MULTI-YEAR COUNTS OF SEA DUCKS AND GULLS IN THE NEARSHORE OF THE PRIBILOF ISLANDS, ALASKA

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ABSTRACT—Monitoring avian populations over both the reproductive and non-reproductive seasons is required to better understand population changes. Obtaining baseline data in remote sites, however, is often difficult during the non-breeding season, especially in ice-driven ecosystems. We determined annual changes in numbers of over-wintering sea duck and large-bodied gull species and identified their main areas of concentration at one of the Pribilof Islands (St. Paul) in the Bering Sea. Formally trained local citizens undertook weekly counts using standardized methods over 3 non-breeding seasons (2008–2009; 2009–2010; 2010–2011) from late autumn to early spring. Sea ducks and large-bodied gulls were present nearshore in considerable numbers from November to January, and maximum counts usually occurred between February and March when sea-ice cover is at its maximum near the Pribilof Islands. We found that one-time counts would underestimate some species (Bufflehead, King Eider, Harlequin Duck), their numbers having peaked earlier in the non-breeding season. Across years, Harlequin Duck (47% occurrence; maximum of 476 total individuals at all sites), Long-tailed Duck (23%; maximum of 627) and King Eider (18%; maximum of 136) were the most common and abundant species. Buffleheads (maximum of 24 individuals) and White-winged Scoters (maximum of 500 individuals) were less common (<5% occurrence), and had distinctive localized distributions in intertidal and lagoon habitats. Only Harlequin Ducks and large-bodied gulls varied annually, with nearly twice as many birds in 2011 as in 2008. Large-bodied gull concentrations (maximum of 1230 individuals; primarily Glaucous-winged Gulls) were mostly associated with dockside and outfall fish offal rather than landfill. Given that large-bodied gulls foraged in the same sites and monthly peaks mirrored those of sea ducks, kleptoparasitism is a potential problem, especially in absence of fishery discards. Our study fills a gap in the current understanding of regional waterfowl and large-bodied gull status during the non-breeding season in the Pribilof Islands, an important over-wintering location.

Keywords: Alaska, Bering Sea, Glaucous-winged Gull, *Larus glaucescens, Mergini*, sea ducks, St. Paul Island, surveys, winter counts

Reliable long-term data on abundance and reproductive success of well-chosen species can be one of the best indications of what is happening in the broader ecosystem (Furness and Camphuysen 1997; Piatt and others 2007). To be useful early warning signals of environmental changes, ecological indicators should ideally be easily measured and have a known response to disturbances, anthropogenic stresses, and changes over time (Dale and Beyeler 2001). Thus, knowing species' responses year-round can be critical as different stressors from the non-breeding season can carry over effects to the breeding season, ultimately affecting population numbers (Renner and others 2014). In remote areas such as the Bering Sea, biological data collection occurs mostly during the breeding season (summer period) because of the logistical challenges and cost of winter sampling (Byrd and others 2008; Renner and others 2014). As a result, there are substantial informational gaps for the non-breeding or over-wintering period (September to May) for most species.

Community-based research is an alternative approach using local residents that has been shown to produce reliable data (for example, Mahoney and others 2009; Dickinson and others 2012; Huntington and others 2013; Fidel and others 2014). Given many participants' lack of formal scientific background, the success of such an endeavor relies strongly on collaboration with experts, consistent methods, and a standardized training program, among other factors (Freitag and Pfeffer 2013). Additionally, community-based research benefits local communities through increasing the scientific understanding of the ecosystem and awareness of the importance of maintaining a healthy environment, and by providing hands-on experience (Haywood and others 2016). There are a number of examples of well-trained local citizens following detailed protocols over multiple years in Alaska citizen-science programs, collecting reliable and useful baseline data (for example, Brewer 2007). In addition, local citizens living in remote communities, such as the Aleuts, are well positioned to address non-breeding data gaps in Alaska because they are familiar with the habitats and species that they depend upon for subsistence.

The sea-ice edge in the Bering Sea has high biological importance for many species throughout the year (Hunt and Stabeno 2002). The Pribilof Islands are located at the southernmost extent of the winter sea-ice pack in the Bering Sea, and as a result are the destination for many migrant species that follow the ice edge. The areas surrounding these islands are essential winter habitat for a number of sea duck species such as Common Eider (*Somateria mollissima*), King Eider (*Somateria spectabilis*), Harlequin Duck (*Histrionicus histrionicus*), Long-tailed Duck (*Clangula hyemalis*), White-winged Scoter (*Melanitta deglandi*), and Red-breasted Merganser (*Mergus serrator*; Sowls 1993, 1997). Two species listed as threatened in Alaska, the Steller Eider (*Somateria fischeri*) and Spectacled Eider (*Polysticta stelleri*), also winter in these islands (Sowls 1997). Sea ducks are known to conduct extensive winter movements to temperate and subarctic regions (Petersen and Flint 2002; Lok and others 2011; Martin and others 2015), apparently triggered by ice formation that abruptly renders non-breeding sites at higher latitudes unsuitable. Because sea ducks require open water to forage, sea-ice cover that prevents access to open water will force birds to move away from an area (Guillemette and others 1993; Bump and Lovvorn 2004). The common pattern of winter movements is therefore one of mass movements of sea ducks from northern to more southern non-breeding sites once sea-ice cover prevents efficient foraging (Oppel and others 2008; Bartzen and others 2016).

The Pribilof Islands are also non-breeding wintering sites for the Glaucous-winged Gull (*Larus glaucescens*), the most abundant large-bodied *Larus* in the Northeastern Pacific (Hayward and Verbeek 2008), and one of the few larids that performs large migratory movements (Hatch and others 2011). The other 2 large-bodied gull species found in Alaska, the Glaucous Gull (*L. hyperboreus*) and Herring Gull (*L. argentatus*), are also winter visitors to the Pribilof Islands, but much less common (Sowls 1997). The occurrence of gulls[1] (*Larus* spp.) on the Pribilof Islands during the non-breeding season overlaps with peak fishing and associated onshore and near shore processing. Little is known about the gull's potential impact on other non-breeding birds, but it has been shown that other large-bodied gull species such as Kelp

[1] Gulls refers to all gull species (*Larus* spp.) including large-bodied gulls.

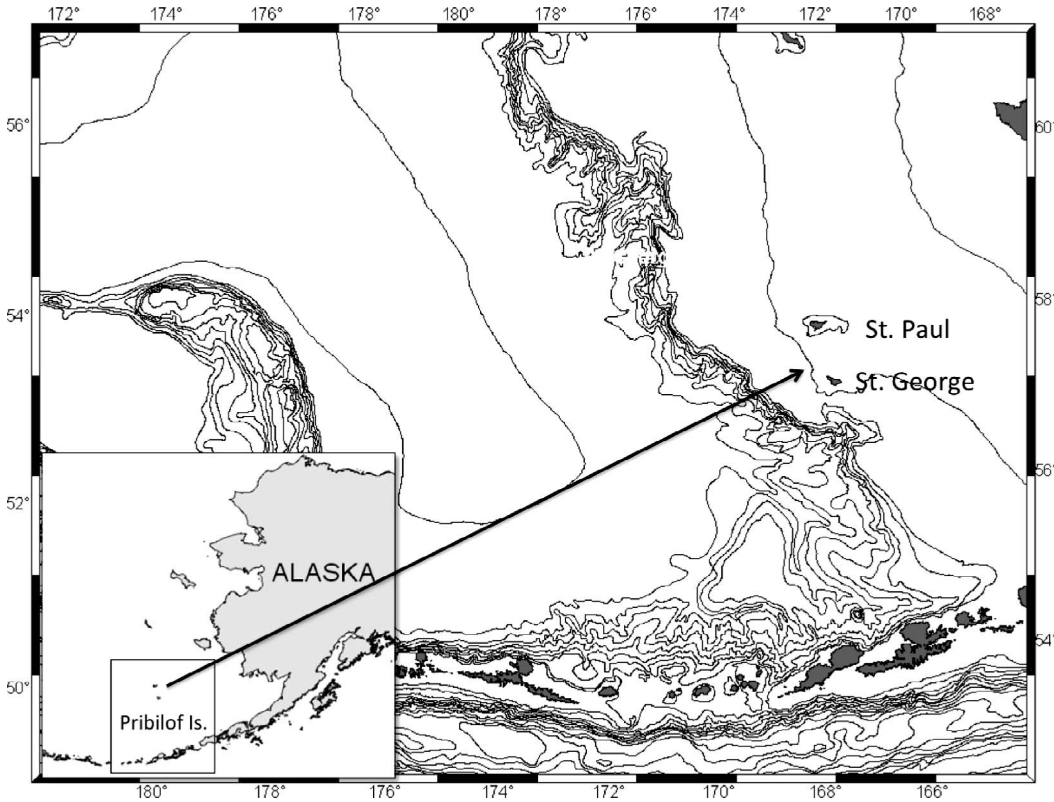

FIGURE 1. Geographic location of St. Paul Island on the Southeastern Bering Sea Continental Shelf, Alaska.

Gulls (*Larus dominicanus*) and Glaucous Gulls can negatively affect foraging of diving and sea ducks through kleptoparisitism (McGehee and Eitnear 2007; Varpe 2010).

The only estimation of the population of sea ducks and large-bodied gulls in the Pribilof Islands comes from one-time counts in March 1993 and 1996 (Sowls 1997). Our main objective was to estimate the relative abundance and distribution of the main sea duck and large-bodied gull species on St. Paul Island using community-based observations. To do so, the St. Paul Ecosystem Conservation Office (ECO), a branch of the Aleut Community of St. Paul Island Tribal Government created to deal with local and regional ecological issues, partnered with regional biologists on this study. The ECO has developed its ability to monitor many aspects of the local environment over the past 10 y, and was in an ideal position to collect non-breeding sea duck and large-bodied gull data. We had 2 objectives. The first was to conduct regular winter counts of the main sea duck and large-bodied gull species over 3 y to identify monthly peaks and areas of concentration across the island that could be helpful to future population and management studies. Our second objective was to incorporate monitoring of non-breeding avian species into a current long-term and locally based database in sufficient quality to be replicated and capable of demonstrating trend variation of focal species on the Pribilof Islands.

METHODS

Location

This study was carried out on St. Paul Island (57°7′N, 170°17′W), the largest of the Pribilof Islands, located approximately 90 km from the very productive continental shelf-break, particularly the Pribilof and Zhemchug Canyons, of the southeastern Bering Sea (Fig. 1). With a surface area of approximately 113 km^2, St. Paul Island contains an assemblage of nearshore habitats, sea cliffs, beaches, sand dunes, and coastal wetlands unique in the central Bering Sea. Most of the 73.2-km shoreline of St. Paul is rugged and rocky, rising to sheer cliffs at several headlands, though long, sandy beaches backed by shifting sand dunes flank a number of shallow bays (Jordan 1898) and are suitable waterfowl habitat. The 3 pronounced southwest, southeast, and northeast "corners" of the island are subject to significant tidal currents. St. Paul Harbor is protected by a manmade breakwater, which gives the harbor and Salt Lagoon some protection from the Bering Sea environment. Ice begins to form along the coast in the northern Bering Sea as early as November and is advected southward, with maximum ice extent typically occurring in March or April (Stabeno and others 2012). During the summer, significant proportions of the world populations of several seabird species breed at the Pribilof Islands, including Red and Black-legged Kittiwakes (*Rissa brevirostris* and *R. tridactyla*), Thick-billed and Common Murres (*Uria lomvia* and *U. aalge*), 3 species of Auklets (*Aethia* spp.), Red-faced Cormorant (*Phalacrocorax urile*), and 2 Puffin species (*Fratercula* spp.). Roughly 75% of the world's population of Red-legged Kittiwakes breed on the Pribilof Islands, a site without major aerial predators (Byrd and others 2008).

Species

Data collection prioritized sea duck species that are visibly distinct, minimizing identification errors, and that occur in sufficient quantities to be useful for annual trend analyses, such as Common and King Eiders, Harlequin Ducks, and Long-tailed Ducks (Sowls 1997). Similarly, data collection for gulls focused on large-bodied gulls, the majority most likely Glaucous-winged Gulls (*Larus glaucescens*), which are considerably more prevalent in Alaska than the other 2 occurring large-bodied gull species, Glaucous Gull and Herring Gull (Sowls 1997).

Database and Procedure

The spatial data model of the Island Sentinel database visualizes the island as a series of Regions in which observers (Sentinels) record observations within specific fields of view from defined and repeatable Vantage Points. "Regions" refer to broad geographic areas on the island separated by geographical, ecological, or political boundaries. Within each Region are "Vantage Points" (distinct points from which observations are made), and "Views" (smaller non-overlapping areas within a Region that can be observed). Vantage Points are associated with GPS location coordinates and mapped in GIS.

Within the spatial structure of the Island Sentinel database, observations are categorized based on the subject of the observation (for example, wildlife or environmental monitoring). Each choice triggers a unique set of coded dropdown menus matching each subject area to facilitate fast and efficient data entry. The coded structure of the database allows for a range of count data, behavioral observations, and interactions between species to be recorded. The database module was implemented to include sea duck and large-bodied gull counts consisting of database tables with associated paper and handheld PC data-entry forms. In particular, a data-entry system for recording verifiable species identifications with associated photographic documentation was developed. Specific components of each observation were coded into forms custom-designed for the sea duck and large-bodied gull program. For each set of observations within a Region, a suite of background environmental conditions were also recorded (for example, weather, wind condition, tide, etc.) to aid in future analyses.

Data collection focused on the non-breeding season or over-wintering months including late autumn and early spring (the survey period), November to May in 2008–2009, September to May in 2009–2010, and October to April in 2010–2011. Survey locations were chosen in order to cover the most important areas of over-wintering bird concentrations as well as areas where surveys could be conducted from vehicles (for instance, unobstructed views of ocean) during winter. Vehicle-based surveys were important to maximizing the likelihood of data collection throughout the survey period, to facilitate access to all survey locations chosen, and to simplify and standardize the protocol (see below). Final survey locations with important bird concentrations were chosen based on their visibility, accessibility, and repeatability across surveyors, as well as continuity with previous survey sites (Sowls 1997). We used a total of 36 Vantage Points covering 9 Regions of the island (Fig. 2). Birds were present in 26 of these Vantage points in 2008–2009, 36 in 2009–2010, and 23 in 2010–2011. Most sea duck survey locations overlapped

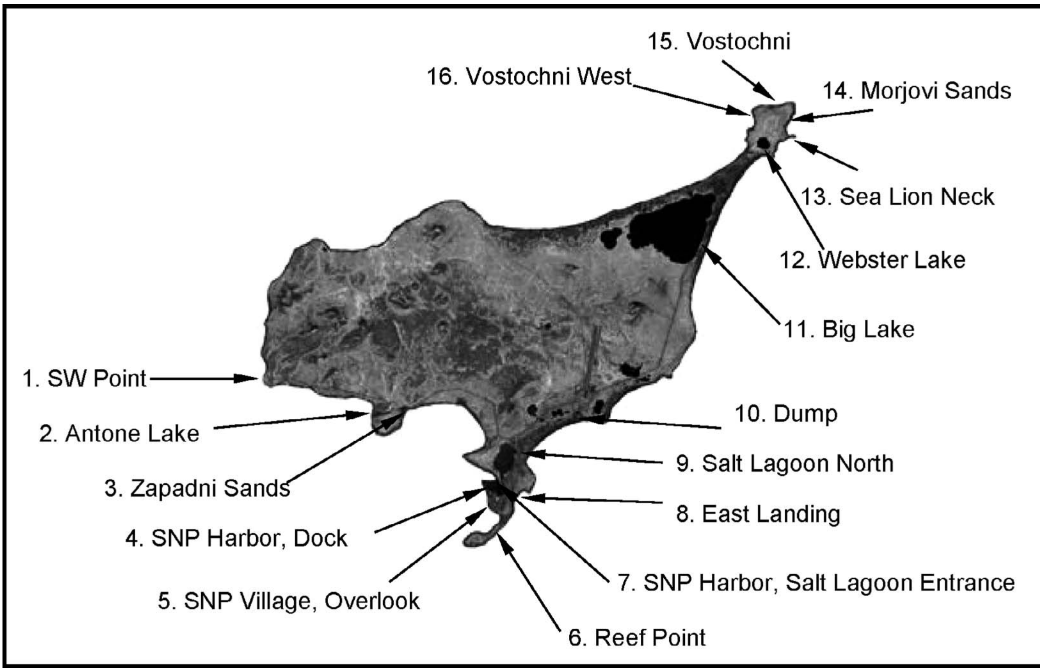

FIGURE 2. Survey regions of sea duck and gull counts at St. Paul Island (SNP), Alaska, during non-breeding season 2008–2009, 2009–2010, and 2010–2011.

with the large-bodied gull survey locations; however, some locations were gull-specific (for example, landfill, Big Lake).

At the onset of the program, experienced personnel trained and tested local citizens on-site in counting, species identification, and data recording. Observations across all island Vantage Points were conducted on a weekly basis, weather permitting. In order to ensure location repeatability, each survey site was identified with GPS coordinates and marker posts. The surveys began as early as 10:10 at the 1st site and finished as late as 16:40 at the last Vantage Point, and were constrained be winter daylight hours. Starting Vantage Points were varied in order to minimize time-of-day bias for any particular site. The observation protocol involved driving to each site and conducting 15- to 30-min scans from the vehicle using a window-mounted spotting scope (40x) and handheld binoculars (10 × 42). Scans involved searching the water in an arc, from left to right, to approximately 1 mile (1.6 km) offshore, and counting and identifying all target birds. The outer limits of the count area were approximate, with the exception of areas that had specifically defined boundaries. Inclement weather and road conditions limited some observations, especially at the most distant sites (NE Point and SW Point).

Exact counts and species identifications were not always possible. To account for this, bird counts were conducted in a hierarchical manner to take advantage of as much information as possible. Two aspects of detail were considered. The first was the amount, which ranged from the general category of present-absent to an exact count. The second involved the category, which ranged from the general category of "sea duck" to being able to classify species and class (such as male, female, or immature). The same methods used for sea ducks were also used for conducting gull counts, except that no attempt was made to sex gulls or to determine hybrids. Unless specifically identified as a different species of gull, all unidentified gulls were categorized as large-bodied gulls. These gulls were most likely to be Glaucous-winged Gulls, the most abundant species present on the island (Sowls 1997). Current Island Sentinel data collection method was adapted using handheld field computers (PDAs) synchronized with a desktop database to the different levels of detail required for this study. When large numbers of birds occurred, count estimations using blocking techniques were used (such as counting 10, using this size/density of block to count 100, then counting all birds in blocks of 100).

Data Analysis

We determined the frequency of occurrence of each focal species based on the total number of times each species was seen at least once in all Vantage Points during a year (Table 1). Mean, maximum number, and date of weekly counts (sum of all Vantage Points) for sea ducks and large-bodied gulls are summarized in Table 1. Weekly counts of the 5 most common and abundant sea duck species and large-bodied gulls were averaged per month for analyzing inter-annual variation of bird counts. For this process, mean counts were analyzed using year as fixed factor and month as a random factor in a general linear model (GLM). Finally, we used the maximum weekly count to identify important areas of sea duck and gull concentration. The distribution of the maximum weekly count (sum of all Vantage Points) was plotted with symbols for each species and year on an island map. Statistical analysis was carried out using PASW Statistics 18. GLM residuals met the assumptions of homogeneity, independence, and normality. Multiple comparisons were undertaken using post-hoc Tukey's HSD tests. Means were expressed as ± standard error of the mean. All comparisons were 2-tailed, and differences were considered significant when $P \leq 0.05$.

RESULTS

The highest numbers of sea ducks and large-bodied gulls were found during February and March; however peak numbers varied among species (Table 1). The most common sea duck species across years were Harlequin Duck, Long-tailed Duck, King Eider, Bufflehead (*Bucephala albeola*), and White-winged Scoter (Table 1). There were no annual differences in the mean numbers of all focal species ($P > 0.05$) except for Harlequin Duck and large-bodied gull (see below).

Counts of all sea duck species and large-bodied gulls show consistently high numbers between November and January in all years. There were additional peaks in March 2011 for most species and in 2008 for Long-tailed Ducks (Fig. 3).

Buffleheads

The peak abundance of Buffleheads was <25 in all years and <5 throughout the rest of the year (Fig. 3a). Geographic distribution of Buffleheads during the date of peak abundance was confined to the southern, more protected areas of the island such as Salt Lagoon (Fig. 4).

Harlequin Ducks

Harlequin Ducks were the most commonly observed sea duck species (47% occurrence) and the 2nd most abundant, based on maximum counts per location (Table 1) and sum of counts throughout the year (Fig. 3b). Their peak abundance from November through January was 300 to 470 individuals, and fluctuated between roughly 50 and 250 between peaks. Harlequin Duck numbers differed among years ($F_{1,\ 63} = 5.051$, $P = 0.009$; Table 1). There were more birds in 2010–2011 than in 2009–2010 (Tukey's HSD test: $P = 0.035$) and in 2008–2009 (Tukey's HSD test: $P = 0.010$). The primary concentrations in all years were observed at Northeast Point, Reef, Southwest Point, and Tolstoi/Zapadni (Fig. 4).

King Eiders

In addition to peak abundances in January 2008–2009 and December 2009–2010, King Eiders had a distinctive secondary peak in abundance during February 2010. Overall, observed numbers were the lowest in 2010–2011 (< 50) and highest in 2009–2010 (136 birds; Fig. 3c). Geographic distribution of King Eiders during the date of peak abundance was confined to the southern island region, particularly the Southwest Region. During 2009–2010 and 2010–2011, King Eiders were more widely distributed in the 3 major Regions, Southwest, Southeast, and Northeast Points, where tidal action can be strong (Fig. 4).

Long-tailed Ducks

Long-tailed Ducks were the most abundant (480–600 in all years) and 2nd most commonly observed (23%) on the island (Table 1 and Fig. 3d). Counts were similar in both number and timeframe in 2009–2010 and 2010–2011. Similar to King Eiders, their abundance peaked in February 2010 and 2011 and in March 2009

TABLE 1. Summary of sea duck species and large-bodied gulls counted during 2008–2011 on St. Paul Island, Alaska.

	2008–2009				2009–2010				2010–2011			
	% Occ.[1]	Mean[2]	Count[3] Max. #	Date[3] Max. #	% Occ.[1]	Mean[2]	Count[3] Max. #	Date[3] Max. #	% Occ.[1]	Mean[2]	Count[3] Max. #	Date[3] Max. #
SEA DUCKS	37.7	78.2±13	603	Mar	50.7	78.5±10	627	Feb	51.0	86.6±12	500	Mar
Barrow's Goldeneye	0.4	5±0	5	Feb 11	3.1	6.6±1	22	Dec 10	0.5	9±1	10	Dec 8
Black Scoter	0	0	0	–	0	0	0	–	1.2	43.3±2	50	Mar 31
Bufflehead	5.3	9.8±3	21	Nov 13	3.3	9.4±3	24	Jan 6	4.8	9.5±1	21	Nov 17
Common Eider	1.3	2±0	2	Nov 6	0.3	2±0	2	Feb 18	0.2	2±0	2	Dec 15
Common Goldeneye	2.6	12.3±6	25	Nov 13	0	0	0	–	3.3	8.3±2	37	Feb 23
Eurasian Wigeon	0	0	0	–	0.2	0	70	Feb 25	0	0	0	–
Harlequin Duck	46.7	137.5±35	349	Jan 30	44.2	156.5±27	442	Dec 10	41.9	243.5±39	476	Mar 24
King Eider	17.6	17.0±6	68	Jan 26	20.9	27.3±7	136	Dec 10	15.6	15.2±4	44	Mar 24
Long-tailed Duck	23.3	124.9±49	603	Mar 19	24.5	98.8±29	627	Feb 25	27.3	113.2±28	489	Feb 9
Steller's Eider	0.9	5.0±1	6	Dec 18	0.5	17.3±6	30	Mar 25	1.4	19.3±4	35	Mar 24
White-winged Scoter	1.8	60.7±45	180	Nov 25	3.0	45.7±21	300	Feb 18	3.8	90.6±53	500	Mar 16
GULLS	24.1	112.4±28	475	Mar	19.4	254.8±48	1051	Oct	14.8	415.8±70	1230	Feb
Large-bodied gull[4]	100	112.4±28	475	Mar 3	100	254.8±48	1051	Oct 9	100	415.8±70	1230	Feb 16

[1] % Occ. (percent occurrence) indicates the frequency at which a group (sea ducks or gulls) or species were seen in all survey locations. 36 Vantage points were visited during each survey but not all sites had birds, and the number of surveys per year varied due to weather conditions (2008–2009 = 936 total locations surveyed; 2009–2010 = 990; 2010–2011 = 756). The % Occ. per group includes all sites including those with zero counts, while the % Occ. per species was calculated based on sites with sea ducks or gulls only.
[2] Mean represents the average of all weekly counts (sum of all birds found across all island Vantage Points).
[3] Max. (Maximum) Count and Date indicates the maximum number of birds during a weekly count and date.
[4] The main gull species in the Pribilof Islands were Glaucous-winged Gulls (Sowls 1997).

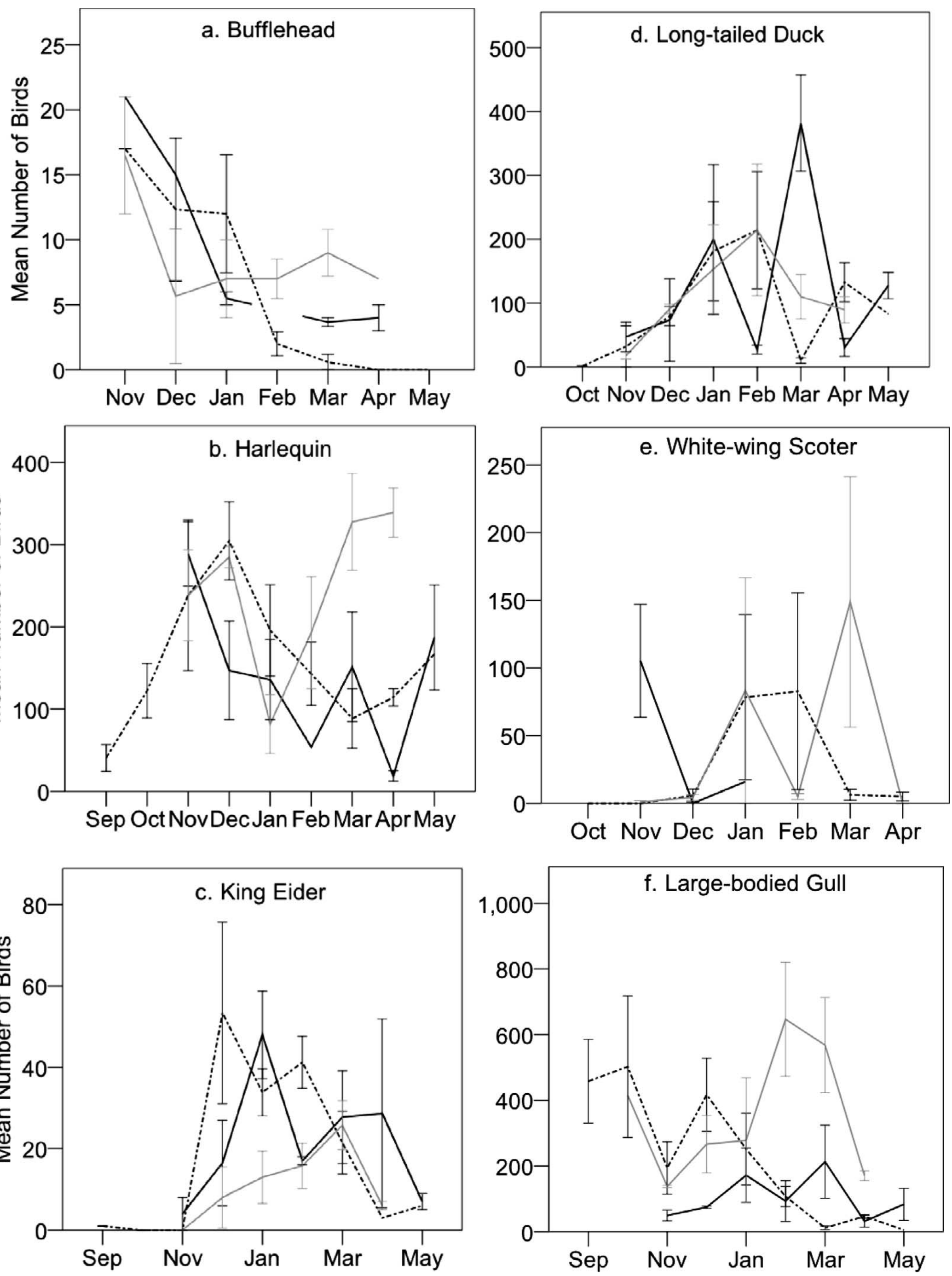

FIGURE 3. Mean numbers of sea ducks (a–e) and large-bodied gulls (f) at St. Paul Island, Alaska, from October–April in 2008–2009 (black line), 2009–2010 (black dotted line), and 2010–2011 (grey line). Values represent monthly means ± SE of weekly counts summed across all island Vantage Points in the study.

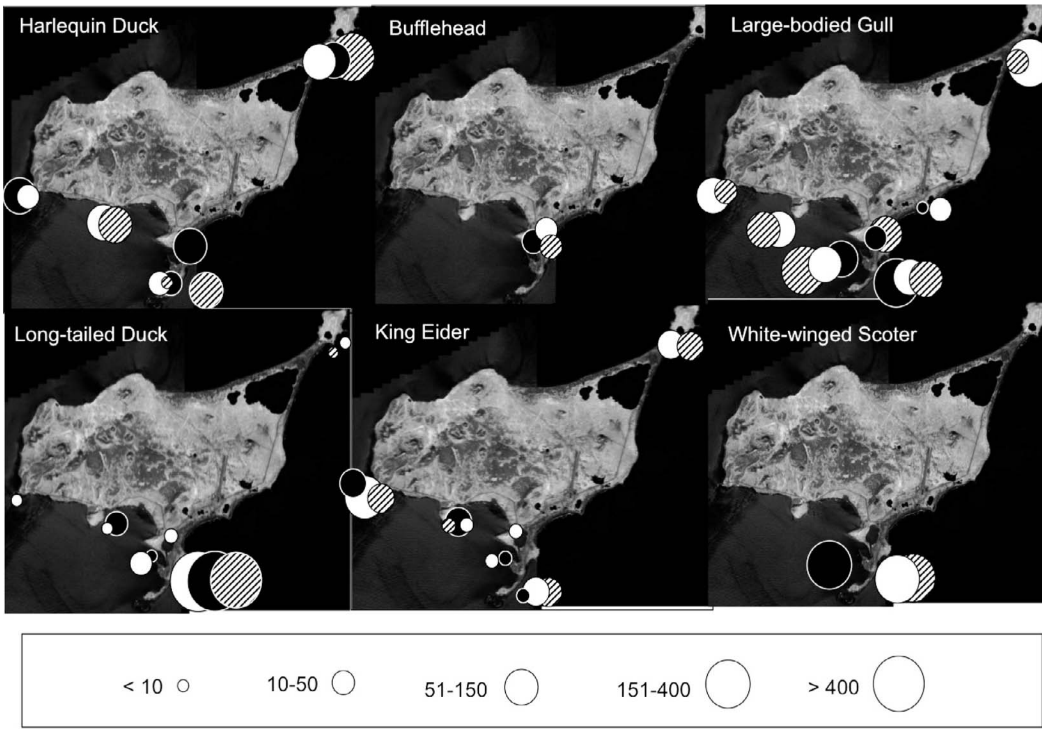

FIGURE 4. Distribution of sea ducks and large-bodied gulls at St. Paul Island, Alaska, during the peak of abundance in 2008–2009 (black circles), 2009–2010 (white), and 2010–2011 (stripes). Each circle represents the number of birds found in each region on the date that the maximum sum across all Vantage Points was found for that species. For example, a total of 442 Harlequin Ducks were counted on 10 December 2009, and most were located at Northeast Point.

(Fig. 3d). Geographically, Long-tailed Ducks concentrated in the Southeast Region in all years, particularly Reef Point (Fig. 4).

White-winged Scoters

Counts of White-winged Scoters were characteristically punctuated in all survey periods although the peak timing varied: November in 2008 (approximately 180 birds), February in 2010 (approximately 300 birds), and March in 2011 (approximately 500 birds) (Fig. 3e). Geographic distribution of White-winged Scoters during the date of peak abundance was confined to the southern portion of the island, on either side of Reef Point, during the three non-breeding seasons (Fig. 4).

Large-bodied Gulls

The numbers and geographic distribution of large-bodied gulls (mainly Glaucous-winged Gulls and occasionally Glaucous Gulls and Herring Gulls), were distinctly different in 2008–2009 compared to the 2009–2010 and 2010–2011 seasons. During the 2008–2009 survey period, the number of individuals gradually increased from November to January and peaked in March at approximately 500 birds. During the 2009–2010 survey period, there was a rapid increase in the early autumn with peak counts in early October (>1000 birds), followed by a similarly rapid decrease. Afterward, numbers fluctuated from 300 to 700 birds until early February. During the 2010–2011 survey period, large-bodied gulls were present in early autumn, but peak numbers occurred later in February and March (1230 birds; Table 1), then remained at around 900 individuals until decreasing in late April (Fig. 3f). Among years, large-bodied gulls differed in total count numbers ($F_{1,\ 63} = 5.956$, P = 0.004; Table 1). There were more birds in 2010–2011 than 2008–2009 (Tukey's HSD test = $P <$

0.0001). During the 2008–2009 survey period, distribution of large-bodied gulls at the date of peak abundance was entirely in the Southeast Region. During the next 2 survey periods they were distributed more widely along the southern shore of the island (Fig. 4).

Other Sea Ducks

Other sea duck species, such as the Black Scoter (*Melanitta americana)* and Eurasian Wigeon (*Anas penelope)*, were only seen in some years in groups of 50–70 individuals (Table 1).

Discussion

Our study provides the first detailed estimation of the local numbers and distribution of sea duck species and the most prevalent large-bodied gull species throughout 3 consecutive non-breeding seasons on one of the Pribilof Islands in the central Bering Sea. Although there was substantial intra-annual variation, total numbers and trends were mostly similar for each species across the study years, facilitating selection of count dates for future surveys. Sea duck and large-bodied gull numbers in nearshore areas were highest between February and March in all years supporting previous one-time counts in March 1993 and March 1996 (Sowls 1997). Nevertheless, one-time censuses could likely underestimate the number of some species of sea ducks. For example, Harlequin Ducks and King Eiders were more abundant earlier in the season between December and January, and all species showed considerable temporal variation.

The 5 most common and abundant sea ducks (Harlequin Duck, Long-tailed Duck, White-winged Scoter, King Eider, Bufflehead) observed in our surveys at St. Paul Island were seen from November to April, but were more abundant between November and January when sea ice off the Bering Sea shelf did not reach the nearshore area off the Pribilof Islands. Nonetheless, 2 of these species (Long-tailed Ducks, Harlequin Ducks) were abundant between February and March 2009 and 2010 when sea-ice cover was at its maximum around the Pribilof Islands (Sullivan and others 2013). These results support the results of other studies showing that the Pribilof Islands and adjacent areas are over-wintering sites and not merely stopover points for some sea duck species reported to winter in the northern Bering Sea (Harlequin Ducks: Phillips and others 2006; Oppel and others 2008) and North Pacific region (Long-tailed Ducks: Bartzen and others 2016). Our study encompassed 3 cold years in the southeastern Bering Sea shelf, with extensive sea-ice cover reaching the Pribilof Islands (Stabeno and others 2012; Sullivan and others 2013). Thus, it is possible that peak dates in sea duck numbers might persist in later winter months (February and March) during warm years. A glimpse of how sea ducks would behave with fluctuating sea-ice pack was observed in the winter of 2010–2011. Increased abundances of all sea duck species in March 2011 coincided with sea ice retreat under southeasterly winds around the Pribilof Islands (Sullivan and others 2013).

We found smaller numbers of King Eiders (40 versus approximately 400 individuals) and Steller's Eiders (36 versus 136), and larger numbers of White-winged Scoters (500 versus 3) compared to those reported by Sowls (1997) in the same month (March) 15 y ago. Although these results are snapshots of local numbers, they agree with studies of population changes of some of these sea duck species in the Pacific. For example, King Eiders declined by 50% from 1976 to 1996 (Suydam and others 2000) as did Steller's Eiders by more than 50% from the 1960s to the 1990s (Palmer 1976; Fredickson and others 2001). The cause of population declines of these eider species is poorly understood. Species-specific life-history traits are likely to influence sea duck resilience to changes in habitat and food sources, as can be expected with future climatic change (Derksen and others 2015).

The distinctive geographic distribution of Buffleheads and White-winged Scoters around the Salt Lagoon area on St. Paul Island (Fig. 2) suggests a more specialized need for tidal-driven habitats with substantial tidal flats exposed during low water (Flint and others 1999). The Salt Lagoon area is tidally connected to the Salt Lagoon Channel, St. Paul Harbor, and the Bering Sea. Salt Lagoon is protected from pack-ice movements and contains a diverse and abundant set of benthic organisms (Flint and others 1999). Our results support the preference of these 2 shallow-diver species, observed in other over-wintering areas, for sheltered bays and inlets with abundant crustaceans and mollusks (Palm and others 2013; Baldassare 2014; Gauthier 2014). Flint and others (2004) also found that Long-tailed Ducks are another species that congregate consistently in the same areas. Over 3 y, we found this species mostly in the southeast region of St. Paul Island, particularly the shallow waters of Reef Point (Fig. 2).

Non-breeding large-bodied gulls, mostly Glaucous-winged Gulls, appear to have increased in numbers on St. Paul Island since the last survey in March 1996 (900 versus 400 birds). Of note, large-bodied gulls did not concentrate in landfill areas such as the dump, but mostly in the village area and southern shore where dockside and outfall fish offal are found. The steady food source from fishery discards might explain an apparent increase in non-breeding large-bodied gulls. There was no observed sign of gull nesting activity on the island supporting non-breeding peaks being a seasonal event due to large migratory movements from other breeding areas (Hatch and others 2011). Thus, the apparent increase of non-breeding large-bodied gulls on St. Paul Island might not be a threat to other seabirds during the summer. In the present study, large-bodied gulls shared the same over-wintering sites and peak times during the year as many sea duck species (for example, in the less ice-covered March 2011). In other areas, the positive relationship between gull numbers and diving ducks in foraging flocks is apparently explained by both commensalism and kleptoparasitism (Marchowski and others 2015). Herring Gulls can steal bivalves from over-wintering diving ducks (Marchowski and others 2015), as can Glaucous Gulls from sea ducks (Varpe 2010). Further studies would determine whether large-bodied gulls on St. Paul Island follow sea ducks for scavenging or stealing prey as a primary food source or to complement fishery discards.

Using well-defined monitoring protocols, our study was successful in establishing a baseline and providing local numbers throughout the non-breeding season of the high-priority sea duck and large-bodied gull species present on St. Paul Island. Our results have 2 important outcomes for resource management. First, they provide information on local wildlife identified as high priority by the USFWS Alaska Maritime National Wildlife Refuge Bering Sea Unit. Second, they demonstrate the cost effectiveness of using existing locally based infrastructure for collecting valuable yet logistically difficult data over the non-breeding season. The latter is viewed as an important step toward developing self-sufficient and long-lasting resource management. Additionally, we expect the data produced during this project will greatly facilitate the development of local ordinances and enforcement as well as more general management needs such as development of a management plan. Collection of logistically difficult yet ecologically important data by trained individuals from local communities can fill an important niche in local species management.

In conclusion, our study fills an important gap in our current understanding of the regional sea duck and gull status during the non-breeding season and promotes significant local capacity on the Pribilof Islands. Both aspects can have long-lasting positive effects for management of these avian species, as well as subsistence and sport-hunting activities.

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