.01	3.83	0.04	14.70	0.07	28.59
05/01/09	121	2654.00	531	75.21	0.02	10.60	0.06	33.01	0.17	91.63
05/02/09	122	1152.00	233	23.30	0.09	20.02	0.18	41.46	0.22	50.56
05/03/09	123	103.00	21	18.00	0.18	3.87	0.16	3.26	0.17	3.47
05/04/09	124	143.00	27	9.00	0.03	0.94	0.03	0.94	0.09	2.45
05/05/09	125	47.00	6	3.16	0.30	1.79	0.23	1.40	0.09	0.51
05/06/09	126	596.00	120	16.94	0.07	7.85	0.10	12.28	0.18	21.54
05/07/09	127	2446.00	489	56.42	0.09	44.98	0.15	72.77	0.15	75.77
05/08/09	128	2148.00	429	57.20	0.11	48.53	0.16	67.11	0.18	75.49
05/09/09	129	1232.00	250	25.86	0.07	17.05	0.15	37.95	0.14	35.31
05/10/09	130	114.00	17	1.79	0.24	4.03	0.33	5.67	0.10	1.64
05/11/09	131	976.00	193	19.97	0.14	27.29	0.22	42.91	0.22	42.12
05/12/09	132	570.00	109	11.47	0.11	12.05	0.22	23.52	0.24	26.58
05/13/09	133	284.00	56	6.11	0.07	3.75	0.13	7.10	0.16	8.87
05/14/09	134	46.00	8	16.00	0.41	3.30	0.04	0.35	0.02	0.17
05/15/09	135	1585.00	318	34.69	0.06	19.66	0.15	49.15	0.19	58.99
05/16/09	136	351.00	67	8.74	0.04	2.48	0.11	7.64	0.12	8.21
05/17/09	137	199.00	35	5.12	0.14	4.75	0.13	4.40	0.10	3.34
05/18/09	138	653.00	131	14.56	0.13	17.05	0.28	37.11	0.13	17.25
05/19/09	139	991.00	194	21.56	0.06	11.55	0.12	22.51	0.23	45.42
05/20/09	140	884.00	178	19.07	0.06	10.07	0.10	17.32	0.16	27.79
05/21/09	141	4167.00	832	34.47	0.03	28.95	0.07	57.10	0.09	75.27
05/22/09	142	1666.00	336	36.65	0.04	12.71	0.08	26.42	0.15	48.81
05/23/09	143	2876.00	573	76.40	0.03	15.14	0.07	40.25	0.08	48.41
05/24/09	144	2963.00	590	68.08	0.06	35.24	0.08	46.59	0.09	54.16
05/25/09	145	668.00	132	14.67	0.13	16.99	0.20	25.89	0.12	15.41
05/26/09	146	268.00	53	21.20	0.10	5.14	0.08	4.35	0.05	2.77
05/27/09	147	1548.00	309	33.71	0.11	35.53	0.22	66.87	0.26	79.65
05/28/09	148	144.00	27	3.24	0.08	2.25	0.06	1.69	0.17	4.50
05/29/09	149	1595.00	319	37.53	0.05	15.60	0.07	23.20	0.09	30.00
05/30/09	150	2546.00	510	57.74	0.04	19.83	0.11	55.29	0.13	68.71
05/31/09	151	302.00	60	3.33	0.12	7.35	0.41	24.64	0.04	2.58
Totals	74 nights	62024	12311			864.64		1417.43		1541.98
Means		838	166	20.72	0.11	11.68	0.13	19.15	0.12	20.84

Table 3. Results of marine radar image analyses for data collected on 39 days (i.e., sunrise to sunset the same day) during the 2009 non migration period (i.e., summer, 1 June - 15 July) on Block Island, New Shoreham, Rhode Island. Meteorological conditions resulted in data not being analyzed for one of the 39 nights during the study period. "Total targets detected" are the number of birds/bats detected in all images collected. "Sum of the sample averages" refers to the target count averaged over the five successive images that constitute a sample (i.e., every 10 minutes). These values are summed for the entire night's data collection to generate a passage estimate. "Target detection rate" represents the number of targets detected per nautical mile of passage front per hour. We also present the proportion and number of targets detected within the three lowest altitudinal strata (i.e., 100, 200, 300 m).

Date	Julian day	Total targets detected	Sum of the sample averages	Target detection rate	Proportion of targets <=100 m	Number of targets <=100 m	Proportion of targets 101-200 m	Number of targets 101-200 m	Proportion of targets 201-300 m	Number of targets 201-300 m
06/01/09	152	285	49	3.72	0.0877	4.30	0.3930	19.26	0.0807	3.95
06/02/09	153	736	145	11.15	0.0747	10.84	0.1807	26.20	0.1861	26.99
06/03/09	154	815	164	17.26	0.2025	33.20	0.1129	18.51	0.1215	19.92
06/04/09	155	547	107	11.26	0.2687	28.76	0.2066	22.10	0.2011	21.52
06/06/09	157	724	139	9.93	0.0829	11.52	0.3867	53.76	0.2500	34.75
06/07/09	158	1333	266	22.67	0.0480	12.77	0.1275	33.92	0.1605	42.70
06/08/09	159	648	130	9.51	0.0926	12.04	0.2685	34.91	0.1898	24.68
06/09/09	160	145	26	3.32	0.1448	3.77	0.2345	6.10	0.0552	1.43
06/10/09	161	187	31	2.24	0.0160	0.50	0.1016	3.15	0.0802	2.49
06/11/09	162	229	38	3.12	0.1528	5.81	0.4891	18.59	0.1135	4.31
06/12/09	163	311	60	6.10	0.0611	3.67	0.2186	13.12	0.0868	5.21
06/13/09	164	1206	244	18.30	0.1144	27.92	0.2405	58.67	0.1658	40.46
06/14/09	165	2404	481	39.53	0.0283	13.61	0.3760	180.88	0.5740	276.11
06/15/09	166	662	129	9.33	0.0695	8.96	0.5891	76.00	0.2085	26.89
06/16/09	167	477	93	6.72	0.2914	27.10	0.3836	35.68	0.1342	12.48
06/17/09	168	2004	398	29.12	0.0399	15.89	0.1407	56.01	0.1712	68.12
06/18/09	169	130	27	4.76	0.4462	12.05	0.1154	3.12	0.2077	5.61
06/19/09	170	163	31	2.30	0.1350	4.18	0.1963	6.09	0.1104	3.42
06/20/09	171	592	118	10.73	0.3564	42.06	0.2922	34.48	0.0895	10.56
06/21/09	172	206	41	4.10	0.4029	16.52	0.0437	1.79	0.0728	2.99
06/22/09	173	87	14	1.50	0.1839	2.57	0.2989	4.18	0.0460	0.64
06/23/09	174	103	19	1.94	0.3107	5.90	0.0388	0.74	0.1359	2.58
06/24/09	175	149	19	2.07	0.3423	6.50	0.1477	2.81	0.1946	3.70
06/25/09	176	462	89	6.51	0.2208	19.65	0.2100	18.69	0.1234	10.98
06/26/09	177	703	142	12.17	0.1323	18.79	0.1565	22.22	0.0811	11.51
06/27/09	178	1264	254	18.14	0.2983	75.76	0.1638	41.60	0.2468	62.70
06/28/09	179	248	47	3.32	0.2661	12.51	0.2419	11.37	0.1653	7.77
06/29/09	180	610	123	8.68	0.1639	20.16	0.3754	46.18	0.0967	11.90
06/30/09	181	1197	239	16.30	0.1170	27.95	0.1571	37.54	0.2272	54.31
07/01/09	182	177	36	4.24	0.2655	9.56	0.0678	2.44	0.1186	4.27
07/02/09	183	781	148	10.83	0.0755	11.18	0.3137	46.43	0.2113	31.27
07/03/09	184	1137	225	15.88	0.2841	63.92	0.2348	52.84	0.1073	24.14
07/04/09	185	256	43	3.00	0.1133	4.87	0.3516	15.12	0.0664	2.86
07/05/09	186	279	50	3.61	0.1541	7.71	0.2688	13.44	0.1649	8.24
07/06/09	187	2179	438	31.66	0.2446	107.14	0.2194	96.08	0.1703	74.57
Tabe 3. Continued										
07/08/09	189	928	184	13.46	0.1649	30.34	0.3071	56.51	0.2069	38.07
07/09/09	190	30	6	7.20	0.1667	1.00	0.0667	0.40	0.0333	0.20
07/15/09	196	16	1	0.38	0.0625	0.06	0.1875	0.19	0.2500	0.25
Totals	38 days	24410	4794			721		1171		985
Means		642.37	126.16	10.16	0.18	18.97	0.23	30.82	0.16	25.91

Table 4. Results of marine radar image analyses for data collected on 38 nights (i.e., sunset to sunrise the following morning) during the 2009 non migration period (1 June - 15 July) on Block Island, New Shoreham, Rhode Island. "Total targets detected" are the number of birds/bats detected in all images collected. "Sum of the sample averages" refers to the target count averaged over the five successive images that constitute a sample (i.e., every 10 minutes). These values are summed for the entire night's data collection to generate a passage estimate. "Target detection rate" represents the number of targets detected per nautical mile of passage front per hour. We also present the proportion and number of targets detected within the three lowest altitudinal strata (i.e., 100, 200, 300 m).

Date	Julian day	Total targets detected	Sum of the sample averages	Target detection rate	Proportion of targets <=100 m	Number of targets <=100 m	Proportion of targets 101-200 m	Number of targets 101-200 m	Proportion of targets 201-300 m	Number of targets 201-300 m
06/01/09	152	7172	1432	159.11	0.05	71.08	0.09	125.59	0.12	171.71
06/02/09	153	4776	959	106.56	0.12	115.46	0.28	267.46	0.20	188.35
06/03/09	154	4305	862	517.20	0.08	72.88	0.14	120.34	0.21	177.21
06/04/09	155	4145	830	93.96	0.08	68.48	0.17	142.97	0.23	190.83
06/05/09	156	13	3	3.60	0.46	1.38	0.00	0.00	0.00	0.00
06/06/09	157	265	53	31.80	0.15	8.00	0.20	10.80	0.21	11.20
06/07/09	158	2991	599	76.47	0.06	34.05	0.10	58.28	0.11	67.89
06/08/09	159	3850	772	107.72	0.05	36.29	0.11	88.03	0.16	124.72
06/09/09	160	2020	399	45.17	0.02	9.48	0.08	32.00	0.13	52.94
06/10/09	161	690	138	16.56	0.04	5.00	0.11	15.00	0.10	14.40
06/11/09	162	538	107	15.66	0.06	6.56	0.14	14.52	0.21	22.28
06/12/09	163	1244	246	28.94	0.07	18.19	0.19	47.66	0.19	46.67
06/13/09	164	155	30	12.00	0.10	2.90	0.12	3.48	0.17	5.23
06/14/09	165	370	74	8.71	0.09	6.40	0.16	11.80	0.15	10.80
06/15/09	166	187	35	4.38	0.22	7.86	0.18	6.18	0.17	5.99
06/16/09	167	285	57	6.71	0.03	1.80	0.22	12.40	0.23	13.00
06/17/09	168	183	33	4.13	0.08	2.70	0.09	3.07	0.17	5.59
06/18/09	169	35	6	3.60	0.23	1.37	0.00	0.00	0.00	0.00
06/19/09	170	829	166	19.53	0.03	4.41	0.13	20.83	0.12	20.42
06/20/09	171	105	21	15.75	0.16	3.40	0.30	6.20	0.19	4.00
06/21/09	172	63	9	1.13	0.00	0.00	0.08	0.71	0.06	0.57
06/22/09	173	120	21	2.52	0.03	0.53	0.08	1.75	0.28	5.95
06/23/09	174	218	41	4.92	0.06	2.63	0.19	7.90	0.20	8.09
06/24/09	175	140	27	3.68	0.14	3.86	0.14	3.66	0.28	7.52
06/25/09	176	492	97	10.98	0.07	6.31	0.07	6.90	0.11	10.45
06/26/09	177	211	42	5.60	0.08	3.38	0.12	4.98	0.16	6.57
06/27/09	178	389	75	8.82	0.04	2.70	0.11	8.48	0.26	19.86
06/28/09	179	347	67	8.20	0.06	4.25	0.16	11.01	0.18	11.97
06/29/09	180	513	105	12.60	0.07	7.57	0.16	16.78	0.21	22.31
06/30/09	181	589	115	14.38	0.06	6.64	0.19	22.26	0.18	20.70
07/01/09	182	165	34	4.00	0.08	2.88	0.16	5.56	0.15	4.95
07/02/09	183	319	62	7.29	0.05	2.92	0.12	7.58	0.08	5.05
07/03/09	184	256	47	5.32	0.05	2.20	0.21	9.91	0.18	8.63
07/04/09	185	174	31	3.96	0.07	2.32	0.14	4.45	0.12	3.74
07/05/09	186	355	71	8.04	0.07	5.20	0.22	15.40	0.12	8.60
Table 4. Continued										
07/06/09	187	485	96	11.08	0.06	5.34	0.14	13.86	0.17	16.03
07/08/09	189	297	57	6.45	0.06	3.45	0.09	5.18	0.05	2.69
07/15/09	196	524	106	11.56	0.07	7.48	0.22	23.26	0.22	22.86
Totals	38 nights	39815	7925			547.38		1156.24		1319.75
Means		1048	208.55	37.05	0.09	14.40	0.14	30.43	0.16	34.73

Table 5. Results of marine radar image analyses for data collected on 153 days (i.e., sunrise to sunset the same day) during the 2009 fall migration period (16 July -15 Dec) on Block Island, New Shoreham, Rhode Island. Radar malfunction, power loss and meteorological conditions resulted in data not being analyzed for 7 of the 153 days during the study period. "Total targets detected" are the number of birds/bats detected in all images collected. "Sum of the sample averages" refers to the target count averaged over the five successive images that constitute a sample (i.e., every 10 minutes). These values are summed for the entire night's data collection to generate a passage estimate. "Target detection rate" represents the number of targets detected per nautical mile of passage front per hour. We also present the proportion and number of targets detected within the three lowest altitudinal strata (i.e., 100, 200, 300 m).

Date	Julian day	Total targets detected	Sum of the sample averages	Target detection rate	Proportion of targets <=100 m	Number of targets <=100 m	Proportion of targets 101-200 m	Number of targets 101-200 m	Proportion of targets 201-300 m	Number of targets 201-300 m
07/16/09	197	279	49	3.27	0.1254	6.15	0.2545	12.47	0.1039	5.09
07/17/09	198	1404	284	34.08	0.3739	106.20	0.3063	86.98	0.1339	38.03
07/18/09	199	114	21	2.57	0.1140	2.39	0.1316	2.76	0.0877	1.84
07/19/09	200	515	97	6.61	0.1709	16.57	0.1320	12.81	0.0971	9.42
07/20/09	201	527	100	6.82	0.1575	15.75	0.1992	19.92	0.1252	12.52
07/21/09	202	139	28	15.27	0.1942	5.44	0.0288	0.81	0.1655	4.63
07/22/09	203	284	57	3.94	0.1056	6.02	0.2113	12.04	0.1585	9.03
07/23/09	204	300	59	8.43	0.2633	15.54	0.1567	9.24	0.1100	6.49
07/24/09	205	262	47	3.76	0.0802	3.77	0.1603	7.53	0.0992	4.66
07/25/09	206	530	101	6.97	0.2208	22.30	0.3377	34.11	0.1434	14.48
07/26/09	207	512	99	7.52	0.0586	5.80	0.2598	25.72	0.1621	16.05
07/27/09	208	226	40	2.76	0.0575	2.30	0.1770	7.08	0.1106	4.42
07/28/09	209	1223	242	16.88	0.0989	23.94	0.1872	45.31	0.1251	30.27
07/29/09	210	592	118	8.63	0.1385	16.34	0.1402	16.54	0.1470	17.34
07/30/09	211	362	67	4.90	0.0552	3.70	0.1188	7.96	0.1243	8.33
08/01/09	213	2468	496	34.60	0.1309	64.91	0.1625	80.59	0.1657	82.20
08/02/09	214	1175	239	19.38	0.0783	18.71	0.1438	34.38	0.1387	33.15
08/03/09	215	4771	958	66.84	0.0799	76.50	0.1140	109.23	0.1694	162.24
08/04/09	216	1818	360	25.12	0.2107	75.84	0.1634	58.81	0.1535	55.25
08/05/09	217	351	68	4.74	0.0969	6.59	0.2365	16.08	0.1624	11.04
08/06/09	218	950	190	17.01	0.1042	19.80	0.1768	33.60	0.1284	24.40
08/07/09	219	1415	278	19.62	0.0495	13.75	0.1647	45.78	0.1597	44.40
08/08/09	220	2525	508	36.29	0.0598	30.38	0.1750	88.93	0.1921	97.58
08/09/09	221	1406	277	20.52	0.1181	32.70	0.1600	44.33	0.1472	40.78
08/10/09	222	344	70	4.94	0.0610	4.27	0.1831	12.82	0.2413	16.89
08/11/09	223	3100	618	44.14	0.0432	26.71	0.1003	62.00	0.0987	61.00
08/12/09	224	4056	811	58.63	0.0372	30.19	0.0690	55.99	0.0587	47.59
08/13/09	225	184	37	11.10	0.1902	7.04	0.1250	4.63	0.0380	1.41
08/14/09	226	1102	218	15.57	0.2024	44.11	0.2414	52.62	0.1443	31.45
08/15/09	227	549	108	8.64	0.1457	15.74	0.1730	18.69	0.1548	16.72
08/16/09	228	716	144	10.41	0.0978	14.08	0.1872	26.95	0.1341	19.31
08/17/09	229	1136	227	16.41	0.1408	31.97	0.1461	33.17	0.1303	29.57
08/18/09	230	777	153	11.06	0.0656	10.04	0.1519	23.24	0.1158	17.72
08/19/09	231	502	99	7.24	0.1056	10.45	0.1653	16.37	0.1434	14.20

Table 5. Continued

08/20/09	232	1890	373	27.29	0.1910	71.24	0.1429	53.29	0.1418	52.89
08/21/09	233	1144	230	17.04	0.0367	8.44	0.1101	25.33	0.1075	24.73
08/22/09	234	516	100	7.50	0.0543	5.43	0.2384	23.84	0.2054	20.54
08/23/09	235	1660	333	24.67	0.0620	20.66	0.0873	29.09	0.0934	31.09
08/24/09	236	2162	432	31.61	0.0934	40.36	0.1610	69.54	0.1785	77.13
08/25/09	237	7344	1469	110.18	0.0556	81.61	0.1661	244.03	0.2394	351.65
08/26/09	238	1277	254	19.29	0.0360	9.15	0.0744	18.90	0.0681	17.30
08/27/09	239	3711	739	55.43	0.0318	23.50	0.0787	58.15	0.1692	125.06
08/28/09	240	733	148	24.67	0.1473	21.81	0.2374	35.13	0.2101	31.09
08/29/09	241	82	16	4.57	0.6098	9.76	0.0244	0.39	0.0000	0.00
08/30/09	242	634	125	13.16	0.0820	10.25	0.0852	10.65	0.1088	13.60
08/31/09	243	1047	208	18.91	0.0220	4.57	0.0879	18.28	0.0802	16.69
09/01/09	244	777	155	11.77	0.0579	8.98	0.1789	27.73	0.2625	40.69
09/02/09	245	488	99	7.62	0.2049	20.29	0.1844	18.26	0.1537	15.22
09/03/09	246	294	57	4.38	0.0816	4.65	0.2959	16.87	0.2177	12.41
09/04/09	247	3623	728	56.00	0.0171	12.46	0.1366	99.46	0.2236	162.76
09/05/09	248	7197	1437	110.54	0.1280	183.89	0.1620	232.81	0.1502	215.84
09/06/09	249	3320	662	51.58	0.0428	28.31	0.0720	47.66	0.0807	53.44
09/07/09	250	1191	236	18.39	0.1898	44.78	0.2057	48.55	0.2435	57.46
09/08/09	251	815	163	12.70	0.1448	23.60	0.2098	34.20	0.2650	43.20
09/09/09	252	725	140	10.91	0.2359	33.02	0.0814	11.39	0.1062	14.87
09/10/09	253	218	40	3.16	0.1881	7.52	0.1560	6.24	0.1009	4.04
09/11/09	254	47	9	4.91	0.4894	4.40	0.0000	0.00	0.0000	0.00
09/12/09	255	126	22	2.81	0.0397	0.87	0.1508	3.32	0.0714	1.57
09/13/09	256	690	138	11.66	0.1014	14.00	0.1942	26.80	0.1565	21.60
09/14/09	257	9543	1904	152.32	0.0725	138.07	0.0906	172.58	0.1293	246.21
09/15/09	258	4278	862	68.96	0.0622	53.60	0.0856	73.75	0.1206	103.97
09/16/09	259	2231	445	41.08	0.1443	64.23	0.1268	56.45	0.1954	86.97
09/17/09	260	275	53	4.30	0.1745	9.25	0.2182	11.56	0.0909	4.82
09/18/09	261	300	56	5.09	0.0800	4.48	0.1933	10.83	0.1600	8.96
09/19/09	262	756	152	12.49	0.0450	6.84	0.1164	17.69	0.1521	23.12
09/20/09	263	2061	414	33.57	0.0529	21.90	0.0932	38.57	0.1334	55.24
09/21/09	264	2052	407	33.00	0.0785	31.93	0.1096	44.63	0.1423	57.92
09/22/09	265	486	93	7.64	0.0802	7.46	0.1420	13.20	0.1379	12.82
09/23/09	266	315	61	5.23	0.0889	5.42	0.1079	6.58	0.1397	8.52
09/24/09	267	4636	929	76.36	0.0218	20.24	0.0567	52.70	0.1342	124.64
09/25/09	268	8312	1666	136.93	0.0381	63.54	0.0691	115.05	0.1207	201.03
09/26/09	269	767	152	12.67	0.0782	11.89	0.2008	30.52	0.1760	26.75
09/27/09	270	24	5	5.00	0.6667	3.33	0.0000	0.00	0.0833	0.42
09/28/09	271	662	134	11.32	0.0498	6.68	0.1042	13.97	0.1088	14.57
09/29/09	272	303	56	4.73	0.0363	2.03	0.1155	6.47	0.1089	6.10
09/30/09	273	383	73	6.35	0.0679	4.96	0.1645	12.01	0.1149	8.39
10/01/09	274	246	48	5.24	0.1098	5.27	0.1504	7.22	0.2561	12.29
10/02/09	275	330	62	5.47	0.2061	12.78	0.1000	6.20	0.1545	9.58
10/03/09	276	35	7	3.82	0.4571	3.20	0.0000	0.00	0.2000	1.40

Table 5. Continued

10/04/09	277	1220	226	33.90	0.0172	3.89	0.0910	20.56	0.0566	12.78
10/05/09	278	2487	498	42.69	0.0201	10.01	0.0133	6.61	0.0692	34.44
10/06/09	279	1148	231	20.09	0.0209	4.83	0.0235	5.43	0.0671	15.49
10/07/09	280	186	37	17.08	0.0430	1.59	0.3548	13.13	0.0753	2.78
10/08/09	281	142	4	2.67	0.0282	0.11	0.0704	0.28	0.0352	0.14
10/09/09	282	431	86	24.57	0.1508	12.97	0.1462	12.57	0.2065	17.76
10/10/09	283	618	121	11.71	0.0178	2.15	0.0437	5.29	0.1472	17.82
10/11/09	284	719	142	12.72	0.1001	14.22	0.1001	14.22	0.2017	28.64
10/12/09	285	619	121	10.84	0.1309	15.83	0.2132	25.80	0.2601	31.47
10/13/09	286	165	32	3.05	0.2000	6.40	0.2485	7.95	0.1455	4.65
10/14/09	287	543	109	9.76	0.1289	14.05	0.1805	19.67	0.2284	24.89
10/15/09	288	112	22	5.74	0.1786	3.93	0.1786	3.93	0.2500	5.50
10/16/09	289	152	28	3.50	0.1250	3.50	0.1513	4.24	0.1250	3.50
10/17/09	290	230	45	4.09	0.1261	5.67	0.2783	12.52	0.1696	7.63
10/19/09	292	514	102	9.42	0.1226	12.50	0.2257	23.02	0.1907	19.45
10/20/09	293	445	84	9.69	0.0719	6.04	0.1169	9.82	0.1708	14.35
10/21/09	294	4748	950	87.69	0.0278	26.41	0.0482	45.82	0.1666	158.27
10/22/09	295	441	82	7.57	0.1202	9.85	0.1270	10.41	0.1587	13.02
10/23/09	296	10	2	6.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
10/24/09	297	91	15	1.80	0.1648	2.47	0.1209	1.81	0.3187	4.78
10/25/09	298	413	81	7.59	0.2155	17.46	0.1356	10.98	0.2155	17.46
10/26/09	299	613	127	12.10	0.1485	18.85	0.2382	30.25	0.2382	30.25
10/27/09	300	116	21	3.60	0.3276	6.88	0.1810	3.80	0.2241	4.71
10/28/09	301	19	2	0.71	0.6842	1.37	0.0000	0.00	0.0000	0.00
10/29/09	302	280	53	5.13	0.1964	10.41	0.1893	10.03	0.3536	18.74
10/30/09	303	452	89	8.61	0.1350	12.01	0.2412	21.46	0.2942	26.19
10/31/09	304	116	22	2.16	0.0603	1.33	0.3276	7.21	0.3534	7.78
11/01/09	305	169	29	3.22	0.1893	5.49	0.2840	8.24	0.0888	2.57
11/02/09	306	248	49	13.36	0.0968	4.74	0.1169	5.73	0.0766	3.75
11/03/09	307	251	47	4.62	0.0757	3.56	0.1633	7.68	0.1633	7.68
11/04/09	308	247	47	6.00	0.1903	8.94	0.1903	8.94	0.2389	11.23
11/05/09	309	430	89	11.87	0.1488	13.25	0.1628	14.49	0.0791	7.04
11/06/09	310	994	196	19.28	0.0644	12.62	0.1700	33.32	0.3099	60.73
11/07/09	311	565	108	10.62	0.2673	28.86	0.1416	15.29	0.2018	21.79
11/08/09	312	206	38	3.74	0.0631	2.40	0.1650	6.27	0.1117	4.24
11/09/09	313	251	47	4.70	0.1315	6.18	0.1992	9.36	0.1633	7.68
11/10/09	314	258	49	4.90	0.0930	4.56	0.1085	5.32	0.1008	4.94
11/11/09	315	659	129	12.90	0.4325	55.79	0.1912	24.66	0.0819	10.57
11/12/09	316	240	46	4.68	0.3292	15.14	0.1208	5.56	0.0833	3.83
11/13/09	317	57	11	6.00	0.0351	0.39	0.0877	0.96	0.0877	0.96
11/14/09	318	46	9	3.38	0.0000	0.00	0.2391	2.15	0.2391	2.15
11/15/09	319	86	13	1.39	0.0698	0.91	0.2558	3.33	0.0000	0.00
11/16/09	320	199	38	3.93	0.0653	2.48	0.1558	5.92	0.0754	2.86
11/17/09	321	357	70	7.24	0.1793	12.55	0.2101	14.71	0.2381	16.67
11/18/09	322	392	75	7.76	0.2398	17.98	0.2398	17.98	0.1327	9.95

Table 5. Continued

11/19/09	323	122	20	2.45	0.2869	5.74	0.2377	4.75	0.0738	1.48
11/20/09	324	73	12	1.50	0.0959	1.15	0.2877	3.45	0.0822	0.99
11/21/09	325	99	20	2.07	0.0606	1.21	0.2626	5.25	0.1414	2.83
11/22/09	326	181	37	3.83	0.2928	10.83	0.2818	10.43	0.1713	6.34
11/23/09	327	80	15	6.43	0.4750	7.13	0.1750	2.63	0.1750	2.63
11/24/09	328	86	14	1.47	0.2093	2.93	0.3605	5.05	0.0698	0.98
11/25/09	329	63	12	1.80	0.1270	1.52	0.0952	1.14	0.1905	2.29
11/26/09	330	145	24	2.53	0.1931	4.63	0.4828	11.59	0.1379	3.31
11/27/09	331	16	3	6.00	0.6875	2.06	0.3125	0.94	0.0000	0.00
11/28/09	332	60	7	0.74	0.0333	0.23	0.5333	3.73	0.1167	0.82
11/29/09	333	72	10	1.07	0.0000	0.00	0.4028	4.03	0.1111	1.11
11/30/09	334	19	4	0.71	0.2632	1.05	0.1579	0.63	0.0000	0.00
12/01/09	335	750	146	19.91	0.0187	2.73	0.2147	31.34	0.3067	44.77
12/02/09	336	120	20	2.40	0.1417	2.83	0.2667	5.33	0.0417	0.83
12/04/09	338	51	11	1.94	0.1569	1.73	0.3922	4.31	0.2157	2.37
12/09/09	343	40	8	2.67	0.5000	4.00	0.1000	0.80	0.0000	0.00
12/10/09	344	79	13	1.42	0.0000	0.00	0.3671	4.77	0.1392	1.81
12/11/09	345	87	11	1.20	0.0000	0.00	0.2414	2.66	0.2989	3.29
12/12/09	346	334	66	7.20	0.0329	2.17	0.3772	24.90	0.2335	15.41
12/13/09	347	47	9	1.59	0.1277	1.15	0.2979	2.68	0.1277	1.15
12/14/09	348	195	37	4.04	0.1077	3.98	0.3846	14.23	0.2000	7.40
12/15/09	349	38	3	0.33	0.1316	0.39	0.2632	0.79	0.0263	0.08
Totals	146 days	141762	28084			2435		3632		4209
Means		970.97	192.36	16.60	0.14	16.68	0.17	24.87	0.14	28.83

Table 6. Results of marine radar image analyses for data collected on 153 nights (i.e., sunset to sunrise the following morning) during the 2009 fall migration period (16 July -15 Dec) on Block Island, New Shoreham, Rhode Island. Radar malfunction, power loss and meteorological conditions resulted in data not being analyzed for 6 of the 153 nights during the study period. "Total targets detected" are the number of birds/bats detected in all images collected. "Sum of the sample averages" refers to the target count averaged over the five successive images that constitute a sample (i.e., every 10 minutes). These values are summed for the entire night's data collection to generate a passage estimate. "Target detection rate" represents the number of targets detected per nautical mile of passage front per hour. We also present the proportion and number of targets detected within the three lowest altitudinal strata (i.e., 100, 200, 300 m).

Date	Julian day	Total targets detected	Sum of the sample averages	Target detection rate	Proportion of targets <=100 m	Number of targets <=100 m	Proportion of targets 101-200 m	Number of targets 101-200 m	Proportion of targets 201-300 m	Number of targets 201-300 m
07/16/09	197	1198	242	29.04	0.13	30.70	0.24	59.19	0.16	38.38
07/17/09	198	1187	253	34.34	0.07	17.05	0.11	27.50	0.14	36.23
07/18/09	199	1526	305	33.27	0.02	7.20	0.14	43.37	0.21	62.56
07/19/09	200	2433	484	52.80	0.03	15.52	0.12	57.69	0.15	71.42
07/20/09	201	955	191	38.20	0.05	9.00	0.11	21.80	0.12	23.40
07/21/09	202	133	26	3.92	0.07	1.76	0.14	3.52	0.16	4.11
07/22/09	203	1808	364	39.71	0.05	17.31	0.15	56.17	0.13	47.11
07/23/09	204	256	51	25.50	0.51	25.90	0.02	0.80	0.43	21.91
07/24/09	205	588	122	14.94	0.07	8.51	0.10	11.62	0.12	14.32
07/25/09	206	650	130	13.93	0.06	7.40	0.25	32.00	0.17	22.40
07/26/09	207	466	95	10.18	0.04	3.47	0.16	15.29	0.11	9.99
07/27/09	208	728	145	15.26	0.04	5.98	0.14	19.92	0.16	23.10
07/28/09	209	858	175	18.75	0.11	19.58	0.14	24.88	0.13	22.64
07/29/09	210	541	108	12.96	0.04	4.19	0.11	11.58	0.13	14.17
07/30/09	211	1156	231	24.32	0.05	12.59	0.11	25.58	0.14	33.37
07/31/09	212	1635	327	57.71	0.01	3.60	0.03	11.40	0.11	34.60
08/01/09	213	3612	721	75.89	0.03	18.56	0.09	67.47	0.12	87.23
08/02/09	214	964	191	19.76	0.03	5.35	0.10	18.82	0.09	17.83
08/03/09	215	2225	446	46.14	0.05	20.25	0.12	52.92	0.17	74.37
08/04/09	216	722	144	14.90	0.05	7.38	0.17	24.33	0.19	26.93
08/05/09	217	17721	3542	360.20	0.02	55.17	0.03	110.13	0.08	279.03
08/06/09	218	6730	1343	134.30	0.04	47.69	0.07	97.58	0.11	143.28
08/07/09	219	14499	2897	294.61	0.02	52.95	0.04	122.48	0.11	314.90
08/08/09	220	6868	1373	137.30	0.04	48.98	0.10	137.54	0.12	158.33
08/09/09	221	2553	507	56.33	0.11	55.01	0.20	101.48	0.17	88.17
08/10/09	222	2421	486	48.60	0.02	11.64	0.12	57.41	0.19	90.13
08/11/09	223	16953	3391	339.10	0.05	172.42	0.12	415.45	0.17	592.67
08/12/09	224	990	197	168.86	0.06	12.54	0.04	7.16	0.08	14.92
08/13/09	225	3887	782	93.84	0.02	15.69	0.06	43.05	0.07	53.92
08/14/09	226	2439	489	48.90	0.04	19.25	0.09	44.91	0.11	53.13
08/15/09	227	2378	476	46.82	0.02	11.61	0.12	56.25	0.13	60.65
08/16/09	228	3616	723	71.11	0.02	16.80	0.10	70.18	0.14	99.97
08/17/09	229	4820	965	94.92	0.04	40.44	0.14	134.94	0.19	185.19
08/18/09	230	2968	594	57.48	0.05	30.82	0.16	93.66	0.16	95.66
08/19/09	231	7854	1568	151.74	0.05	73.07	0.11	176.88	0.13	199.24

Table 6. Continued

08/20/09	232	5347	1069	103.45	0.05	56.58	0.10	106.36	0.11	119.56
08/21/09	233	1198	244	23.61	0.06	14.46	0.16	39.72	0.24	58.66
08/22/09	234	7993	1600	195.92	0.02	28.42	0.04	59.45	0.05	87.88
08/23/09	235	10112	2024	192.76	0.03	54.04	0.08	158.53	0.11	230.58
08/24/09	236	26147	5232	490.50	0.03	163.48	0.07	369.18	0.10	537.87
08/25/09	237	11874	2376	222.75	0.03	67.83	0.10	246.32	0.12	294.75
08/26/09	238	13605	2720	286.32	0.06	165.54	0.13	351.47	0.13	355.67
08/27/09	239	23463	4691	439.78	0.04	175.34	0.08	395.47	0.11	499.43
08/28/09	240	701	129	154.80	0.24	30.92	0.21	27.05	0.13	16.93
08/29/09	241	3417	680	72.86	0.06	40.00	0.13	87.56	0.08	56.52
08/30/09	242	3266	656	60.55	0.06	36.76	0.14	92.60	0.16	102.84
08/31/09	243	6856	1378	127.20	0.04	54.47	0.09	121.60	0.10	137.48
09/01/09	244	2602	522	48.18	0.09	46.14	0.20	102.71	0.17	88.87
09/02/09	245	1706	340	30.91	0.08	25.51	0.17	58.59	0.14	48.63
09/03/09	246	1500	302	27.45	0.06	19.13	0.14	40.87	0.10	31.41
09/04/09	247	4291	858	78.00	0.05	42.59	0.10	89.58	0.12	102.98
09/05/09	248	7426	1493	135.73	0.03	49.86	0.06	85.65	0.09	134.10
09/06/09	249	2204	440	39.40	0.08	33.14	0.17	74.07	0.16	70.07
09/07/09	250	2358	471	42.18	0.08	38.35	0.21	96.68	0.15	72.71
09/08/09	251	2285	458	46.58	0.14	63.54	0.21	96.01	0.18	82.38
09/09/09	252	1632	327	28.85	0.05	15.03	0.08	24.65	0.12	40.07
09/10/09	253	466	93	9.00	0.04	3.59	0.14	12.57	0.11	10.38
09/11/09	254	142	25	2.73	0.03	0.70	0.10	2.46	0.07	1.76
09/12/09	255	3007	601	68.04	0.02	13.99	0.04	23.18	0.05	31.58
09/13/09	256	4697	936	81.39	0.06	54.40	0.09	83.90	0.10	90.47
09/14/09	257	3466	694	60.35	0.10	71.28	0.19	135.16	0.18	124.74
09/15/09	258	2867	571	77.86	0.09	53.57	0.18	99.98	0.16	92.41
09/16/09	259	2567	515	44.14	0.03	16.85	0.06	31.10	0.10	49.75
09/17/09	260	2091	419	35.91	0.06	26.05	0.12	50.10	0.16	65.53
09/18/09	261	2034	409	35.06	0.04	17.29	0.09	34.79	0.12	49.26
09/19/09	262	3322	662	56.74	0.07	49.22	0.16	104.82	0.16	107.61
09/20/09	263	1644	328	28.11	0.07	21.55	0.11	37.11	0.14	46.29
09/21/09	264	2188	438	37.54	0.04	16.82	0.16	69.86	0.18	78.27
09/22/09	265	2025	402	33.97	0.07	28.98	0.12	46.25	0.16	63.13
09/23/09	266	3395	677	60.63	0.04	24.73	0.08	53.44	0.08	57.43
09/24/09	267	23323	4668	394.48	0.05	249.58	0.11	518.98	0.13	610.04
09/25/09	268	7956	1591	132.58	0.04	61.99	0.08	123.58	0.10	160.98
09/26/09	269	3621	723	71.11	0.02	16.97	0.08	60.50	0.13	90.65
09/27/09	270	1505	306	25.15	0.04	12.00	0.09	26.03	0.06	17.89
09/28/09	271	1926	383	62.11	0.04	15.71	0.09	35.99	0.19	71.19
09/29/09	272	1155	231	18.99	0.04	10.20	0.13	30.80	0.10	22.80
09/30/09	273	6120	1222	99.08	0.03	36.94	0.09	116.01	0.13	156.14
10/01/09	274	1432	287	30.21	0.09	25.45	0.18	51.91	0.15	42.49
10/02/09	275	715	144	15.71	0.06	9.06	0.32	45.92	0.27	39.27
10/03/09	276	1880	376	31.77	0.11	41.80	0.15	56.80	0.12	46.60

Table 6. Continued

10/04/09	277	5091	1022	82.86	0.05	48.18	0.11	113.82	0.16	159.79
10/05/09	278	2997	599	48.57	0.05	29.98	0.11	64.76	0.11	68.75
10/06/09	279	1676	335	37.92	0.09	29.78	0.18	60.16	0.15	48.77
10/07/09	280	1401	280	22.11	0.06	17.39	0.11	30.78	0.13	36.57
10/08/09	281	20107	4016	330.08	0.09	345.54	0.16	629.75	0.18	739.01
10/09/09	282	4852	970	66.14	0.12	118.15	0.18	177.13	0.24	236.30
10/10/09	283	10820	2165	168.70	0.07	148.67	0.13	277.13	0.15	324.95
10/11/09	284	2175	436	33.97	0.04	17.44	0.09	40.49	0.16	67.76
10/12/09	285	2351	470	40.29	0.08	39.78	0.13	60.17	0.17	82.17
10/13/09	286	4274	860	67.89	0.02	16.50	0.05	39.84	0.08	65.19
10/14/09	287	5584	1112	86.65	0.06	70.69	0.12	136.41	0.14	154.53
10/16/09	289	2911	584	44.92	0.03	15.05	0.05	27.48	0.11	66.20
10/17/09	290	3031	606	84.56	0.03	15.79	0.06	33.79	0.13	77.37
10/18/09	291	172	36	4.41	0.09	3.14	0.21	7.53	0.08	2.72
10/19/09	292	7864	1571	119.32	0.09	136.24	0.10	161.42	0.09	147.63
10/20/09	293	2174	434	32.96	0.11	47.91	0.13	55.50	0.14	59.69
10/21/09	294	2271	455	34.56	0.07	33.46	0.12	53.29	0.16	73.93
10/22/09	295	1504	301	32.84	0.06	17.81	0.08	24.82	0.18	52.84
10/23/09	296	1033	202	22.44	0.10	19.75	0.27	54.75	0.26	53.19
10/24/09	297	512	105	12.60	0.10	10.25	0.05	5.33	0.13	14.15
10/25/09	298	5939	1187	89.03	0.06	75.15	0.08	94.54	0.11	127.31
10/26/09	299	2845	567	42.00	0.04	24.91	0.10	59.19	0.13	73.94
10/27/09	300	177	35	8.40	0.10	3.56	0.01	0.40	0.27	9.49
10/28/09	301	339	68	7.03	0.07	4.61	0.08	5.62	0.14	9.63
10/29/09	302	4943	986	74.89	0.03	30.12	0.04	35.31	0.06	59.04
10/30/09	303	303	58	4.64	0.07	3.83	0.09	4.98	0.21	12.06
10/31/09	304	148	28	3.91	0.16	4.54	0.05	1.51	0.13	3.59
11/01/09	305	3823	762	57.87	0.04	33.69	0.09	72.15	0.12	92.68
11/02/09	306	1094	220	16.10	0.08	18.10	0.12	26.34	0.17	38.41
11/03/09	307	242	44	3.26	0.14	6.18	0.14	6.18	0.16	6.91
11/04/09	308	866	173	18.54	0.17	28.97	0.17	29.57	0.17	29.77
11/05/09	309	486	96	13.09	0.12	11.46	0.13	12.64	0.20	19.36
11/06/09	310	2364	471	34.05	0.06	28.69	0.11	52.40	0.11	52.20
11/07/09	311	247	46	3.33	0.11	4.84	0.17	7.82	0.12	5.59
11/08/09	312	1806	359	25.64	0.03	11.73	0.07	26.84	0.13	45.32
11/09/09	313	399	76	5.43	0.05	3.62	0.07	4.95	0.18	13.52
11/10/09	314	1821	363	26.56	0.05	17.54	0.07	26.31	0.17	62.00
11/11/09	315	815	166	11.86	0.04	5.91	0.10	15.89	0.22	36.87
11/12/09	316	332	58	4.09	0.04	2.45	0.10	5.94	0.17	9.61
11/14/09	318	131	23	1.97	0.14	3.16	0.07	1.58	0.05	1.05
11/15/09	319	1656	329	23.22	0.07	22.85	0.08	25.63	0.11	35.16
11/16/09	320	1321	262	18.28	0.02	6.35	0.08	20.63	0.12	31.54
11/17/09	321	503	97	6.77	0.05	4.82	0.17	16.20	0.22	21.02
11/18/09	322	272	49	3.42	0.07	3.60	0.12	5.76	0.15	7.21
11/19/09	323	2057	408	36.00	0.03	13.29	0.08	33.52	0.14	58.51

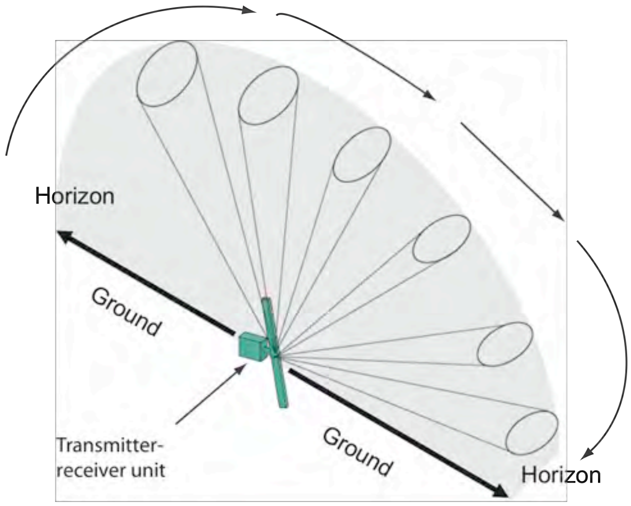
Table 6. Continued

11/20/09	324	188	35	2.44	0.03	1.12	0.18	6.14	0.13	4.47
11/21/09	325	310	55	3.84	0.03	1.77	0.14	7.63	0.14	7.63
11/22/09	326	180	33	2.36	0.03	0.92	0.01	0.37	0.13	4.22
11/23/09	327	21	3	1.29	0.05	0.14	0.00	0.00	0.00	0.00
11/24/09	328	101	18	1.26	0.08	1.43	0.08	1.43	0.10	1.78
11/25/09	329	221	41	3.97	0.20	8.35	0.37	15.03	0.12	5.01
11/26/09	330	215	35	2.26	0.17	5.86	0.36	12.70	0.12	4.23
11/27/09	331	378	75	8.04	0.13	9.72	0.74	55.36	0.04	3.37
11/28/09	332	180	28	1.91	0.13	3.58	0.28	7.78	0.13	3.73
11/29/09	333	106	18	1.23	0.06	1.02	0.16	2.89	0.07	1.19
11/30/09	334	251	47	4.78	0.06	2.81	0.13	5.99	0.12	5.80
12/01/09	335	190	34	2.96	0.21	7.16	0.17	5.73	0.19	6.44
12/02/09	336	41	7	2.80	0.02	0.17	0.20	1.37	0.22	1.54
12/04/09	338	210	39	3.21	0.13	5.20	0.22	8.54	0.14	5.39
12/08/09	342	237	45	4.66	0.04	1.71	0.13	5.70	0.17	7.59
12/09/09	343	278	54	3.86	0.03	1.55	0.12	6.22	0.03	1.36
12/10/09	344	157	25	1.69	0.04	0.96	0.27	6.85	0.27	6.85
12/11/09	345	123	19	1.28	0.02	0.31	0.42	8.03	0.28	5.41
12/12/09	346	126	20	1.35	0.06	1.27	0.20	3.97	0.25	5.08
12/13/09	347	85	13	1.37	0.09	1.22	0.09	1.22	0.02	0.31
12/14/09	348	3200	638	45.57	0.00	0.00	0.00	0.00	0.00	0.00
12/15/09	349	1625	319	22.52	0.01	3.53	0.04	12.17	0.05	16.10
Totals	147 nights	470017	93886			4620.50		9651.66		11902.14
Means		3197.39	638.68	61.79	0.07	31.43	0.13	65.66	0.14	80.97

Table 7. Results from General Linear Model procedures investigating relationships between the proportion of targets detected in the two lowest altitudinal strata (i.e., 0-100, 101-200 m arcsine transformed) and total targets detected in all strata (i.e., sum of the 10-minute sample averages, log transformed).

Season		0-100			101-200		
	Period	Coefficient	*F*	*P*	Coefficient	*F*	*P*
Spring							
	Day	-0.036	0.48	0.49	-0.137	14.4	<0.0001
	Night	-0.183	45.95	<0.0001	0.006	0.04	0.85
Summer							
	Day	-0.037	0.67	0.42	0.067	2.21	0.15
	Night	-0.073	5.65	0.02	0.07	5.67	0.02
Fall							
	Day	-0.0001	8.92	0.003	-0.0001	8.42	0.004
	Night	-0.045	15.56	<0.0001	-0.04	6.71	0.01

Figure 1. Dual radar system with horizontally and vertically oriented antennas that operate simultaneously. This system allows for data collection on passage (horizontal and vertical), altitude (vertical) and flight direction (horizontal).



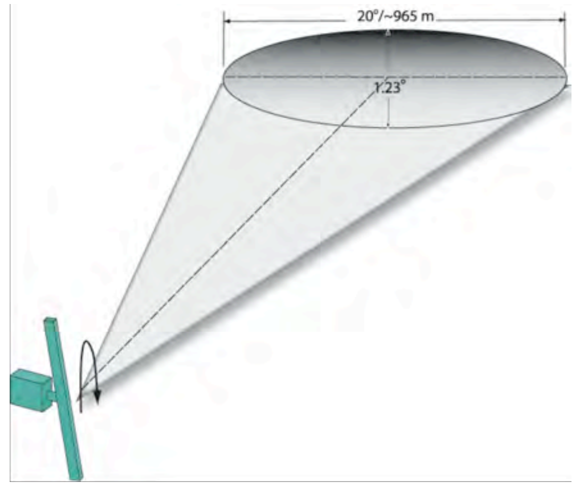


Figure 2. Graphical depiction of scanning operation of vertically-oriented radar. In this orientation, the transmitter-receiver unit is mounted perpendicular to the ground so that the radar antenna's rotation results in a 180^{o}, horizon-to-horizon scan (radar does not transmit when antenna is oriented groundward). When the radar's range is set to 0.75 nm (1.4 km, 4557 ft) it samples ~0.98 km3 of air space. Data collected in "vertical" scanning mode can be used to estimate (1) target altitude and (2) target passage magnitude.

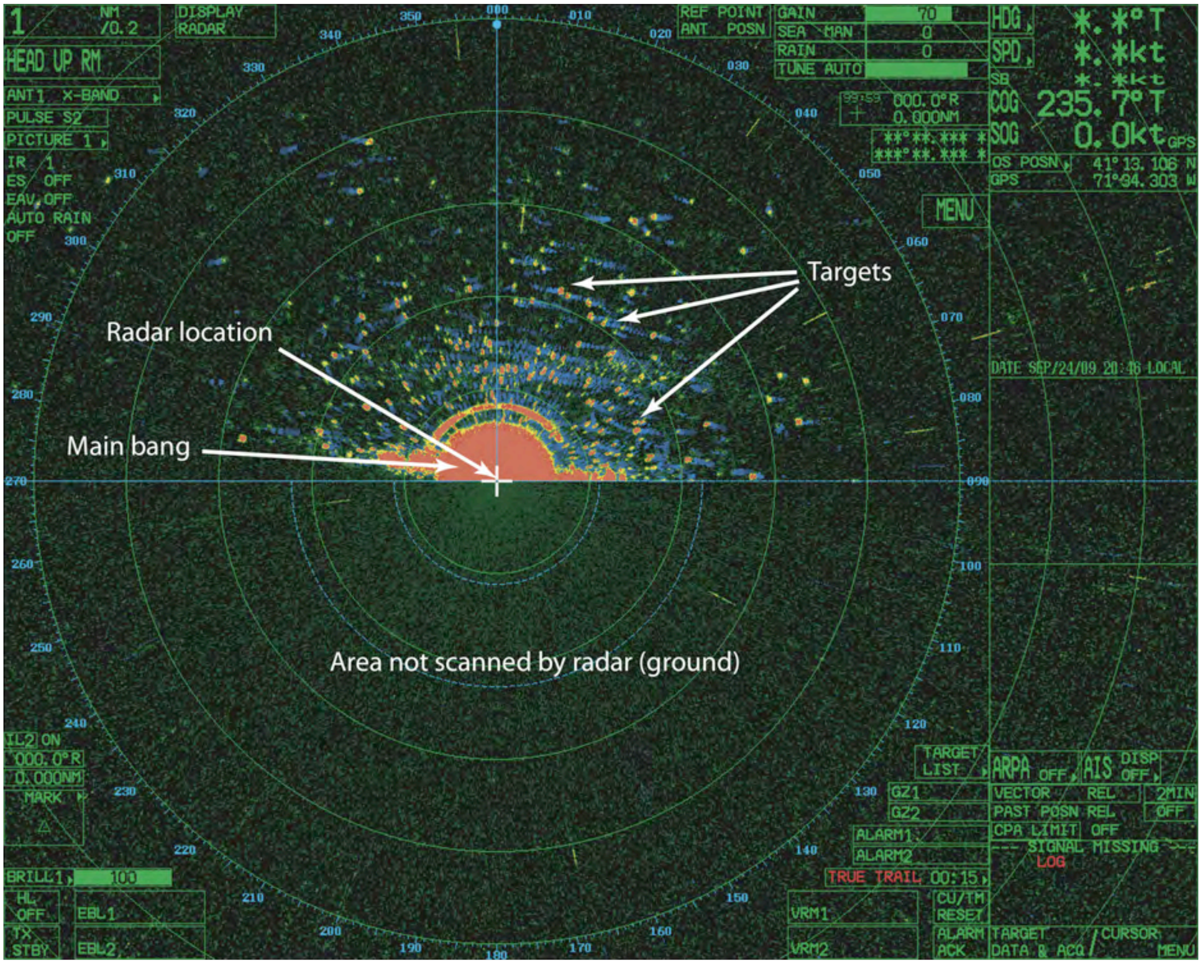


Figure. 3. Data image from the "vertical" radar collected on 8 October 2009 at 2133 EDT (9:33 PM). The small red ellipses with the blue tails are bird or bats flying through the radar's sample space. The height above the blue dotted line splitting the image indicates each target's altitude. The large, circular red area in the center of the image is the "main bang" an area of interference generated by an inherent to marine radars. Note that the radar in the vertical orientation does not transmit or receive electromagnetic energy when the antenna scans toward the ground so no targets are shown below the blue dotted line.

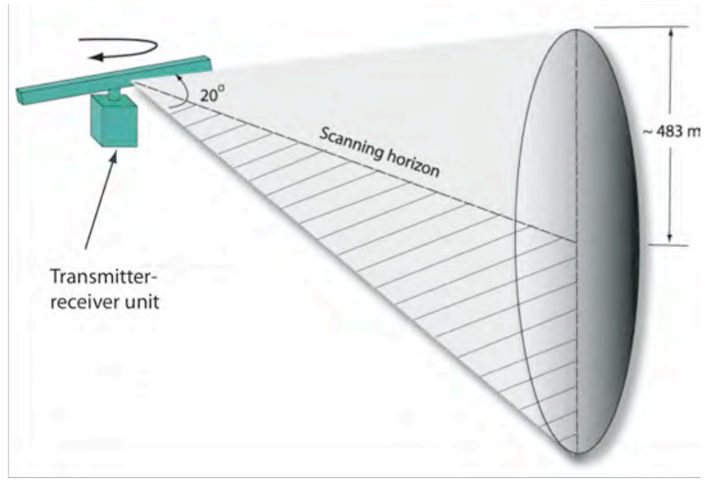


Figure 4. Graphic representation of scanning operation of horizontally-oriented radar. In this orientation, the antenna rotates in a plane parallel to the ground resulting in a 360^{o} scan with a that samples 10^{o} above and below the scanning horizon. With the radar's range set to 1 nautical mile (1.85 km, 6076 ft) which is the effective detection range for small passerines with 25 kW radar) it samples up to 483 m arl (above radar level) and ~4.0 km3 of air space. Data collected in "horizontal" scanning mode can be used to estimate (1) target flight direction and speed and (2) target passage magnitude.

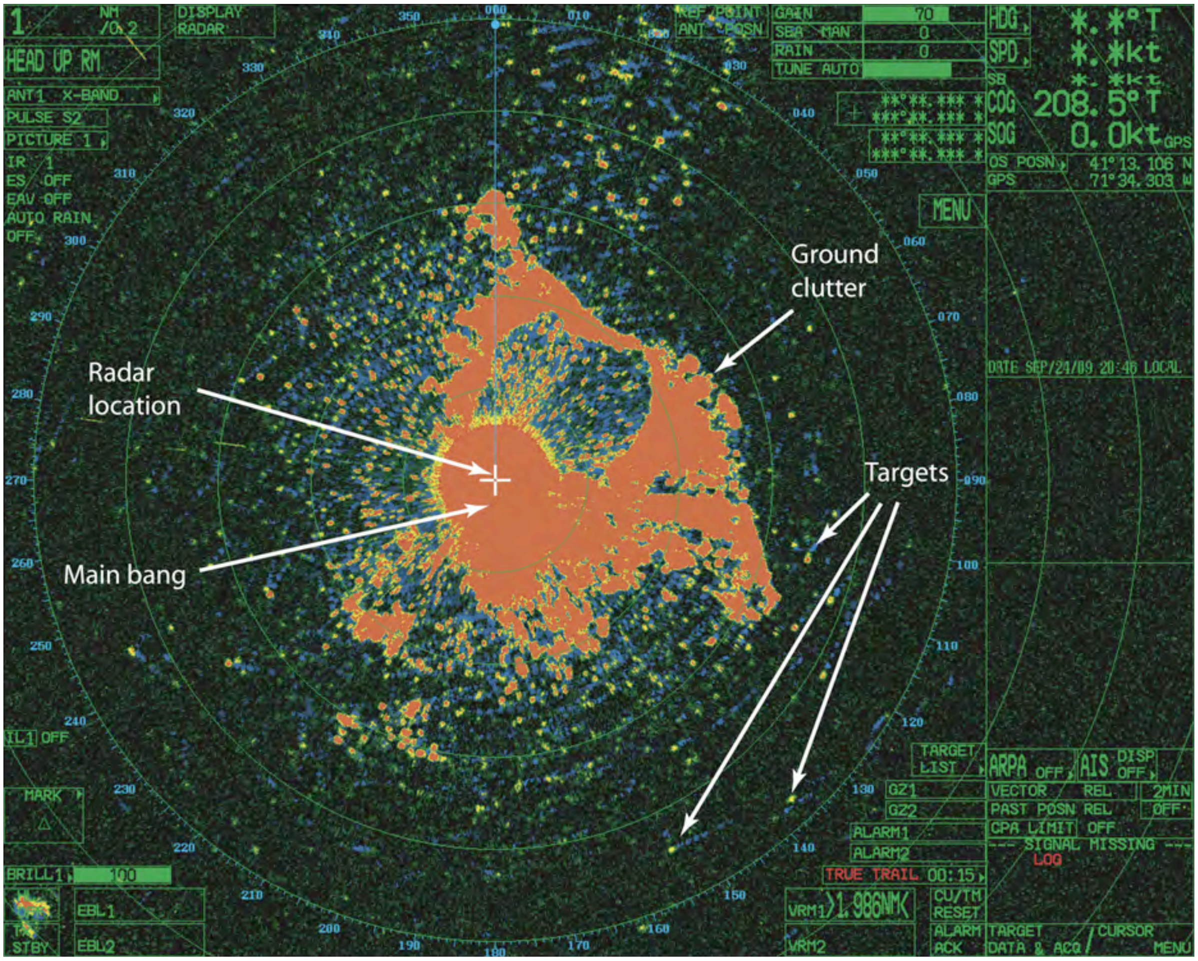


Figure 5. Data image from the “horizontal” radar collected on 8 October 2009 at 2133 EDT (9:33 PM). The small red ellipses with the blue trails are bird or bats flying through the radar’s sample space. A blue trail shows the 15 second track history of its associated target, so represents its general flight direction. The large, cirucular red area in the center of the image is the “main bang” an area of interference or “ground clutter” generated by an inherent to marine radars. The large, irregularly-shaped areas primarily to the east of radar’s location is electromagnetic energy being reflected from the surrounding landform.

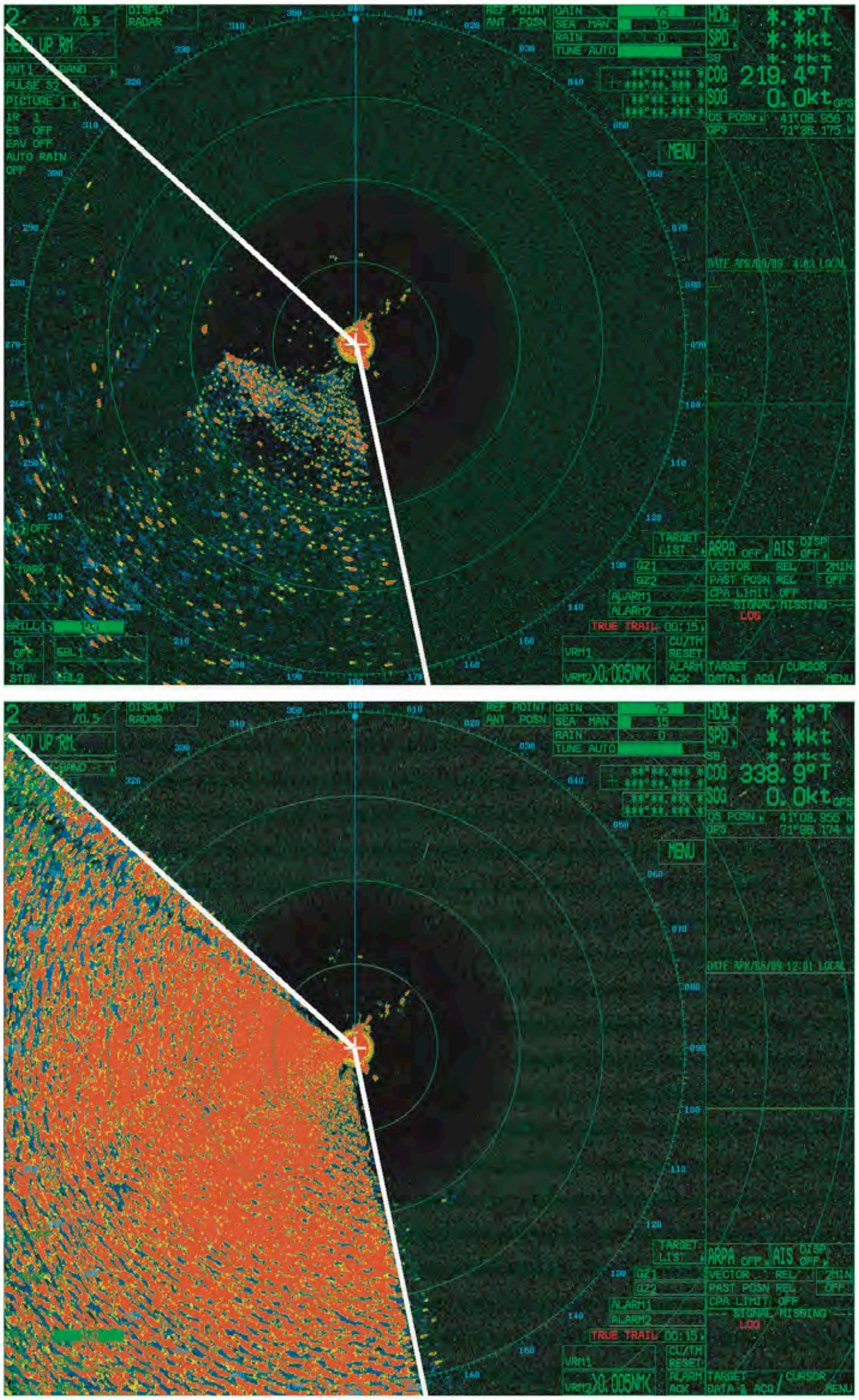


Figure 6. Images from horizontal radar showing backscatter of radar energy from wave action along the southeastern coast of Block Island. Upper panel show normal extent of backscatter. Lower panel shows extreme incidence of backscatter. White lines describe the radar's view of the ocean. View of the ocean from approximately 90-170° (i.e., E - S) was occluded by a rise along the edge of the landform. Areas from approximately 305-90° (NW-E) were over land so did not experience backscatter.

Figure 7. Radar unit with parabollic dish antenna. Custom mounting allow the antenna to be raised or lowered in 2.5° increments above the scanning horizon.

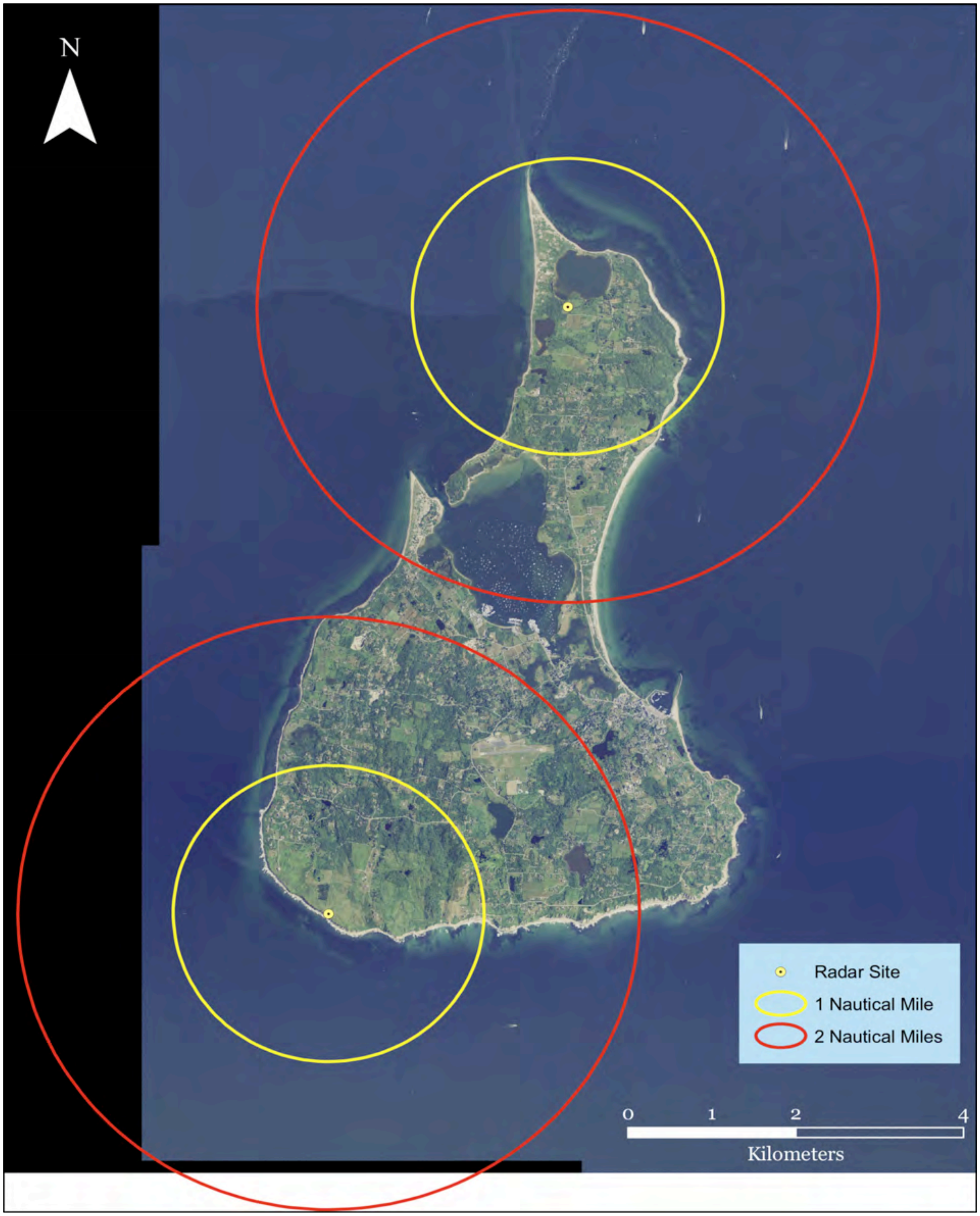


Figure 8. Radar study sites on Block Island, 2009. Study site along southeastern coast of the island was used from 19 March - 30 April. The radar system was located at the northern site 1 May - 15 December. Vertical radar

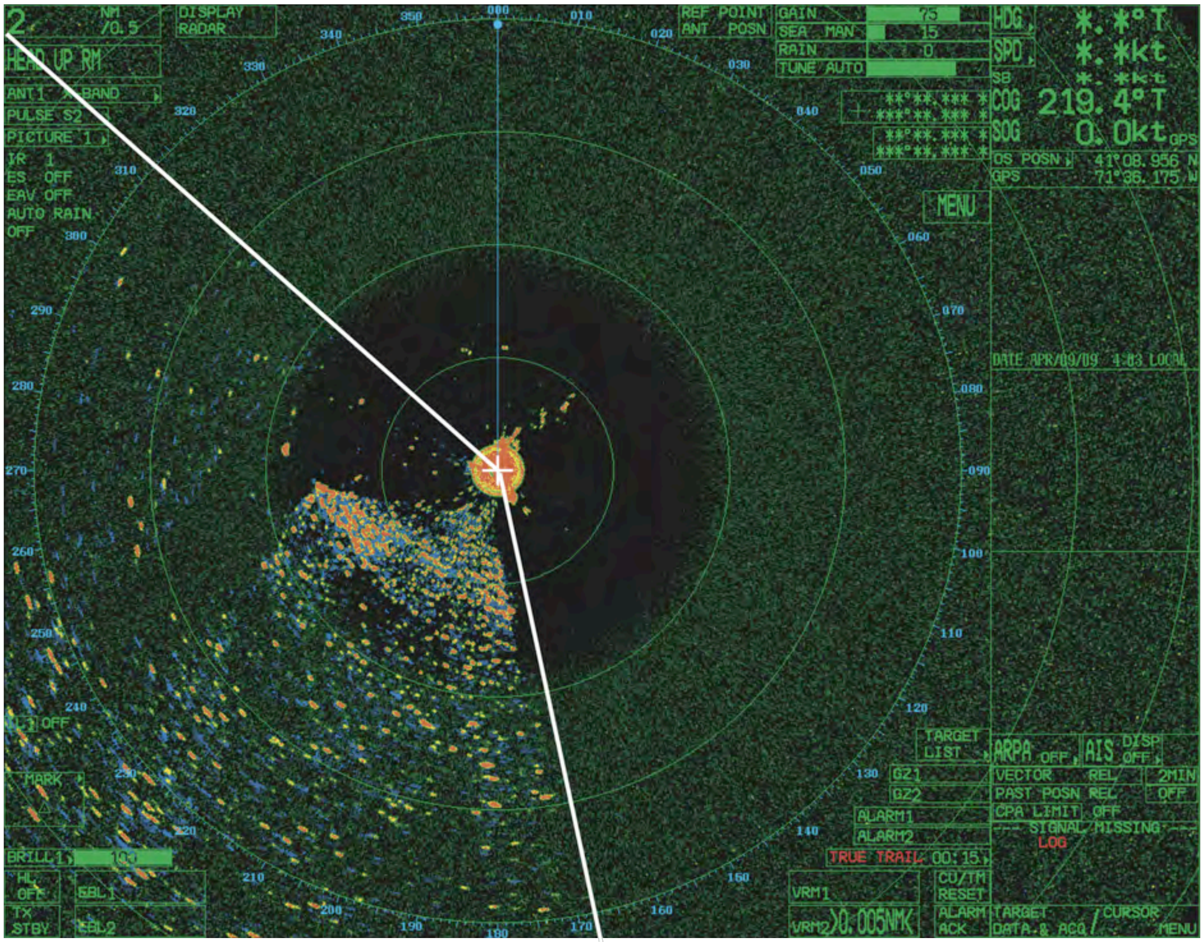


Figure 9. Horizontal radar's view from the southeastern study site. The view of the ocean occurred from approximately 170-300° (i.e., S-NW, ~130°area between white lines, rotating clockwise). The radar's view of the ocean between 90-170° (i.e., E - S) was occluded by a rise along the edge of the landform although the airspace above the landfrom was visible. Areas from approximately 305-90° (NW-E) were over land. This image shows mild backscatter from wave action along the coast out to at least 2 miles. Areas over land did not experience backscatter.

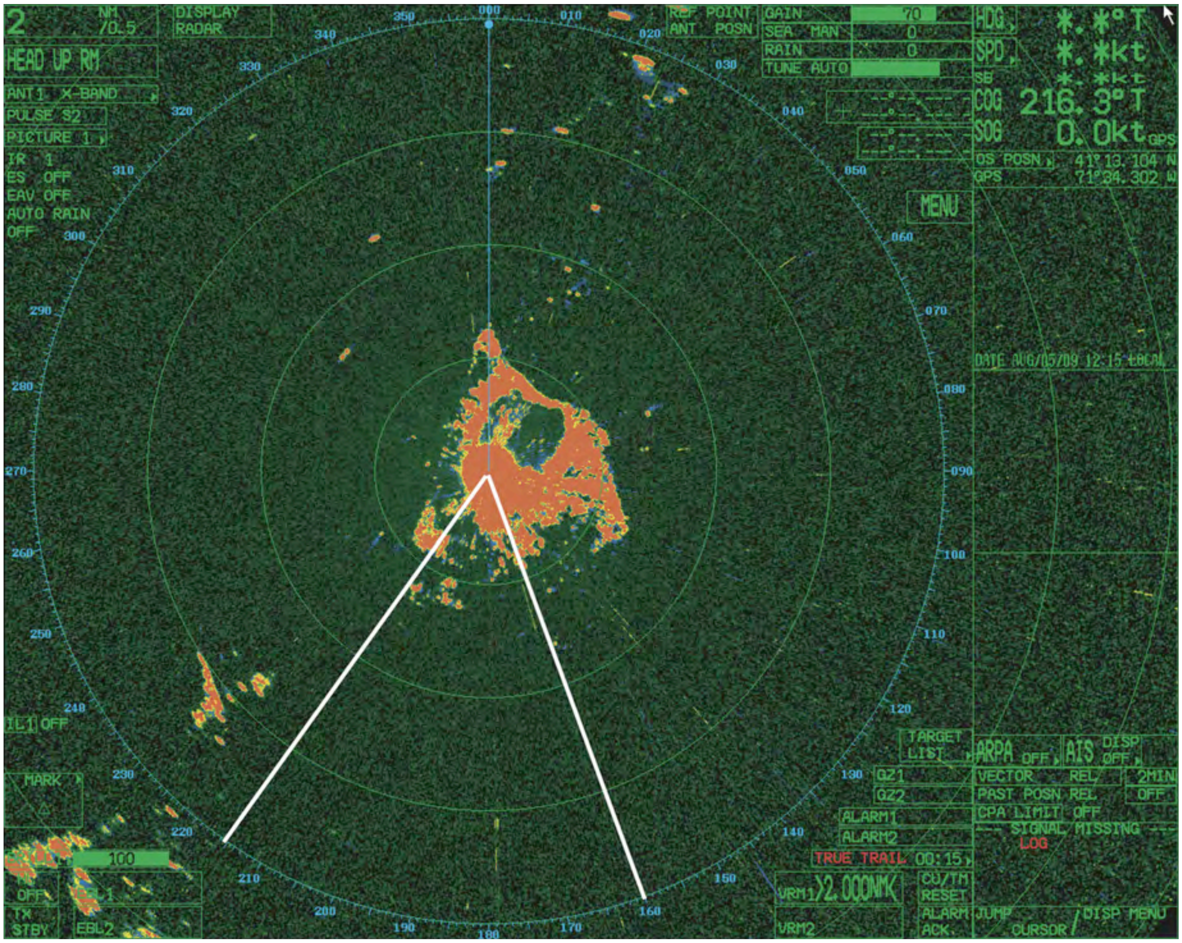


Figure 10. Horizontal radar's view from the northern study site. The view of the ocean occurred from approximately 215-160^o (i.e., SW-SE, ~305^{o}area between white lines, rotating clockwise). The large red areas near the center of the radar image is backscatter of eclectromagnetic energy from the surrounding landscape, which occluded target detection in this area.

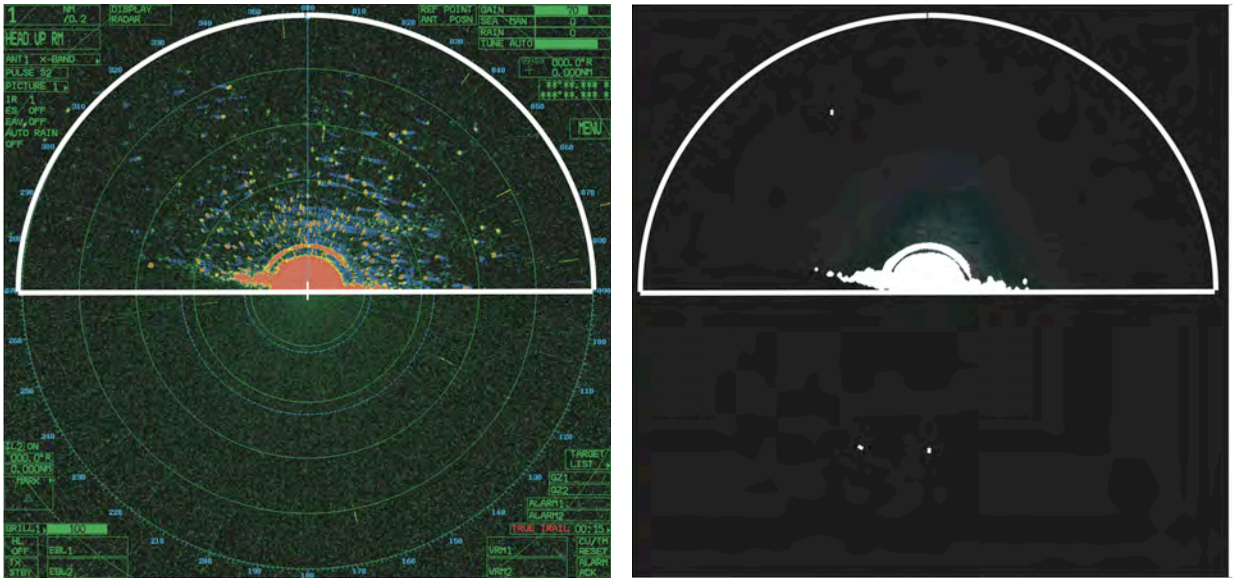


Figure 11. (Left) Data image from vertically oriented radar collected on 24 September 2009, 2046 EDT 08:46 PM). The thick white line graphically represents how NJAS's integrated image processing software defines the sample area. (Right) Template generated by NJAS's integrated image processing software for data collected on the same date as data image on the left. The template is used as a mask to remove stationary reflectors (i.e., main bang, ground clutter, see Figs. 3, 5 for reference) from data images.

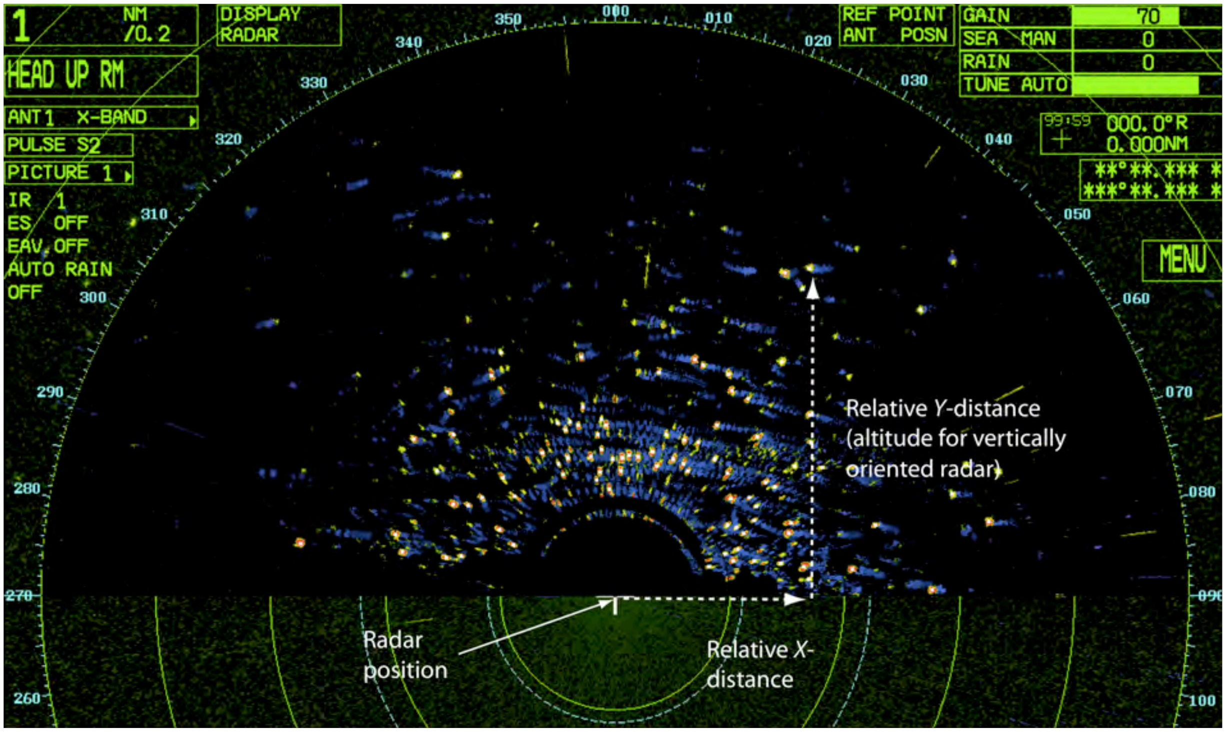


Figure 12. Data image collected on 24 September 2009 at 2046 EDT (8:46 PM), with the vertically-oriented radar. NJAS integrated image processing software removes targets with low reflectivity, smooths the data and locates and marks the centroid of each discrete target that remains. In this representation target centroids are marked with white dots. Because coordinates of the scan center (i.e., radar position, GPS) and the image's pixel dimensions are known, we can calculate a target's distance from the radar in the *X-, Y*-planes. This allows us to calculate any target's altitude (vertical radar) or *X-, Y*-coordinates (horizontal radar).

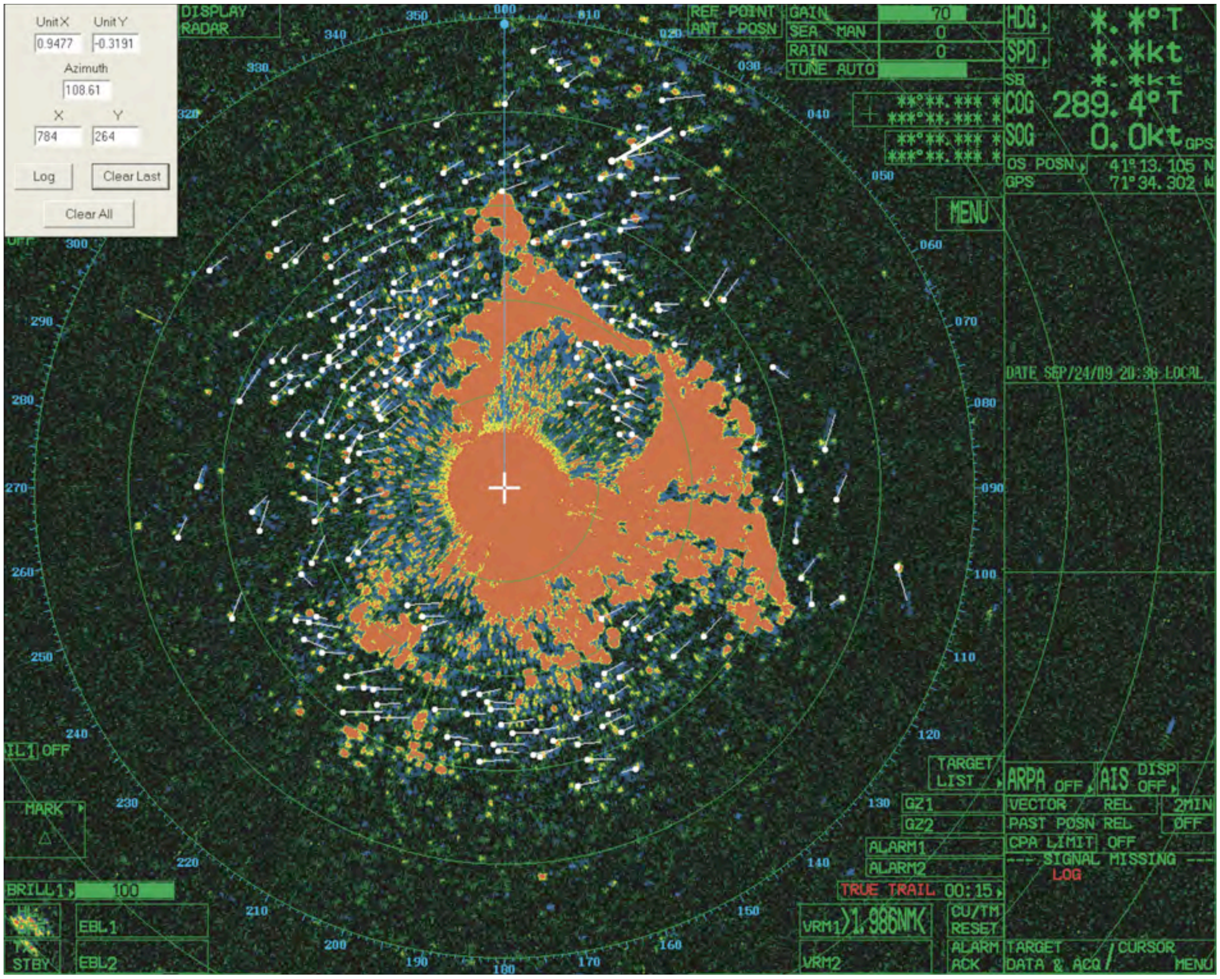


Figure 13. Data image collected on 24 September 2009 at 2036 EDT (8:36 PM) with the horizontal radar. The image shows target tracks (white circles with white tails) created using NJAS proprietary software to calculate target directions. The end of a target's trail (blue dotted line, see Figs. 3 and 5 for reference) and the target (green, yellow or red ellipses) is marked (in that order) using the computer's mouse and cursor. The program outputs the position of the trail's tail and the target and from these calculates the target's direction of movement.

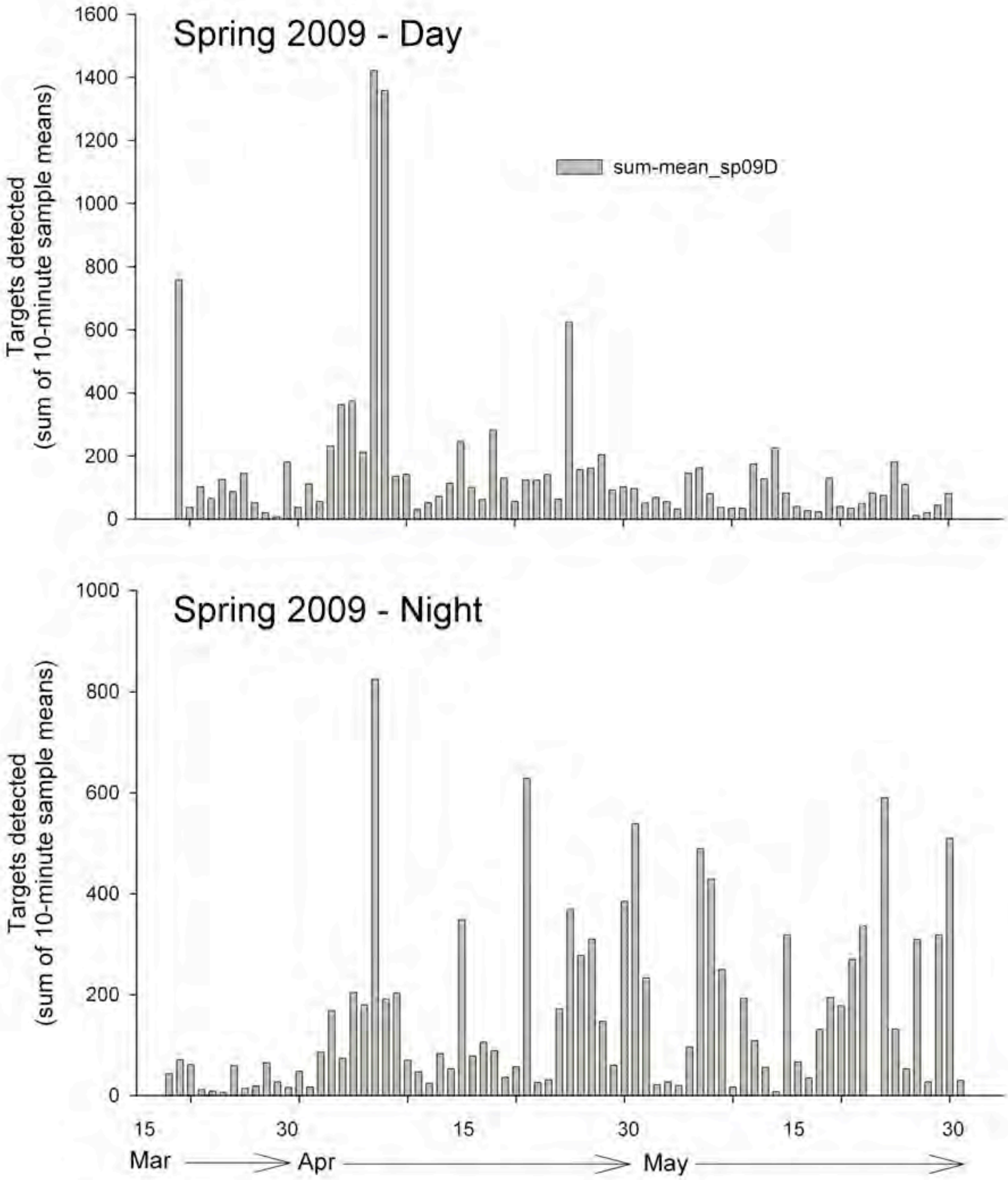


Figure 14. Seasonal temporal pattern in targets detected (sum of 10-minute sample means) during day (i.e. sunrise to sunset, upper panel) and night (sunset to sunrise the following morning, lower panel) data collection periods, spring (19 Mar-31 May) 2009.

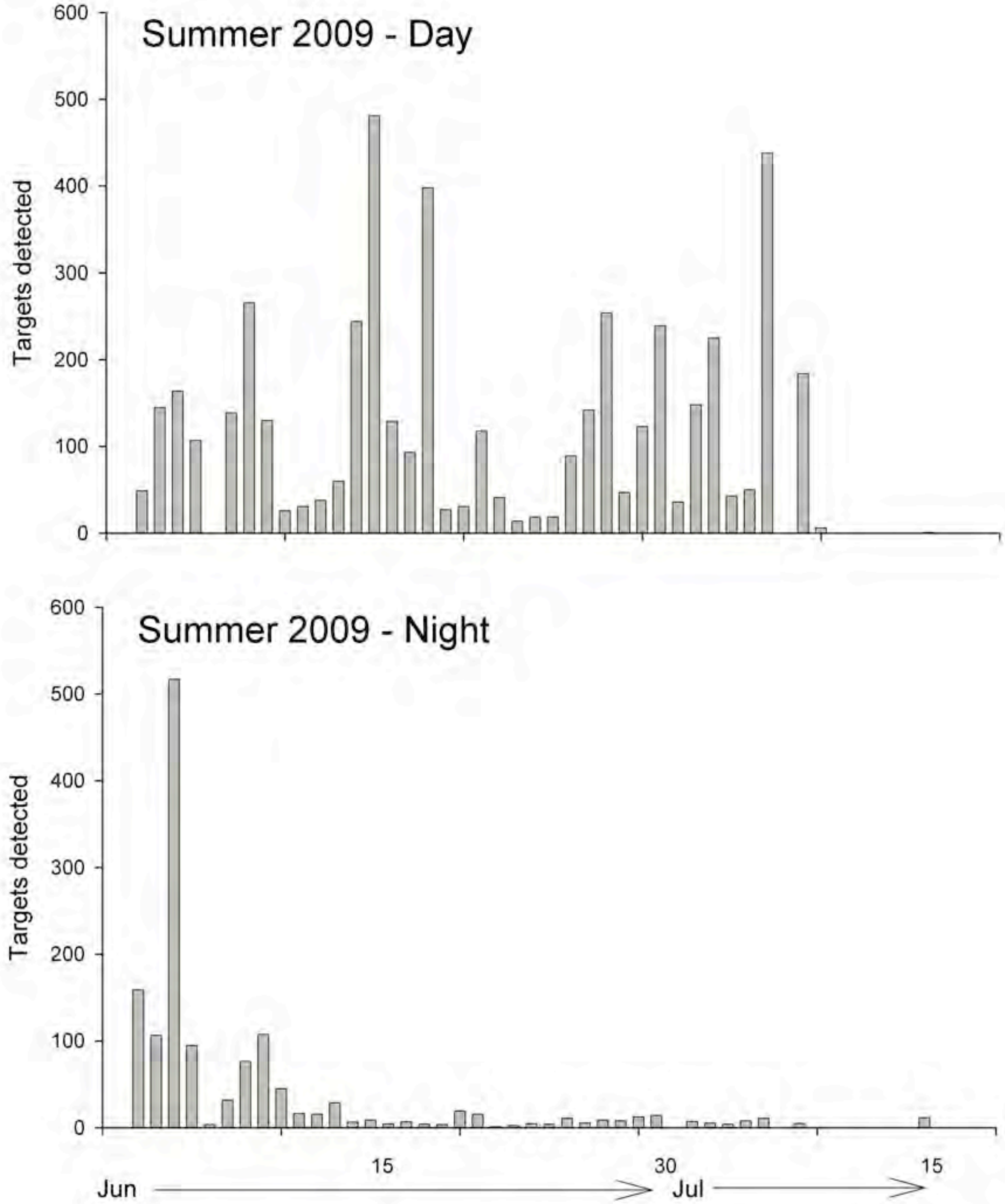


Figure 15. Seasonal temporal pattern in targets detected (sum of 10-minute sample means) during day (i.e. sunrise to sunset, upper panel) and night (sunset to sunrise the following morning, lower panel) data collection periods, summer (1 June - 31 July) 2009.

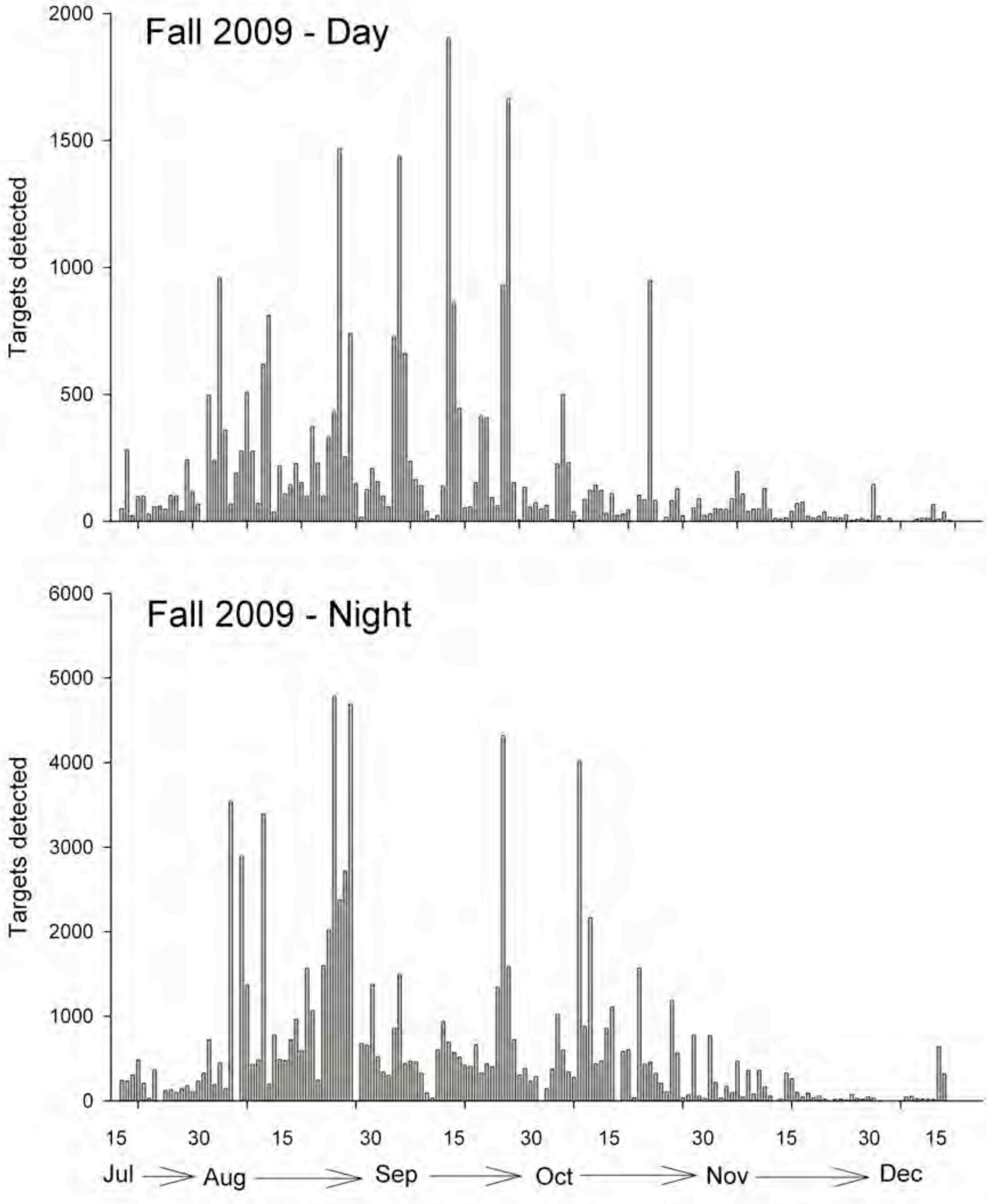


Figure 16. Seasonal temporal pattern in targets detected (sum of 10-minute sample means) during day (i.e. sunrise to sunset, upper panel) and night (sunset to sunrise the following morning, lower panel) data collection periods, fall (16 July - 15 December) 2009.

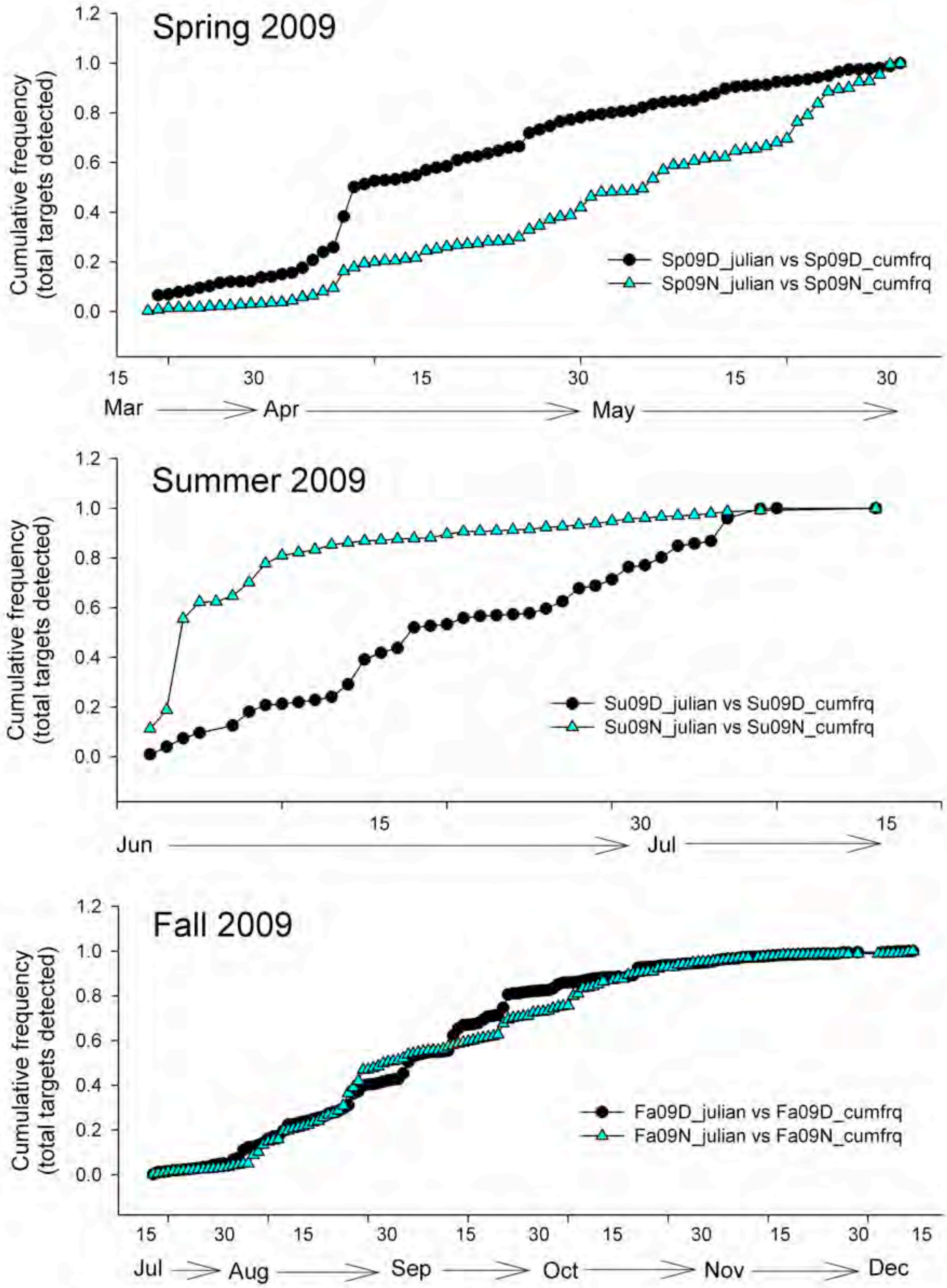


Figure 17. Cumulative frequency distributions for total targets detected (sum of 10-minute sample means) during day (i.e. sunrise to sunset, upper panel) and night (sunset to sunrise the following morning, lower panel) data collection periods, spring (upper), summer (center) and fall (lower) 2009.

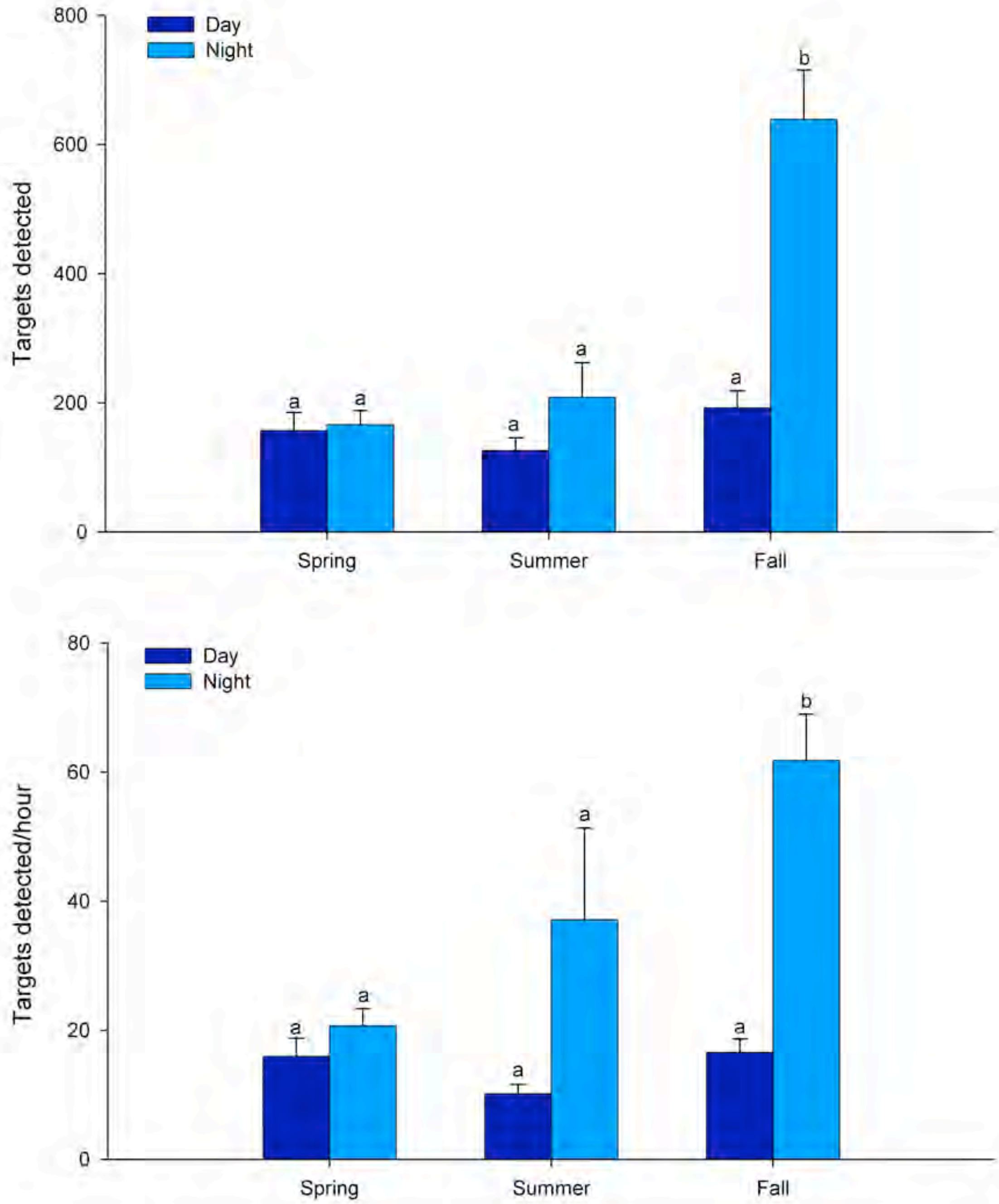


Figure 18. Targets detected (upper panel) and target detection rate (i.e., targets/hour, lower panel) for each season and period (i.e., day, night) during 2009 study of bird/bat movement patterns on Block Island, Rhode Island and in its near-coastal waters (within 2 nautical miles). In each graph, bars with the same letter are not statistically different from each other.

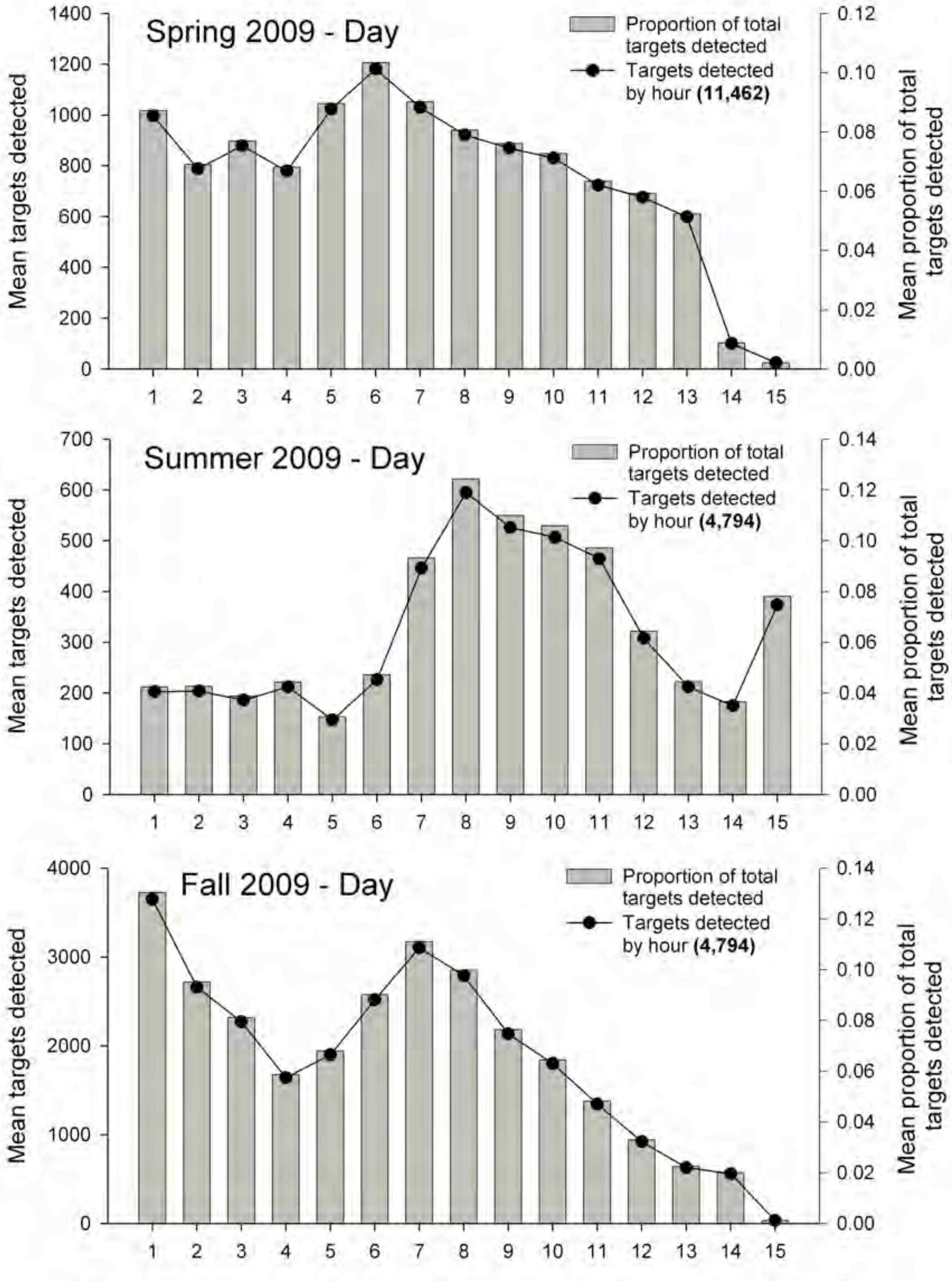


Figure 19. Mean targets detected and proportion of total targets detected by hour during the "day" (sunrise to sunset the same day) for spring migration (19 Mar - 31 May), summer (1 June - 15 July) and fall migration (16 July - 15 December) data collection periods.

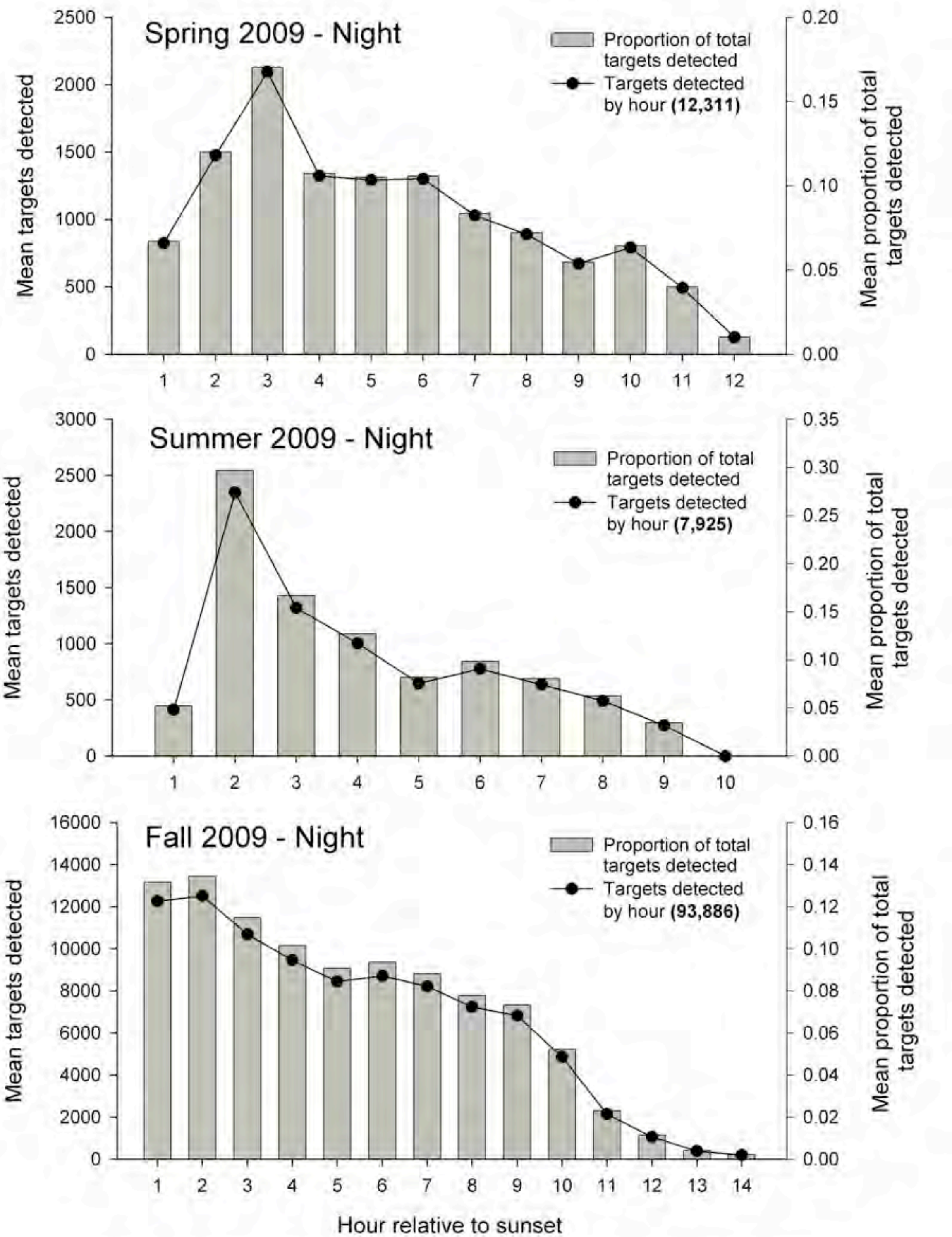


Figure 20. Mean targets detected and proportion of total targets detected by hour during the "night" (sunset to sunrise the following morning) for spring migration (19 Mar - 31 May), summer (1 June - 15 July) and fall migration (16 July - 15 December) data collection periods.

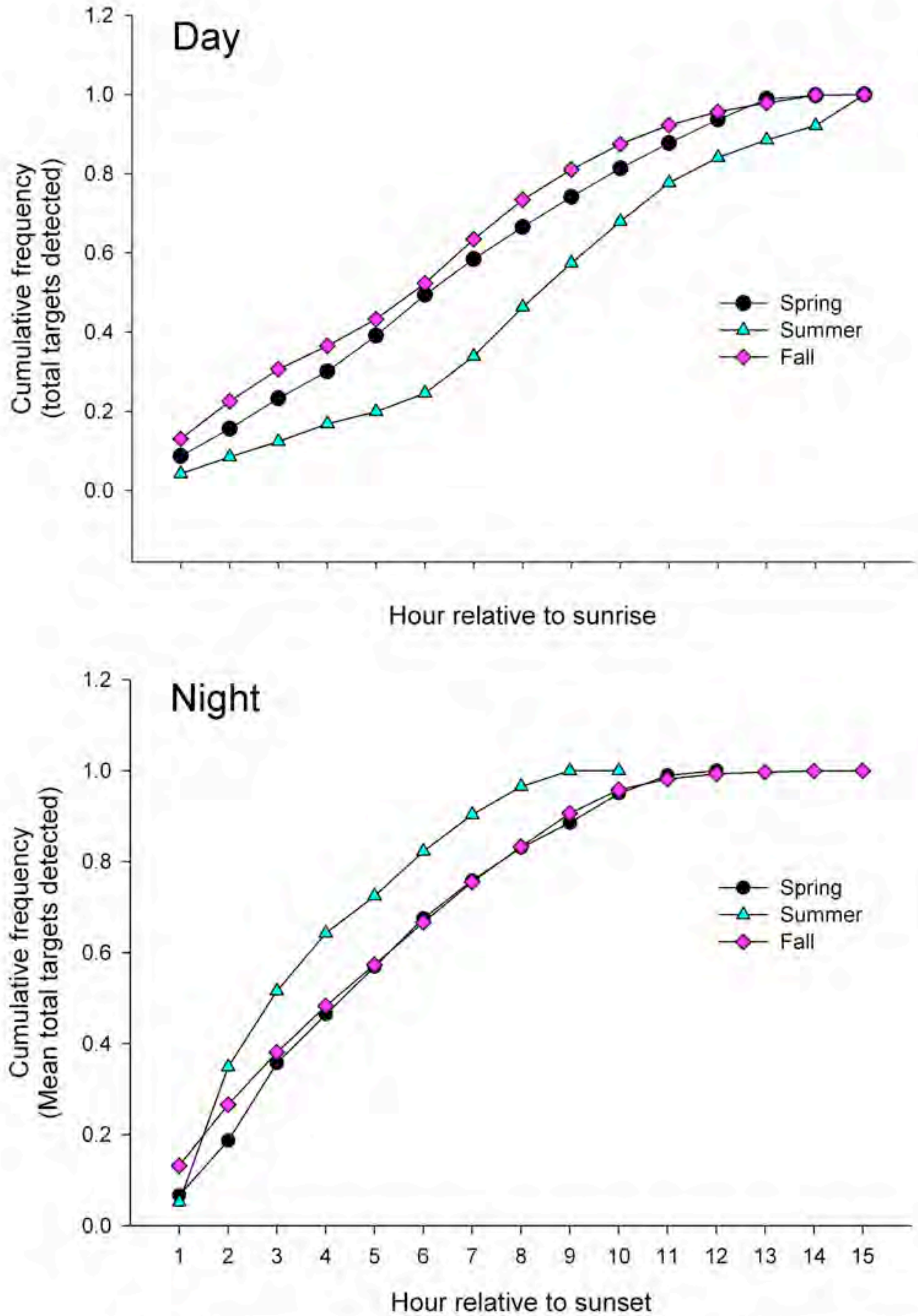


Figure 21. Hourly cumulative frequency distributions relative to sunrise (i.e., day data collection period, upper panel) and relative to sunset (i.e., night data collection, lower panel) for mean total targets detected (i.e., sum of 10-minute sample means for each hour averaged over entire season) during spring (19 Mar-31 May), summer (1 June - 15 July) and fall (16 July - 15 December) 2009.

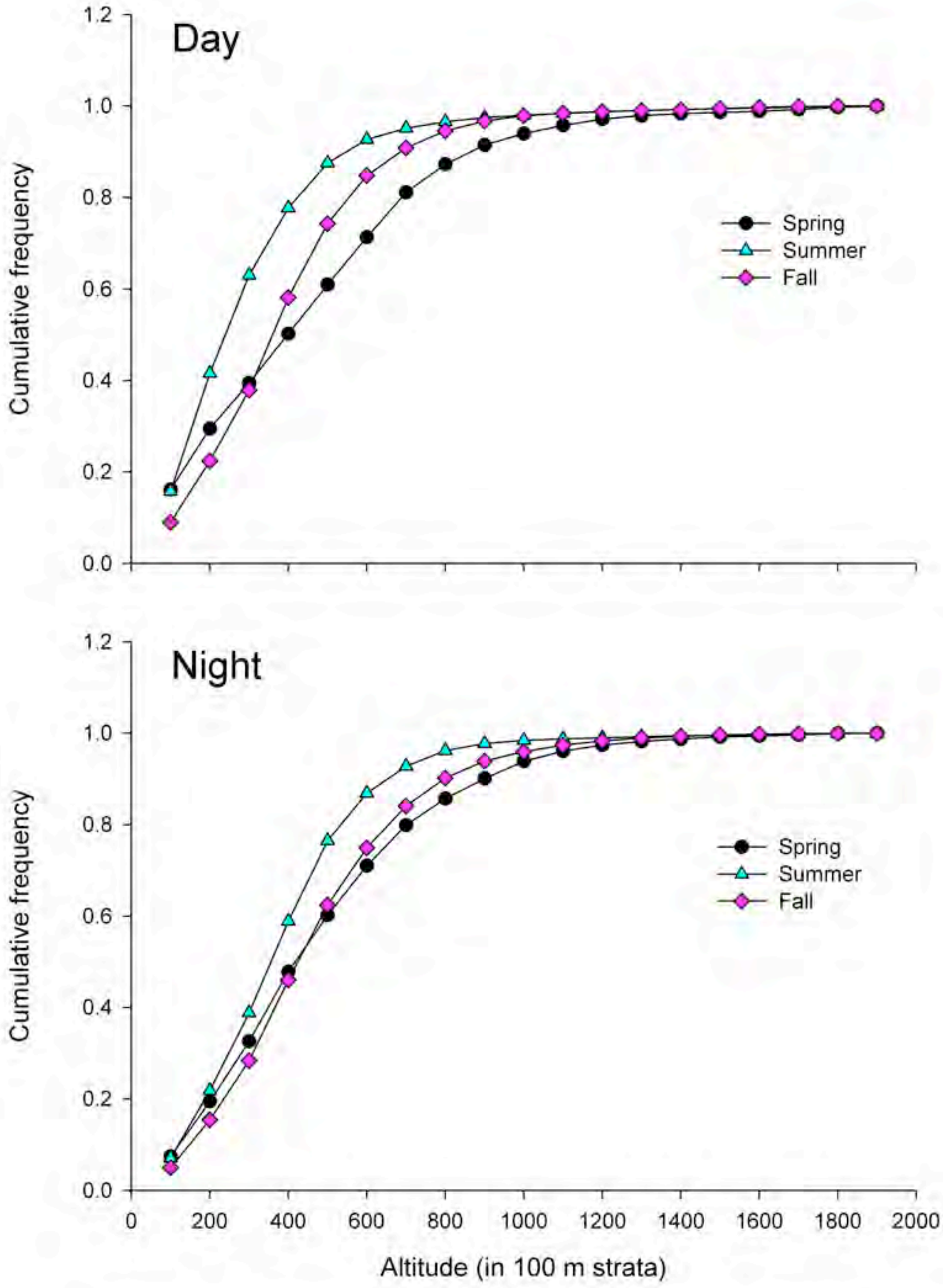


Figure 22. Cumulative frequency distributions for targets detected in each of 19, 100 m altitudinal strata (i.e., 1900 meters = ~1 nautical mile, the range setting for the vertical radar). during day (i.e. sunrise to sunset, upper panel) and night (sunset to sunrise the following morning, lower panel) data collection periods, spring (upper), summer (center) and fall (lower) 2009.

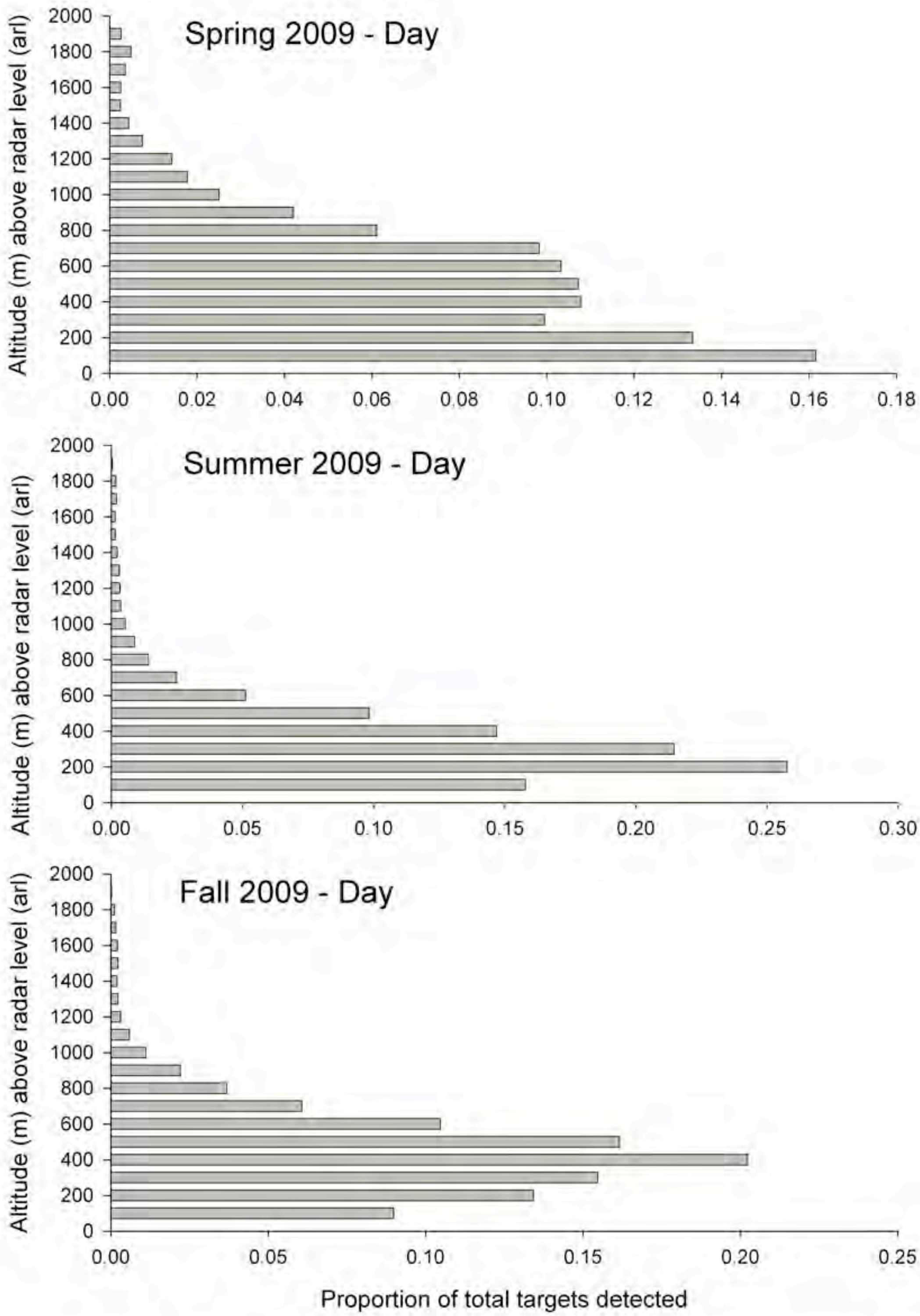


Fig. 23. Altitudinal distribution of targets detected in the day (sunrise-sunset the same day) during spring migration (19 Mar-31 May), summer (1 Jun-15 July) and fall migration (16 July-15 December) periods.

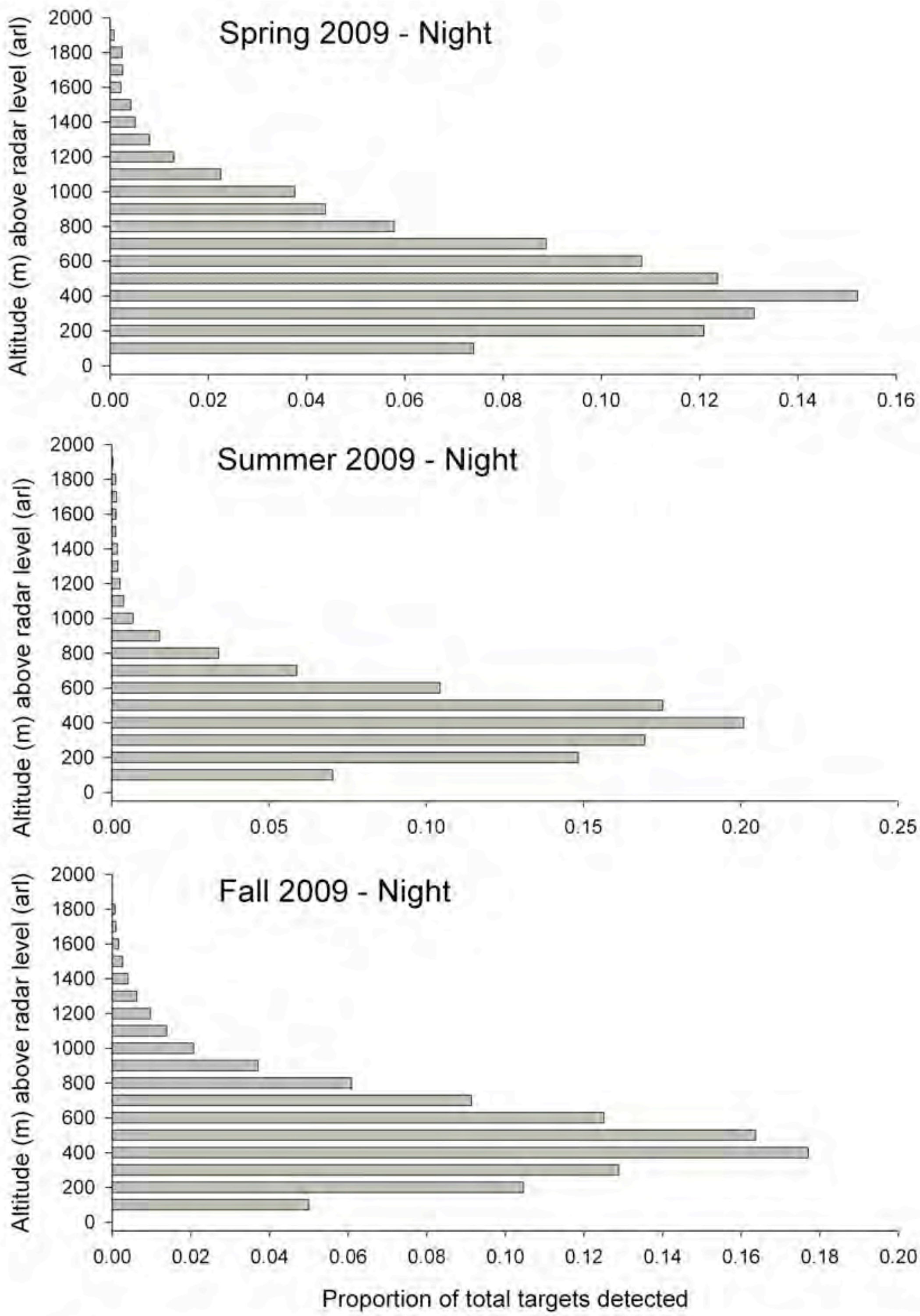


Fig. 24. Altitudinal distribution of targets detected at night (sunset-sunrise) the following morning) during spring migration (19 Mar-31 May), summer (1 Jun-15 July) and fall migration (16 July-15 December) periods.

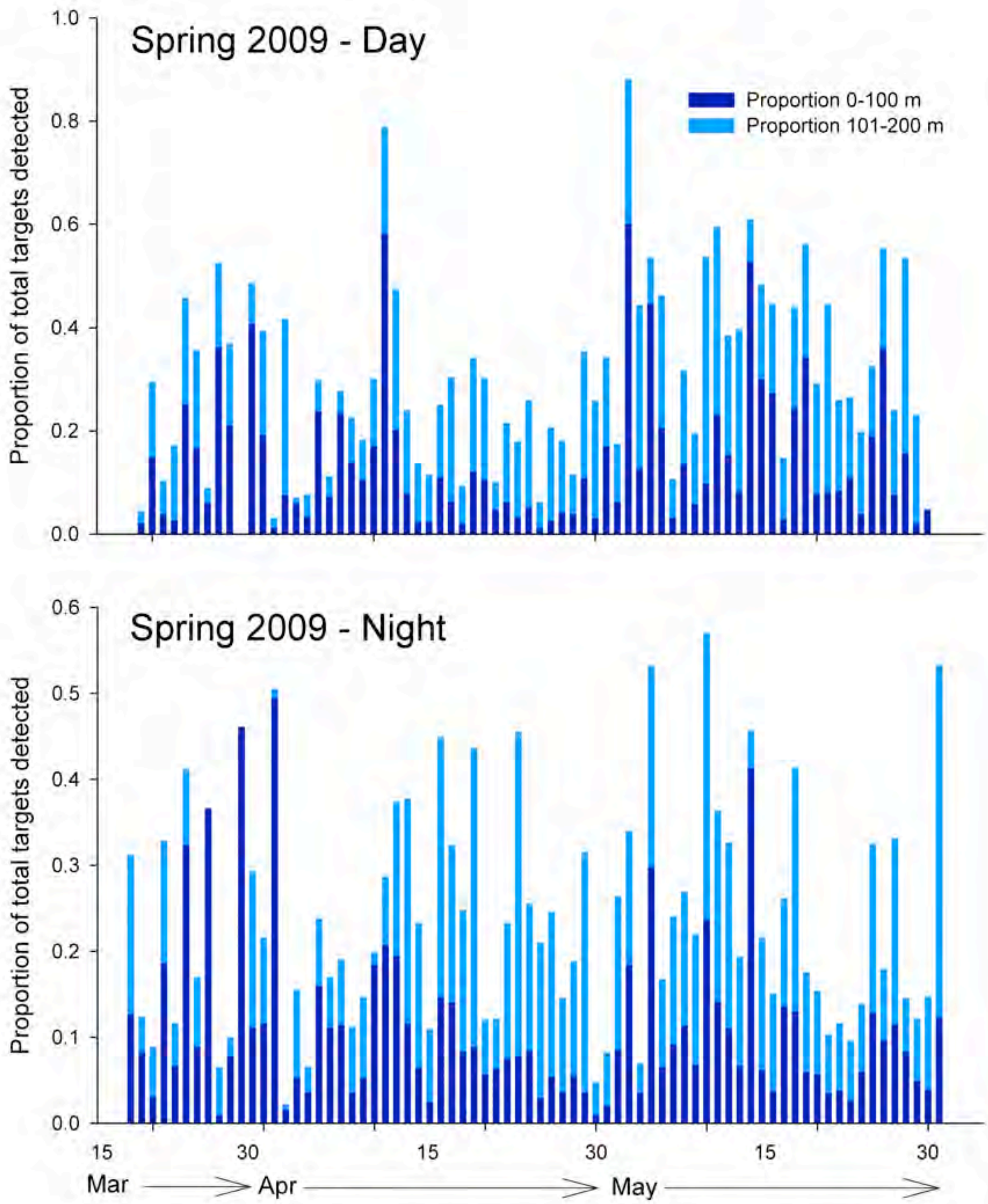


Figure 25. Seasonal temporal pattern in the proportion of targets detected <= 100 m and between 101 m and 200 m during day (upper panel) and night (lower panel) data collection periods, spring (19 Mar-31 May) 2009.

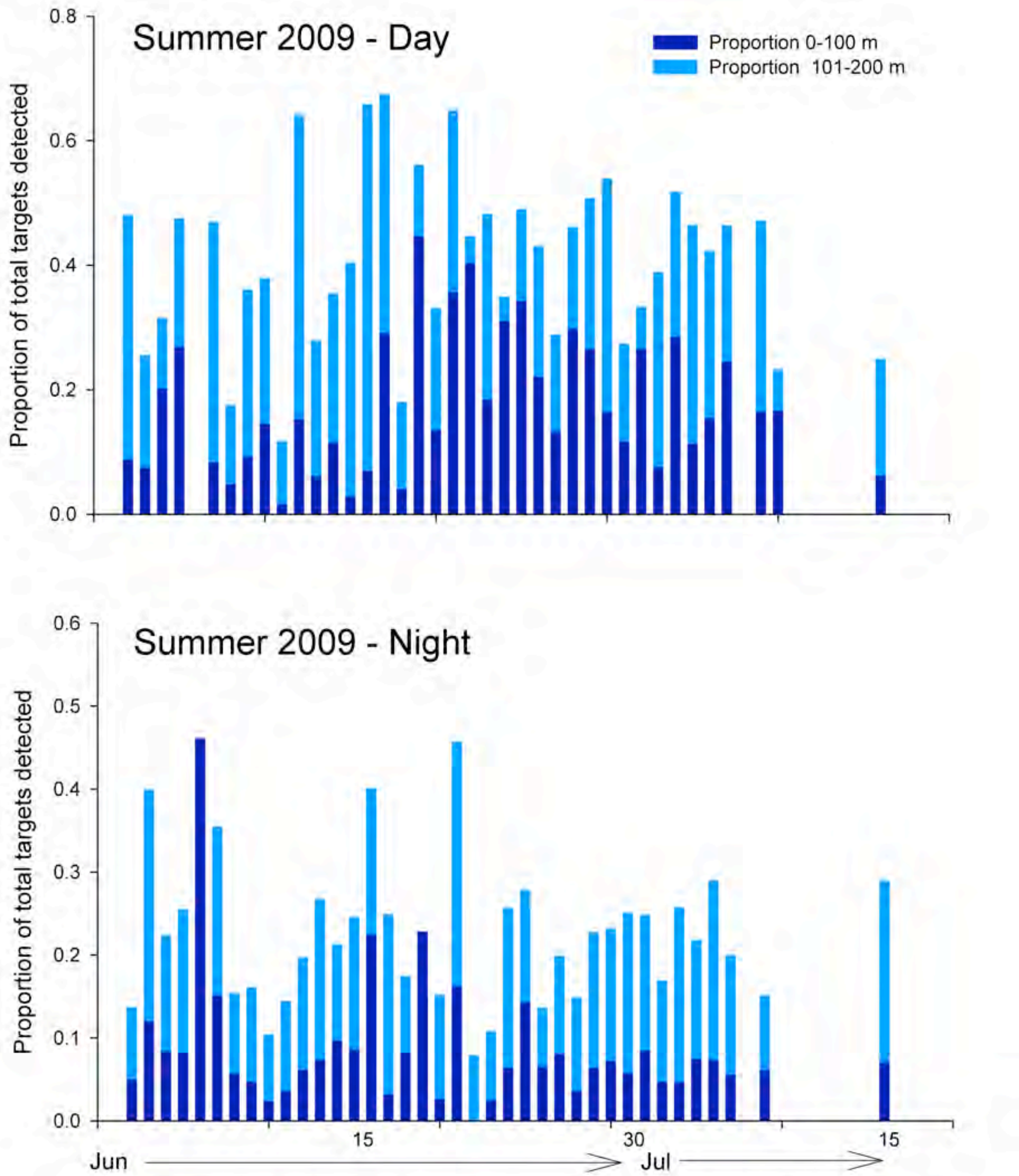


Figure 26. Seasonal temporal pattern in the proportion of targets detected <= 100 m and between 101 m and 200 m during day (upper panel) and night (lower panel) data collection periods, summer (1June - 15 July) 2009.

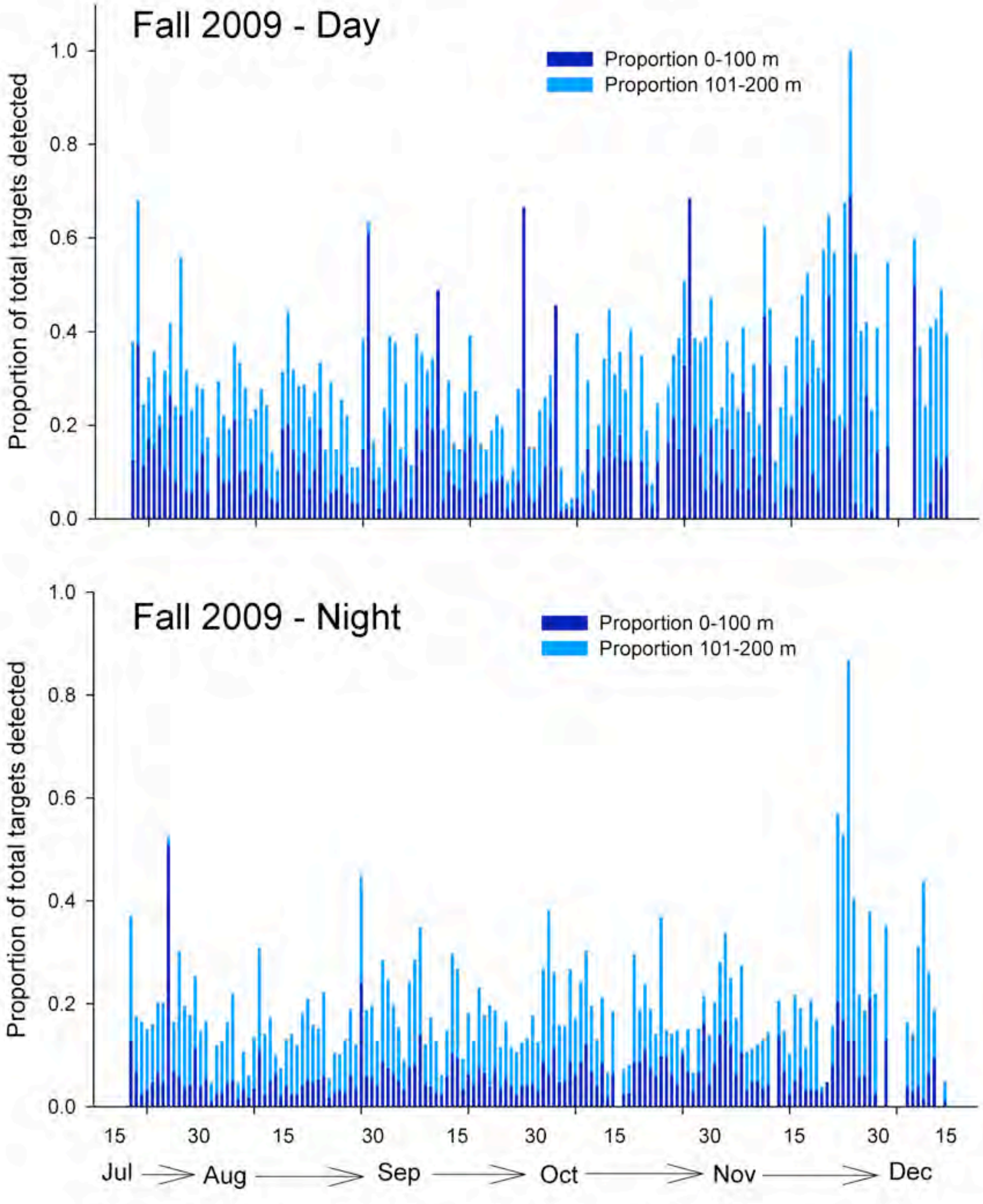


Figure 27. Seasonal temporal pattern in the proportion of targets detected <= 100 m and between 101 m and 200 m during day (upper panel) and night (lower panel) data collection periods, fall (16 July - 15 December) 2009.

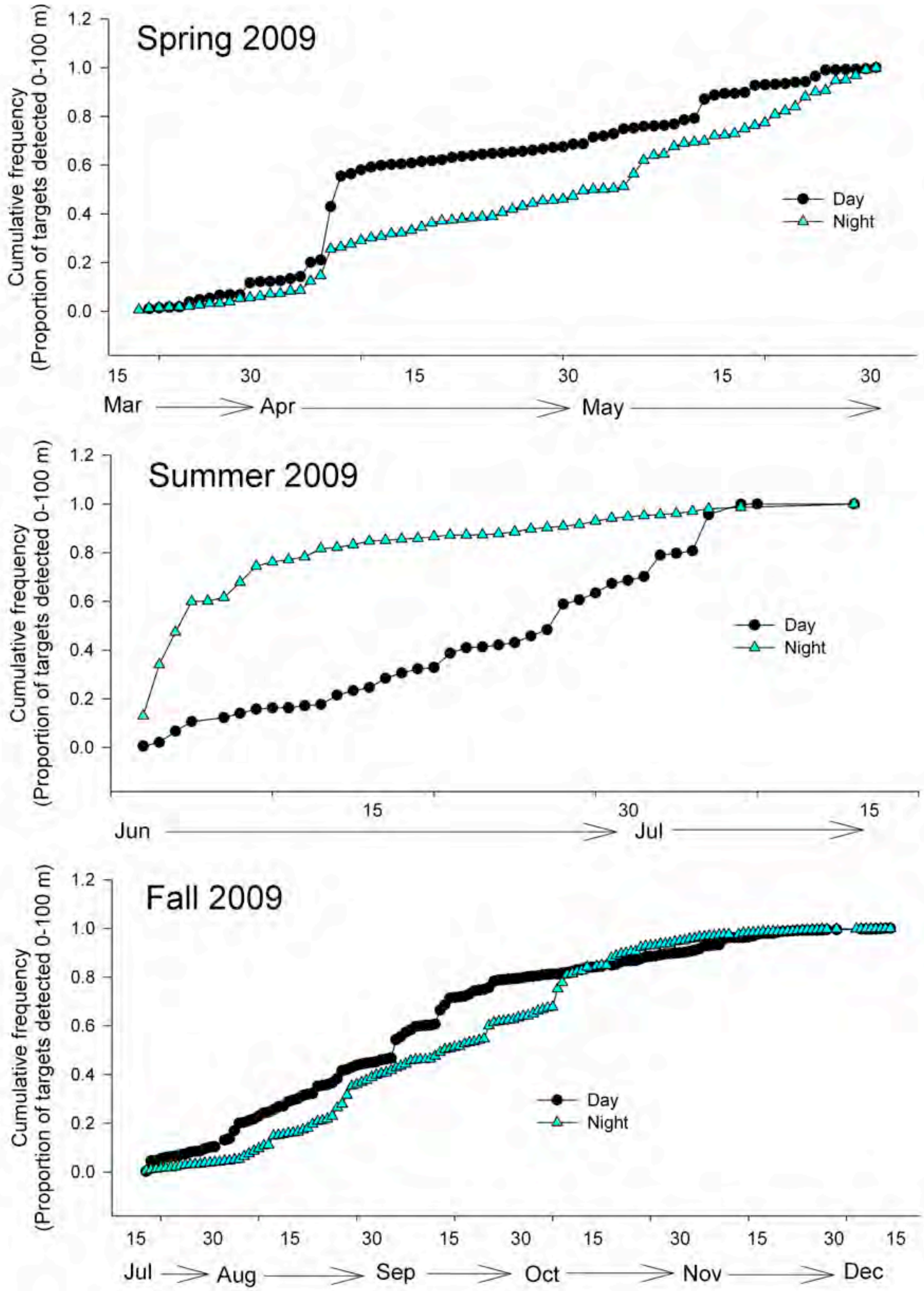


Figure 28. Cumulative frequency distributions for the proportion of targets detected in the 0-100 m strata) during day (i.e. sunrise to sunset) and night (sunset to sunrise the following morning) data collection periods, spring (upper), summer (center) and fall (lower) 2009.

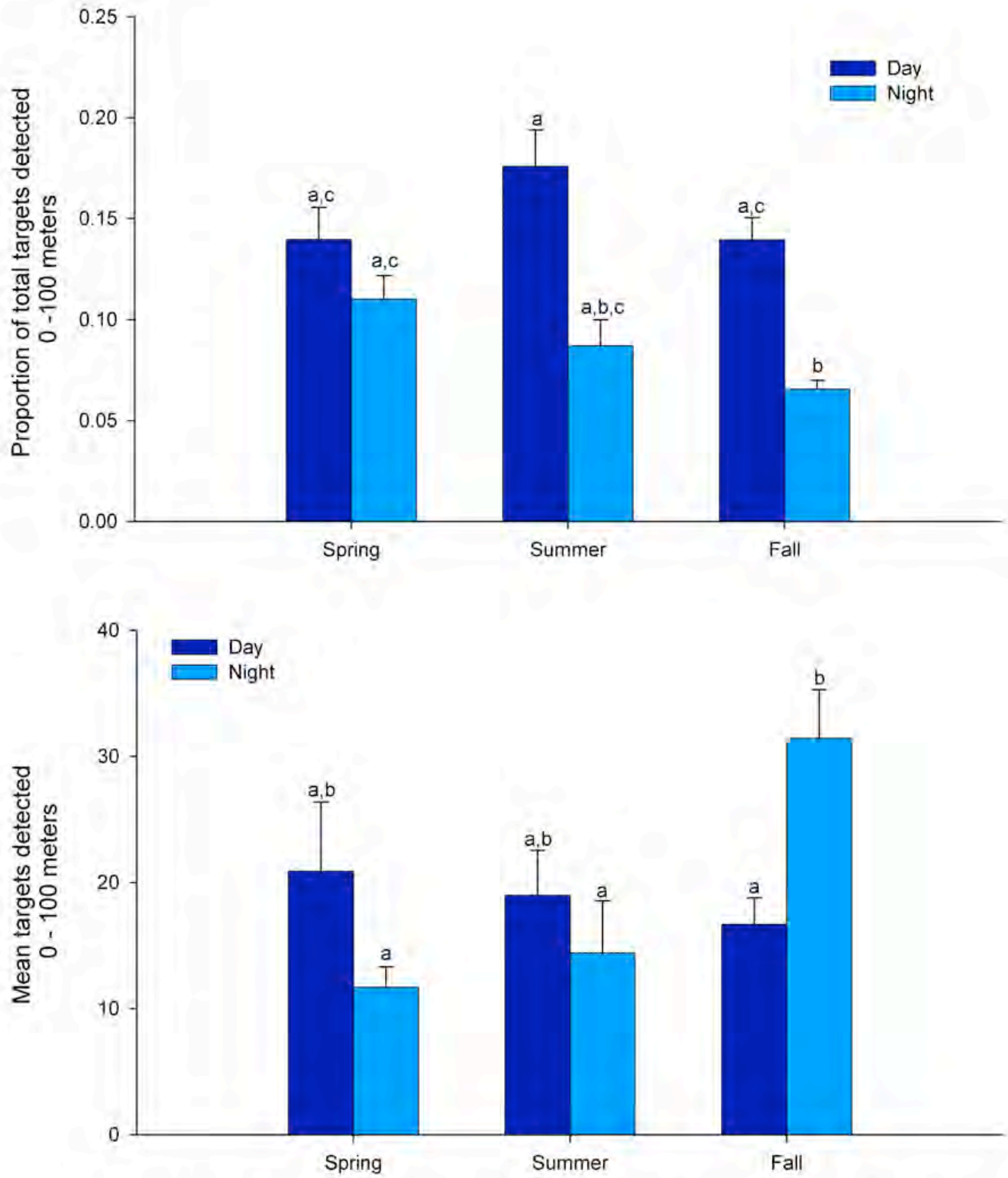


Figure 29. Proportion of targets detected (upper panel) and mean target detected (i.e., sums of 10-minutes sample averages, lower panel) in the 0-100 m for each season and period (i.e., day, night) during 2009 study of bird/bat movement patterns on Block Island, Rhode Island and in its near-coastal waters (within 2 nautical miles). In each graph, bars with the same letter are not statistically different from each other.

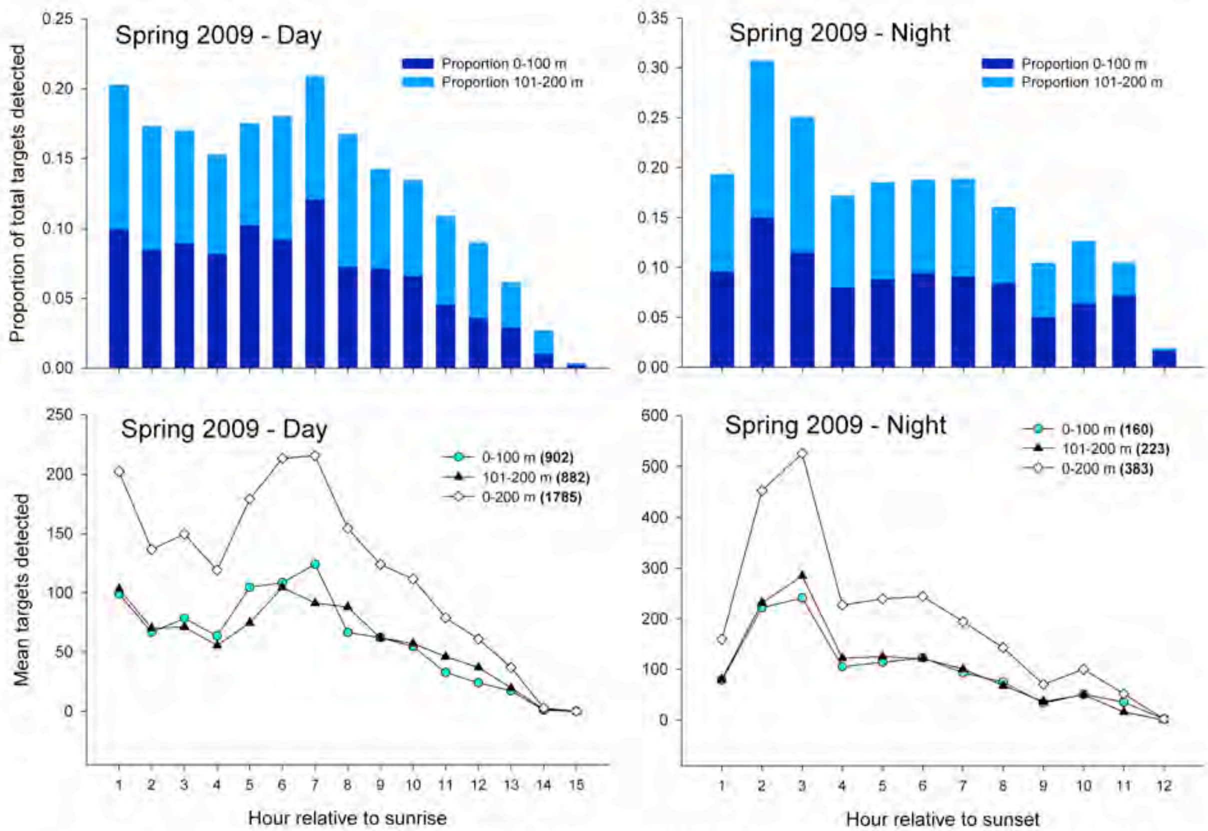


Figure 30. (Upper panels) Mean proportion of targets by hour detected <=100 m and between 101 m and 200 m above radar level (arl) in spring (19 Mar - 31 May 2009 during day and night sampling period. (Lower panels) Mean number of targets by hour detected at <=100 m and between 101 m and 200 m arl.

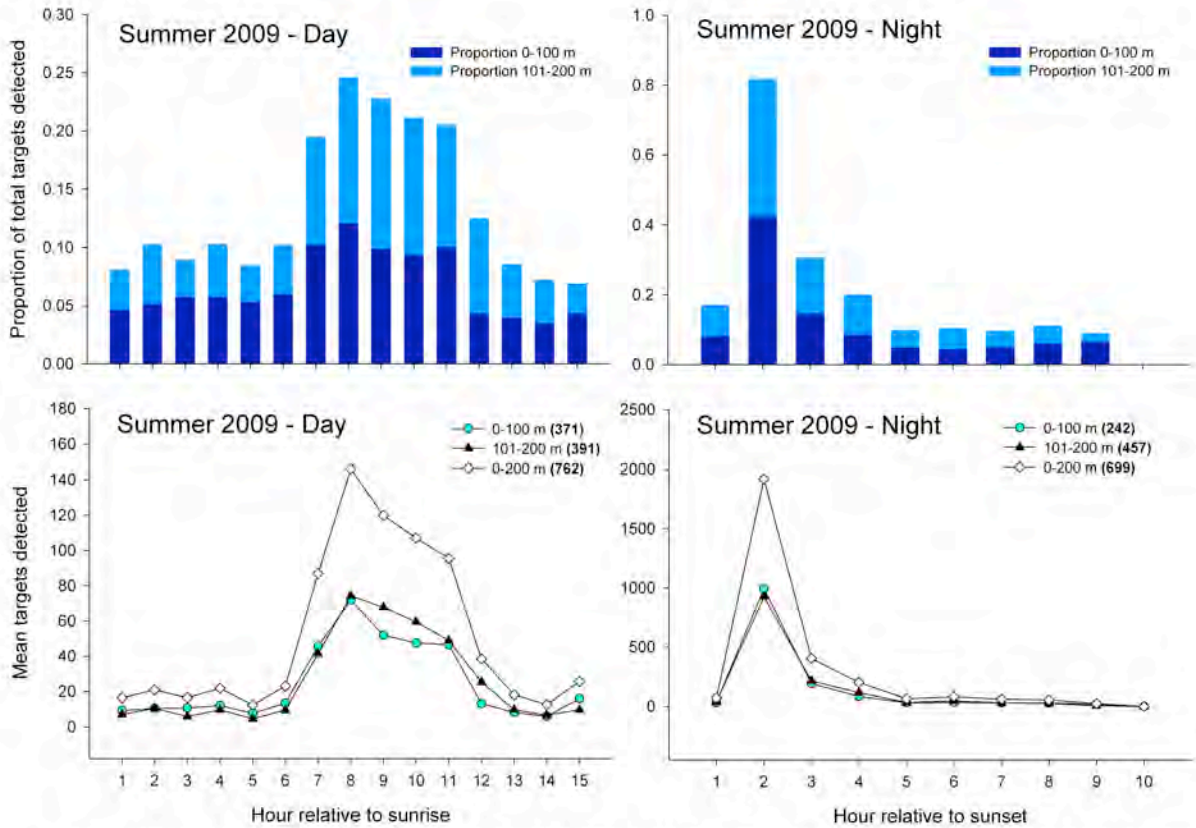


Figure 31. (Upper panels) Mean proportion of targets by hour detected <=100 m and between 101 m and 200 m above radar level (arl) in summer (1 Jun - 15 July 2009 during day and night sampling period. (Lower panels) Mean number of targets by hour detected at <=100 m and between 101 m and 200 m arl.

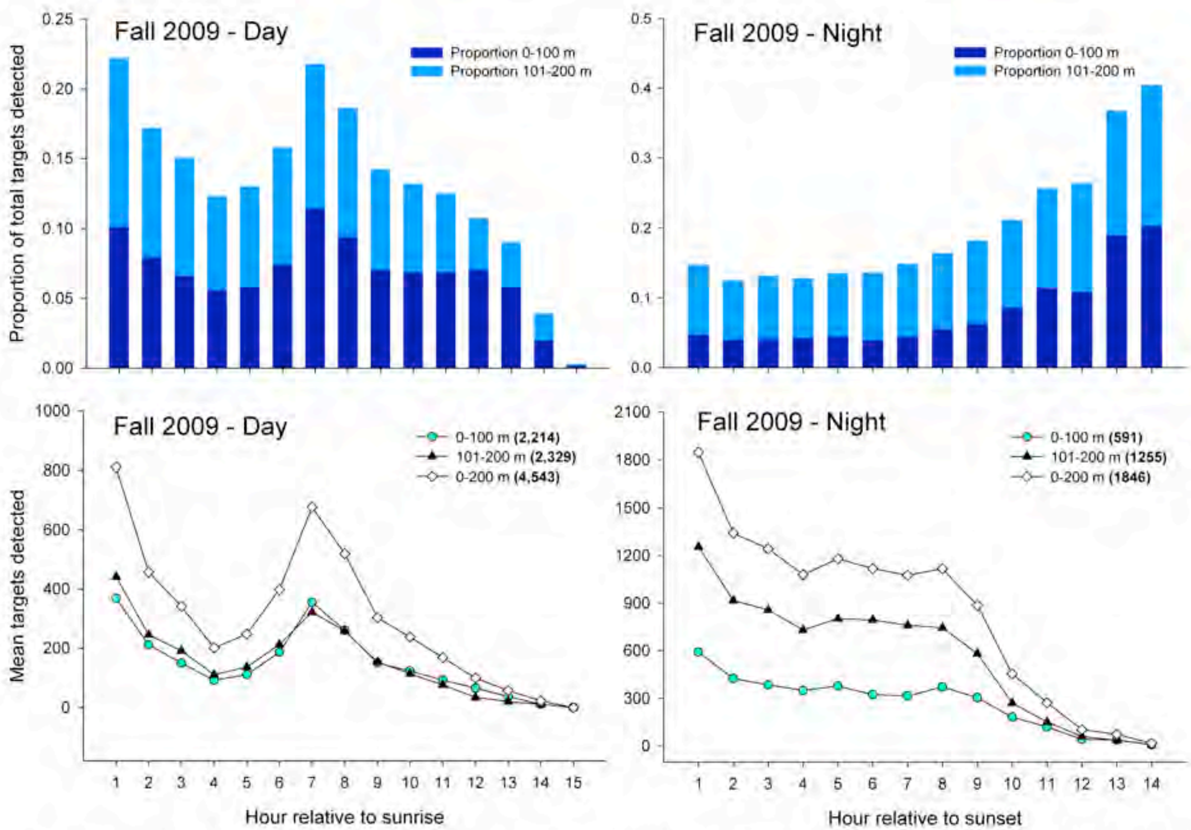


Figure 32. (Upper panels) Mean proportion of targets by hour detected <=100 m and between 101 m and 200 m above radar level (arl) in fall (16 July - 15 december 2009 during day and night sampling period. (Lower panels) Mean number of targets by hour detected at <=100 m and between 101 m and 200 m arl.

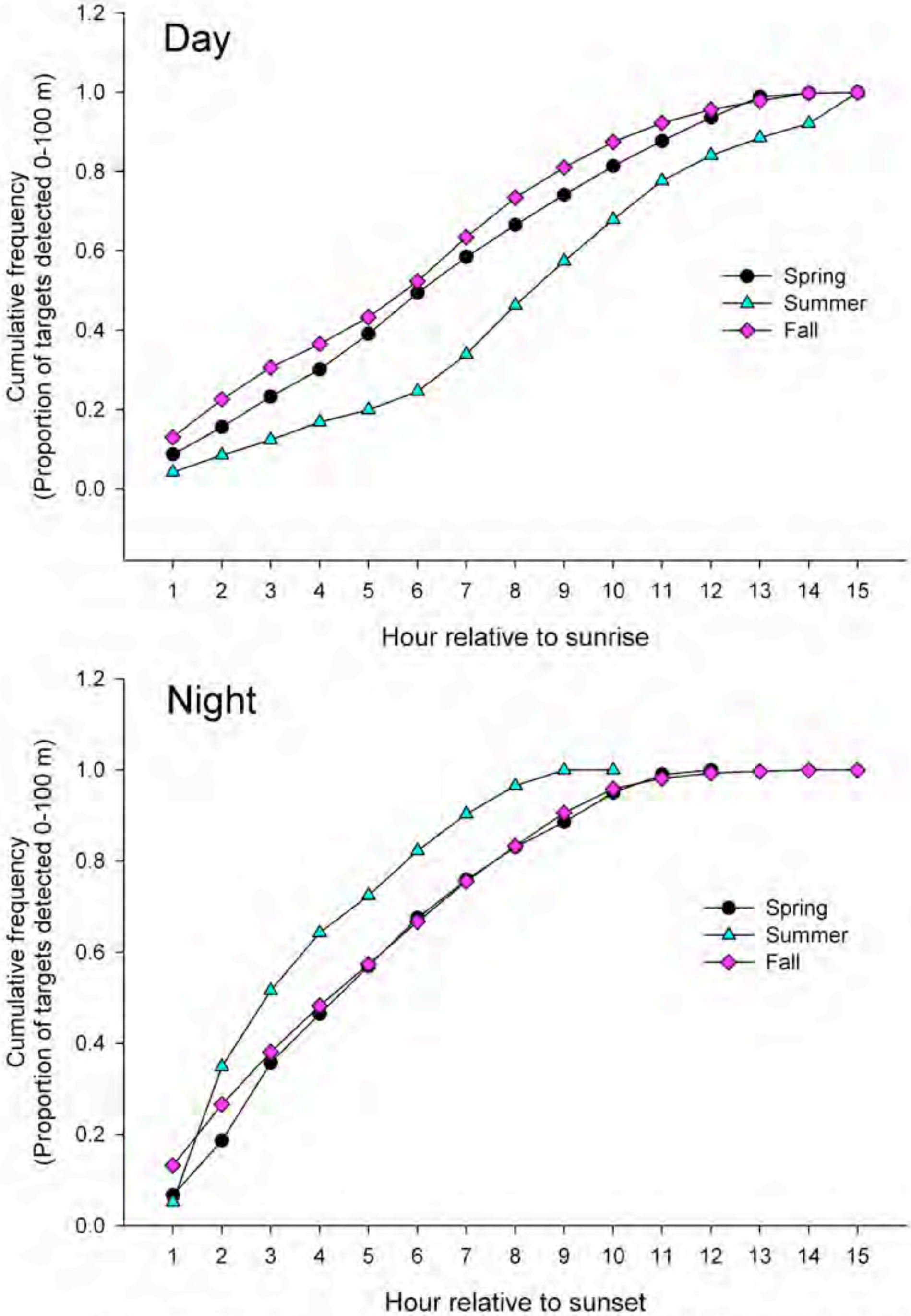


Figure 33. Hourly cumulative frequency distributions relative to sunrise (i.e., day data collection period, upper panel) and relative to sunset (i.e., night data collection, lower panel) for the proportion of targets detected at or below 100 m during spring (19 Mar-31 May), summer (1 June - 15 July) and fall (16 July - 15 December) 2009.

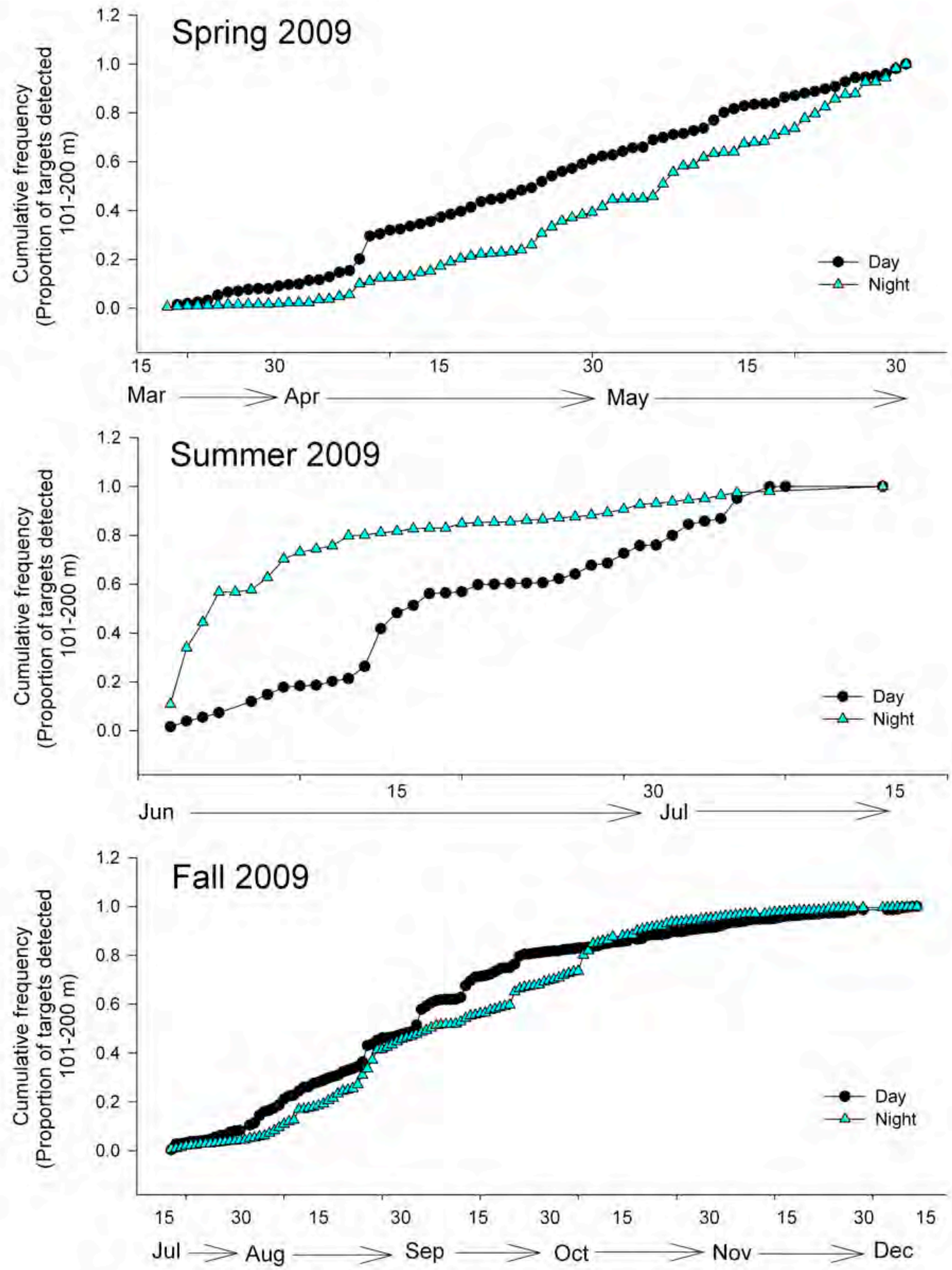
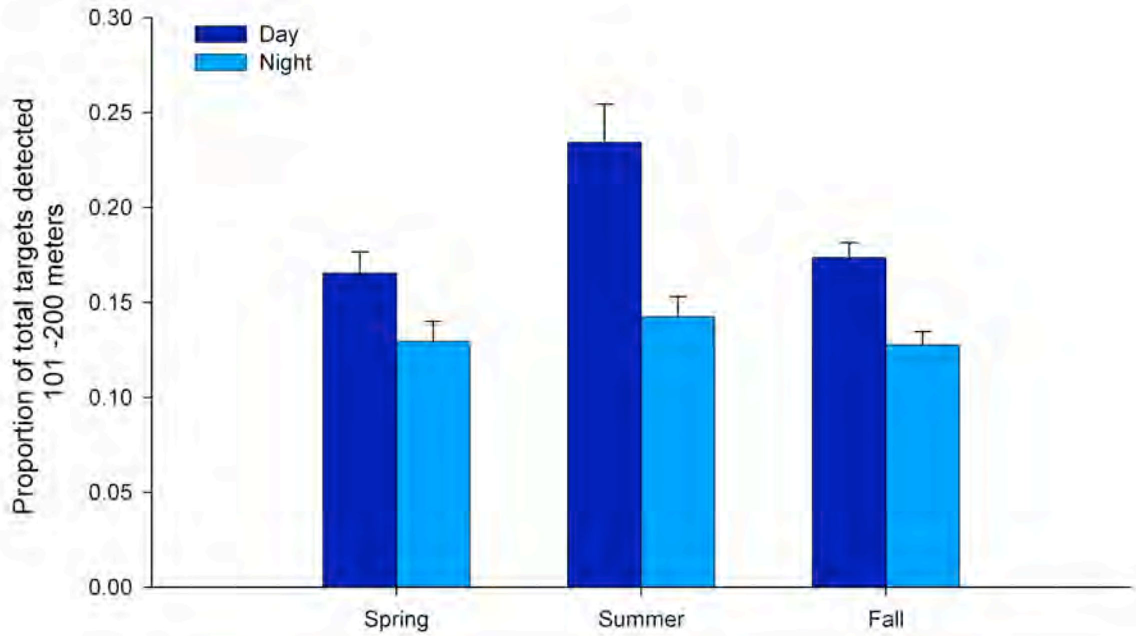


Figure 34. Cumulative frequency distributions for the proportion of targets detected in the 101-200 m strata during day (i.e. sunrise to sunset) and night (sunset to sunrise the following morning) data collection periods, spring (upper), summer (center) and fall (lower) 2009.



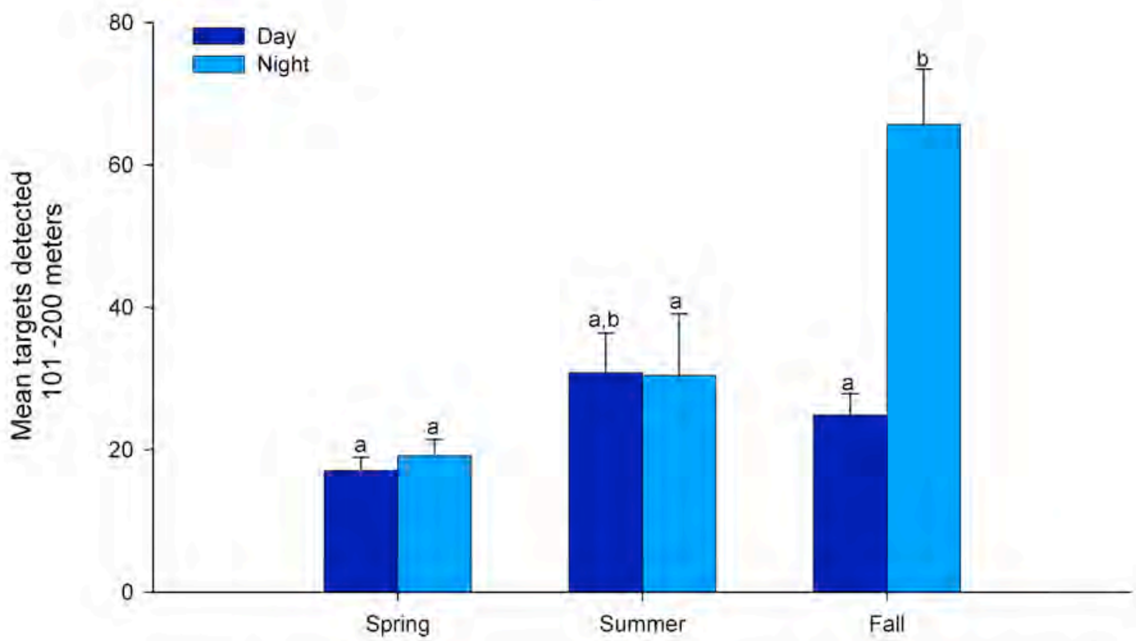


Figure 35. Proportion of targets detected (upper panel) and mean target detected (i.e., sums of 10-minutes sample averages, lower panel) in the 101-200 m stratum for each season and period (i.e., day, night) during 2009 study of bird/bat movement patterns on Block Island, Rhode Island and in its near-coastal waters (within 2 nautical miles). In each graph, bars with the same letter are not statistically different from each other.

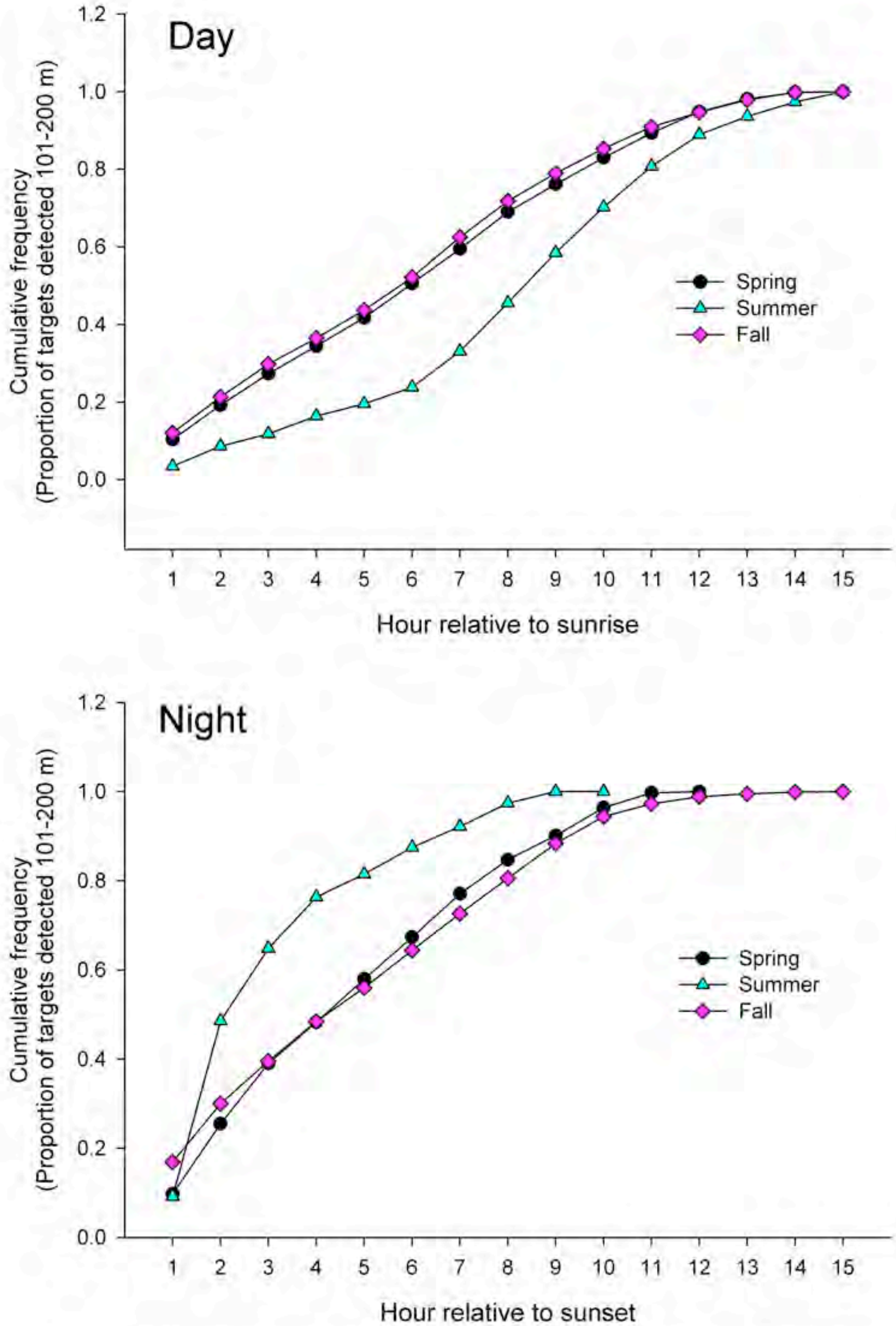


Figure 36. Hourly cumulative frequency distributions relative to sunrise (i.e., day data collection period, upper panel) and relative to sunset (i.e., night data collection, lower panel) for the proportion of targets detected in the 101-200 m stratum during spring (19 Mar-31 May), summer (1 June - 15 July) and fall (16 July - 15 December) 2009.

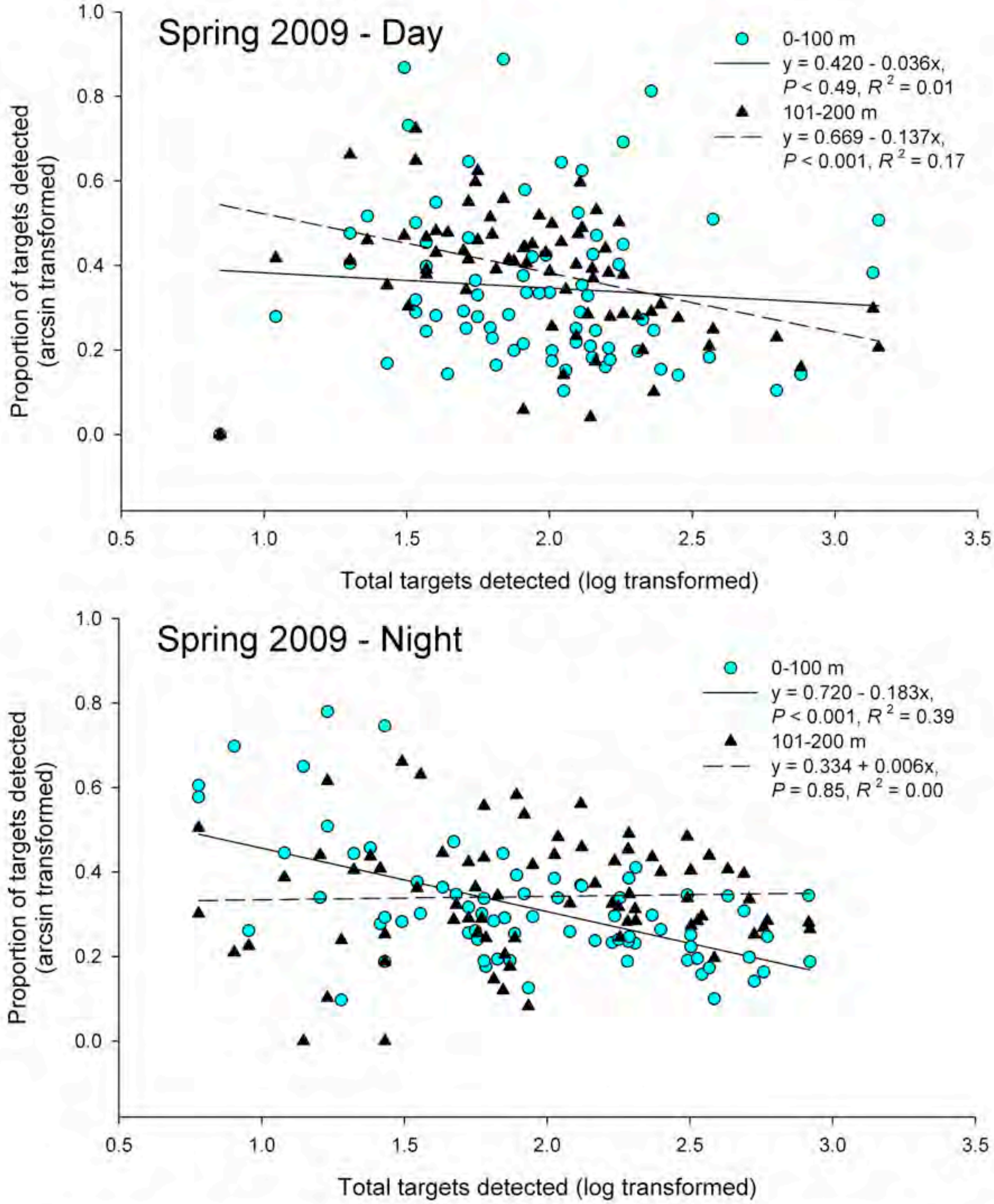
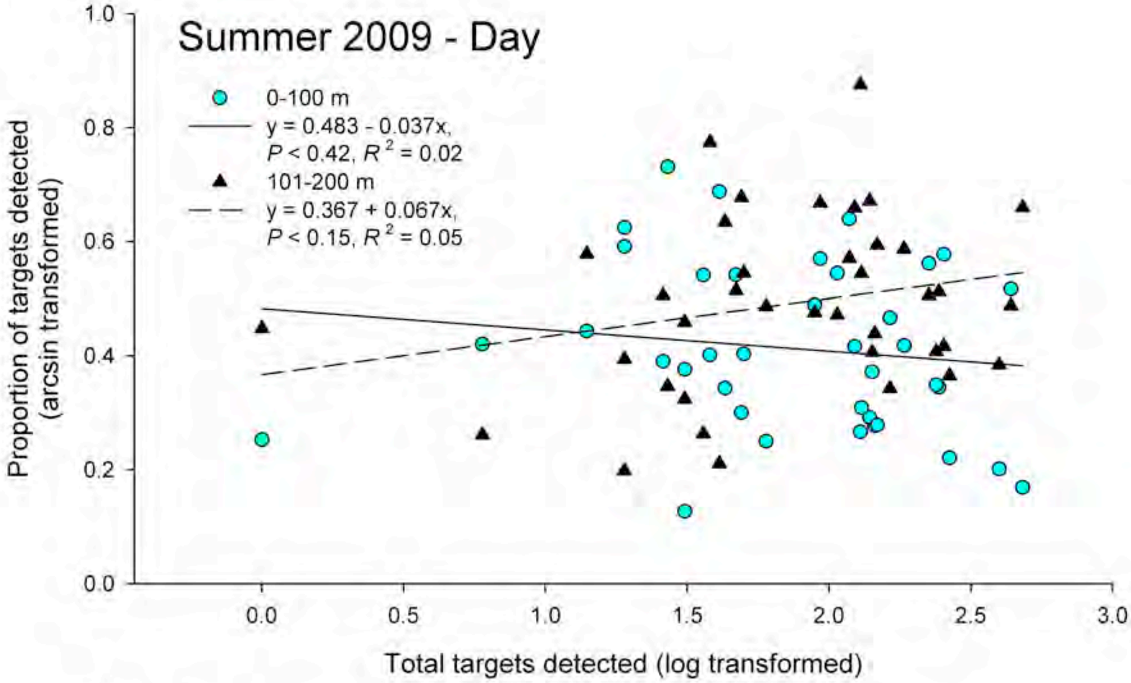


Figure 37. Relationship between the proportion of targets detected in the two lowest altitudinal strata (i.e., <= 100 m, between 100 and 200 m) and total targets detected (i.e., sum of the 10-minute sample averages) during day and night data collection periods, spring 2009.



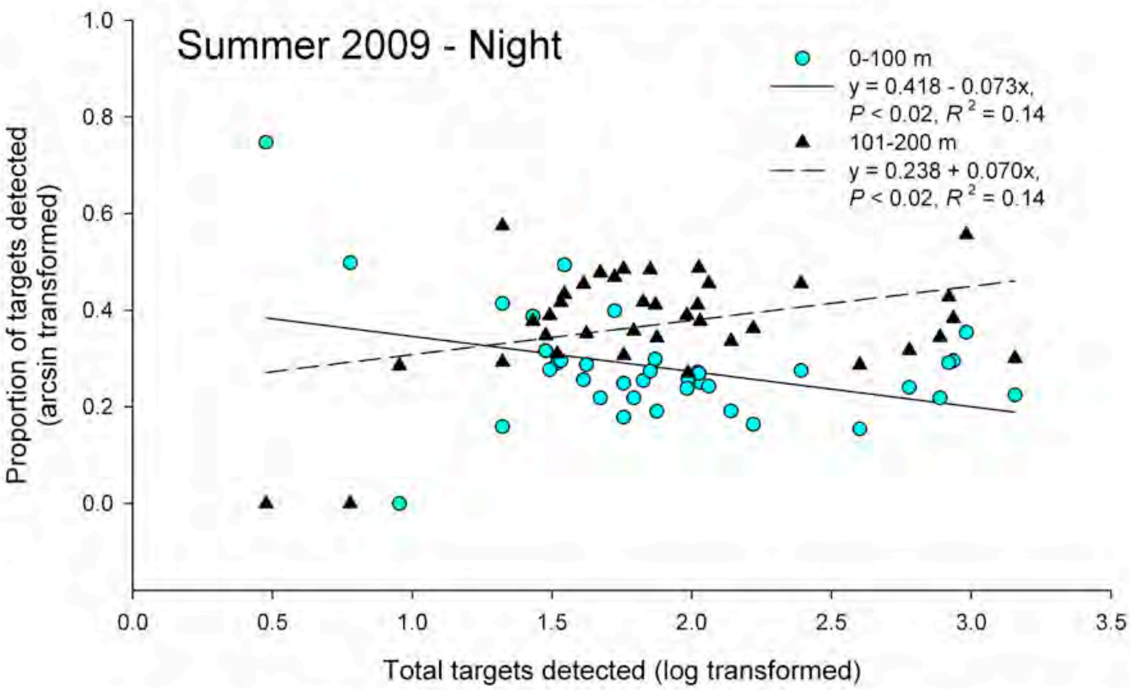
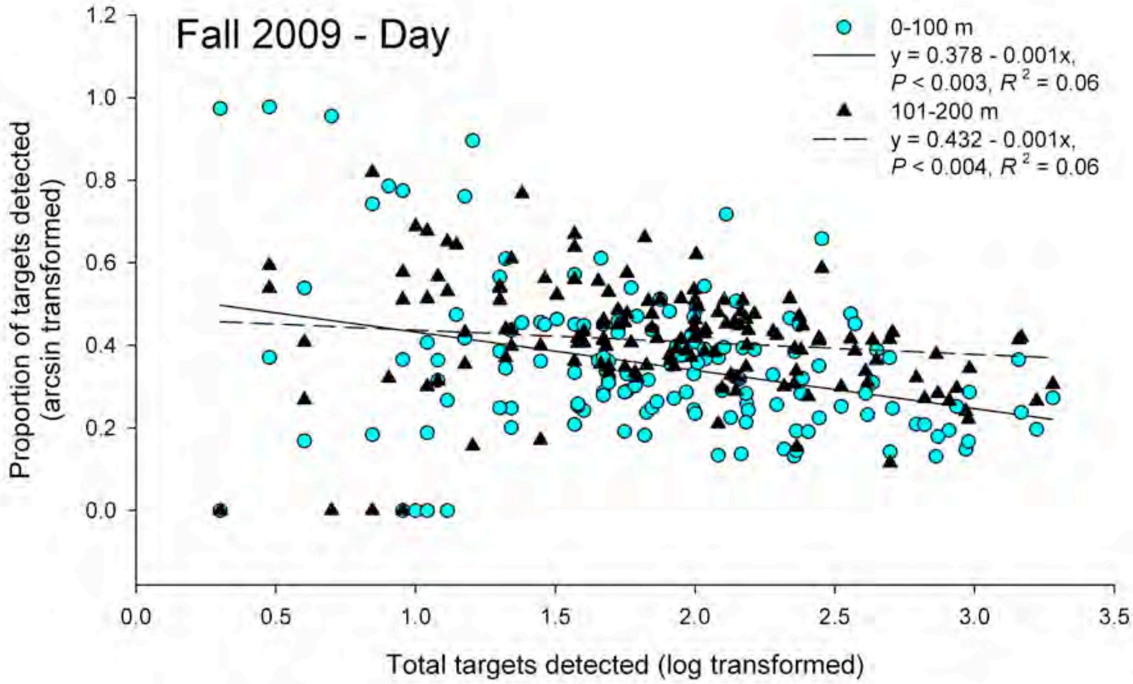


Figure 38. Relationship between the proportion of targets detected in the two lowest altitudinal strata (i.e., <= 100 m, between 100 and 200 m) and total targets detected (i.e., sum of the 10-minute sample averages) during day and night data collection periods, summer 2009.



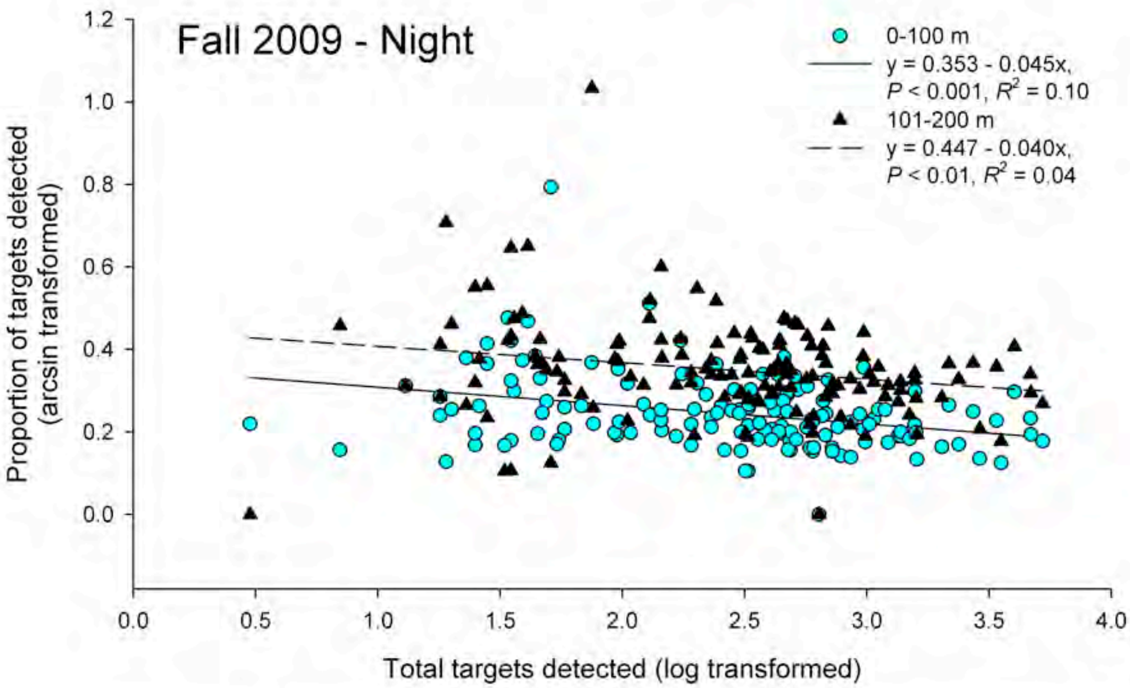


Figure 39. Relationship between the proportion of targets detected in the two lowest altitudinal strata (i.e., <= 100 m, between 100 and 200 m) and total targets detected (i.e., sum of the 10-minute sample averages) during day and night data collection periods, fall 2009.

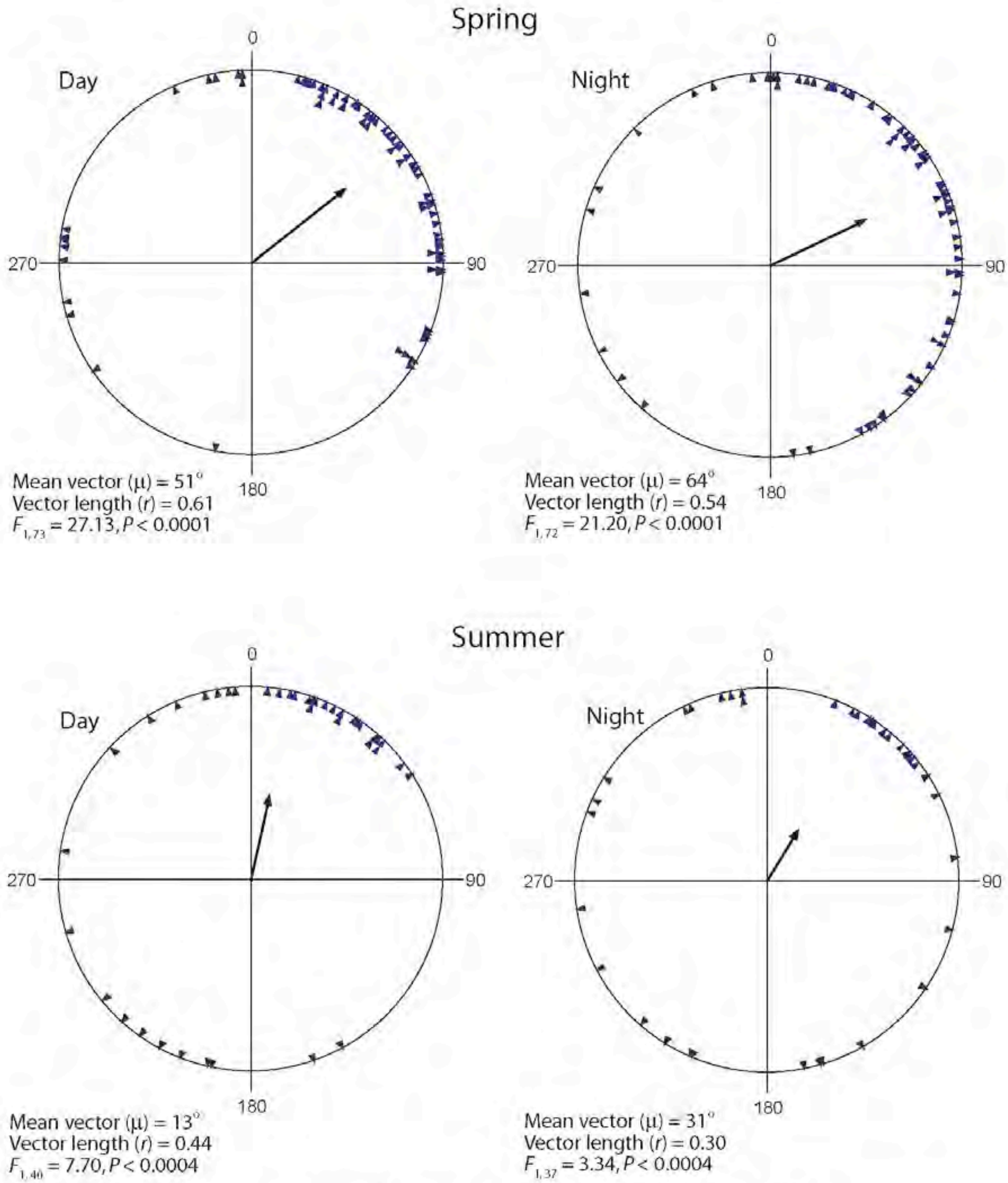


Fig. 40. Second-order mean vectors (i.e., mean of meanns) in spring and summer 2009 for day and night data collection periods. Blue triangles around the perimeter of each circle represent first-order mean vectors. Arrows point in the direction of the second-order mean vector and their length represents the vector length Vector lenght is an index or circular variance with values ranging between 0 and 1. The higher the value, the lower the variance in the mean vector.

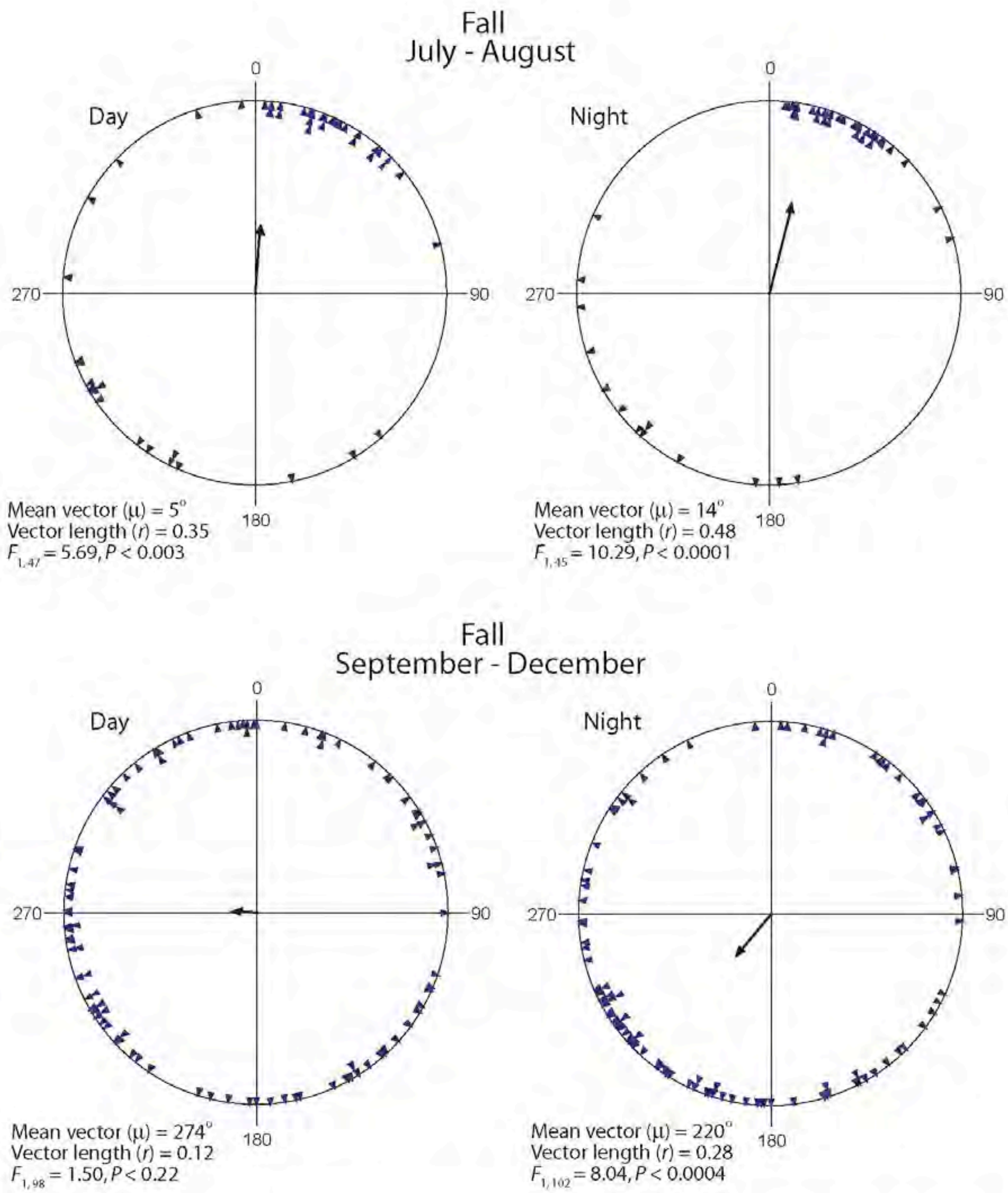


Fig. 41. Second-order mean vectors (i.e., mean of meanns) in fall, July - August and September - December 2009 for day and night data collection periods. Blue triangles around the perimeter of each circle represent first-order mean vectors. Arrows point in the direction of the second-order mean vector and their length represents the vector length Vector lenght is an index or circular variance with values ranging between 0 and 1. The higher the value, the lower the variance in the mean vector.