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Rhode Island Ocean Special Area Management Plan:

Studies Investigating the Spatial Distribution and Abundance of Marine Birds in Nearshore and Offshore Waters of Rhode Island

By

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Abstract

This final report for the Ocean Special Area Management Plan Implementation (OSI) summarizes aerial surveys conducted from 20 October 2010 to 22 July 2012. These surveys were a continuation of avian research conducted as part of the Rhode Island Ocean Special Area Management Plan (OSAMP) to quantify the phenology, spatial distribution, abundance, and flight ecology of birds using the nearshore and offshore waters of Rhode Island (see Paton et al. 2010, Winiarski et al. 2011).

We conducted aerial line-transect surveys (24 total transects, 8 transects per survey, 3 km apart) from 20 October 2010 to 22 July 2012 at a fixed altitude of 76 m and at a constant speed of 160 km/ hr.

We conducted aerial surveys on 41 days and had a total of 8,577 observations or 80,679 detections of 20 species groups. The most common species group, in terms of total observations, were large gulls (Herring (*Larus argentatus*) and Great Black-backed Gull (*L. marinus*)), loons (Common (*Gavia immer*) and Red-throated Loon (*G. stellata*)), Northern Gannets (*Morus bassanus*) and alcids (Razorbill (*Alca torda*), Common Murre (*Uria aalge*), Dovekie (*Alle alle*), and Atlantic Puffin (*Fratercula arctica*)) while the most abundant species groups in terms of the total number of individuals detected were large gulls, scoters (Black (*Melanitta americana*), Surf (*M. perspicllata*), and White-winged Scoter (*M. fusca*)), Common Eider (*Somateria mollissima*), alcids, loons and Northern Gannets.

We documented considerable interseasonal and interannual variation in the abundance of species groups. For this report, we present information on the spatial distribution and abundance (flock size) for species groups throughout the OSAMP study area. This now represents the longest running, systematic aerial survey dataset of marine birds in eastern North America.

Regulators and developers can use this information to assist with siting decisions for renewable energy projects in the OSAMP study area. In addition, it provides useful, quantitative baseline information on the spatial distribution and abundance of birds in the OSAMP study area prior to construction of renewable energy projects. Thus, this information could be used to assess future changes in marine bird distribution and abundance and highlights those species or species group abundant enough to document future changes in abundance and distribution.

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1 Introduction

1.1 Ocean SAMP background and the scope of this report.

Based on previous research primarily in Europe, birds are likely to be one of the taxonomic groups most affected by offshore energy development (e.g., offshore wind farm development) through: (1) increased mortality from collisions (but see Petersen et al. 2005 and Plonczkier and Simms 2012), (2) displacement from preferred habitats (Petersen et al. 2011), 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 and our previous reports (Paton et al. 2010, Winiarski et al. 2011) provides essential biological data that will inform development of Ocean Special Area Management Plan (SAMP) policy. The U.S. Fish and Wildlife Service has suggested that three years of baseline information of avian use of potential development sites is necessary to make permitting decisions (T. Chapman, USFWS, Region 1, New Hampshire). In addition, baseline studies are needed by the U.S. Army Corps of Engineers, and state agencies including the R.I. Department of Environmental Management because these agencies are responsible for assessing potential impacts from renewable energy development on all wildlife, including birds.

This report follows two interim reports by Paton et al. (2010) and Winiarski et al. (2011). Our goal for this report was to present supplementary aerial survey results from 20 October 2010 to 22 July 2012 and identify patterns in the spatial distribution and abundance of birds in the Ocean SAMP study area.

1.2 Description of the study area

The Ocean SAMP study area encompasses approximately 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 describes 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 area.

Bathymetry is one of the primary physical features that determines the distribution of many marine birds in the Ocean SAMP area. 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, and Long Island Sound, and is connected to 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 originating on 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) and that now forms an underwater connection between Block Island Sound and the Inner Continental Shelf .

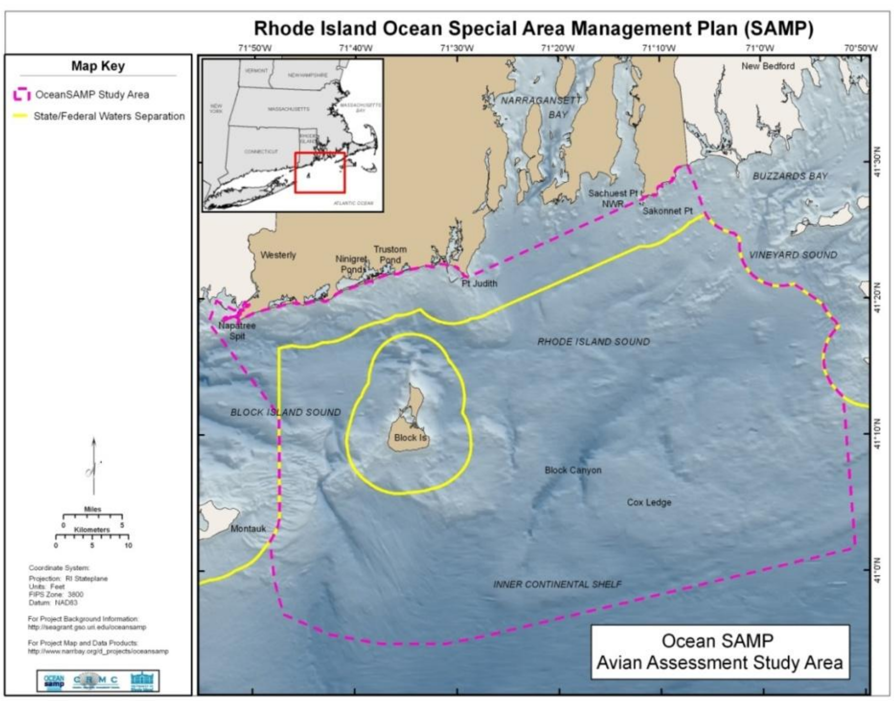

Figure 1. Study boundaries for the Rhode Island Special Area Management Plan. The yellow line depicts the 3-mile state waters boundary, while the pink line depicts the study area boundary, which extends as far as 16 miles offshore at its furthest point, hence in federal waters.

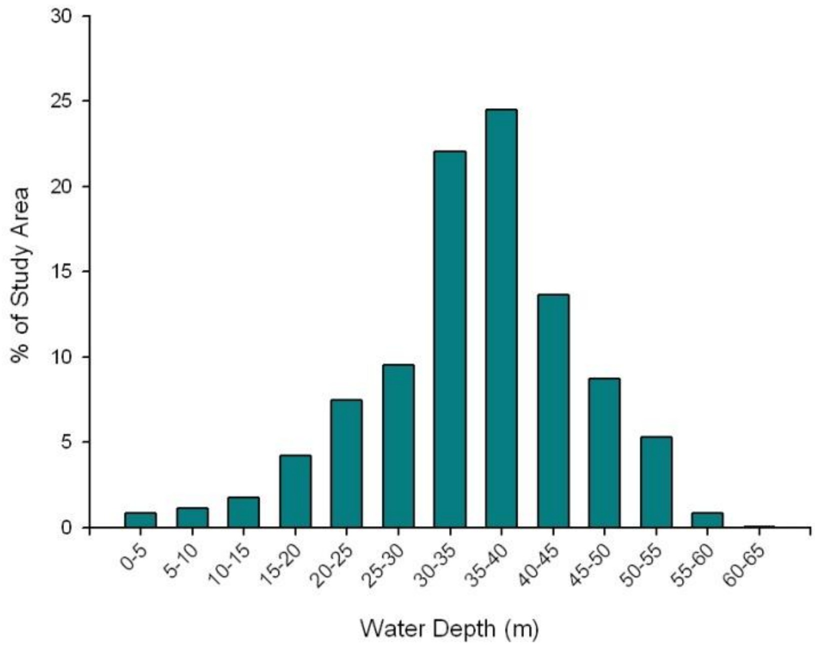

Figure 2. Bathymetry of the Ocean SAMP study area based on 6500 uniformly distributed points placed within study area boundaries. Approximately 8% of the area is <20 m deep and 86% is 20-50 m deep.

Water temperature in winter ranges from 3-6°C, with water on the bottom several degrees warmer than near the surface (Codiga and Ullman 2010). In summer, water temperature ranges from 10-21°C, with surface water approximately 10°C warmer than bottom water. Thus, the water column tends to be stratified in the summer, whereas 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 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, though these species also feed on demersal fish. Unfortunately, there are currently 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 Ocean SAMP boundaries. We know even less about interannual variation in abundance and distribution of benthic prey, which could be one of the main factors determining where seaducks forage annually (Loring 2012).

The topography and composition of the seafloor within the Ocean SAMP study area is primarily the result of glacial processes. LaFrance et al. (2010) subdivided the seafloor 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]. 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 deposition 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 Rhode Island Sound, which likely 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 1m.

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. 1).

2 Methods

2.1 Offshore Avian Assessment: Aerial Surveys

2.1.1 Survey Techniques

We conducted systematic aerial surveys approximately three times per month from 20 October 2010 to 22 July 2012 to quantify the abundance of all species of marine birds within the Ocean SAMP study area. Based on our observations of the movement phenology of waterbirds during land-based point counts in nearshore habitats from January to Feb 2009 (Paton et al. 2010), we conducted the aerial surveys during mid-day (usually 1000-1500 hrs) to ensure that birds had completed their post-dawn movements but had not yet begun their pre-sunset movements from roosting to feeding areas. We conducted surveys along 24 transect lines oriented perpendicular to the coast that were spaced 3 km apart, with an average transect length of 46.3 km ± 12.3 km (SD) (min = 7.8 km, max = 58.0 km) (Fig. 3). We conducted all aerial surveys from a twin engine Cessna Skymaster aircraft that flew at an altitude of 76 m (250 ft) above mean sea level at a constant speed of 160 km per hr (100 miles per hr).

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). We used two observers and surveyed three distance bins out to 1000m (A = 44-163 m, B = 164-432 m and C = 433-1000 m) from both sides of the plane, with boundaries of the observation bins marked on the aircraft's wing struts with black electric tape (Camphuysen et al. 2004). Observers used their unaided eye to detect individual birds or flocks. To ensure that observers only recorded birds within these fixed distances, we used a clinometer to mark set angles with black electrical tape on the aircraft's wing struts. Observers recorded all individuals and flocks to species when possible or to an avian guild (e.g., alcids, loons) when necessary. Individuals or flocks were recorded as either on the water or in flight.

We also recorded any biological (e.g., whales) or anthropogenic (e.g., fishing boats or floating debris) influences detected during the survey that were apparently attracting birds to the area. 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), whitecaps (none, minimal, moderate, and heavy), and survey conditions (poor, fair, good, excellent). Observers recorded individual sightings with a time stamp (to the nearest second) on a digital voice recorder. Each observer had a digital stopwatch that was synchronized with a global positioning system (GPS; Garmin model No. 496) which recorded the aircraft's position every 2 seconds. Surveys were not performed when wind speed exceeded 20 knots (23 mph) or 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 problematic on sunny days when surveying transect lines from north to south. If glare compromised the detection of birds on one side of the plane, that surveyor went "off" survey.

We present results of aerial surveys by season, where we defined **Winter** from 1 Dec to 29 Feb, **Spring** from 1 March to 21 May, **Summer** from 1 June to 31 August, and **Fall** from 1 September to 30 November.

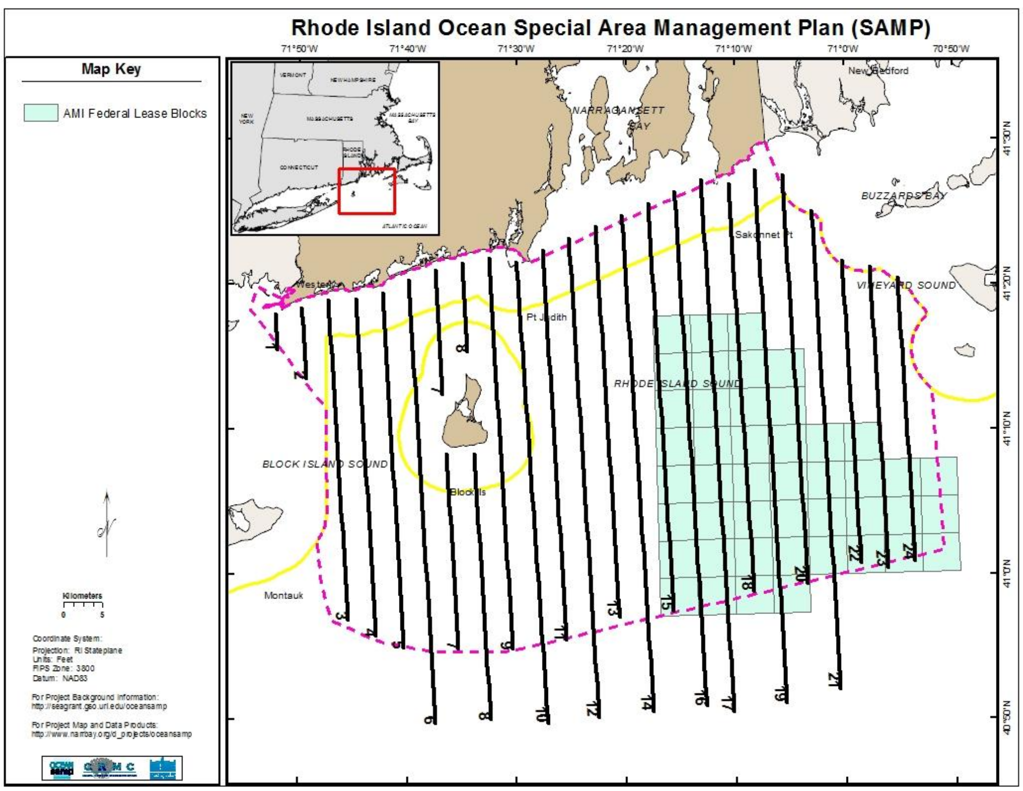

Figure 3. Location of 24 aerial transects sampled from October 2010 to July 2012. The light green area depicts federal lease blocks in the Area of Mutual Interest between Rhode Island and Massachusetts.

3 Results

3.1 Overall Summary

We conducted a total of 41 aerial surveys from 20 October 2010 to 22 July 2012, with all transects surveyed approximately 14 times during this period and a total of 328 transects surveyed during this time interval (Table 1).

Each detection represented a unique flock of birds observed during surveys, thus a detection could represent a single individual or a large flock of birds. We had a total of 8,577 observations of 80,679 individuals (Table 2), with substantial interseasonal variation in the number of detections and number of individual per detection (Tables 2 to 5). There were more individual per detection in the study area in winter than summer (Tables 2 to 5).

Among species groups, large gulls (Herring and Great Black-backed Gulls; 2,606 observations) were the most common detections, followed by loons (both Common and Red-throated Loon; 1,594 observations), Northern Gannets (1,442 observations), and alcids (Razorbill, Common and Thick-billed Murre, Dovekie, Atlantic Puffin; 1,451 observations) (Table 3).

In terms of the total number of individuals detected (80,679 total individuals**)**, large gulls (39,799 individuals), scoters (Black, Surf, and White-winged Scoter; 16,461 individuals), and Northern Gannets (7,931 individuals) were the most abundant species groups observed during aerial surveys (Table 3).

As would be expected, there was considerable interseasonal variation in the number of observations (Table 4) and number of individuals (Table 5) observed during aerial surveys from October 2010 to July 2012. Species groups whose abundance peaked in summer included petrels, shearwaters, and terns, while other species groups were most abundant during winter including loons, seaducks, and alcids. Other groups that are migrants through the study area had pulses come through in spring and fall (e.g., Northern Gannets).

Table 1. Summary of when aerial surveys were conducted (x means survey occurred) and which transects were sampled during aerial surveys of the Ocean SAMP study area from October 2010 to July 2012 (see Fig. 3 for locations of transects).

	Aerial Transect Line																							
Date of survey	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
10/20/2010			X			X			X			X			X			X			X			X
11/1/2010		X			X			X			X			X			X			X			X	
12/10/2010	X			X			X			X			X			X			X			X		
12/17/2010														X			X			X			X	
1/20/2011		X			X			X			X			X			X			X			X	
1/28/2011			X			X			X			X			X			X			X			X
2/7/2011	X			X			X			X			X			X			X			X		
2/17/2011		X			X			X			X			X			X			X			X	
2/23/2011			X			X			X			X			X			X			X			X
3/4/2011	X			X			X			X			X			X			X			X		
3/15/2011		X			X			X			X			X			X			X			X	
4/7/2011			X			X			X			X			X			X			X			X
4/19/2011	X			X			X			X			X			X			X			X		
5/2/2011		X			X			X			X			X			X			X			X	
5/13/2011			X			X			X			X			X			X			X			X
5/31/2011	X			X			X			X			X			X			X			X		

Aerial Transect Line																								
Date of survey	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
6/6/2011		X			X			X			X			X			X			X			X	
7/25/2011			X			X			X			X			X			X			X			X
7/30/2011	X			X			X			X			X			X			X			X		
8/5/2011			X			X			X			X			X			X			X			X
8/17/2011		X			X			X			X			X			X			X			X	
8/31/2011	X			X			X			X			X			X			X			X		
9/12/2011	X	X	X	X		X			X			X			X			X			X			X
9/21/2011					X			X			X			X			X			X			X	
9/26/2011	X			X			X			X			X			X			X			X		
10/7/2011			X			X			X			X			X			X			X			X
10/11/2011		X			X			X			X			X			X			X			X	
11/6/2011	X			X			X			X			X			X			X			X		
12/4/2011			X			X			X			X			X			X			X			X
12/9/2011	X			X			X			X			X			X			X			X		
12/13/2011		X			X			X			X			X			X			X			X	
1/9/2012			X			X			X			X			X			X			X			X
1/28/2012	X			X			X			X			X			X			X			X		
2/4/2012		X			X			X			X			X			X			X			X	
2/19/2012			X			X			X			X			X			X			X			X

	Aerial Transect Line																						
Date of survey	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
3/24/2012	X			X			X			X			X			X			X			X		
5/12/2012		X			X			X			X			X			X			X			X	
6/9/2012			X			X			X			X			X			X			X			X
6/30/2012	X			X			X			X			X			X			X			X		
7/7/2012		X			X			X			X			X			X			X			X	
7/14/2012			X			X			X			X			X			X			X			X
7/22/2012	X			X			X			X			X			X			X			X		

Table 2. Seasonal variation in the number of observations and number of individuals observed during aerial line-transect surveys in the Rhode Island Ocean SAMP study area.

	Number of surveys	Mean number of observations per survey	Total number of observations	Mean number of individuals per survey	Total number of Individuals
Fall 2010	2	133	265	583	1,166
Winter 2010-2011	6	249	1,496	2009	12,055
Spring 2011	7	260	1,820	1147	8,029
Summer 2011	6	93	560	562	3,373
Fall 2011	7	152	1,062	2143	15,001
Winter 2011-2012	7	356	2,491	2736	19,153
Spring 2011	2	163	325	9766	19,531
Summer 2012	5	112	558	474	2,371

Table 3. Total number of observations and number of individuals by species groups during aerial line-transect surveys from October 2010 to July 2012.

Species Group	Total number of observations	Total number of individuals
Alcids	1451	4797
Brant	1	7
Cormorant	19	55
Egrets	2	2
Common Eider	128	5858
Northern Fulmar	44	93
Northern Gannet	1442	7931
Gulls	2606	39799
Jaegers	2	2

Black-legged Kittiwake	232	874
Loons	1594	2490
Long-tailed Duck	12	37
Red-breasted Merganser	9	11
Passerines	7	10
Petrels	456	895
Phalaropes	3	28
Scoters	222	16461
Shearwaters	195	980
Shorebirds	3	13
Terns	149	336
Grand Total	**8577**	**80679**

Table 4. Seasonal variation in the number of observations for species groups based on aerial line-transect surveys conducted between October 2010 and July 2012.

Species Group	Fall 2010	Fall 2011	Spring 2011	Spring 2012	Summer 2011	Summer 2012	Winter 2010-2011	Winter 2011-2012	Grand Total
Alcids	3	10	297	29	0	0	469	643	1451
Brant	0	0	1	0	0	0	0	0	1
Cormorants	1	0	8	1	2	2	3	2	19
Egrets	0	0	0	0	2	0	0	0	2
Common Eider	0	6	32	9	0	0	45	36	128
Northern Fulmar	0	6	0	2	0	0	2	34	44
Northern Gannet	60	236	417	75	5	2	109	538	1442
Gulls	178	612	429	115	222	283	251	516	2606
Jaegers	0	1	1	0	0	0	0	0	2
Kittiwakes	0	10	27	0	0	1	77	117	232
Loons	11	40	493	58	4	6	467	515	1594
Long-tailed Duck	0	0	0	0	0	0	4	8	12
Merganser	1	0	2	3	0	0	1	2	9

Passerine	0	7	0	0	0	0	0	0	7
Petrels	1	52	35	5	209	154	0	0	456
Phalaropes	0	3	0	0	0	0	0	0	3
Scoters	9	10	50	11	0	0	68	74	222
Shearwaters	1	59	3	3	77	47	0	5	195
Shorebirds	0	0	0	1	1	0	0	1	3
Terns	0	10	25	13	38	63	0	0	149
Grand Total	**265**	**1062**	**1820**	**325**	**560**	**558**	**1496**	**2491**	**8577**

Table 5. Seasonal variation in the total number of individuals detected for species groups based on aerial line-transect surveys conducted between October 2010 and July 2012.

Species Group	Fall 2010	Fall 2011	Spring 2011	Spring 2012	Summer 2011	Summer 2012	Winter 2010-2011	Winter 2011-2012	Grand Total
Alcids	4	34	1417	47	0	0	1611	1684	4797
Brant	0	0	7	0	0	0	0	0	7
Cormorants	12	0	26	1	2	3	6	5	55
Egrets	0	0	0	0	2	0	0	0	2
Common Eider	0	410	615	1376	0	0	1373	2084	5858
Northern Fulmar	0	8	0	2	0	0	2	81	93
Northern Gannet	116	2395	1290	146	5	2	143	3834	7931
Gulls	862	11711	2219	13603	1974	1901	1949	5580	39799
Jaegers	0	1	1	0	0	0	0	0	2
Kittiwakes	0	11	45	0	0	1	114	703	874
Loons	15	49	752	88	9	10	717	850	2490
Long-tailed Duck	0	0	0	0	0	0	21	16	37
Mergansers	1	0	2	3	0	0	3	2	11
Passerines	0	10	0	0	0	0	0	0	10

Petrels	1	85	43	5	562	199	0	0	895
Phalaropes	0	28	0	0	0	0	0	0	28
Scoters	154	99	1557	4228	0	0	6116	4307	16461
Shearwaters	1	144	3	3	744	80	0	5	980
Shorebirds	0	0	0	6	5	0	0	2	13
Terns	0	16	52	23	70	175	0	0	336
Grand Total	**1166**	**15001**	**8029**	**19531**	**3373**	**2371**	**12055**	**19153**	**80679**

3.2 Species Accounts

Below we present results by species group from aerial surveys conducted from 20 October 2010 to 22 July 2012. See Paton et al. 2010 and Winiarski et al. 2011 for a more comphrehensive review of results from land-based point count surveys, ship-based line-transect surveys and aerial strip transect surveys conducted prior to August 2010.

3.2.1 Loons

We detected three species of loons (Gaviidae): Common Loon (*Gavia immer*), Red-throated Loon (*G. stellata*), and Pacific Loon (*G. pacifica*). We pooled observations of loons due to difficulties in separating Pacific, Red-throated and Common Loons during aerial surveys. Loons were one of the most commonly detected species groups during aerial surveys from 20 October 2010 to 22 July 2012 (Table 3). Loons were commonly detected in winter and spring and much less common in summer and fall (Tables 4 and 5). Based on the distribution of observations, loons were widely dispersed throughout the study area, although there was a tendency for loons to use shallow, nearshore habitats more than deep, offshore areas regardless of season (Fig. 4). Loons were most commonly observed alone or in small groups, but could be found in flocks of up to 30 individuals (Fig. 5). Loon observations were mainly of individuals or flocks sitting on the surface of the water versus flying (Fig. 6).

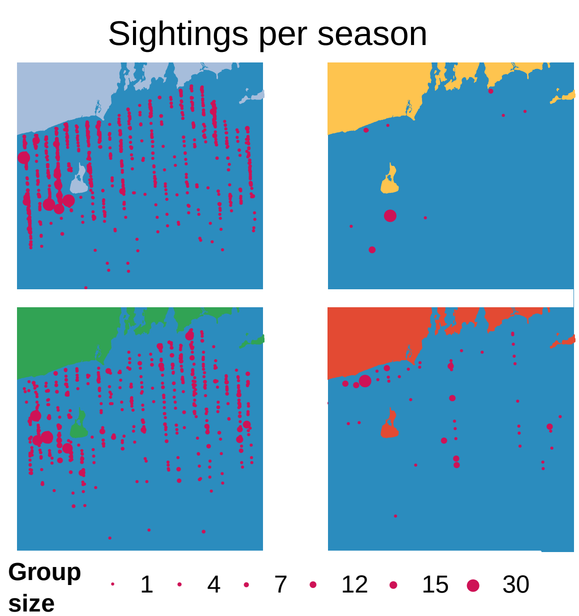

Figure 4. Observations of loons (red circles) by season (Winter = Gray, Spring = Green, Fall = Red, Summer = Yellow). Larger group size is indicated by a larger circle.

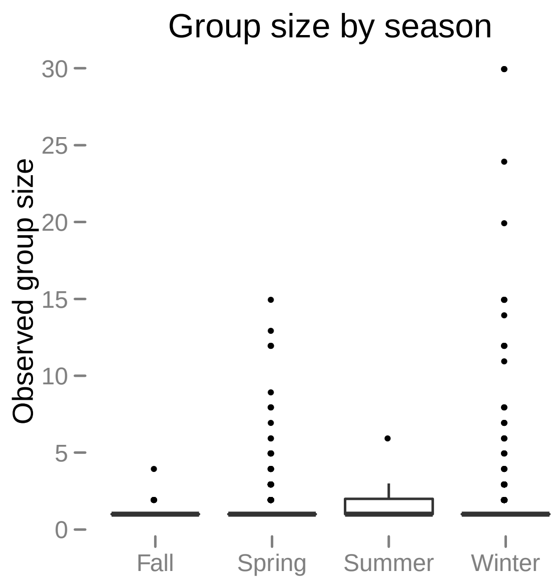

Figure 5. Interseasonal variation in loon group size for each detection during aerial surveys.

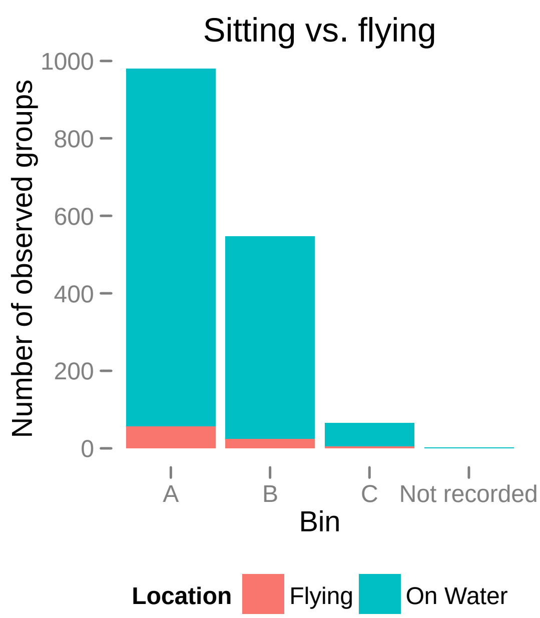

Figure 6. Number of loon observations by distance bin (A= 44-163m, B= 164-432m, C=433-1000m) during aerial surveys and behavior (sitting on water or flying).

3.2.2 Grebes

We detected two species of grebes (Podicipedidae) in the Ocean SAMP study area: Horned Grebe (Podiceps auritus) and Red-necked Grebe (P. grisegena)(Paton et al. 2010, Winiarski et al. 2010). Grebes were not detected on aerial surveys from 20 October 2010 to 22 July 2012, because they are most common in nearshore waters (< 1km from shore) where coverage by aerial surveys is generally poor.

3.2.3 Shearwaters

We detected four species of shearwaters (Procellariidae) in the Ocean SAMP study area: Cory's Shearwater (*Calonectris diomedea*), Great Shearwater (*Puffinus. gravis*), Manx Shearwater (*P puffinus*) and Sooty Shearwater (*P. griseus*) (Paton et al. 2010, Winiarski et al. 2010). Shearwaters were most abundant during aerial surveys conducted in the summer and early fall (Tables 4 and 5) and most common in the offshore portion of the study area (Fig. 7). Shearwaters were most commonly observed alone or in small groups, but could be found in flocks of up to a few hundred individuals (Fig. 8). Shearwater observations were mainly of individuals flying just above the surface of the water (Fig. 9).

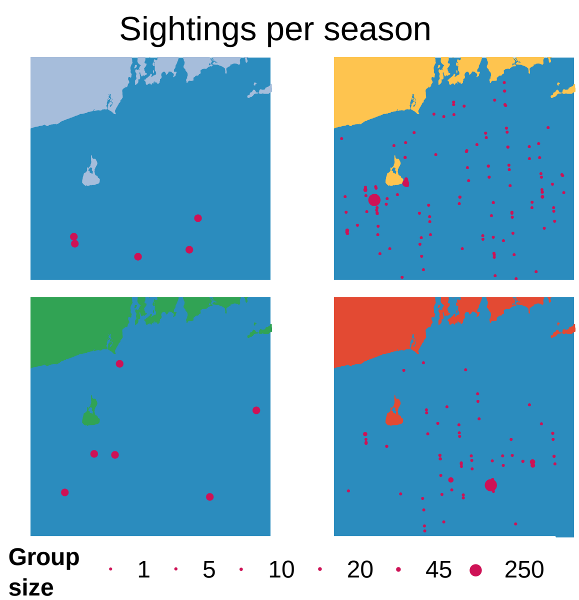

Figure 7. Observations of shearwaters (red circles) by season (Winter = Gray, Spring = Green, Fall = Red, Summer = Yellow). Larger group size is indicated by a larger circle.

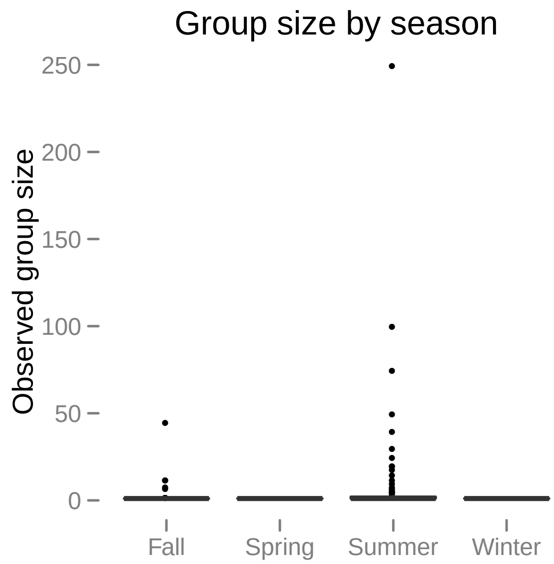

Figure 8. Interseasonal variation in shearwater group size for each detection during aerial surveys.

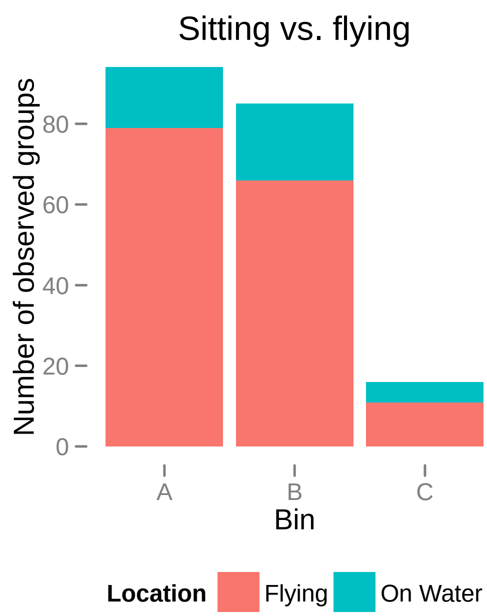

Figure 9. Number of shearwater observations by distance bin (A= 44-163m, B= 164-432m, C=433-1000m) during aerial surveys and behavior (sitting on water or flying).

3.2.4 Fulmars

We detected one species of fulmar (Procellariidae) in the Ocean SAMP study area: Northern Fulmar (*Flumarus glacialis*)(Paton et al. 2010, Winiarski et al. 2010). Fulmars were rarely detected during aerial surveys from 20 October 2010 to July 2012 but were present during the fall and winter (Tables 4 and 5) and most common in the offshore portion of our study area (Fig. 10). Fulmars were most commonly observed in small groups, but could be found in flocks of up to 25 individuals (Fig. 11). Fulmar observations were mainly of individuals or small flocks flying (Fig. 12).

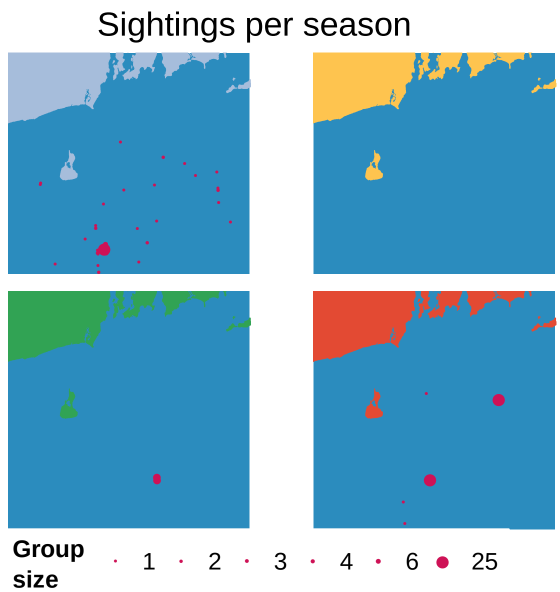

Figure 10. Observations of fulmars (red circles) by season (Winter = Gray, Spring = Green, Fall = Red, Summer = Yellow). Larger group size is indicated by a larger circle.

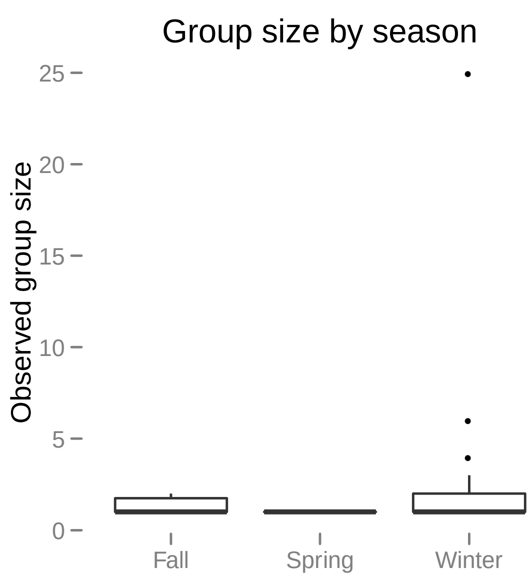

Figure 11. Interseasonal variation in fulmar group size for each detection during aerial surveys.

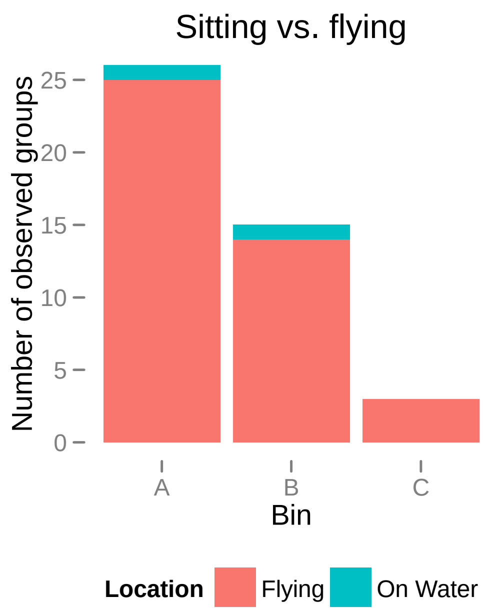

Figure 12. Number of fulmar observations by distance bin (A= 44-163m, B= 164-432m, C=433-1000m) during aerial surveys and behavior (sitting on water or flying).

3.2.4 Petrels

We have detected two species of storm-petrels (Hydrobatidae) in the Ocean SAMP area: Wilson's Storm-Petrel (*Oceanites oceanicus*) and Leach's Storm-Petrel (*Oceanodroma leucorhoa*) (Paton et al. 2010, Winiarski et al. 2010). Petrels were common during aerial surveys from 20 October 2010 to 22 July 2012 from spring to fall, but most abundant during summer (Tables 3 and 4). Petrels were most common during our aerial surveys in offshore portions of the study area but were found relatively close to shore, especially during the summer months (Fig. 13). It is not possible to distinguish between the two species during aerial surveys, but we assume a very high proportion of the storm-petrels detected during aerial surveys were Wilson's Storm-Petrel. Petrels were most commonly observed alone or in small groups, but could be found in flocks of up to 70 individuals (Fig. 14). All petrel observations were of individuals flying close to the surface of the water (Fig. 15).

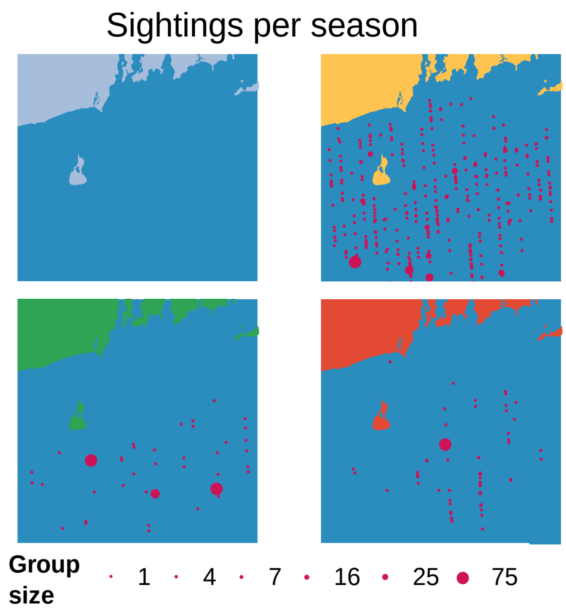

Figure 13. Observations of storm-petrels (red circles) by season (Winter = Gray, Spring = Green, Fall = Red, Summer = Yellow). Larger group size is indicated by a larger circle.

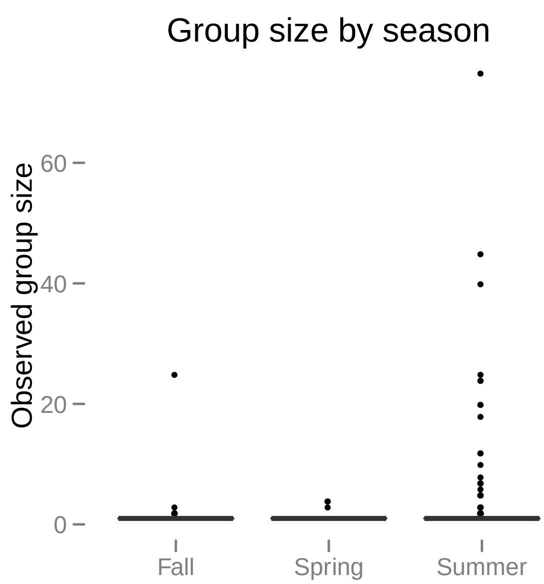

Figure 14. Interseasonal variation in storm-petrel group size for each detection during aerial surveys.

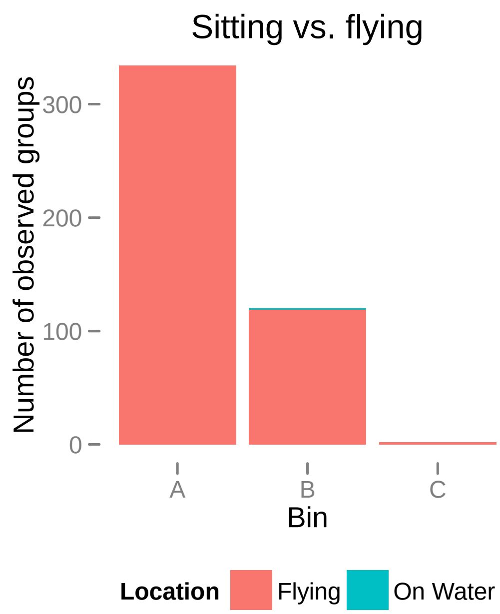

Figure 15. Number of petrel observations by distance bin (A= 44-163m, B= 164-432m, C=433-1000m) during aerial surveys and behavior (sitting on water or flying).

3.2.5 Gannets

Northern Gannet (*Morus bassanus*) is the only species of the family Sulidae found in the Ocean SAMP area (Paton et al. 2010 and Winiarski et al. 2011). Gannets were most abundant in the OSAMP study area during aerial surveys from 20 October 2010 to 22 July 2012 in the fall and spring (Tables 4 and 5). The distribution of this species is closely linked to commercial fishing activity, as most large foraging flocks were detected near commercial draggers (K. Winiarski, pers. obs). They were widely distributed through the study area (Fig. 16), but this distribution was primarily a function of where fishing vessels were located. Northern Gannets were most commonly observed alone or in small groups, but could be found in flocks of up to 700 individuals (Fig. 17). Northern Gannet observations were a mix of individuals or flocks sitting on the surface of the water and flying (Fig. 18).

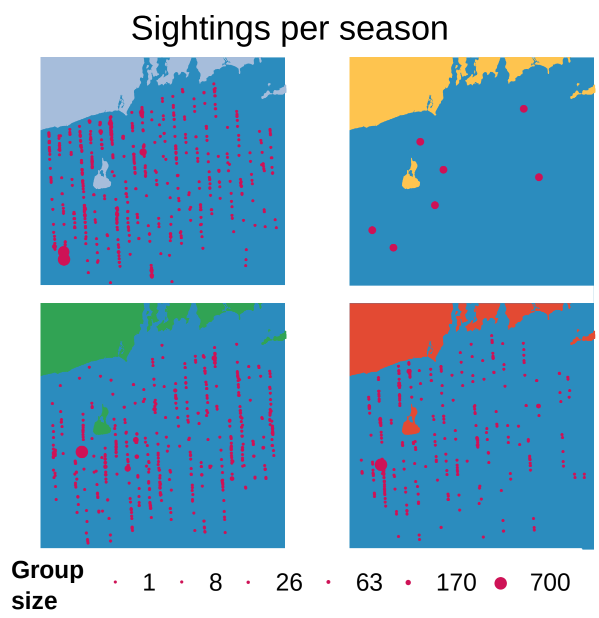

Figure 16. Observations of gannets (red circles) by season (Winter = Gray, Spring = Green, Fall = Red, Summer = Yellow). Larger group size is indicated by a larger circle.

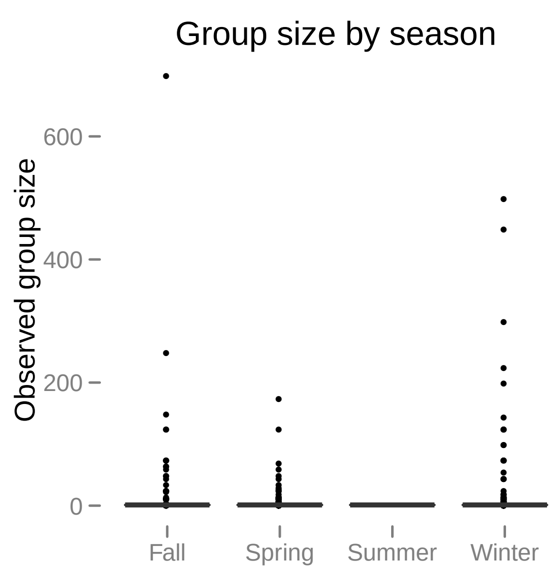

Figure 17. Interseasonal variation in gannet group size for each detection during aerial surveys.

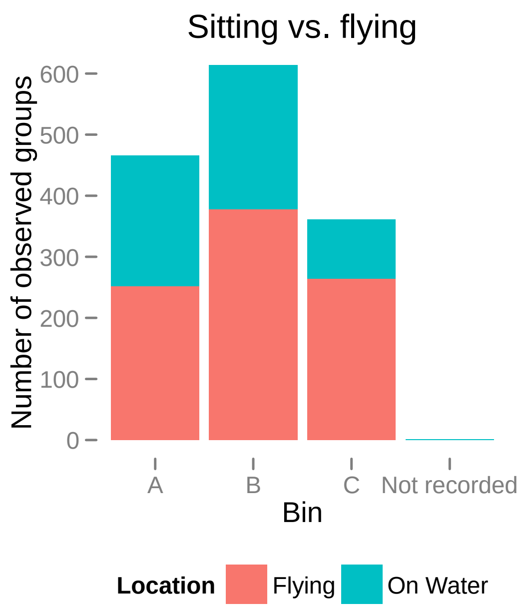

Figure 18. Number of gannet observations by distance bin (A= 44-163m, B= 164-432m, C=433-1000m) during aerial surveys and behavior (sitting on water or flying).

3.2.6 Cormorants

We detected two species of cormorants (Phalacrocoracidae) in the Ocean SAMP study area: Double-crested Cormorant (*Phalacrocorax auritus*) and Great Cormorant (*P. carbo*) (Paton et al. 2010, Winiarski et al. 2011). However, we rarely detected cormorants during aerial surveys from 20 October 2010 to 22 July 2012 (Table 3 to 5) because they primarily use nearshore habitats (<1km from shore) where coverage by aerial surveys is relatively poor (Fig. 19). Cormorants were most commonly observed alone or in small groups, but were found in flocks of up to 20 individuals (Fig. 20). Cormorant observations were a mixture of individuals or flocks sitting on the surface of the water and flying (Fig. 21).

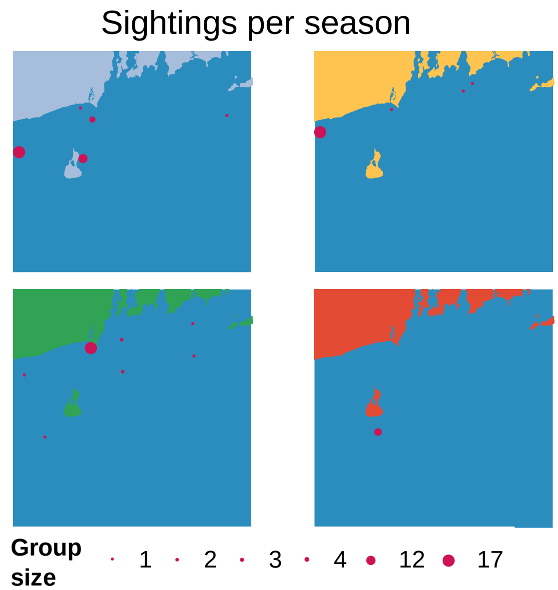

Figure 19. Observations of cormorants (red circles) by season (Winter = Gray, Spring = Green, Fall = Red, Summer = Yellow). Larger group size is indicated by a larger circle.

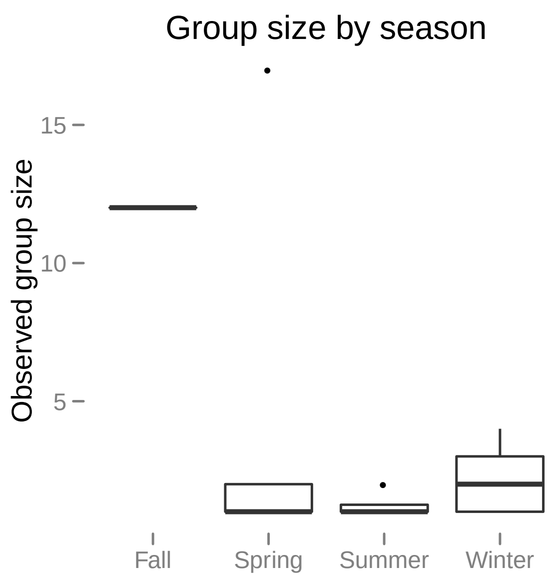

Figure 20. Interseasonal variation in cormorant group size for each detection during aerial surveys.

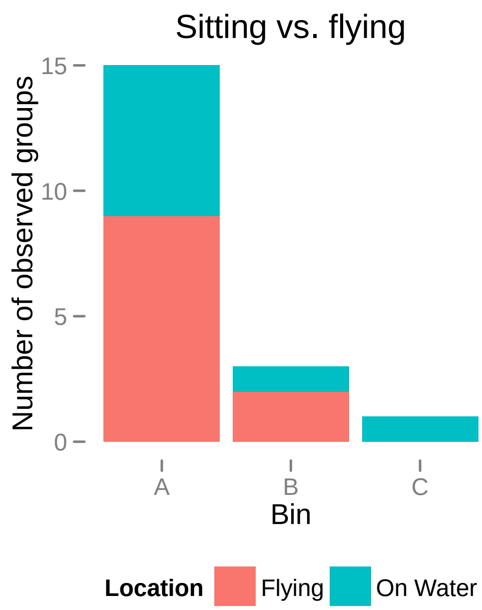

Figure 21. Number of cormorant observations by distance bin (A= 44-163m, B= 164-432m, C=433-1000m) during aerial surveys and behavior (sitting on water or flying).

3.2.7 Wading Birds

We detected seven species of wading birds (Herons and egrets; Ardeidae, Ibises; Threskiornithidae) in the Ocean SAMP area: Great Blue Heron (*Ardea herodias*), Great Egret (*Ardea alba*), Snowy Egret (*Egretta thula*), Cattle Egret (*Bubulcus ibis*), Green Heron (*Butorides virescens*), Black-crowned Night-Heron (*Nycticorax nycticorax*), and Glossy Ibis (*Plegadis falcinellus*)(Paton et al. 2010 and Winiarski et al. 2011). However, these species nest in colonies on islands in Narragansett Bay and Block Island and primarily forage in saltmarsh habitats, thus were rarely detected during aerial surveys from 20 October 2010 to 22 July 2012, with the only observations during the summer (Tables 3 to 5). The two observations were of egrets that were observed flying between the mainland and Block Island (Fig. 22).

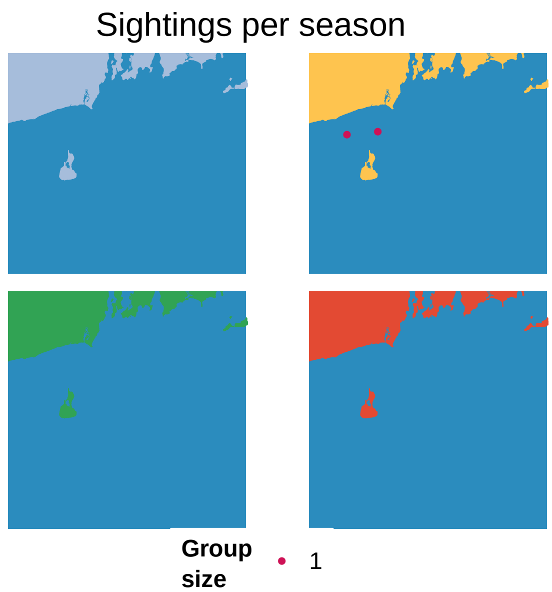

Figure 22. Observations of egrets (red circles) by season (Winter = Gray, Spring = Green, Fall = Red, Summer = Yellow). Larger group size is indicated by a larger circle.

3.2.8 Waterfowl

We detected 18 species of waterfowl (Anatidae) in the Ocean SAMP study area: two species of swans (Mute (*Cygnus olor*) and Tundra Swan (*C. columbianus*)), two species of geese (Canada Goose [*Branta canadensis*] and Brant [*B. bernicla*]), seven species of dabbling ducks (Wood Duck (*Aix sponsa*), Mallard (*Anas platyrhynchos*), American Black Duck (*A. rubripes*), Gadwall (*A. strepera*), Northern Pintail (*A. acuta*), American Wigeon (*A. americana*) and Green-winged Teal (*A. crecca*)), 11 species of diving duck (Greater Scaup (*Aythya marila*), Lesser Scaup (*A. affinis*), Ring-necked Duck (*A. collaris*), Redhead (*A. americanus*), Common Goldeneye (*Bucephala clangula*), Barrow's Goldeneye (*B. islandica*), Bufflehead (*B. albeola*), Ruddy Duck (*Oxyura jamaicensis*), Hooded Merganser (*Lophodytes cucullatus*), Red-breasted Merganser (*Mergus serrator*), and Common Merganser (*Mergus merganser*)), and six species of seaducks (Common Eider (*Somateria mollissima*), King Eider (*S. spectabilis*), Black Scoter (*Melanitta americanus*), Surf Scoter (*M. perspicillata*), White-winged Scoter (*M. fusca*), and Long-tailed Duck (*Clangula hyemalis*)) (Paton et al. 2010, Winiarski et al. 2011). The only species groups we detected during aerial surveys from 20 October 2010 to 22 July 2012 were mergansers, eiders, scoters, and Long-tailed Ducks (Tables 3 to 5), as all other waterfowl are restricted to habitats too close to shore to be detected during our aerial surveys. Mergansers, eider and scoter were detected from fall to spring, while Long-tailed Ducks were detected only during winter (Tables 4 and 5). All waterfowl were found in relatively nearshore waters, except scoter, which were relatively abundant in more offshore waters than we previously expected (Figs. 23, 26, 29, 31 and 34). Scoter and eider were most commonly observed in large flocks, but could be found in smaller groups (Figs 23 and 26)). Mergansers, Long-tailed Ducks and brant were found in smaller groups (Figs. 29, 31 and 34). Waterfowl observations were mainly of individuals or flocks sitting on the surface of the water versus flying (Figs. 25, 28, 30 and 33).

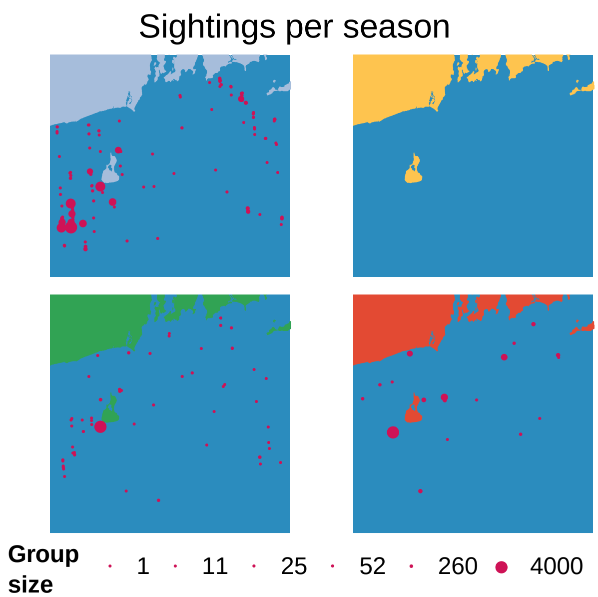

Figure 23. Observations of scoters (red circles) by season (Winter = Gray, Spring = Green, Fall = Red, Summer = Yellow). Larger group size is indicated by a larger circle.

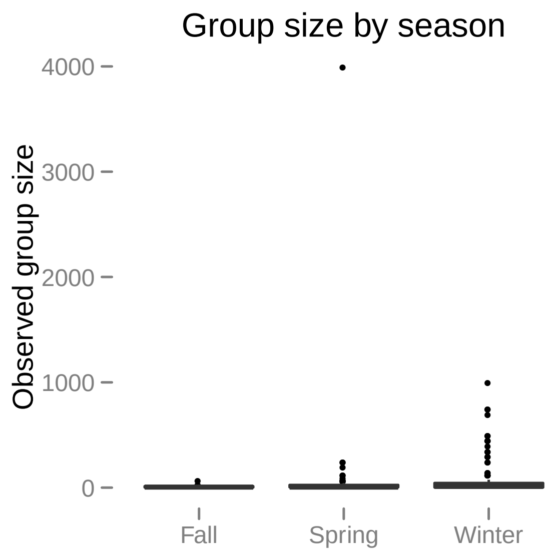

Figure 24. Interseasonal variation in scoter group size for each detection during aerial surveys.

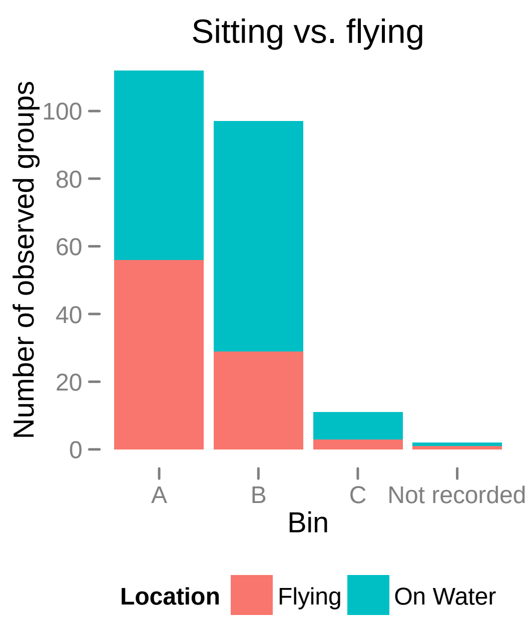

Figure 25. Number of scoter observations by distance bin (A= 44-163m, B= 164-432m, C=433-1000m) during aerial surveys and behavior (sitting on water or flying).

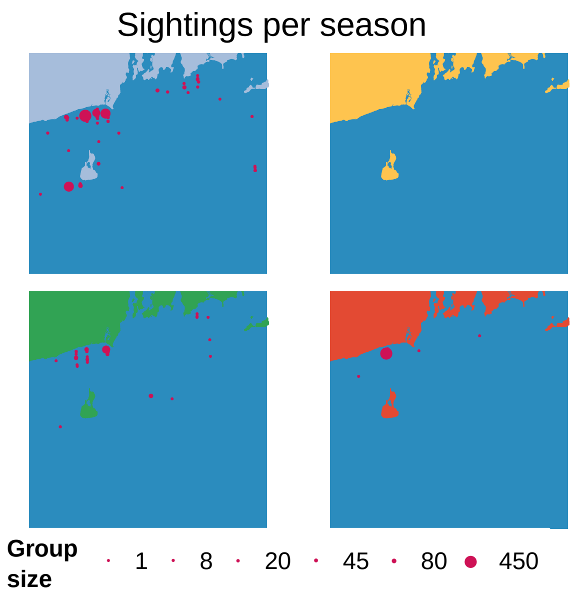

Figure 26. Observations of Common Eider (red circles) by season (Winter = Gray, Spring = Green, Fall = Red, Summer = Yellow). Larger group size is indicated by a larger circle.

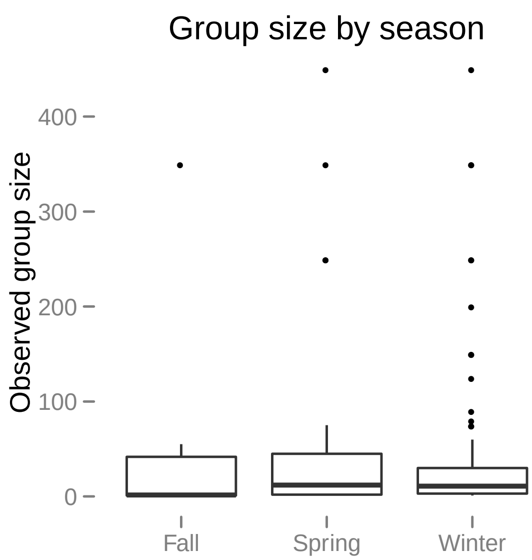

Figure 27. Interseasonal variation in Common Eider group size for each detection during aerial surveys.

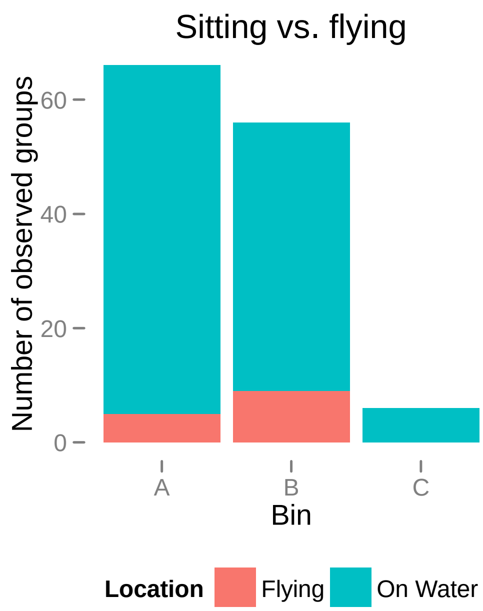

Figure 28. Number of Common Eider observations by distance bin (A= 44-163m, B= 164-432m, C=433-1000m) during aerial surveys and behavior (sitting on water or flying).

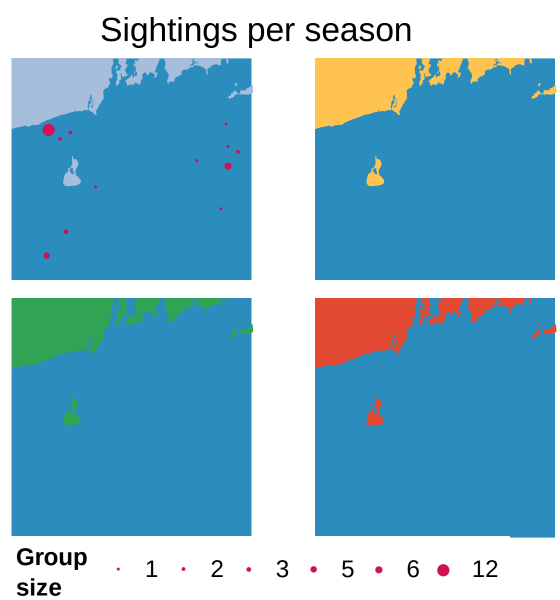

Figure 29. Observations of Long-tailed Ducks (red circles) by season (Winter = Gray, Spring = Green, Fall = Red, Summer = Yellow). Larger group size is indicated by a larger circle.

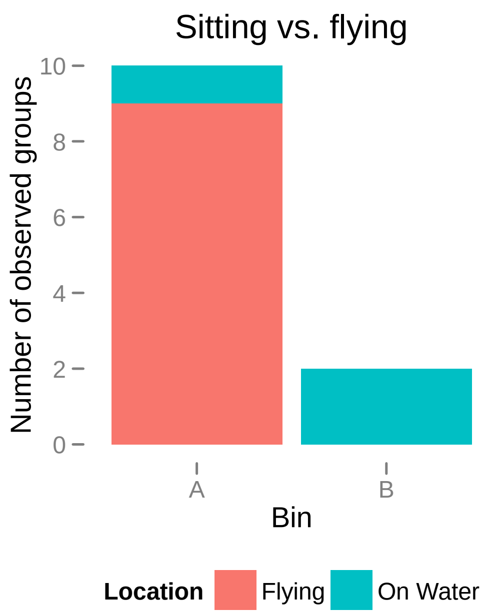

Figure 30. Number of Long-tailed Duck observations by distance bin (A= 44-163m, B= 164-432m, C=433-1000m) during aerial surveys and behavior (sitting on water or flying).

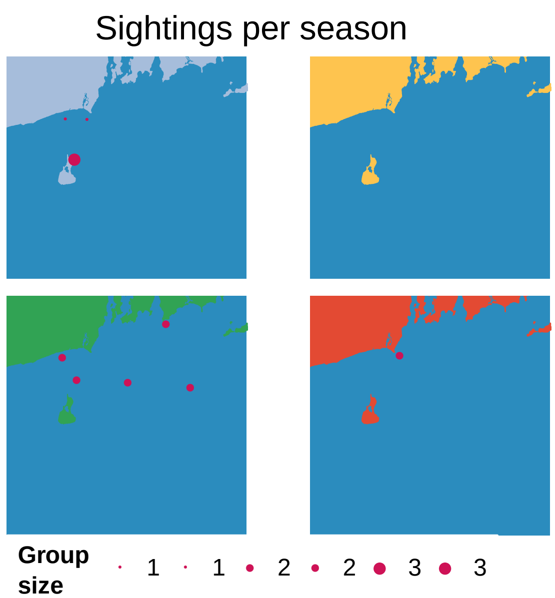

Figure 31. Observations of mergansers (red circles) by season (Winter = Gray, Spring = Green, Fall = Red, Summer = Yellow). Larger group size is indicated by a larger circle.

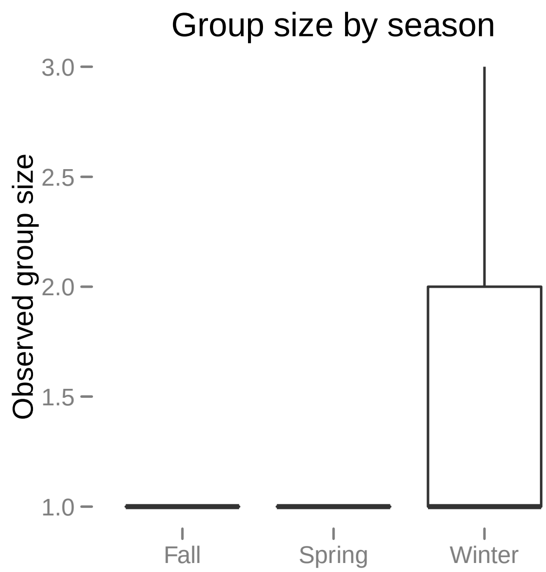

Figure 32. Interseasonal variation in merganser group size for each detection during aerial surveys.

Figure 33. Number of merganser observations by distance bin (A= 44-163m, B= 164-432m, C=433-1000m) during aerial surveys and behavior (sitting on water or flying).

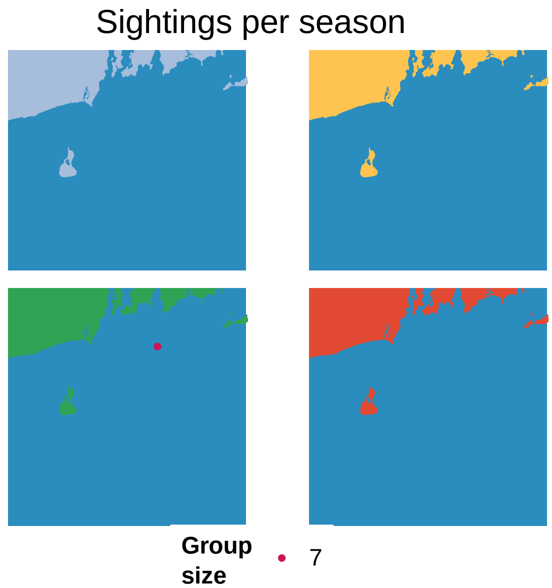

Figure 34. Observations of Atlantic Brant (red circles) by season (Winter = Gray, Spring = Green, Fall = Red, Summer = Yellow). Larger group size is indicated by a larger circle.

3.2.9 Shorebirds/Phalaropes

We detected 19 species of shorebirds and phalaropes (Scolopacidae) in the Ocean SAMP area (Paton et al. 2010, Winiarski et al. 2011). However, we had relatively few observations of shorebirds or phalaropes during our aerial surveys from 20 October 2010 to 22 July 2012 (Tables 3 to 5). The few observations of shorebirds we had were generally close to shore (Fig. 35). We had two observations of phalaropes during fall 2011 in offshore waters of the study area (Fig. 36). Phalaropes were most commonly observed alone or in small groups, but could be found in flocks of up to 30 individuals (Fig. 37). Phalarope observations were mainly of individuals or flocks sitting on the surface of the water versus flying (Fig. 38).

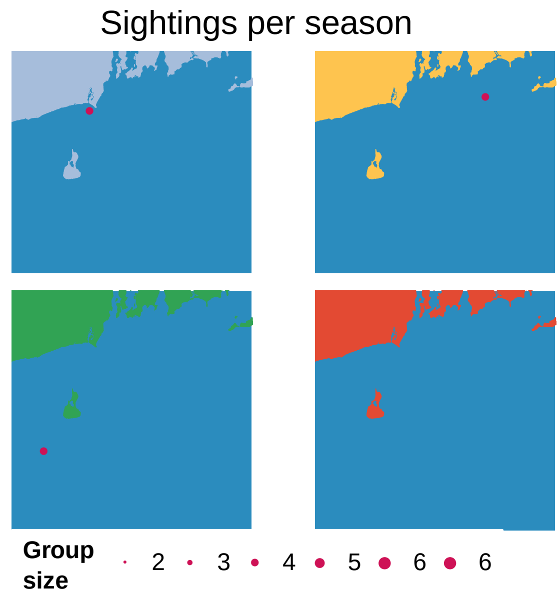

Figure 35. Observations of shorebirds (red circles) by season (Winter = Gray, Spring = Green, Fall = Red, Summer = Yellow). Larger group size is indicated by a larger circle.

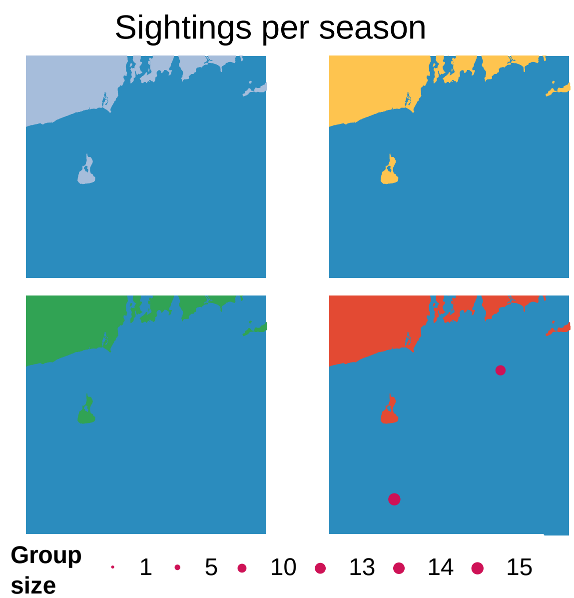

Figure 36. Observations of phalaropes (red circles) by season (Winter = Gray, Spring = Green, Fall = Red, Summer = Yellow). Larger group size is indicated by a larger circle.

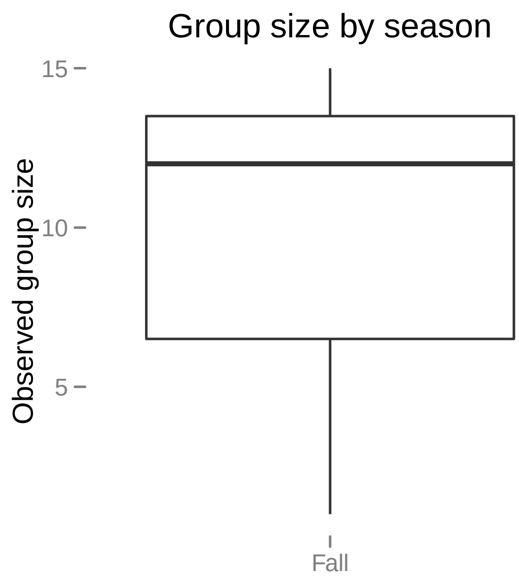

Figure 37. Interseasonal variation in phalarope group size for each detection during aerial surveys.

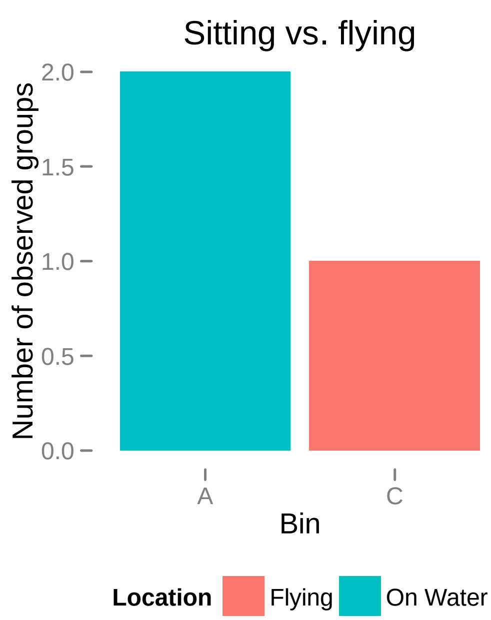

Figure 38. Number of phalarope observations by distance bin (A= 44-163m, B= 164-432m, C=433-1000m) during aerial surveys and behavior (sitting on water or flying).

3.2.10 Jaegers

We detected three species of jaeger (Stercorariidae) in the Ocean SAMP study area: Parasitic Jaeger (*Stercorarius parasiticus*), Long-tailed Jaeger (*S. longicaudus*) and Pomarine Jaeger (*S. pomarinus*)(Paton et al. 2010, Winiarski et al. 2011). Jaegars were rarely detected during aerial surveys conducted from 20 October 2010 to 22 July 2012 (Tables 3 to 5), with the few observations occurring in offshore portions of the study area (Fig. 39).

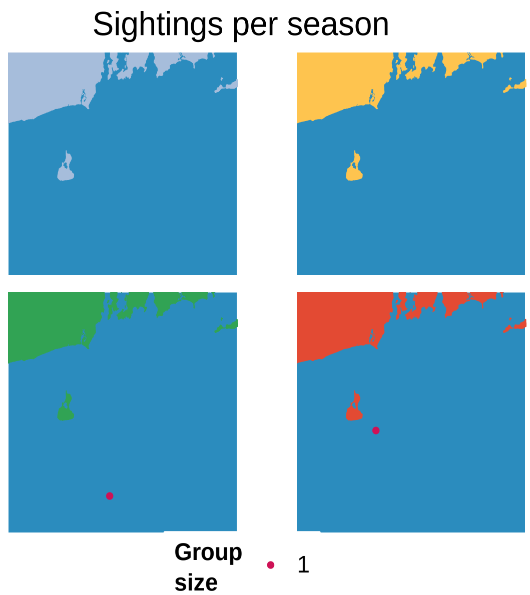

Figure 39. Number of phalarope observations by distance bin (A= 44-163m, B= 164-432m, C=433-1000m) and observed location (sitting on water or flying).

3.2.11 Gulls

We detected 10 species of gulls (Laridae) in the Ocean SAMP study area: Bonaparte's (*Larus philaelphia*), Black-headed (*L. ridibundus*), Glaucous (*L. hyperboreus*), Laughing (*L. atricilla*), Ring-billed (*L. delawarensis*), Herring (*L. argentatus*), Iceland (*L. glaucoides*), Lesser Black-backed (*L. fuscus*), and Great Black-backed Gull (*L. marinus*)(Paton et al. 2010, Winiarski et al. 2011). Gulls were found year round in our study area and were the most abundant birds detected during aerial surveys from 20 October 2010 to 22 July 2012 (Tables 3 to 5). They were widely distributed throughout the OSAMP study area (Fig. 40). Gulls were most commonly in large flocks, and could be found in flocks of up to 10,000 individuals (Fig. 41). Gull observations were a mix of individuals or flocks sitting on the surface of the water and flying (Fig. 42).

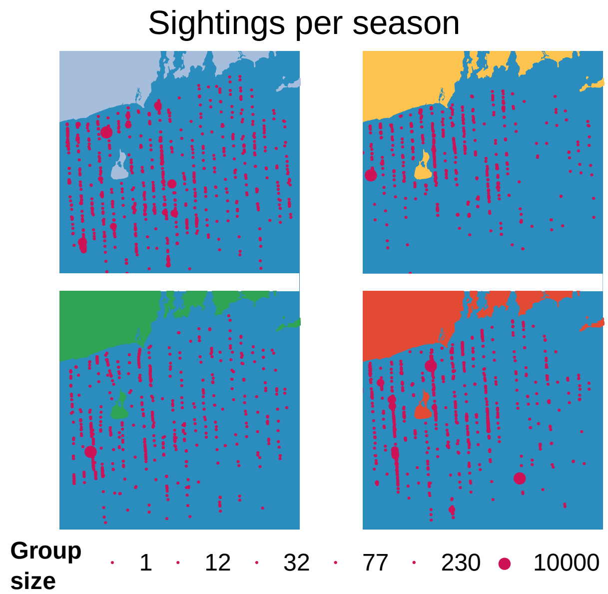

Figure 40. Observations of gulls (red circles) by season (Winter = Gray, Spring = Green, Fall = Red, Summer = Yellow). Larger group size is indicated by a larger circle.

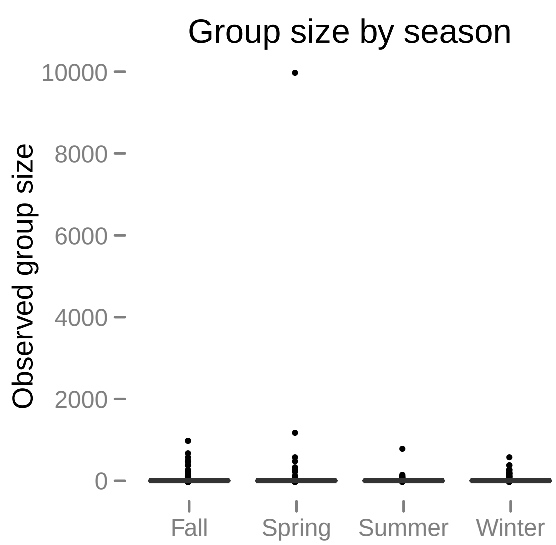

Figure 41. Interseasonal variation in gull group size for each detection during aerial surveys.

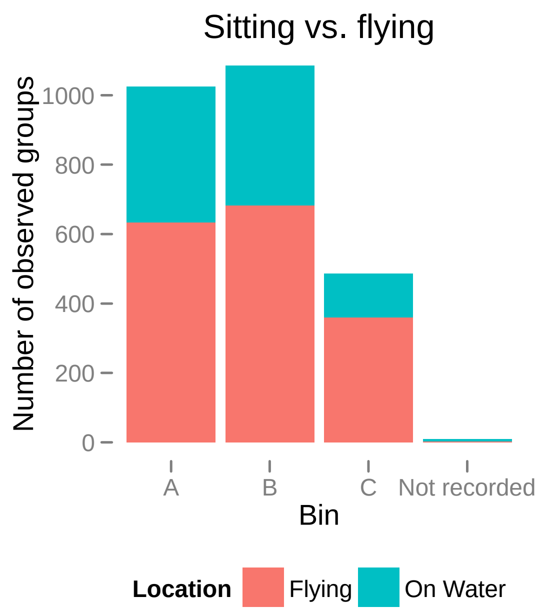

Figure 42. Number of gull observations by distance bin (A= 44-163m, B= 164-432m, C=433-1000m) during aerial surveys and behavior (sitting on water or flying).

3.2.12 Kittiwakes

We detected one species of kittiwake (Laridae) in the Ocean SAMP study area: the Black-legged Kittiwake (*Rissa tridactyla*)(Paton et al. 2010 and Winiarski et al. 2011). Kittiwakes were detected during our aerial transects conducted 20 October 2010 to 22 July 2012 from fall to spring, but were most abundant during the winter (Tables 3 to 5) and were distributed throughout the offshore portion of the OSAMP study area (Figs. 43). Kittiwakes were most commonly observed alone or in small groups, but could be found in flocks of up to 500 individuals (Fig. 44). Kittiwake observations were mainly of individuals or flocks flying (Fig. 45).

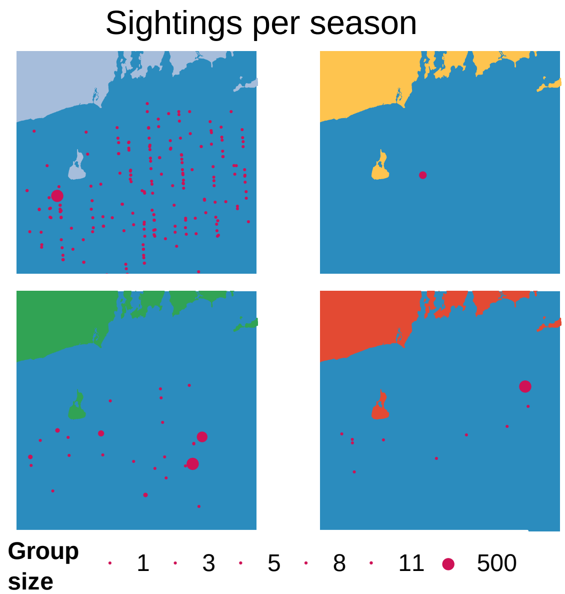

Figure 43. Observations of kittiwakes (red circles) by season (Winter = Gray, Spring = Green, Fall = Red, Summer = Yellow). Larger group size is indicated by a larger circle.

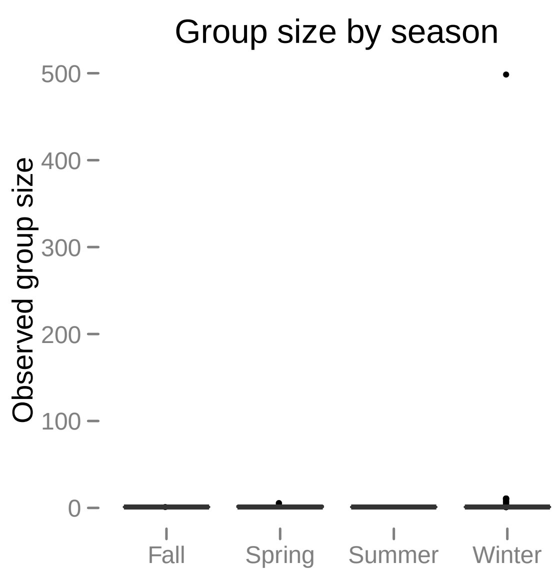

Figure 44. Interseasonal variation in kittiwake group size for each detection during aerial surveys.

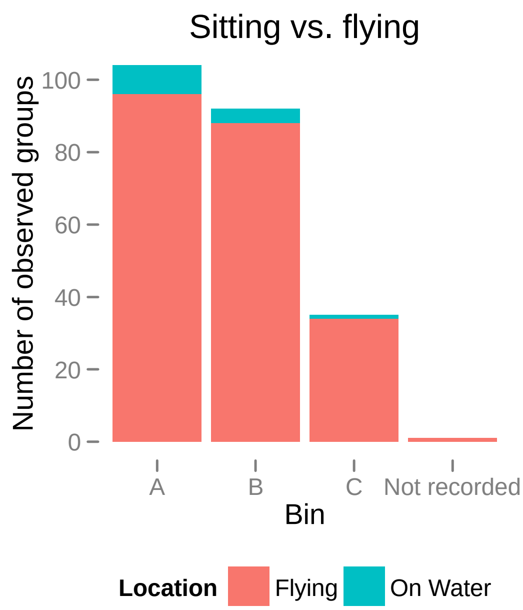

Figure 45. Number of kittiwake observations by distance bin (A= 44-163m, B= 164-432m, C=433-1000m) during aerial surveys and behavior (sitting on water or flying).

3.2.13 Terns and skimmers

We detected seven species of terns (Sternidae) and one species of skimmer (Rynchopidae) in the Ocean SAMP study area: Caspian (*Sterna caspia*), Royal (*S. maxima*), Common (*S. hirundo*), Forster's (*S. forsteri*), Roseate (*S. dougallii*), Least (*S. caspia*), Black Tern (*Chlidonias niger*) and Black Skimmer (Paton et al. 2010, Winiarski et al. 2011). During aerial surveys from 20 October 2010 to 22 July 2012, terns were detected from spring to fall, but they were most abundant during summer and distributed across the study area (Fig. 46). Terns were most commonly observed in small groups, but could be found in flocks of up to 80 individuals (Fig. 47). Tern observations were mainly of individuals flying, with only detection of birds sitting on the water (Fig. 48).

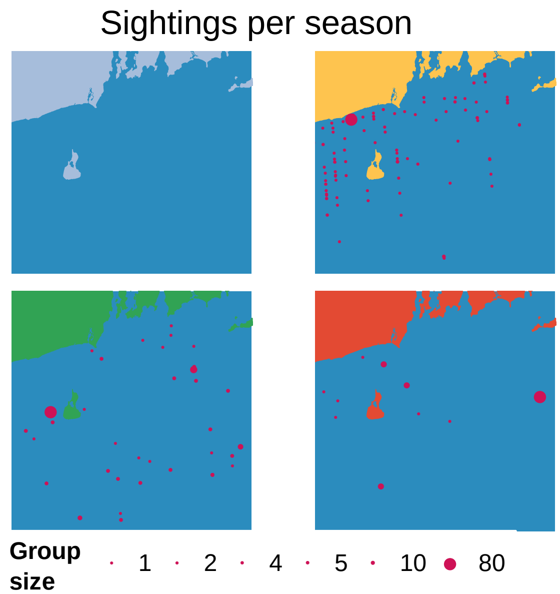

Figure 46. Observations of terns (red circles) by season (Winter = Gray, Spring = Green, Fall = Red, Summer = Yellow). Larger group size is indicated by a larger circle.

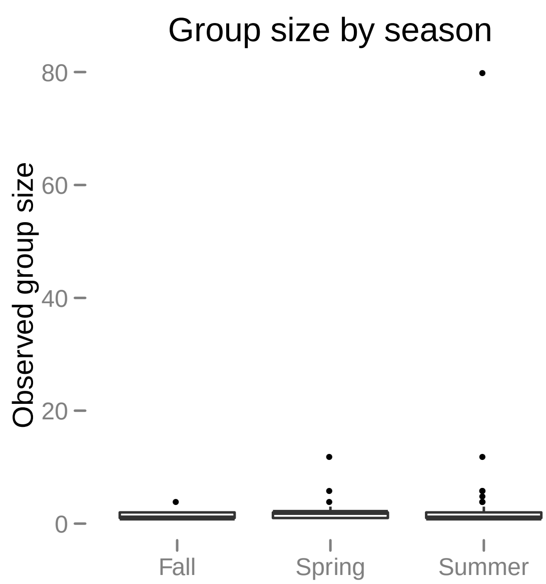

Figure 47. Interseasonal variation in tern group size for each detection during aerial surveys.

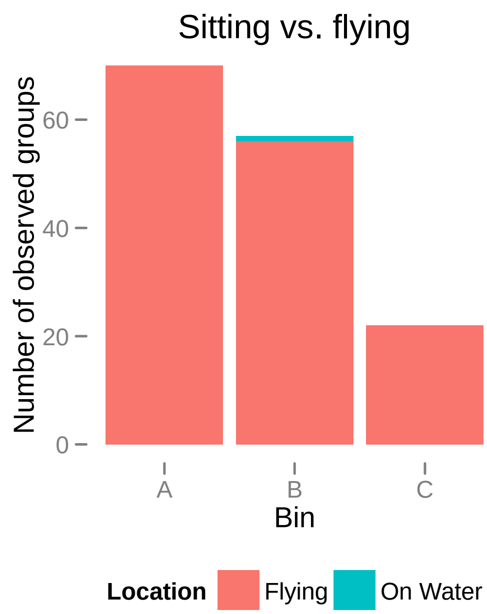

Figure 48. Number of tern observations by distance bin (A= 44-163m, B= 164-432m, C=433-1000m) during aerial surveys and behavior (sitting on water or flying).

3.2.14 Alcids

We detected six species of alcids (Alcidae) in the Ocean SAMP study area: Razorbill (*Alca torda*), Common Murre (*Uria aalge*), Thick-billed Murre (*U. lomvia*), Dovekie (*Alle alle*), Black Guillemot (*Cepphus grille*) and Atlantic Puffin (*Fratercula arctica*)(Paton et al. 2010 and Winiarski et al. 2011). Alcids were among the most abundant species groups detected on aerial surveys from 20 October 2010 to 22 July 2012 and were common from fall to spring, but they were most abundant in winter and spring in the OSAMP study area (Tables 4 and 5). They were widely distributed throughout the study area (Fig. 49). Alcids were most commonly observed alone or in small groups, but could be found in flocks of up to 150 individuals (Fig. 50). Alcid observations were mainly of individuals or flocks sitting on the surface of the water (Fig. 51).

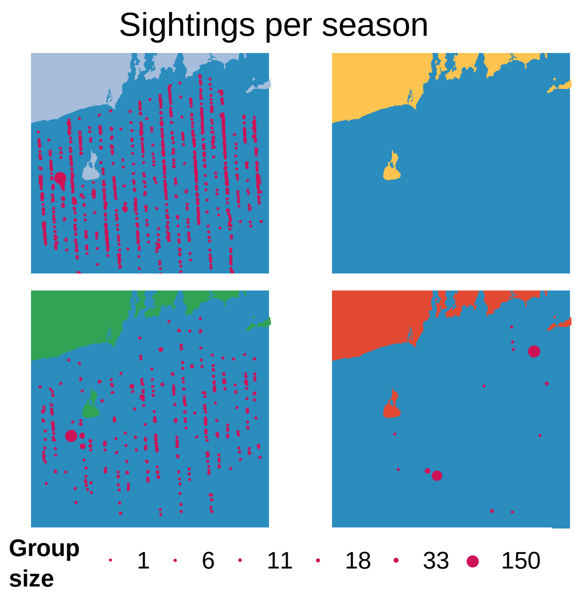

Figure 49. Observations of alcids (red circles) by season (Winter = Gray, Spring = Green, Fall = Red, Summer = Yellow). Larger group size is indicated by a larger circle.

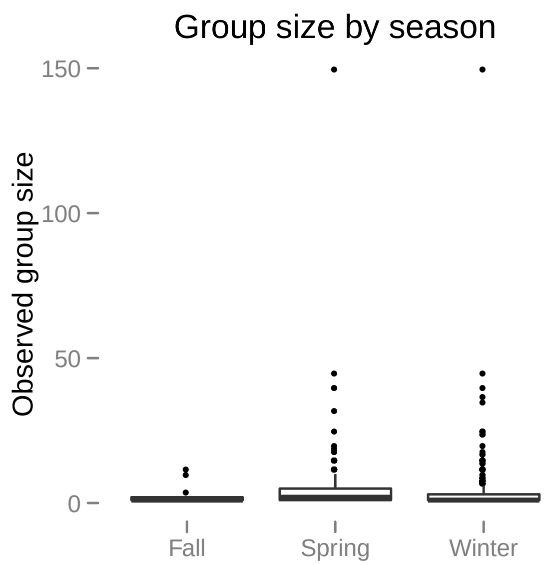

Figure 50. Interseasonal variation in alcid group size for each detection during aerial surveys.

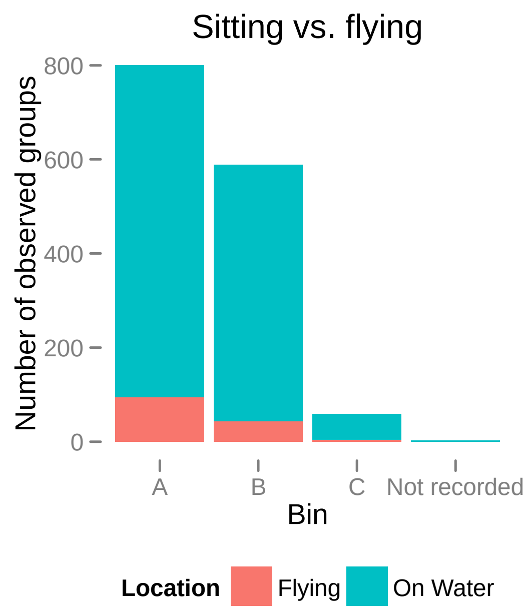

Figure 51. Number of alcid observations by distance bin (A= 44-163m, B= 164-432m, C=433-1000m) during aerial surveys and behavior (sitting on water or flying).

3.2.15 Passerines

Aerial surveys are not designed to detect passerines, although there were a few anecdotal observations (Tables 2 to 5). Passerines were detected only during the fall on aerial-based surveys conducted from 20 October 2010 to 22 July 2012 and were distributed in nearshore waters or waters within close proximity to Block Island (Fig. 52).

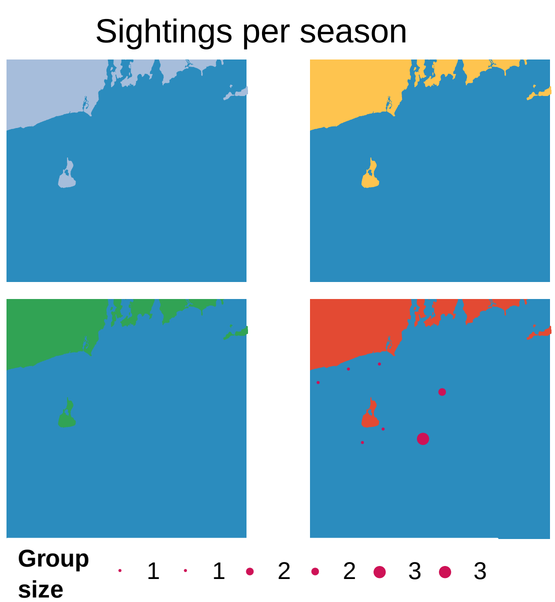

Figure 52. Observations of Passerines (red circles) by season (Winter = Gray, Spring = Green, Fall = Red, Summer = Yellow). Larger group size is indicated by a larger circle.

4 Conclusion

This report describes avian surveys conducted from 22 October 2010 to 22 July 2012 from an aerial survey platform as part of the OSI project. This report follows two OSAMP avian interim reports by Paton et al. (2010) and Winiarski et al. (2011). This data set along with previous survey data reported in Paton et al. (2010) and Winiarski et al. (2011) offers a long term, comprehensive look athe distribution and abundance of marine birds in the OSAMP study area and is critical information for regulators and developers for future decisions regarding siting and monitoring of proposed renewable energy facilities.

4.1 Threatened and Endangered Species

There were no confirmed detections of Roseate Terns (federally listed as endangered), or Piping Plovers (federally listed as threatened) and Red Knots, (candidate for federal listing) on our aerial surveys, but we did detect Roseate Terns in the OSAMP area on our previous land-based and ship-based surveys (see Paton et al. 2010 and Winiarski et al. 2011). It is important to note that during these aerial surveys it was not possible to identify terns or shorebirds to the species level. Terns were relatively abundant on our aerial surveys across our study area during spring and summer in both the nearshore and offshore environment and it is likely that a small perecentage of these detected individuals were Roseate Terns. Only a few shorebirds were detected on the aerial surveys and it is unlikely any of these detetions were Piping Plovers or Red Knots, but it is important to note that our aerial surveys were primarily designed to assess the distribution and abundance of foraging marine birds and were really not designed or intended to detect commuting individuals, especially those making pre-dawn and dusk movements when these listed birds may more abundant in the OSAMP study area. The movement ecology of these species is still poorly understood and at this point any suggestions that any of this federally listed are likely or not likely to commute through the OSAMP is pure speculation.

In addition, the detection probabilities of these small shorebirds is very low during aerial (e.g., Piping Plover have a 15- inch wingspan, while Red Knots have about a 20-inch wingspan), particularly because during migratory movements these species probably often flying at higher altitudes than our plane that was only flying 76 m elevation. We do the largest Roseate Tern colony in North America is located on Great Gull Island in Long Island Sound, and many of these birds stage on Cape Cod during the fall (B. Harris, Mass Audubon, pers. comm.). However it is uncertain how these birds commute through the OSAMP area to reach Cape Cod, although we do know some individuals do roost on Block Island (see see Paton et al. 2010 and Winiarski et al. 2011). There is a possibility that terns are nocturnal migrants when conducting these movements, making it impossible to detect these movements during diurnal aerial surveys, thus future research on the movement ecology is possibly warrented.

4.2 Renewable Energy Siting

4.2.1 Nearshore Waters

Current Rhode Island OSAMP policy is that waters <20m deep are off limits to future renewable energy development. The rationale for this recommendation is that these waters are known to be important areas for foraging seaducks (primarily scoters and eider) in our study area based on the results of our avian studies for the OSAMP and the available seaduck literature. The results of our aerial surveys and previous surveys Paton et al. 2010 and Winiarski et al. 2011 found that waters >20m are also important areas for neashore species such as loons, alcids, gannets, terns, gulls and to a lesser extent seaducks. It is important that proposed developments in these water depths are less important for these species versus areas known to be potential hotspots (i.e., southwest ledge of Block Island, RI towards Montauk, NY).

4.2.2 Offshore Waters

The aerial surveys presented in this report and previous avian surveys conducted in the OSAMP area described by Paton et al. 2010 and Winiarski et al. 2011 show that the offshore waters of the OSAMP study area are important areas for marine birds throughout the year including gulls, gannets, shearwaters, petrels, kittiwakes, terns, alcids and fulmars. As with the nearshore waters, renewable energy development site selection in offshore waters should consider avoiding areas that have high densities of marine birds. It is important to note that the distribution and abundance of many of these offshore species is driven by commercial fishing in the OSAMP area with many species taking advantage of high amounts of discard from the commercial fisheries, especially the bottom-trawling fishery.

4.3 Renewable Energy Monitoring

Monitoring the effects of renewable energy development (construction and operation) will be driven by the siting location, as this will determine the species and abundance of birds potentially affected (both negatively and positively).

4.3.1 Displacement/Attraction

Baseline marine bird data from the aerial surveys and previous surveys documented in Paton et al. 2010 and Winiarski et al. 2011 provide regulators and developers with strong guidance on which species and time of the year monitoring should be done based on siting location. Developments sited in nearshore waters should monitor seaducks, loons, gannets, gulls, and terns, however use of either aerial or ship-based surveys is not species specific. Timing of monitoring surveys should be when these species are most abundant in the study area. For example, monitoring changes in densities of loons should be done in the winter and spring months when birds are most abundant in the OSAMP area, not in the summer when these birds are found in very low densities. Species that are relatively uncommon and found in low densities are not worth the time and resources to monitor since the statistical power for these species will be too low to detect any significant change in densities. In theory, siting of developments in areas of relatively low bird densities should reduce the time and resources needed for displacement monitoring. Species composition and density will also drive choice of survey platform. For example, if seaducks are potentially going to be displaced from the development siting location, it would not be effective to conduct ship-based surveys as this method works poorly to document seaduck densities.

4.3.2 Collision

Baseline marine bird data from the aerial surveys and previous surveys documented in Paton et al. 2010 and Winiarski et al. 2011 again provide regulators with strong guidance and which species and the time of the year monitoring should be done based on siting location. Collision monitoring should take place when species are most abundant (i.e., higher rates of commuting birds) and during migratory periods when passage rates of birds are also high. Specific siting locations will determine which species are at risk of collision. Many of the more pelagic species (shearwaters, petrels, and alcids) fly relatively low to the surface of the water and are probably at very low risk of collision.

4.3.3 Barrier Effects

Marine bird surveys to date in the OSAMP have not been designed to quantify the movement ecology of marine birds in the OSAMP area. Both diurnal and migratory movements of marine birds common to the OSAMP area are poorly understood, but this does not mean that changes in avian movement as a result of renewable energy facilities is not an important effect to monitor. Seaducks are known to fly around facilities both during migration and during daily diurnal movements. Seaducks in the OSAMP area are known to move offshore to roost, and any facility in nearshore waters could serve as a barrier to these birds.

4.4 Research Gaps

In Europe, where much of the impact monitoring where these facilities have been installed are in relatively shallow nearshore waters and monitoring has been focused on nearshore species (seaducks, gulls, loons; see Petersen et al. 2006). Response of many species (especially pelagic species) to construction and development is unknown and at this point is speculative. If facilities are developed in the deeper offshore waters of the OSAMP area, it will be important to monitor the effects of these facilities on these marine birds. Paton et al. 2010 and Winiarski et al. 2011 documented many nearshore species migrating in offshore waters so it is important to remember that these species populations could still potentially be negatively affected even in areas where these birds are not commonly found.

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