San Diego Bay Avian Species Surveys 2016-2017

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Cover photo courtesy of Timothy Burr, 2017. Bufflehead.

Long-Billed Curlew. © Timothy Burr, 2017.

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Thanks to all who brought their skills and enthusiasm to documenting bird use of San Diego Bay– it has been a privilege. And thanks especially to the **Port of San Diego** *and* **U.S. Navy** *for funding this work.*

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Black Skimmers. © Timothy Burr, 2017.

Executive Summary

This report details results from the San Diego Bay avian surveys conducted between July 2016 and June 2017. This work was jointly funded by the Port of San Diego (Port) and the U.S. Navy (Navy) Naval Bases Coronado, San Diego, and Point Loma, in San Diego, California.

The goal of this project was to: *Establish a scientifically defensible baseline and conduct a long-term trend monitoring program to census water-dependent birds (shorebirds, waterfowl, gulls, terns, and others) of San Diego Bay to assist in the protection and management of the bay and its associated species.*

The vision of the Port and Navy was to conduct a comprehensive survey of avian use of San Diego Bay that covered the entire bay in a single year, and contained focused methods to detect specific classes of birds (i.e., shorebirds, waterfowl, and seabirds), and detect their trends over time. The sampling protocol was developed through a collaborative process among biologists with expertise on local avian fauna. Finally, the survey protocol was developed collaboratively with the U.S. Fish and Wildlife Service Refuges, a landowner in south San Diego Bay. Initial surveys under this methodology were completed in 2006-07. The survey was repeated in 2009-10, and detailed here is the third iteration of this long-term monitoring project.

Shoreline surveys took place monthly between July 2016 and June 2017, conducted in the four hours before low tide. These ebbing tide surveys were designed to capture bird use of foraging habitats as mudflats and other substrates became exposed by the receding water. Quarterly peaking tide surveys were also conducted, over the crest of the tide. These surveys were designed to observe high tide refugia and congregation areas, and bird use areas which would be missed during ebbing tide surveys. Mid-water surveys to detect the presence of waterfowl occurred monthly between November 2016 and February 2017, when maximum migratory waterbird presence was expected. To complete the survey within a morning window, two boats were deployed. One started at the mouth of the bay and the other at the south end of the bay near the salt ponds, following established routes, and meeting in the bay's center. Point counts were conducted at 23 locations along the shoreline routes where specific distance of observation is recorded for a timed duration. Point counts allow for calculation of bird density that can be compared to other locations and over time at the same location due to this standardization, unlike the shoreline surveys that cover differing acreages and extend for variable survey times. These results represent an index and not a true measure of density because they do not account for bias related to probability of detection.

A total of 564,752 individual bird observations, representing 161 distinct species, were recorded during the shoreline and mid-water surveys in 2016-17. Additionally, during the point counts 102,944 individual observations were recorded during point counts (as the point counts were taken along with the shoreline survey these numbers are not independent). The point counts are a subset of the shoreline survey in that they likely counted the same birds, so are not included in total observations reported.

A total of 556,619 observations were made during the shoreline portion of the 2016-17 survey effort. Of these, 434,594 birds and 154 species were observed during the ebbing tide surveys and 122,025 birds and 154 species were observed during the peaking tide surveys. Birds were generally denser along extensive mudflat areas in the south bay, in some salt ponds, and around the bait barge in north bay. The salt ponds had the greatest density of observed birds, while the north-central and south-central regions had the lowest density.

The number of individual birds observed per month during the ebbing tide surveys varied considerably with a high of 69,752 in December 2016 followed by a low of 5,992 in May 2017 (see Table 3-2). Overall, trends were very consistent with the 2006-07 and 2009-10 surveys. For both the ebbing and peaking tide surveys, the highest numbers of birds were observed in late fall/early winter, while a considerable drop occurred in the late spring/summer period (see Table 3-3). Comparing abundance in bay subregions among the three survey periods, the numbers of birds observed in the salt works increased dramatically since 2006-07 (see Figure 3-2). The increase in numbers of birds at the salt works is likely a result of habitat restoration efforts to re-open some of the ponds to tidal flushing, providing additional foraging area.

Bird densities during the ebbing versus the peaking tide surveys were noticeably different at several locations in the bay (see Map 3-3). The bait barge at the north end of the bay, as well as several mudflat and marsh areas in the south bay, accumulated birds during the ebbing tide survey, particularly in the southeastern portion of the bay. During the peaking tide survey, the bird density was much higher in the interior salt ponds, which were a key concentration area. Additional peaking tide concentrations occurred in a few areas along the Coronado shore, near the enhancement island in the central bay, and in many of the harbors throughout San Diego Bay.

Several species showed marked differences in overall abundance during the shoreline ebbing tide surveys from 2006-07 to 2016-17 (see Table 3-5). A total of 14 species were at least 20% less abundant in 2016-17, with Red-necked Phalaropes (*Phalaropus lobatus*) showing the greatest decline from 13,974 observed in 2006-07 to only 1,270 observed in 2016-17. Three other species were at least 50% less abundant in 2016-17 (Marbled Godwit [*Limosa fedoa*], Ring-billed Gull [*Larus delawarensis*], and Bufflehead [*Bucephala albeola*]). Five species were at least twice as abundant in 2016-17 (Belding's Savannah Sparrow [*Passerculus sandwichensis beldi*], Royal Tern [*Thalasseus maxima*], Least Sandpiper [*Calidris minutilla*], Brant [*Branta bernicla*], and Elegant Tern [*T. elegans*]), while seven other species increased by at least 50% (American Avocet [*Recurvirostra americana*], California Least Tern [*Sternula antillarum browni*], Northern Shoveler [*Anas clypeata*], Brandt's Cormorant [*Phalacrocorax penicillatus*], California Gull [*Larus californicus californicus*], Eared Grebe [*Podiceps nigricollis*], Western Sandpiper [*Calidris mauri*]).

Point count surveys were conducted simultaneously with shoreline surveys and constitute a subsample of the shoreline effort with standardized survey area and timed duration. Results showed a similar pattern between the two, though all metrics were slightly lower due to the smaller area covered and time limit to the point counts. Densities are reported in Section 3.3.1 and Appendix E.

A total of 8,133 individual birds were observed during the mid-water surveys, with 32 species recorded. The number of individual birds observed during the mid-water surveys has declined with each subsequent survey since 2006-07 (see Table 3-7). Like in previous survey years, the number of individual birds observed peaked in January. Birds observed during the mid-water surveys were predominantly waterfowl (81.4% of all observations) and seabirds (18.4% of all observations) (see Table 3-9). Surf Scoters (*Melanitta perspicillata*) were the most abundant species, with over 5,600 observations, with Brants (645 birds observed) and Western Gulls (*Larus occidentalis wymani*; 474 birds observed) the next most abundant (see Table 3-10).

A decline in the numbers of waterfowl seen during the mid-water surveys in 2009-10 compared to 2006-07 continued in 2016-17, dropping to less than half of what had been seen in 2009-10. Much of the decline was due to a halving of the Surf Scoter count. There was a slight increase in certain waterfowl (scaup [*Aythya* sp.] and Redhead [*Aythya americana*]).

It is recommended that these surveys continue every three to five years. In addition, annual or biennial point count surveys would allow for the discernment of natural variation in observer coverage and population size and would facilitate interpretation of trends in the five-year surveys. Recommendations for the future as well as a summary of issues encountered during this survey are discussed more fully in Chapter 4. While the high value of these surveys remains their long-term and comprehensive nature, much benefit could be extracted from the data sets by analyzing correlations between habitat use and types of habitat, and peaking tide versus ebbing tide use areas and movement between them. The rich data set could be used for many further analyses, including comparison to the trends along the Pacific Flyway.

Data sets are stored and delivered in three separate Microsoft Excel files for all three survey events from 2006-07, 2009-10, and the current 2016-17.

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Lesser Scaup. © Timothy Burr, 2017.

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Acronyms and Abbreviations

AOU	American Ornithologists' Union
CDFW	California Department of Fish and Wildlife
AKN	Avian Knowledge Network
BMDE	Bird Monitoring Data Exchange
GPS	Global Positioning System
ha	hectare(s)
INRMP	Integrated Natural Resources Management Plan
MLLW	mean lower low water
NASSCO	National Steel and Shipbuilding Company
NAVFAC	Naval Facilities Engineering Command
Navy	U.S. Department of the Navy
NRDA	Natural Resource Damage Assessment
Port	Port of San Diego
SCB	Southern California Bight
SDNHM	San Diego Natural History Museum
USFWS	U.S. Fish and Wildlife Service

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1.0 Introduction

This report details results from the San Diego Bay avian surveys conducted between July 2016 and June 2017, in support of the 2013 San Diego Bay Integrated Natural Resources Management Plan (INRMP) (Port of San Diego [Port] and U.S. Department of the Navy [Navy] 2013). This work was jointly funded by the Port and the Navy in San Diego, California. Surveys under this long-term program were initially completed in 2006-07, then repeated in 2009-10. Those detailed herein represent the third iteration of this long-term monitoring project.

The vision of the Port and Navy was to develop the first comprehensive survey of avian species in a single year that covered the entire bay, utilizing focused methods to detect multiple classes of bay-dependent birds (i.e., shorebirds, waterfowl, and seabirds). The methods in this survey are intended for future long-term monitoring as well as for comparing these results to those of other major survey efforts regionally. For this reason, the sampling protocol was developed through a collaborative process among biologists with expertise on local avian fauna, with the San Diego Natural History Museum (SDNHM), and with the U.S. Fish and Wildlife Service (USFWS) Refuges, a landowner in south San Diego Bay. Refuge personnel surveyed the salt ponds, using this protocol, concurrently with the Navy and Port sponsored bay-wide surveys.

Photo 1-1. View of tidal marshlands across from Pepper Park in 2016.

1.1 Project Goals and Objectives

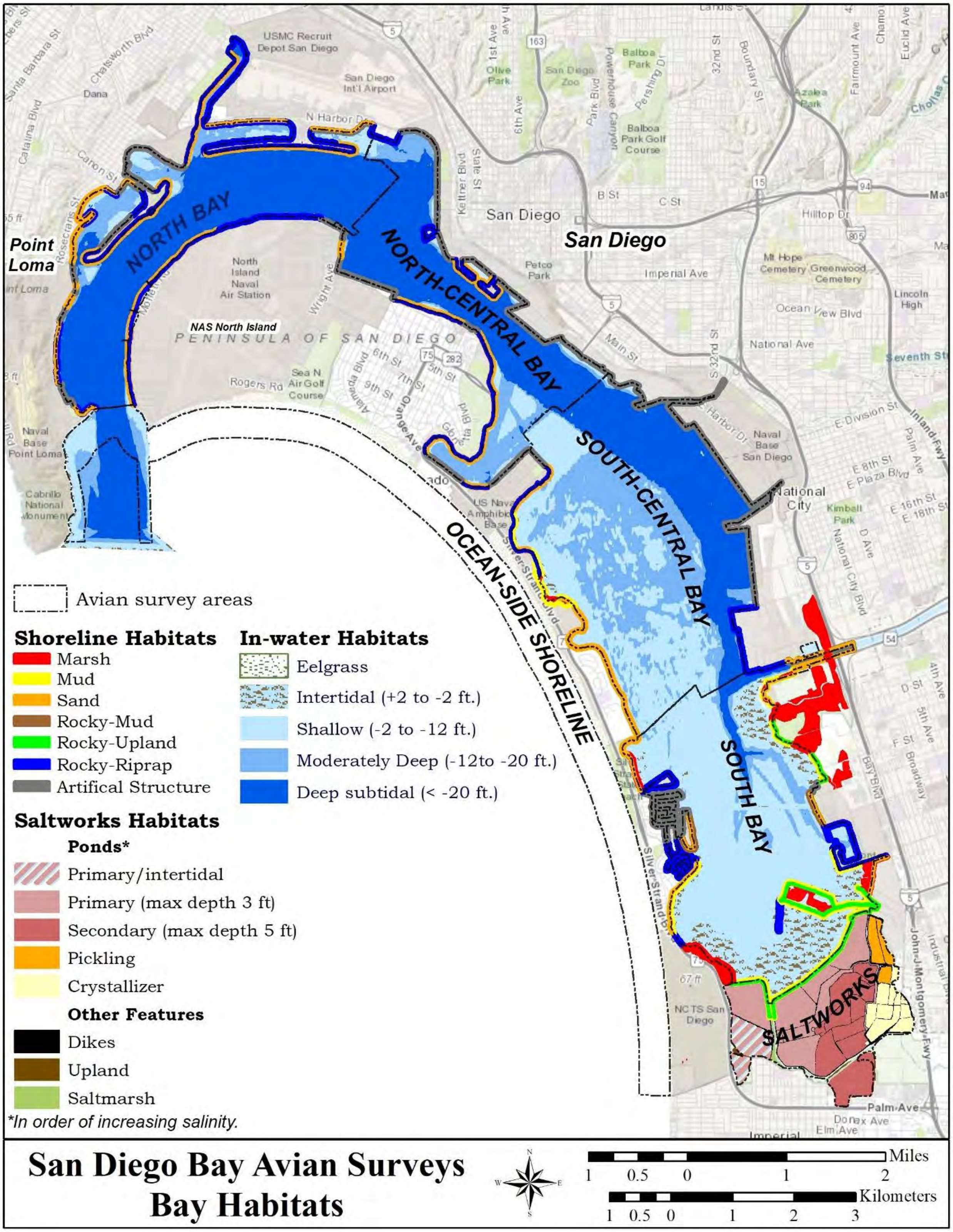
The goal of this project was to: *Establish a scientifically defensible baseline and conduct a long-term trend monitoring program to census water-dependent birds (shorebirds, waterfowl, gulls, terns, and others) of San Diego Bay to assist in the protection and management of the bay and its associated species.*

To achieve this goal, the survey design sought to capture the density and distribution of avian species among bay subregions and among census locations throughout a year-long cycle of monitoring. Repeating these surveys every three to five years would allow the detection of a significant change in the population of key species utilizing the bay (defined in this report as a 20% change in abundance between surveys). Identifying species experiencing a long-term decline (or increase) in population will allow agencies managing the natural resources of the bay to adapt management strategies to focus on these species and their habitats.

1.2 Study Area Setting

San Diego Bay is part of the greater ecosystem of the Southern California Bight (SCB) (Map 1-1), which encompasses the region from Point Conception, California to Punta Banda, Mexico. San Diego Bay covers 14,115 acres (5,714 hectares [ha]) of water and 4,940 acres (2,000 ha) of tidelands (including the saltworks in the southern end of the bay) (Port and Navy 2013) (Map 1-2). This project encompassed the entirety of the San Diego Bay area, from the open water to the intertidal shorelines and immediately adjacent uplands, as well as the coastal strand on the west side of the Coronado peninsula.

Map 1-1. San Diego Bay avian surveys regional context.



Map 1-2. San Diego Bay habitats.

Due to its position along the transition zone between cold subarctic waters and warmer subtropical water, San Diego Bay experiences a large variability in the structure of its bird communities throughout the seasons (USFWS 2005). The bay is a part of the Pacific Flyway used by millions of birds traveling between northern breeding grounds and southern wintering sites. It supports large populations of over-wintering birds depending on bay resources for food, shelter, resting, and staging before migration (Hickey et al. 2003). San Diego Bay provides the largest expanse of protected bay waters in southern California to migrants on the Flyway (Hickey et al. 2003). The bay also serves as the northern range for tropical species, including some that breed and nest locally.

More than 300 bird species have been documented to use the bay (Port and Navy 2013) with close to half directly depending on it, sometimes in large numbers (Macdonald et al. 1990; Page et al. 1999; USFWS 1994; Terp 1998; Tierra Data Inc. 2009, 2011). The majority, representing 30 families, are migratory and use the bay as a winter stopover, while others come to nest or are resident species present year-round. Some migrants not usually found in the area, disoriented in their travel, on the edges of their range, or simply looking for suitable habitat, are regarded as vagrants. Although vagrants are not ordinarily regarded as dependent on the bay, a considerable number pass through and visit each year (Unitt 2004).

Migrant species regularly observed in high abundance on the San Diego Bay include Eared Grebe (*Podiceps nigricollis*), Western Sandpiper (*Calidris mauri*), and Red-necked Phalarope (*Phalaropus lobatus*). When compared to other midwinter populations of the SCB, the bay provides habitat for more than half of the entire midwinter duck population (USFWS 1995). A comparison to the 1994 winter waterbird population estimate of the Pacific Flyway and the state of California (Bartonek 1994) showed the bay also supporting a substantial proportion of midwinter seabird and waterbird populations.

San Diego Bay provides breeding, wintering, and/or stopover habitat for most shorebirds identified in the Southern Pacific U.S. Shorebird Conservation Plan as retaining primary importance within the region and has been identified as a Western Hemisphere Shorebird Reserve Network site of Regional Importance (Hickey et al. 2003). The bay supports eight of the ten species for which coastal habitats in the Southern Pacific Region are especially important, including the Black-bellied Plover (*Pluvialis squatarola*), Western Snowy Plover (*Charadrius nivosus nivosus*), Semipalmated Plover (*Charadrius semipalmatus*), Willet (*Tringa semipalmata*), Marbled Godwit (*Limosa fedoa*), Black Turnstone (*Arenaria melanocephala*), Short-billed Dowitcher (*Limnodromus griseus*), and Red-necked Phalarope (Hickey et al. 2003). The bay supports significant percentages of Black-necked Stilt (*Himantopus mexicanus*) and Willet in the spring, when over 5% of these species' populations are present; and for Red Knot (*Calidris canutus*) in the fall, spring, and winter, when almost a third of the U.S. Pacific Coast population can be present in the bay (Hickey et al. 2003).

Most shorebirds form roosting flocks during high tide, then disperse to forage on intertidal mudflats as prey are exposed with the ebbing tide. This results in concentrations of shorebirds on beaches, salt ponds, levees, and marsh edges during tidal peaks, as well as in shifting and movements as the tides change, and in concentrations on shorelines and flats as tides ebb (SDNHM and Avian Research Associates 2014; Burger and Olla 1984; Colwell 2010; Recher 1966; Stenzel et al. 2002; Warnock and Takekawa 1995). Significant numbers of seabirds and shorebirds establish nests on the salt pond levees each spring and summer (USFWS 1994; Patton 1999, 2012). These include the federally and state endangered California Least Tern (*Sternula antillarum browni*) and federally threatened Western Snowy Plover. Large multispecies breeding colonies include Double-crested Cormorant (*Phalacrocorax auritus*), Caspian Tern (*Hydroprogne caspia*), Royal Tern (*Thalasseus maxima*), Elegant Tern (*T. elegans*), Forster's Tern (*Sterna forsteri*), Gull-billed Tern (*Geochelidon nilotica*), and Black Skimmer (*Rynchops niger*). American Avocet (*Recurvirostra americana*) and Black-necked Stilt nest on the levees throughout the salt ponds. Smaller numbers of nesting Mallard (*Anas platyrhyncos*), Gadwall (*A. strepera*), and Killdeer (*Charadrius vociferus*) are scattered throughout the salt ponds. Widespread nesting songbirds include Horned Lark (*Eremophila alpestris*) and state endangered Belding's Savannah Sparrow (*Passerculus sandwichensis beldi*) (SDNHM and Avian Research Associates 2014).

San Diego Bay has been divided into four separate hydrodynamic regions based on water circulation, temperature, and salinity. These four regions are the marine, thermal, seasonally hypersaline, and seasonally estuarine (Largier 1995; Largier et al. 1996). For our efforts, these areas correspond to the north, north-central, south-central, and south regions of the bay, with additional survey areas in the salt works and the ocean outside of the bay (see Map 1-2).

Photo 1-2. Intertidal mudflats near Chula Vista Marina.

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Heermann's Gull. © Timothy Burr, 2017.

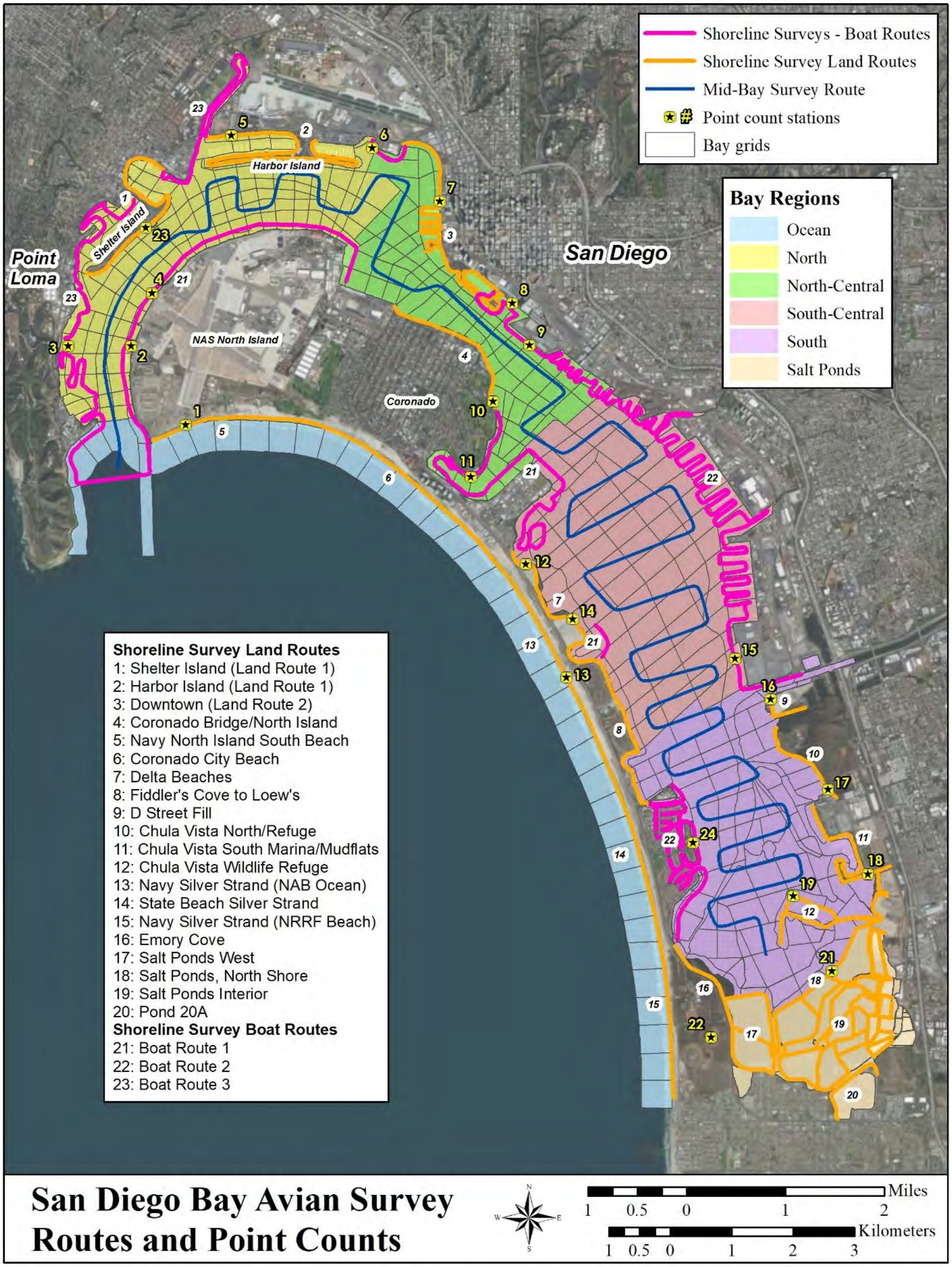
2.0 Methods

The 2006-07, 2009-10, and 2016-2017 surveys are the most comprehensive ever undertaken in San Diego Bay, with methods specifically targeted for maximum detectability of water-dependent birds and how they use habitats of the bay. Covering the entire bay in one year, the surveys documented abundance and richness of all birds in all parts of the bay, as well as along the ocean shoreline of the Coronado peninsula.

Methods for this avian survey were consistent with those utilized in 2006-07 and 2009-10. The survey protocol was developed collaboratively with expert San Diego Bay area birders, the SDNHM, and the USFWS Ecological Services and Refuges. The criteria used to develop methods are described in Tierra Data Inc. (2009). A key objective was to allow detection of a significant change in the population of key species utilizing the bay, defined as a 20% change in abundance between survey years. Methods were developed to focus detection of aquatic birds (i.e., shorebirds, waterfowl, gulls and terns). Marsh birds such as rails, passerines, herons, and egrets were not specifically targeted, and are best surveyed under other specific methodology due to their more secretive behavior; however, these species and all other birds were recorded when observed. The observations collected in the salt works in south San Diego Bay, part of the San Diego Bay National Wildlife Refuge, were funded independently by USFWS for part of the survey period through the Southwest Wetlands Interpretive Center. The data for all salt pond observations collected with that funding is joined with and analyzed in this report, as the same methods were used.

Surveys were broken into three methodologies: Paired Shoreline Surveys, Mid-Water Surveys, and Point Counts. Map 2-1 shows survey locations. Appendix A contains figures showing grid cell locations for the survey routes. Detailed protocols are presented in the sections below and in Appendix B.

- Paired Shoreline Surveys were conducted monthly for ebbing tides and quarterly for peaking tides. The Paired Shoreline Surveys were conducted on 19 unique shore routes, including 17 land routes surveyed on foot and two routes surveyed by bicycle. Paired ebbing and peaking tide surveys were conducted quarterly to document potential shifts in avian abundance, diversity, and use by different foraging guilds at each tidal stage. Observers transited each defined route recording species and number of individual birds in the grid cell where first sighted, and substrate where the bird was first sighted. The grid system has cells of unequal size based on water depth and habitat and has been used for survey or monitoring projects in San Diego Bay for over 15 years (see Map 2-1 and Appendix B).



Map 2-1. Avian survey routes and point count stations in San Diego Bay in 2016-17.

- Mid-Water Surveys were conducted on a meandering route surveyed by boat focusing on mid-water areas not easily observed from the shoreline. These were focused in winter months when migrating waterfowl was expected to be most abundant. All data collection protocols were the same as the shoreline surveys, but these mid-water routes were not timed with tidal cycle; rather, they were conducted in the morning hours when winds were calmer than in the afternoon. Like the shoreline surveys, observations were also recorded by grid cell (see Map 2-1 and Appendix B).
- Point Count Surveys were conducted using fixed distances and timed durations at 23 locations. These points were chosen for several different reasons, including coordination with other monitoring efforts, as sites of special management concern to the Navy or Port, or as known bird congregation areas. Concentric rings (50-, 100-, and 500-meter radius) were developed around these points and an "instantaneous" count of each species within the rings was taken.

Table 2-1 lists observers who participated in this project. Many other individuals participated in various capacities, such as vessel pilots, data recorders, data entry, error checking, and analysis. The number of observers required for this effort reflects the fact that surveys were conducted over the whole bay simultaneously.

Table 2-1. Individuals who participated in identifying birds for the San Diego Bay bird survey.

Observers		
Mark Billings	John Konecny	Robert Patton
Elizabeth Copper	Joseph Kean	Maggie Lee Post
Gretchen Cummings	John Lovio	Rachel Smith
Kim Ferree	Karly Moore	Lea Squires
Brian Foster	Katrina Murbock	Phil Unitt
Gabriela Ibarguchi	Thomas Myers	Ignacio Vilches

2.1 Shoreline Surveys

Shoreline surveys took place monthly between July 2016 and June 2017 (Table 2-2) on 22 survey routes (see Map 2-1). Surveys were conducted within four hours preceding low tide. Ebbing tide surveys are designed to capture bird use of foraging habitats such as mudflats and other substrates which become exposed by receding water.

Peaking tide surveys were also conducted, over the crest of the tide, four times throughout the year—August, November, February, and May. At the discretion of field observers, additional peaking tide surveys were conducted in other months on the ocean beaches of the Silver Strand and salt works areas to capture known bird concentrations there during peaking tide. (These additional peaking tide data sets are not included in analysis when comparing this survey to previous surveys since they would artificially inflate the 2016-17 numbers.) It was the intention to complete all surveys over the course of three days; however, at times adverse weather conditions delayed survey teams.

Table 2-2. Survey dates and tides for the San Diego Bay shoreline surveys.

Month	Survey Days	Tidal Cycle
July 2016	18-20	Ebbing
August	29-31	Peaking and Ebbing
September	15-17	Ebbing
October	26-28	Ebbing
November	14-17	Peaking and Ebbing
December	10-13, 15	Ebbing
January 2017	9-11, 17	Ebbing
February	26-28; 1, 2 (March)[1]	Peaking and Ebbing
March	23-25	Ebbing
April	24-26	Ebbing[2]
May	23-25	Peaking and Ebbing[3]
June	20-23	Ebbing[4]

[1] Some surveys were delayed due to adverse weather conditions.
[2] Peaking tide surveys were also conducted during April for 10 routes.
[3] On 10 routes either peaking or ebbing surveys were conducted, not both. Both surveys were conducted on the other 12 routes.
[4] On 2 routes the field observers opted for conducting surveys at peaking instead of ebbing tide.

Scheduling of ebbing tide surveys was sometimes fine-tuned based on experience of subareas throughout a tidal cycle. For example, due to substrate elevation and topography, optimal habitat exposure for shorebirds in the southern portion of the western ponds was found to occur as tide ebbs from 6.0 to 5.5 feet above mean lower low water (MLLW). Surveys progressed from south to north as the tide receded into the south bay to capture the best tidal window. Start times at the flats of Emory Cove and the north shore of the salt works were targeted to coincide with ebbing tide levels of 3.0 to 2.5 feet. The observers were requested to photograph the time of maximum exposure of each route, with a time stamp on the photo, so that timing of surveys for maximum detection of shorebirds could be refined for each survey segment. Appendix C contains habitat and tide analysis forms to determine time of maximum exposure of habitat for different locations around the bay.

The shoreline surveys were conducted either on foot, bicycle or boat, depending upon the most advantageous view and access (Photo 2-1). Map 2-1 identifies shoreline survey boat routes and land routes. Many land and water locations consisted of Navy security zones. Private areas, such as the National Steel and Shipbuilding Company (NASSCO) shipyard, hire individual security patrols. A security form was forwarded to the appropriate Points of Contact one week prior to survey work.

Photo 2-1. Examples of shoreline survey areas. (Left) Silver Strand State Beach. (Right) View of North Bay from the survey boat.

Observers were assigned an area and transited an established route recording species, number of individual birds observed, and substrate where the bird was first sighted. Substrate classifications were defined as:

- Air: a bird flying;
- Upland: a bird anywhere above the high-water line;
  - Trees/tall vegetation
  - Shrubs/mid-height vegetation
  - Low forbs/grasses
  - Unvegetated ground – (≤5% vegetation) Ex: dirt
  - Hard artificial substrate – Ex: asphalt or sidewalk
  - Artificial perch – Ex: lamp post, wire, fence
- Tidal: a bird on or in the water, on a structure that is in or above the water, or in any intertidal area;
  - Above-water attached structure – Ex: dock/pier, long-term docked boat
  - In-water perch – Ex: buoy, boom, lobster trap, boat, pilings, etc.
  - Riprap
  - Vegetated – Ex: salt march
  - Sandy beach
  - Mud
  - Open water

In addition to species and substrate information, time of day, air temperature, wind, cloud cover, visibility, and precipitation were recorded.

2.2 Mid-Water Surveys

Surveys focusing on detecting birds using the open water were conducted once monthly between November 2016 and February 2017, when maximum migratory waterfowl were expected (Table 2-3). During the winter, these species assemble in rafts or flocks. Surveys began in the morning, and all were completed by early afternoon. Wind and water conditions were monitored and survey times adjusted to ensure conditions were as optimal as possible on the day selected for visibility. Survey times were also adjusted to avoid conditions such as high winds during which birds might not be foraging as expected. Weather conditions are generally more calm and consistent during mornings than afternoons, when chop from increasing winds can make it difficult to detect rafting waterbirds. Additionally, survey start times were scheduled early to avoid the typical increase of boat traffic on the bay through mid-day.

Table 2-3. Mid-water survey dates and times.

Survey Date		Time (24-hour clock, U.S. Pacific Time)
Month	Day	
November 2016	17	07:30
December 2016	15	06:45
January 2017	17	09:00
February 2017	March 1*	07:00

**Weather conditions forced a delay to the February surveys.*

Two boats were needed to complete the surveys to cover the entire bay in a single morning. One vessel started at the mouth of the bay and the other at the south end of the bay near the salt ponds. Radio contact between the two was maintained ensuring start times and survey pace. The boats traveled between 5 and 20 miles per hour, stopping very briefly to count rafting birds if necessary. Boats moved throughout the bay ensuring that all open water cells in the bay, as well as a few cells touching the shoreline in narrow areas of the bay, were covered in the waterbird surveys. Observers tracked their position in the bay using a hand-held global positioning system (GPS) unit displaying the bay grid and a location beacon. Instructions were to survey for waterbirds. All bird observations were recorded by grid. Field conditions within each cell were noted, including date, start and stop times, tidal conditions, ambient temperature, estimated wind speed and direction, precipitation, percent of cloud cover, and visibility.

2.3 Point Counts

In addition to the shoreline survey of grid cells, point counts are conducted at established locations along the shoreline routes. Observations are recorded for a timed duration within a specified distance from the observer's location to allow for calculation of bird density, unlike the shoreline surveys which cover differing acreages and can extend for variable survey durations. The calculation of bird density for a set time and area allows a comparison to other locations, and to the same location over time, due to this standardization. The results represent an index and not a true measure of density because they do not account for bias related to probability of detection (Royle et al. 2005).

A total of 22 point count stations were established 2006-07 and 2009-10. Two new stations were established in 2016-17: Station 23 was established at Shelter Island and Station 24 at the Gran Caribe Isle. These two stations were added to establish the baseline bird abundance and diversity at locations where the Port had future development plans. Below is a summary of why the various locations were identified for density estimates that could be used as an index for comparative purposes.

- Natural Resource Damage Assessment (NRDA) sites: Points 1, 2, 3, 12, 13, 16, 18, 19, and 20;
- Long-term fish sampling locations established by Allen (1999): Points 4, 10, 14, and 19;
- Sites of special management interest to the Navy or Port: Points 1, 6, 7, 8, 9, 15, 16, 17, 21, 22, 23 and 24; and
- Known bird congregation areas: Points 1, 4, 5, 10, 11, 12, 13, 16, 20, 21.

At each point count station, all birds observed during a 15-minute period (broken into three increments of five minutes each) were recorded as occurring within one of three concentric rings (50-, 100-, and 500-meter radius) around each point count station. An exception was made at the Gran Caribe Isle (Station 24), where the "point" consisted of a timed walk along the western shore six acres south of the isthmus. As with the shoreline surveys, birds flying overhead were included in the count, if they occurred within the circle at the beginning of the count. The substrate on which the birds were seen was also recorded in the same way as the shoreline surveys.

Map 2-2. Point Count Station 24 (Gran Caribe Isle) in 2016-17.

Density was calculated by dividing the number of individual birds observed by the total area observable of the 500-meter radius around each point. Each point had a potential observable area of 78.4 ha. However, for many of the point count locations, the base 500-meter radius included areas of non-tidal upland (Figure 2-1) and areas that were obstructed from view. As these surveys were intended to focus solely on shorelines and in-water habitats, these obstructed and upland areas were not included in the observations and the density calculations were therefore performed using only the observable shoreline and tidal areas. As these counts are done at the same time as the shoreline transect surveys and are thus a subset of those, all analyses of totals and trends use only data collected during shoreline and waterbird surveys. The density data from point counts can be compared directly for site-specific trends over time (see Section 3.3.3 and Appendix E).

Sketches of habitat associated with point count locations were completed during the 2009-10 surveys (see Tierra Data Inc. 2011).

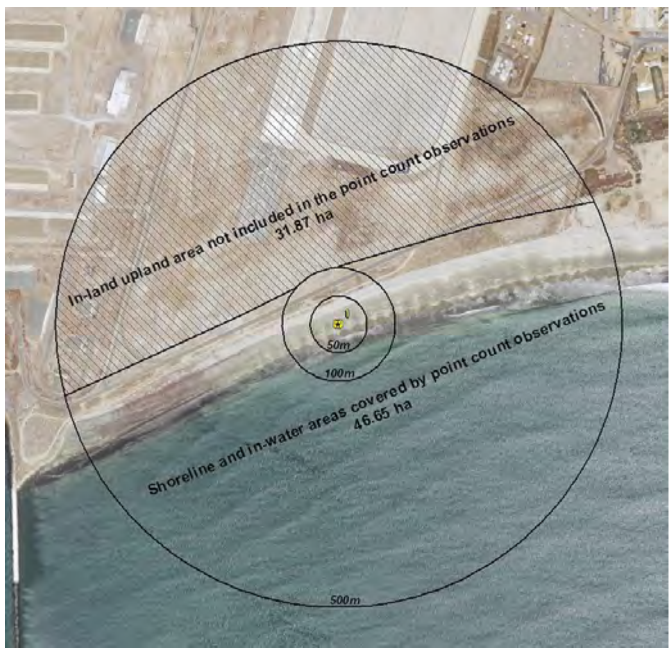


Figure 2-1. Point Count Station 1. Example of how survey areas were adjusted prior to calculating bird density by excluding areas of non-tidal upland and visually obstructed areas during the point count.

2.4 Data Collection and Summary

Observations were recorded digitally or on paper data sheets, based on observer preference. For those observers opting for digital recording of data, an application for use on tablet devices or on cell phones was provided. The data form application was designed using ESRI Collector to be filled out and downloaded to a central database when completed. All data were compiled into Microsoft Excel spreadsheets. Original data forms were maintained to allow for error checking and following up with observers to answer questions about specific records.

Data sheets and survey protocols are presented in Appendix B. Each observer was paired with a person to record to facilitate keeping eyes on the water or shore rather than on a notebook or tablet, and for timely submittal of data records.

Bay Regions

Data were summarized by grid cell and by six bay subregions: North, North-Central, South-Central, South, Salt Works, and Ocean Beach, which encompassed the Pacific Ocean side of Silver Strand. Abundance (total number of observations), species richness (individual species per grid cell or region), and species diversity (evenness of species distribution by grid cell or region) were all calculated and reported, and density (observations per area of grid cell) was calculated for ranking purposes and depiction on a map.

Seasonality

To depict how birds fluctuate in abundance, the data were grouped into four seasons. For the ebbing tide surveys, which were done every month, the seasons were evaluated as follows:

- Winter (December, January, **February**),
- Spring (March, *April*, **May**),
- Summer (June, July, **August**),
- and Fall (September, October, **November**).

The peaking tide surveys were conducted quarterly, and therefore each season is represented by only one month's data (shown in **bold** above), with one exception. In May 2017, only ebbing tide surveys were performed on six of the surveys routes. In April 2017, peaking tide surveys were performed in addition to the ebbing tide surveys on certain shoreline routes, including the six routes lacking May peaking tide surveys. Therefore, the spring peaking tide data analyzed in this report represent a combination of the six extra April peaking tide data sets and all the May surveys such that each route was represented once in the analysis of the spring peaking tide surveys.

As the ebbing tide surveys included three monthly surveys per season, and the peaking tide surveys included only one each, directly comparing the resulting numbers would be misleading. To allow for direct comparisons of peaking and ebbing tide surveys by season, three-month averages of bird abundance, density, richness, and diversity were calculated.

Abundance and Density

Initial calculations and mapping consisted of species lists with abundance data in each cell of the survey grid for both the shoreline and mid-water surveys. However, since the bay grid cells vary in size, abundance numbers alone can be misleading. A more accurate measure is the density of birds observed in each cell, calculated by dividing the total number of observations by the cell area in hectares. All observations were used for this measure whether they indicated specific species or merely the group.

Species Richness

Species richness was calculated as the total number of unique species observed within each survey cell. Only identified species were used for this calculation (i.e., observations recorded only to group, such as “Gull sp.”, were not used since it was not determined to be a unique species). Species richness provides a measure of the diversity of bird species inhabiting certain regions of the bay, and specific grid cells within each region.

3.0 Results

A total of 564,752 individual bird observations, representing 161 distinct species, were recorded during the shoreline and mid-water surveys in 2016-17. Additionally, a total of 102,944 individual observations were recorded during point counts at 23 locations around the bay.

Appendix D presents a combined species list for all surveys (Table D-1), species lists and number of individual birds observed per month during the shoreline surveys at ebbing (Table D-2) and peaking tides (Table D-3), and species and number observed during the mid-water surveys (Table D-4). Appendix E presents the species lists and numbers observed at each point count station. Summaries for each survey type are presented separately below. Appendix F contains summaries of birds observed by grid, organized by region as shown on Map 2-1. Appendix G contains species profiles and ebbing tide survey results for the three survey periods since 2006 for the more abundant species.

3.1 Shoreline Surveys

3.1.1 Abundance

A total of 556,619 observations were made during the shoreline portion of the 2016-17 survey effort. Of these, 434,594 birds and 154 species were observed during the ebbing tide surveys and 122,025 birds and 154 species were observed during the peaking tide surveys. Abundance of observed birds is greatest along extensive mudflat areas in the south bay, in certain salt ponds, and around the bait barge in north bay. The salt ponds have the greatest abundance of observed birds, while the north-central and south-central regions have the lowest. Table 3-1 and Figure 3-1 compare the numbers of birds observed among the surveyed bay regions.

In 2016-17 the total number of observations in the ebbing tide surveys was somewhat lower in all regions except the south bay and salt ponds, which have seen a steady increase in abundance over the course of the three surveys (Figure 3-1). For the peaking tide surveys, the total number of observations in 2016-17 was lower for all regions compared to the previous surveys.

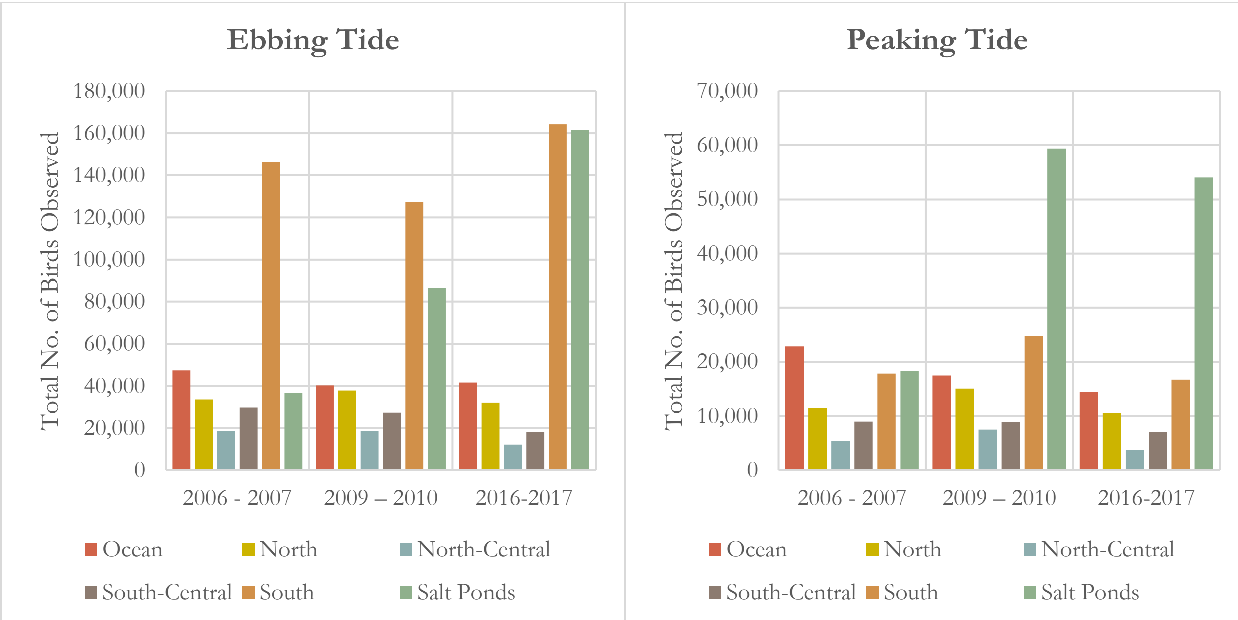


Figure 3-1. Comparison of total bird abundance by bay region in 2006-07, 2009-10, and 2016-17 during ebbing (left) and peaking (right) tide shoreline surveys.

Table 3-1. Number of individual birds observed in each of the bay regions in 2006-07, 2009-10, and 2016-17 shoreline surveys.*

Region	2006-07		2009-10		2016-17	
	Ebbing	Peaking	Ebbing	Peaking	Ebbing[1]	Peaking[2,3]
Ocean	47,399	22,867	40,211	17,486	41,907	15,625
North	33,531	11,457	37,756	15,061	28,694	10,323
North-Central	18,584	5,414	18,596	7,472	12,131	3,902
South-Central	29,742	8,953	27,298	8,890	18,022	5,871
South	146,517	17,811	127,495	24,786	164,297	18,547
Salt Ponds	36,631	18,285	86,389	59,375	169,543	67,757
Total	**312,404**	**84,787**	**337,745**	**133,070**	**434,594**	**122,025**

*Note that total observations in 2016-17 include surveys conducted in May and July, which were not surveyed in the two previous survey periods.

[1] In May 2017, four routes were not surveyed at ebbing tide; Salt Pond Interior (Salt Ponds), Emory Cove (South Bay), Coronado City Beach & Silver Strand State Beach (Ocean).

[2] Numbers include only those peaking tide surveys conducted in August, November, February, and May.

[3] In May 2017, six routes were not surveyed at peaking tide; CVWR & D Street Fill (South Bay), Salt Ponds North Shore & Pond 20A (Salt Ponds), Coronado Bridge/North Island (North-Central Bay), Fiddler's Cove/Loew's (South-Central and South Bay).

The number of individual birds observed per month during the ebbing tide surveys varied considerably with a high of 69,752 in December 2016 followed by a low of 5,992 in May 2017 (Table 3-2). Overall trends were very consistent with the 2006-07 and the 2009-10 surveys. Although, out of all three survey periods, four of the monthly surveys in 2016-17 produced the highest number of individual birds recorded. For both the ebbing and peaking tide surveys, the highest numbers of individual birds were observed in late fall/early winter, while a considerable drop occurred in the late spring/summer period (Table 3-3). Compared to previous surveys, the 2016-17 surveys saw the highest numbers of individual birds observed during three of the four seasons (winter, spring, and summer). The higher numbers of individual birds observed in 2016-17 were likely due to increased avian usage of the salt ponds. While observations in all other bay regions have remained fairly constant or fluctuated over the three survey periods, the numbers of individual birds observed in the salt works have increased dramatically since 2006-07 (Figure 3-2). This is likely a result of efforts to re-open some of the ponds to tidal flushing, providing additional foraging area. A similar increase in bird observations during peaking tides was also seen (Figure 3-2).

Table 3-2. Number of individual birds observed each month during the ebbing tide and peaking tide shoreline surveys. Highest and Lowest numbers for each survey type, within each survey period are highlighted.

	Number of Individual Birds Observed					
	2006-07		2009-10		2016-17	
Month	Ebbing	Peaking	Ebbing	Peaking	Ebbing	Peaking
January	48,651	-	46,338	-	56,615	-
February	36,202	35,077	35,617	34,560	42,935	32,558
March	44,340	-	34,958	**12,176**	41,079	-
April	16,904	**23,291**	**12,656**	-	20,427	18,634[1]
May	-	-	-	-	**5,992**[2]	**9,096**[2]
June	**15,014**	-	16,049	**44,406**	15,354	-
July	-	-	-	-	46,931	-
August	28,560	27,996	17,229	-	19,604	27,826
September	55,143	-	46,204	-	38,459	-
October	42,761	-	25,622	41,928	41,704	-
November	42,093	**35,443**	**54,037**	-	35,545	**33,596**
December	**58,087**	-	49,035	-	**69,636**	-

[1] Peaking tide surveys were conducted on ten routes although April was originally planned to be ebbing tide surveys only.

[2] May surveys were originally planned to include both ebbing and peaking tide surveys. However, peaking tide surveys were not conducted on six survey routes, and ebbing tide surveys were not conducted on four other routes.

Table 3-3. Number of individual birds observed each season during the ebbing tide shoreline surveys. Highest and Lowest numbers for each survey type, within each survey period are highlighted in bold.

	Number of Individual Birds Observed					
	2006-07		2009-10		2016-17	
Season	Ebbing	Peaking	Ebbing	Peaking	Ebbing	Peaking
Winter (Dec.-Feb.)	**142,940**	35,077	**130,990**	34,560	169,186	32,558
Spring (Mar.-May)	61,244	**23,291**	47,614	**12,176**	121,428	11,531[1]
Summer (Jun.-Aug.)	**43,574**	27,996	**33,278**	**44,406**	**81,889**	**27,826**
Fall (Sep.-Nov.)	139,997	**35,443**	125,863	41,928	115,708	**33,596**

[1] The spring peaking tide surveys in 2017 were conducted primarily in May. However, since peaking tide surveys on six routes were not conducted in May, data from April 2017 for those routes were compiled with the May data for the other 14 routes such that each route was represented. The other four routes for which peaking tide surveys were conducted in April are not included this summary.

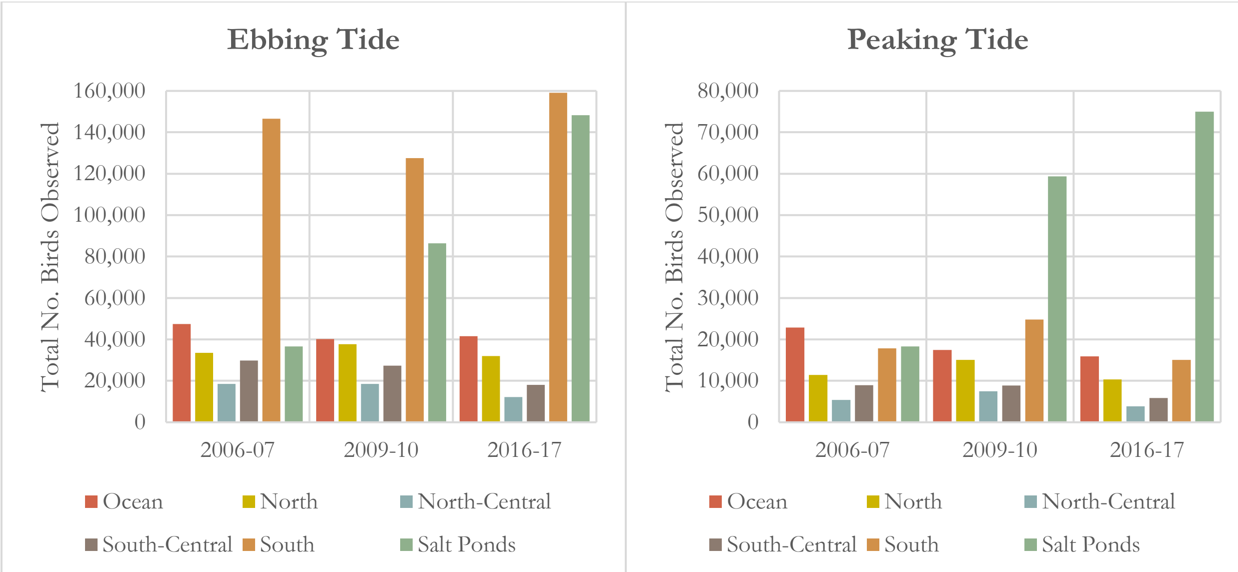


Figure 3-2. Distribution of total birds observed by bay region in 2006-07, 2009-10, and 2016-17 during ebbing (left) and peaking (right) tide shoreline surveys.

3.1.2 Abundance by Species and Species Assemblage

The most abundant species observed during the ebbing tide surveys within each species assemblage are given in Table 3-4.

Table 3-4. Top three species observed by species assemblage during ebbing tide shoreline surveys in 2016-17.

Marshbirds	**No. Observed**	**Terrestrial Birds**	**No. Observed**
Belding's Savannah Sparrow	1,745	Rock Pigeon	5,146
Snowy Egret	846	House Finch	2,691
Great Blue Heron	709	Horned Lark	1,461
Seabirds	**No. Observed**	**Waterfowl**	**No. Observed**
Elegant Tern	32,808	Eared Grebe	16,554
Western Gull	23,432	Surf Scoter	14,789
California Gull	9,897	Brant	13,785
Shorebirds	**No. Observed**		
Western Sandpiper	129,683		
Peep sp.	14,812		
Willet	11,984		

Several species showed marked differences in overall abundance during the ebbing tide shoreline surveys from 2006-07 to 2016-17 (Table 3-5). A total of 14 species were at least 20% less abundant in 2016-17, while 17 other species increased by at least 20%. Red-necked Phalaropes showed the greatest decline from 13,974 individuals observed in 2006-07 to only 1,270 individuals observed in 2016-17. Three other species were at least 50% less abundant in 2016-17 (Marbled Godwit, Ring-billed Gull [*Larus delawarensis*], and Bufflehead [*Bucephala albeola*]).

Table 3-5. Species with counts of 1,000+ individuals during the shoreline ebbing tide surveys showing a change of >20% between 2006-07 and 2016-17.

Species	2016-17	2009-10	2006-07	Difference 2006-07/2016-17	% Change
Species Decreased from 2006-07 to 2016-17					
Red-necked Phalarope	1,270	8,803	13,974	-12,704	-90.9
Ring-billed Gull	2,068	2,972	4,955	-2,887	-58.3
Bufflehead	1,302	3,223	2,986	-1,684	-56.4
Marbled Godwit	10,563	13,517	23,654	-13,091	-55.3
Heermann's Gull	3,478	7,434	6,572	-3,094	-47.1
Mallard	1,085	1,087	2,016	-931	-46.2
Brown Pelican	3,867	7,512	6,664	-2,797	-42.0
Double-crested Cormorant	3,760	6,057	6,398	-2,638	-41.2
Black Skimmer	2,314	687	3,655	-1,341	-36.7
Rock Pigeon	4,945	5,109	7,641	-2,696	-35.3
Willet	11,984	7,932	17,978	-5,994	-33.3
Sanderling	7,204	7,975	10,498	-3,294	-31.4
Black-necked Stilt	2,061	1,998	2,756	-695	-25.2
Forster's Tern	2,096	2,518	2,757	-661	-24.0
Species Increases from 2006-07 to 2016-17					
Royal Tern	4,041	1,370	1,135	2,906	256.0
Elegant Tern	32,808	12,836	10,124	22,684	224.1
Least Sandpiper	10,029	2,989	3,452	6,577	190.5
Brant	13,785	5,050	5,168	8,617	166.7
Belding's Savannah Sparrow	1,745	1,175	714	1,031	144.4
California Gull	9,897	4,722	4,966	4,931	99.3
California Least Tern	1,855	565	990	865	87.4
Northern Shoveler	3,104	1,646	1,660	1,444	87.0
Western Sandpiper	129,708	66,781	77,716	51,992	66.9
Brandt's Cormorant	8,448	10,589	5,306	3,142	59.2
American Avocet	1,186	522	758	428	56.5
Eared Grebe	16,554	13,376	10,718	5,836	54.5
Semipalmated Plover	6,322	3,832	4,700	1,622	34.5
Black-bellied Plover	11,822	9,255	9,063	2,759	30.4
House Finch	2,691	1,165	2,136	555	26.0
Horned Lark	1,461	774	1,173	288	24.6
Western Snowy Plover	2,205	1,848	1,789	416	23.3

Five species were at least twice as abundant in 2016-17 (Belding's Savannah Sparrow, Royal Tern, Least Sandpiper [*Calidris minutilla*], Brant [*Branta bernicla*], and Elegant Tern), while seven other species increased by at least 50% (American Avocet, California Least Tern, Northern Shoveler [*Anas clypeata*], Brandt's Cormorant [*Phalacrocorax penicillatus*], California Gull [*Larus californicus californicus*], Eared Grebe, and Western Sandpiper).

Shorebirds were the most abundant of the five assemblages during 2016-17 shoreline surveys, with over 92,000 individuals observed during the winter ebbing tides. The only period when shorebirds were not the most abundant assemblage was during the summer ebbing tides when seabirds were the most observed (33,615 seabirds, 30,701 shorebirds). Results organized by species assemblage are shown in Figure 3-3, showing seasonal abundance of birds observed during the shoreline surveys at peaking tide (one survey per season) and ebbing tide (average of three surveys per season). Seasonally, shorebirds and waterfowl were most abundant during the winter ebbing tide surveys, in comparison to the summer and spring. Shorebirds were also very abundant in the fall, while waterfowl abundance was relatively low the rest of the year. Seabirds showed a reverse seasonality, with the highest number observed in the summer. Marsh birds and terrestrial bird abundances remained relatively even from season-to-season. Most salt marsh birds and many birds that occupy the urban interface are resident rather than migratory so their number would not be expected to fluctuate through the year.

Among bay subregions, the salt ponds and south bay had the highest abundances observed, primarily among shorebirds (Figure 3-4; Figure 3-5). Eared Grebes dominated the grebe counts in 2016-17, and abundance was focused within the interior, non-tidal salt ponds.

3.1.3 Density

Density of birds observed in 2016-17 varied greatly by season and location (Figure 3-6; Map 3-1; Map 3-2), with the highest densities observed in the salt ponds during the winter and fall surveys. In most seasons and bay regions, the observed density of birds at peaking and ebbing tide were generally similar, with a few exceptions. In the winter surveys, higher densities were observed during ebbing tide in the south bay, while in the salt ponds the peaking tide surveys had higher densities. A similar comparison is seen in the summer, though at much lower densities. In the spring and fall, however, the ebbing tide surveys showed the higher densities in both the south bay and salt ponds.

Bird densities during the ebbing and peaking tide survey were noticeably different at several locations in the bay (Map 3-3). The bait barge at the north end of the bay as well as several mudflat and marsh areas in the south bay had additional birds during ebbing tide, particularly in the southeastern portion of the bay. During the peaking tide, the bird density was much higher in the interior salt ponds, which were a key concentration area. Additional peaking tide concentrations occurred in a few areas along the Coronado shore, near the enhancement island in the central bay, and in many of the harbors.

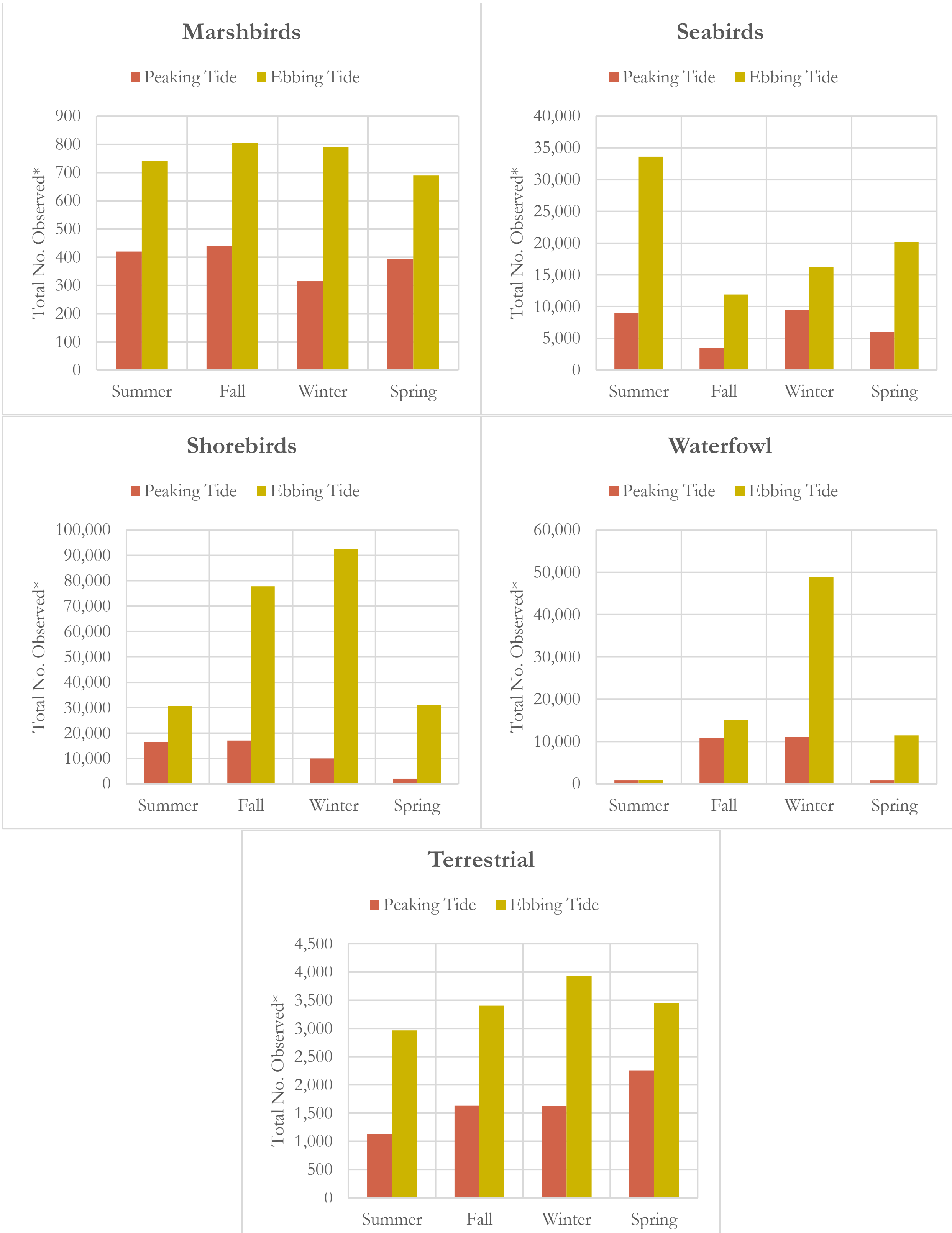


Figure 3-3. Seasonal abundance of birds by species assemblage observed during the shoreline surveys at peaking tide (one survey per season) and ebbing tide (average of three surveys per season).

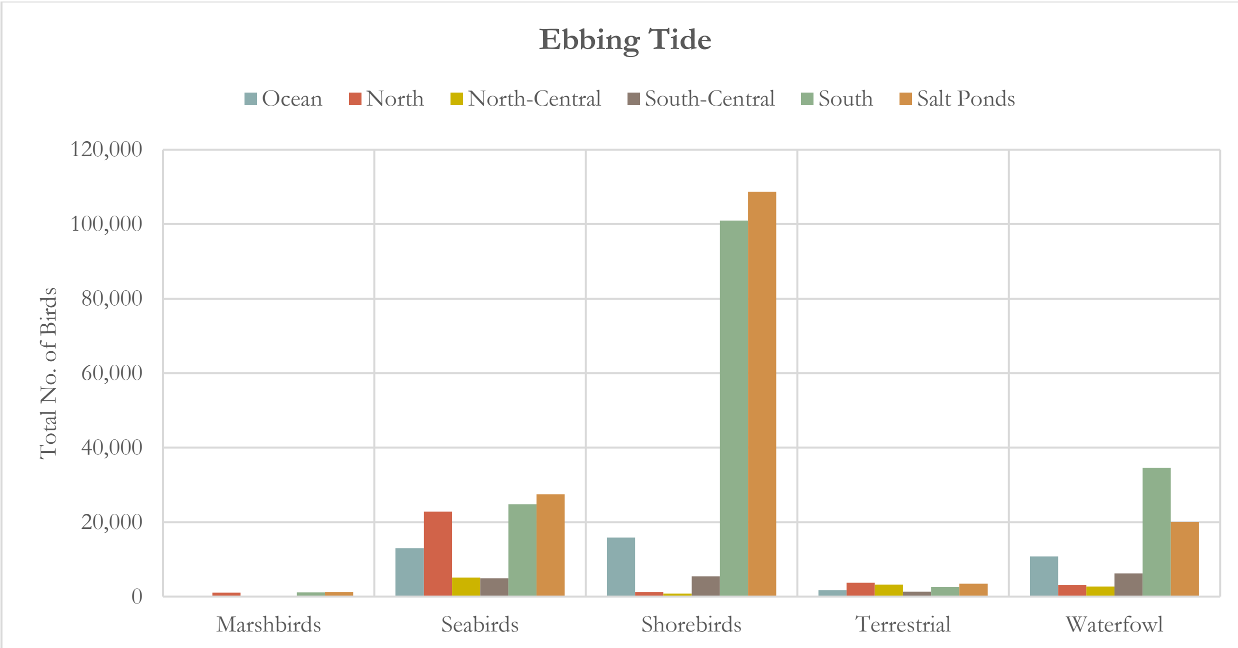


Figure 3-4. Distribution of bird species assemblages during the 2016-17 ebbing tide shoreline surveys.

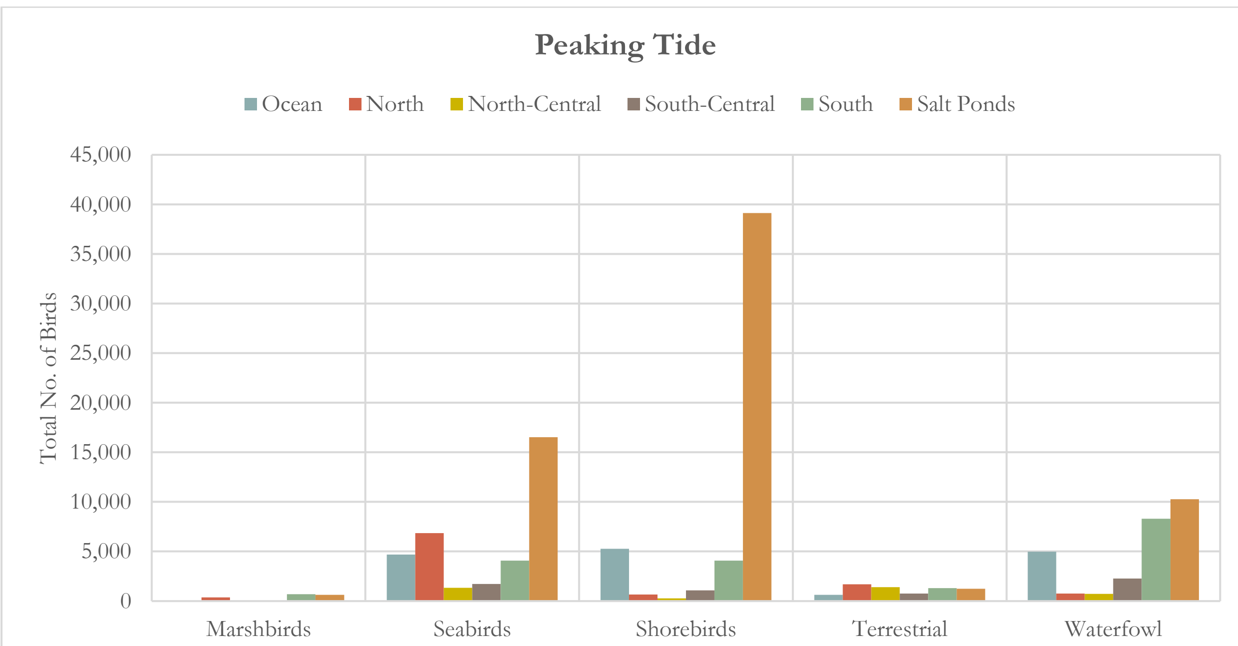


Figure 3-5. Distribution of bird species assemblages during the 2016-17 peaking tide shoreline surveys.

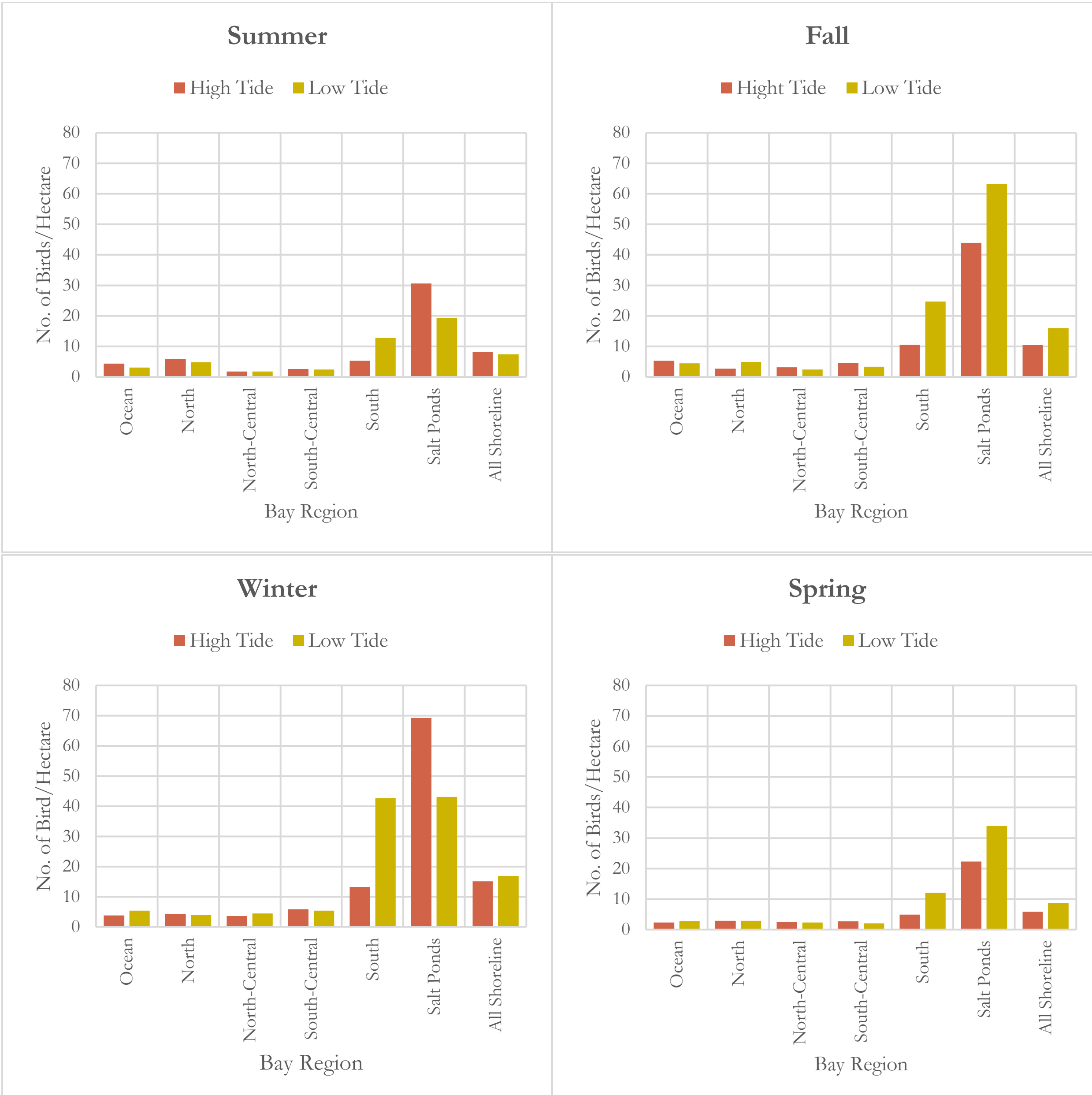
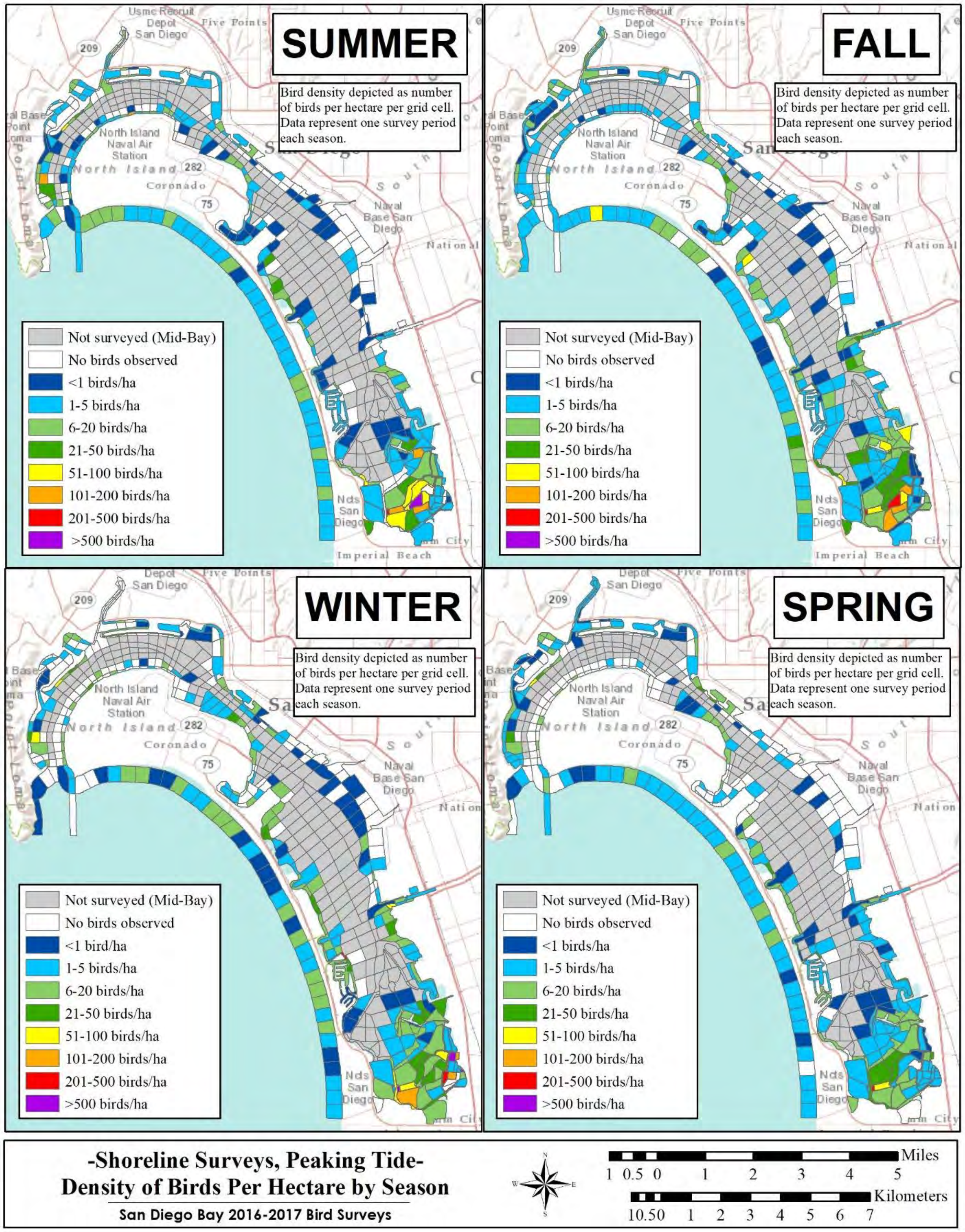
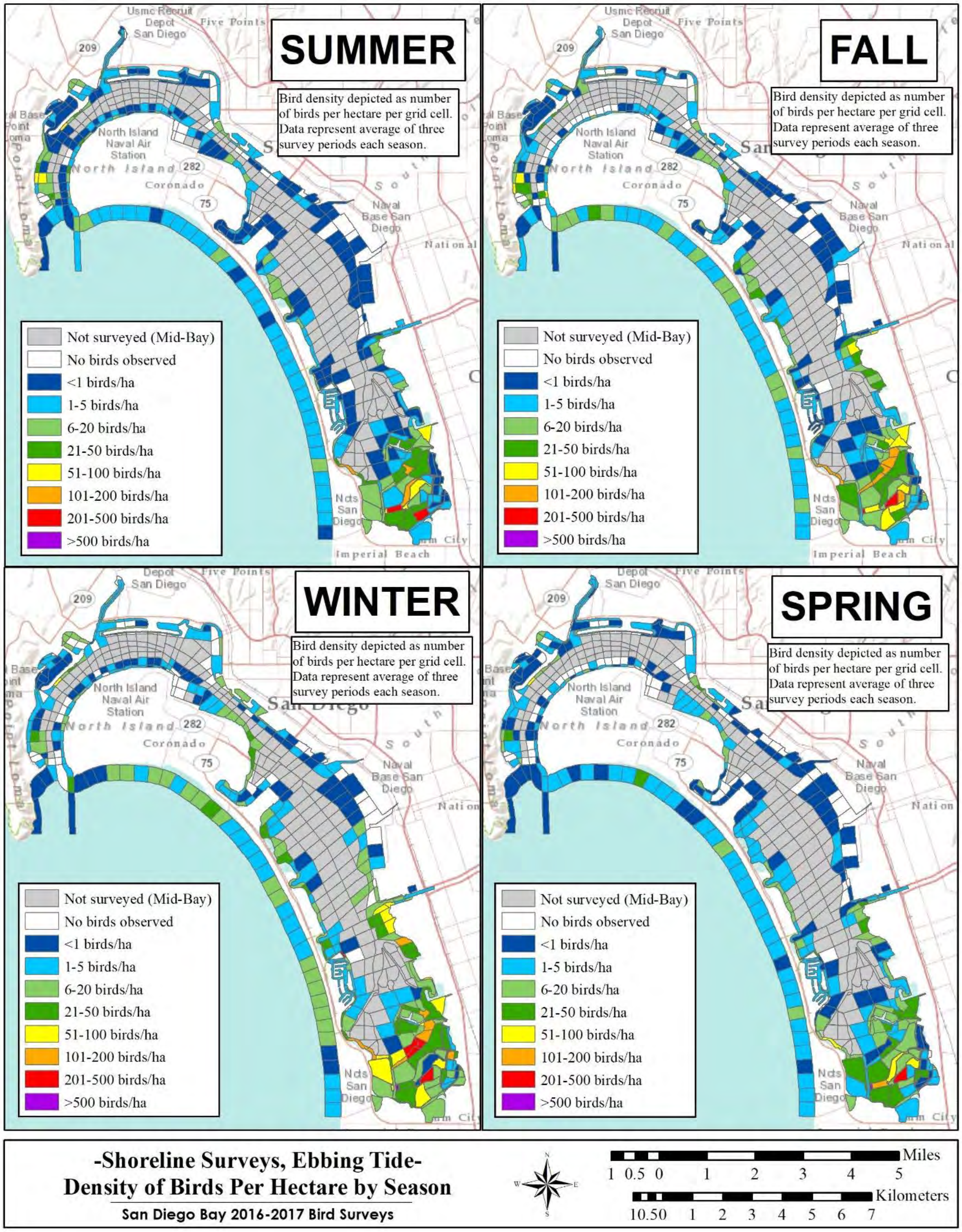


Figure 3-6. Seasonal density (number of individual birds per hectare) of birds observed during ebbing and peaking tide shoreline surveys by bay region in 2016-17.



Map 3-1. Density of birds observed during the 2016-17 peaking tide shoreline surveys in San Diego Bay.



Map 3-2. Density of birds observed during the 2016-17 ebbing tide shoreline surveys in San Diego Bay.

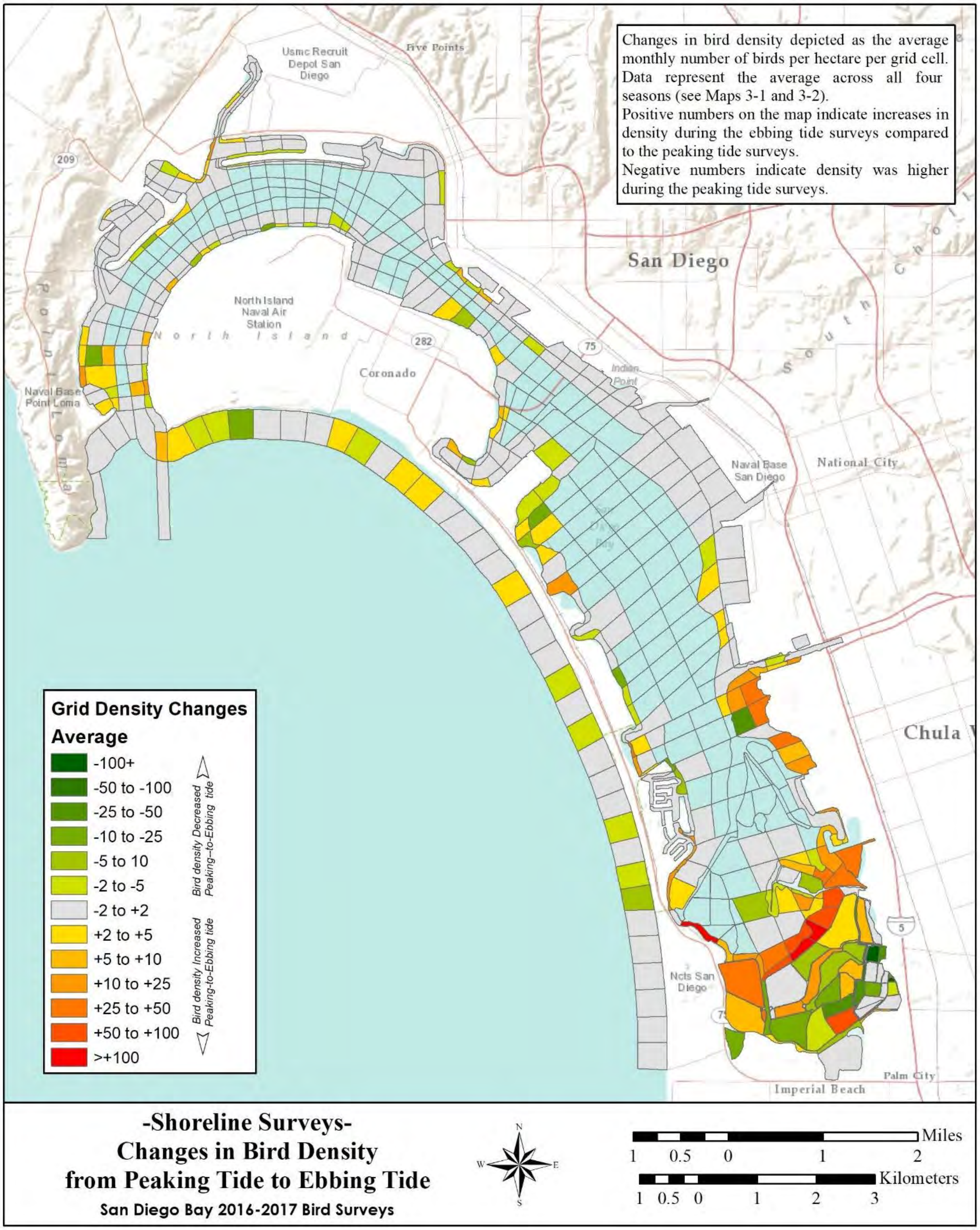
3.1.4 Species Richness

During the bay bird surveys 161 distinct species or subspecies were observed, compared to over 300 on record for San Diego Bay (Port and Navy 2013). The total number of species observed in 2016-17 (peaking and ebbing tide surveys combined) was lower than in previous years except for the south bay and salt ponds (Table 3-6). Species richness in 2016-17 was greatest in the south bay and salt ponds, and lowest in the north-central subregion (Table 3-6). Species richness was greatest along the southern edge of the south bay (mudflat just north of the salt ponds) and the salt ponds, as well as along the eastern shore of the south bay (Chula Vista Wildlife Refuge) (Map 3-4). Species richness was lowest along the eastern shore of the north-central and south-central bay, and along the north shore of North Island. The lower number of species observed in the peaking tide surveys compared to the ebbing tide surveys is likely due to different number of surveys (four surveys at peaking tide compared to 10-12 surveys at ebbing tide each year).

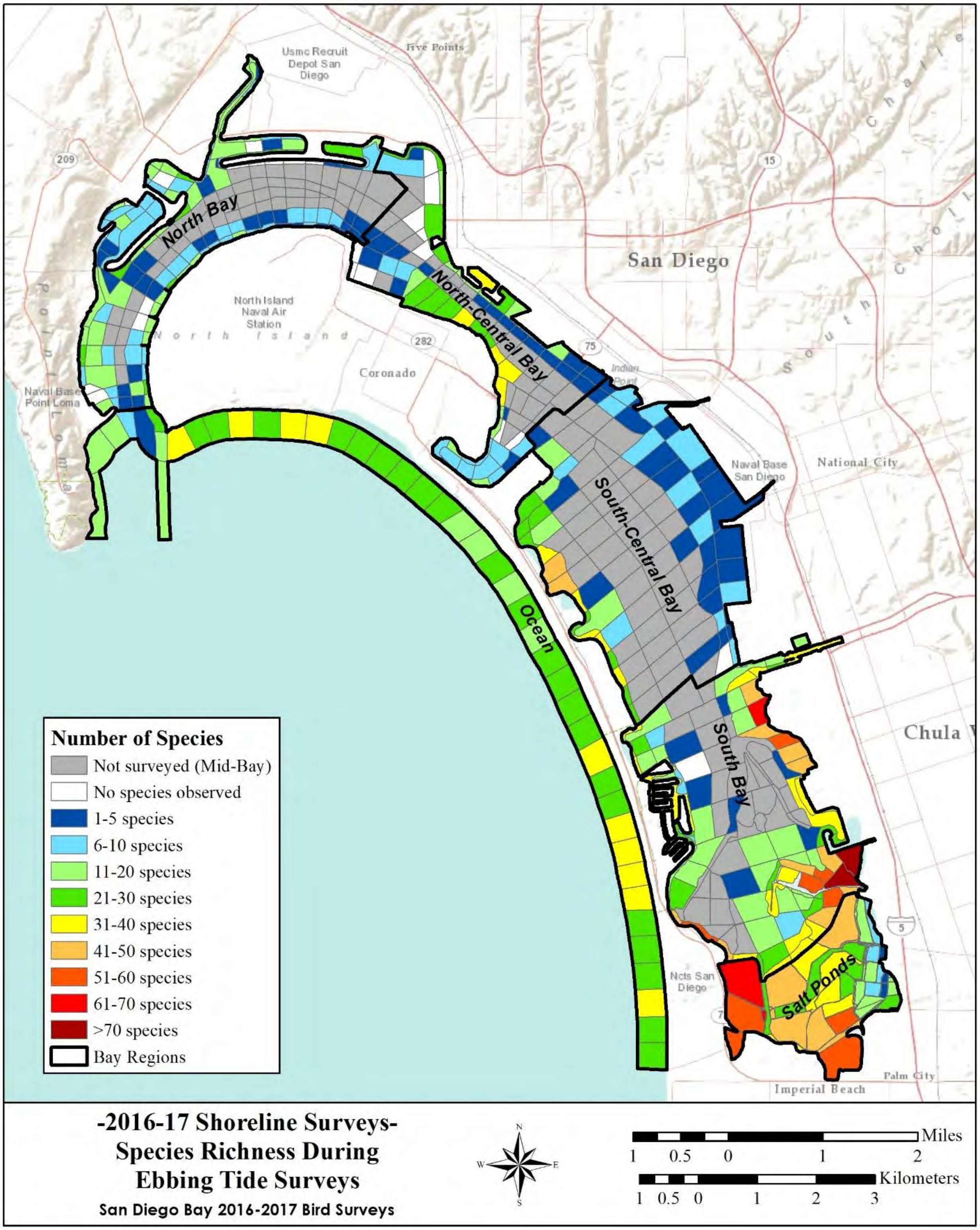
Table 3-6. Number of distinct species observed by region during the 2006-07, 2009-10, and 2016-17 shoreline surveys.

Region	2006-07			2009-10			2016-17		
	Total Species	Ebbing Tide*	Peaking Tide	Total Species	Ebbing Tide*	Peaking Tide	Total Species	Ebbing Tide*	Peaking Tide
Ocean	106	100	87	91	79	75	90	86	73
North	107	98	72	98	91	81	90	84	68
North-Central	89	79	73	92	79	72	80	75	64
South-Central	100	94	81	100	94	83	93	87	70
South	140	132	114	131	127	103	141	129	1127
Salt Ponds	128	119	109	128	123	105	132	117	112
All Regions	183	168	156	174	164	144	164	150	151

*In 2006-07 and 2009-10, only ten ebbing tide surveys were conducted. In 2016-17 ebbing tide surveys were conducted all 12 months.



Map 3-3. Changes in bird density between the 2016-17 peaking tide and ebbing tide shoreline surveys.



Map 3-4. Species richness observed during the 2016-17 ebbing tide shoreline surveys.

3.2 Mid-Water Surveys

3.2.1 Abundance and Density

A total of 8,133 birds were observed during the mid-water surveys, with 32 species recorded. The number of individual birds observed during the mid-water surveys has declined with each subsequent survey since 2006-07 (Table 3-7). The decline in numbers is especially pronounced in the south-central and south bay regions.

Like the previous surveys, the number of individual birds observed peaked in January. But while the previous surveys also had high numbers of birds observed in December, the 2016-17 surveys did not (Table 3-8).

Table 3-7. Number of individual birds observed by region during the 2006-07, 2009-10, and 2016-17 mid-water surveys.

Region	2006-07	2009-10	2016-17
Mouth of Bay*	316	N/A	251
North	1,396	1,736	1,407
North-Central	421	3,286	723
South-Central	18,307	7,755	2,447
South	11,312	7,725	3,305
Total	**31,752**	**20,502**	**8,133**

*Includes only 8 grid cells outside of the mouth of San Diego Bay, which were not surveyed in 2009-10.

Table 3-8. Number of individual birds observed per month during the 2006-07, 2009-10, and 2016-17 mid-water surveys.

Month	Number of Individual Birds Observed		
	2006-07	2009-10	2016-17
November	4,207	3,105	2,003
December	8,777	7,484	1,837
January	11,663	6,879	3,107
February	7,105	3,034	1,186

3.2.2 Abundance by Species Assemblage

Birds observed during the mid-water surveys were predominantly waterfowl (81.4% of all observations) and seabirds (18.4% of all observations) (Table 3-9). Seventeen species of seabirds were recorded, and 12 species of waterfowl. Surf Scoters (*Melanitta perspicillata*) were the most abundant species seen, with over 5,600 individual observations, with Brants (645 individual birds observed) and Western Gulls (*Larus occidentalis wymani*; 474 individual birds observed) the next most abundant (Table 3-10).

Table 3-9. Number of individual birds observed per month and species assemblage during mid-water surveys in 2016-17.

Species Assemblage	Nov. 2016	Dec. 2016	Jan. 2017	Feb. 2017	Total
Marshbirds	2	1	2	0	5
Seabirds	185	356	821	135	1,497
Shorebirds	0	2	12	0	14
Waterfowl	1,816	1,478	2,272	1,051	6,617
Total	**2,003**	**1,837**	**3,107**	**1,186**	**8,133**

Table 3-10. Waterfowl and seabird bird species with at least 50 observations during the 2016-17 mid-water surveys. Highest and Lowest numbers for each species are highlighted in bold.

Species	Nov. 2016	Dec. 2016	Jan. 2017	Feb. 2017	Totals
Waterfowl					
Surf Scoter	**723**	1,395	1,551	**1,964**	5,633
Brant	228	**52**	**236**	129	645
Bufflehead	20	22	**9**	**73**	124
Lesser Scaup	**70**	0	0	0	70
Seabirds					
Western Gull	100	**87**	95	**192**	474
Brandt's Cormorant	**13**	35	27	**315**	390
Cormorant sp.	**0**	50	**0**	**206**	256
Heermann's Gull	**4**	**58**	6	34	102
Brown Pelican	**7**	**49**	17	19	92

3.2.3 Species Richness

A total of 32 distinct species were observed during the mid-water surveys in 2016-17, compared to 43 in 2006-07 and 44 in 2009-10. Species richness was highest in the north and south bay regions (Table 3-11; Map 3-5), and was lower than in previous surveys in all but the north bay.

Unlike previous surveys, species richness remained relatively constant month-to-month (Table 3-12).

While some of the top ten most abundant species in 2016-17 showed little change in numbers compared to previous surveys, several were far less abundant (Table 3-13). This is especially true of the Surf Scoter, which has decreased in number each survey year from a high of 27,417 individuals in 2006-07 to just 5,633 individuals in 2016-17. The decline in Surf Scoters was especially pronounced in the south-central and south bay regions, which had an average abundance across the 2006-07 and 2009-10 surveys of 16,835 and 14,389 individuals each. In 2016-17, the two regions had just 6,026 and 6,623 individuals, respectively. The north, north-central, and ocean regions together had an average of 2,433 Surf Scoters over the two previous surveys and 1,987 individuals in 2016-17.

Brandt's Cormorants have also declined in abundance from 1,301 individuals in 2006-07 to 390 individuals in 2016-17. Brant was the only species observed to be more abundant in 2016-17.

Table 3-11. Species richness by region during the the 2006-07, 2009-10, and 2016-17 mid-water surveys.

Region	Species Observed		
	2006–07	2009–10	2016-17
Mouth of Bay	9	N/A*	11
North	21	23	20
North-Central	16	24	13
South-Central	24	25	15
South	31	34	19

*The grid cells at the mouth of the bay (cells C1-C4) in the ocean region were not surveyed during this survey.

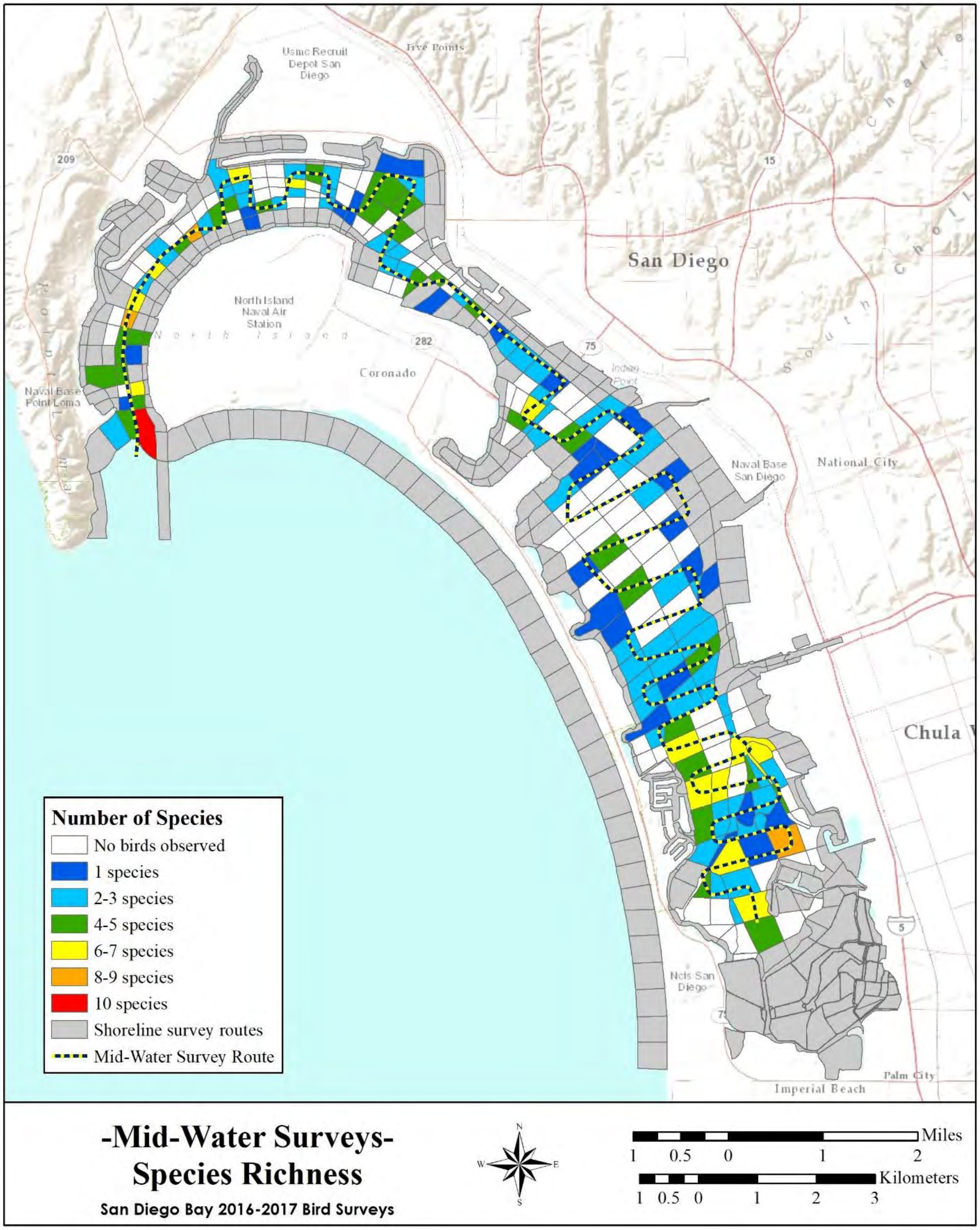
Table 3-12. Species richness by month during the the 2006-07, 2009-10, and 2016-17 mid-water surveys.

Month	Species Observed		
	2006–07	2009-10	2016-17
November	34	21	18
December	22	28	18
January	27	30	18
February	20	22	16

Table 3-13. Ten most abundant species observed during the 2006-07, 2009-10, and 2016-17 mid-water surveys.

Species	10 Most Abundant Species 2016-17 Mid-Water Survey		
	2006-07	2009-10	2016-17
Surf Scoter	27,417	14,327	5,633
Brant	270	316	645
Western Gull	457	404	474
Brandt's Cormorant	1,301	844	390
Lesser Scaup*	502	2,256	270
Bufflehead	756	740	124
Heermann's Gull	167	205	102
Brown Pelican	155	213	92
Royal Tern	33	18	44
Eared Grebe	72	105	41

* - combined lesser scaup and scaup sp. records



Map 3-5. Species richness observed during the bay mid-water surveys in 2016-17.

3.3 Point Count Surveys

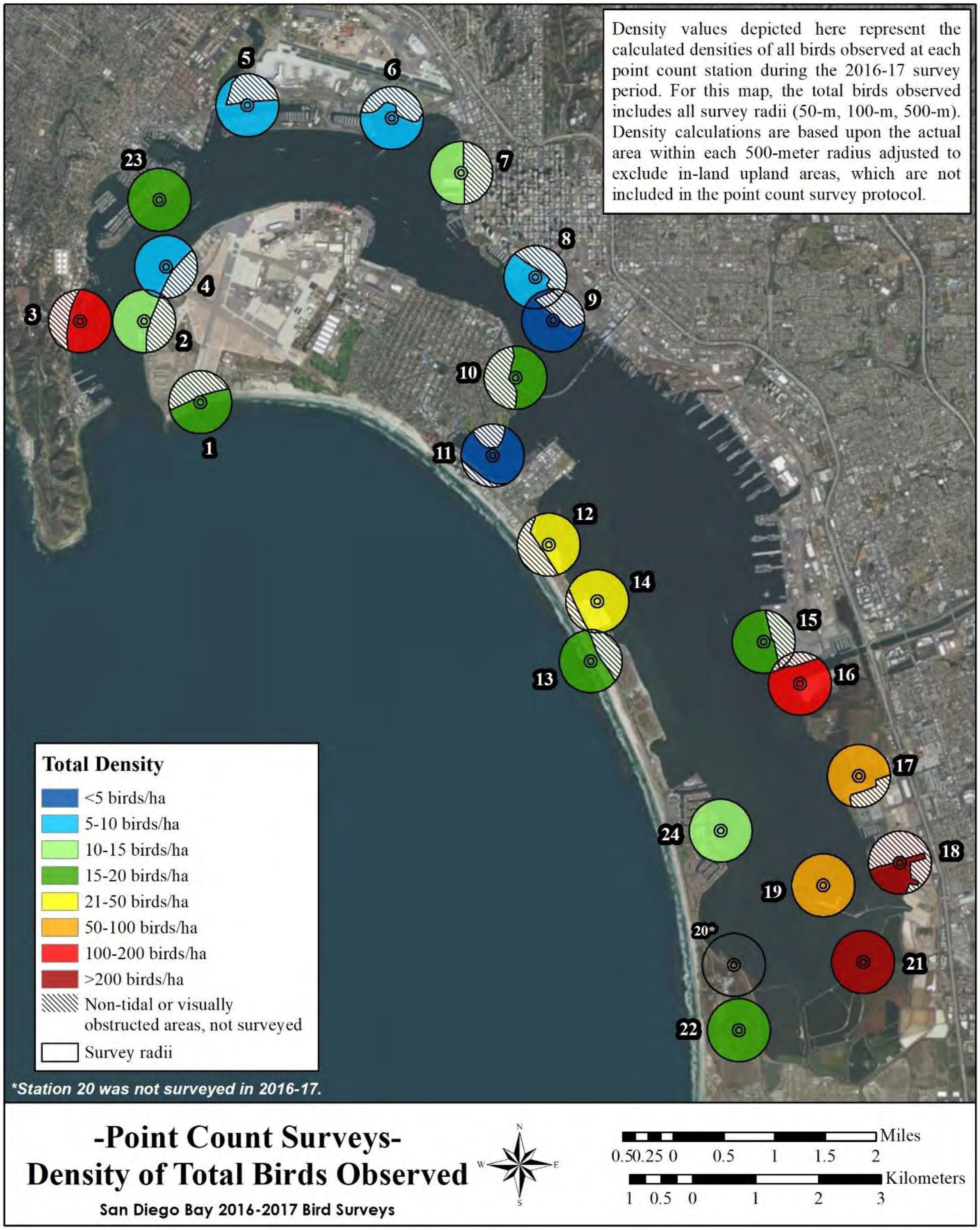
3.3.1 Abundance and Density

A total of 88,894 individual birds were observed during the point count surveys (Table 3-14), with the greatest number observed at Station 21 on the north shore of the salt ponds (39,235 birds observed, mostly Elegant Terns). The lowest number observed was at Station 9 located north of the Coronado bridge on the east shore of the bay, with only 235 individual birds observed. The highest overall densities of birds (>100 birds per hectare) were observed at Station 21 (Salt Ponds-North Shore), Station 18 (Chula Vista South-Marina/Mudflats, Station 16 (D Street Fill), and Station 3 (Point Loma, near the bait barge) (Map 3-6). The lowest densities (<10 birds per hectare) were observed at stations in the north and north-central bay regions.

Table 3-14. Total number of individual birds observed per month at each point count station in 2016-17. Highest and Lowest numbers for each station are highlighted in bold.

Station ID	Jul. 2016	Aug. 2016	Sep. 2016	Oct. 2016	Nov. 2016	Dec. 2016	Jan. 2017	Feb. 2017	Mar. 2017	Apr. 2017	May. 2017	Jun. 2017	Total	Avg Count
1	106	18	116	113	127	46	67	**2**	27	**183**	6	87	898	74.8
2	71	37	73	**30**	**98**	47	51	69	nd	nd	36	85	597	59.7
3	375	**1,274**	770	754	86	354	618	**26**	344	393	198	421	5,613	467.8
4	**139**	18	52	**9**	51	76	29	55	25	nd	19	62	535	48.6
5	26	nd	88	**14**	29	**61**	42	36	20	29	25	42	412	37.5
6	12	53	19	34	27	**79**	67	47	37	**11**	13	nd	399	36.3
7	56	40	37	30	78	66	67	48	28	**15**	31	**90**	586	48.8
8	46	33	32	38	26	60	**70**	52	22	**7**	23	28	437	36.4
9	8	**4**	5	10	15	37	**89**	16	13	8	10	20	235	19.6
10	nd	**16**	30	22	39	112	**183**	107	66	53	34	34	696	63.3
11	nd	24	10	**3**	44	43	**48**	30	23	nd	8	25	258	25.8
12	nd	109	101	56	82	**445**	160	380	**18**	98	166	41	1,656	150.5
13	nd	67	**12**	64	236	15	65	**263**	217	34	83	15	1,071	97.4
14	nd	445	94	235	91	**699**	287	80	68	68	55	**28**	2,150	195.5
15	4	5	**3**	**3**	57	300	**374**	29	104	6	**3**	16	904	75.3
16	460	194	1,606	nd	841	**2,253**	1,117	1,211	1,394	501	nd	**79**	9,656	965.6
17	106	39	479	191	1,147	**1,222**	1,015	334	157	25	113	**23**	4,851	404.3
18	**164**	403	770	402	1,356	1,536	748	**1,868**	973	608	174	326	9,328	777.3
19	253	198	**63**	129	839	847	691	**1,003**	678	293	233	369	5,596	466.3
21	**8,446**	**200**	2,735	4,744	5,833	4,411	5,850	2,678	nd	2,127	637	1,574	39,235	3,539.1
22	**855**	33	nd	13	30	16	**7**	81	155	26	13	33	1,262	114.7
23	111	nd	222	102	**263**	198	123	84	**43**	65	86	150	1,447	131.5
24	37	38	94	32	87	84	97	**21**	**351**	146	42	43	1,072	89.3
Total	**11,275**	**3,248**	**7,411**	**7,028**	**11,482**	**13,007**	**11,865**	**8,520**	**4,763**	**4,696**	**2,008**	**3,591**	**88,894**	**395.9**

'nd' = data not available



Map 3-6. Overall density of birds observed within point count station survey areas in 2016-17.

Seasonally, the highest densities were observed in the winter surveys (24.5 birds/ha), with the lowest density observed in the spring surveys (8.9 birds/ha) (Table 3-15).

Table 3-15. Overall density of birds observed by season at each point count station in 2016-17. Highest and Lowest numbers for each station are highlighted in bold.

Point Count Station	Overall Density *(#birds/ha)*			
	Summer	Fall	Winter	Spring
1	4.5	**7.6**	**2.5**	4.6
2	3.8	**4.0**	3.3	**0.7**
3	**37.8**	29.4	18.2	**17.1**
4	**4.1**	2.1	3.0	**0.8**
5	**1.3**	2.6	**2.7**	1.5
6	1.4	1.7	**4.0**	**1.3**
7	**4.2**	3.3	4.1	**1.7**
8	2.3	2.0	**3.9**	**1.1**
9	**0.6**	**0.6**	**2.8**	**0.6**
10	**1.2**	2.1	**9.4**	3.6
11	0.9	1.0	**2.1**	**0.5**
12	**3.0**	4.7	**19.4**	5.6
13	**1.5**	5.5	**6.1**	5.9
14	6.8	6.0	**15.3**	**2.7**
15	**0.5**	1.2	**13.2**	2.1
16	**10.8**	36.2	**67.7**	28.0
17	**2.7**	29.2	**41.4**	4.7
18	**29.9**	84.7	**139.1**	58.8
19	**10.4**	13.1	**32.4**	15.3
21	130.2	**169.5**	164.8	**35.2**
22	**11.7**	**0.5**	1.3	2.5
23	3.3	**7.5**	5.2	**2.5**
24	**1.5**	2.7	2.6	**6.9**
Average	**11.9**	**18.1**	**24.5**	**8.9**
Min	**0.5**	**0.5**	**1.3**	**0.5**
Max	**130.2**	**169.5**	**164.8**	**58.8**

3.3.2 Species Richness

Species richness per point count station ranged from a low of 12 species at Station 9 (Terminal Street) to a high of 64 species at Station 18 (Chula Vista South-Marina/Mudflats (Table 3-16). Species lists for each point count station are provided in Appendix E.

Table 3-16. Species richness at point count stations in 2016-17. Highest and Lowest numbers for each station are highlighted in bold.

Point Count Station	Jul. 2016	Aug. 2016	Sep. 2016	Oct. 2016	Nov. 2016	Dec. 2016	Jan. 2017	Feb. 2017	Mar. 2017	Apr. 2017	May. 2017	Jun. 2017	Total Species
1	6	4	7	**14**	13	3	7	**0**	1	**14**	2	11	30
2	9	**4**	8	10	**16**	9	10	9	nd	nd	6	11	31
3	9	9	9	12	11	13	12	**8**	**18**	12	10	13	30
4	9	6	8	3	**12**	10	8	7	5	nd	**3**	9	32
5	6	nd	6	8	6	9	7	**12**	7	**3**	8	11	32
6	5	6	**4**	6	9	**10**	9	**10**	9	5	5	nd	31
7	5	4	4	5	**7**	6	6	6	4	**2**	5	6	21
8	4	7	**3**	7	6	9	8	8	9	**3**	6	**11**	27
9	2	**1**	**1**	**1**	3	4	**8**	4	3	2	3	2	12
10	nd	6	**2**	8	9	8	**17**	14	14	14	10	6	34
11	nd	2	5	**1**	10	7	**11**	5	3	nd	4	6	25
12	nd	9	8	6	9	18	12	**20**	3	11	10	**1**	43
13	nd	10	9	6	11	**2**	3	6	**13**	4	8	3	30
14	nd	**18**	9	14	7	10	14	15	9	**18**	15	**6**	48
15	2	2	2	3	4	4	3	**6**	4	**1**	2	**6**	15
16	15	**14**	15	nd	**27**	22	**27**	22	21	23	nd	16	50
17	11	10	11	**6**	21	**22**	19	16	14	12	**22**	8	57
18	**8**	12	12	**20**	15	**20**	19	16	17	**20**	18	17	64
19	12	11	15	13	17	22	**26**	17	13	13	**10**	11	48
21	9	**7**	**27**	24	20	25	25	21	nd	25	25	15	49
22	4	5	nd	5	9	4	**1**	9	**17**	7	3	9	38
23	7	nd	9	6	9	**12**	8	8	10	**5**	**12**	11	28
24	6	**4**	11	13	17	18	**19**	9	12	16	8	12	51
Total Species	**46**	**51**	**54**	**64**	**84**	**69**	**71**	**68**	**73**	**63**	**61**	**57**	**129**
Average	7	7	8	9	12	12	12	11	10	11	9	9	36
Min	2	1	1	1	3	2	1	0	1	1	2	1	12
Max	15	18	27	24	27	25	27	22	21	25	25	17	64

3.3.3 Long-Term Trends

Over the course of the three surveys, the numbers of birds observed at the point count station have fluctuated (Figure 3-7), but some clear trends are apparent. Total birds observed in the summer surveys has increased each year, but while the winter and fall totals for 2016-17 were higher than 2006-07, they were lower than in 2009-10. The number of individual birds observed at each point count station also show few trends, although certain stations do stand out (Table 3-17). The largest declines in numbers have been seen at Station 18 (Chula Vista Mudflats), Station 14 (Delta Beaches-South), and Station 1 (North Island South Beach). The largest increases have been recorded at Station 21 (Salt Ponds North Shor), Station 19 (Chula Vista Wildlife Reserve), Station 3 (Point Loma), and Station 16 (D Street Fill).

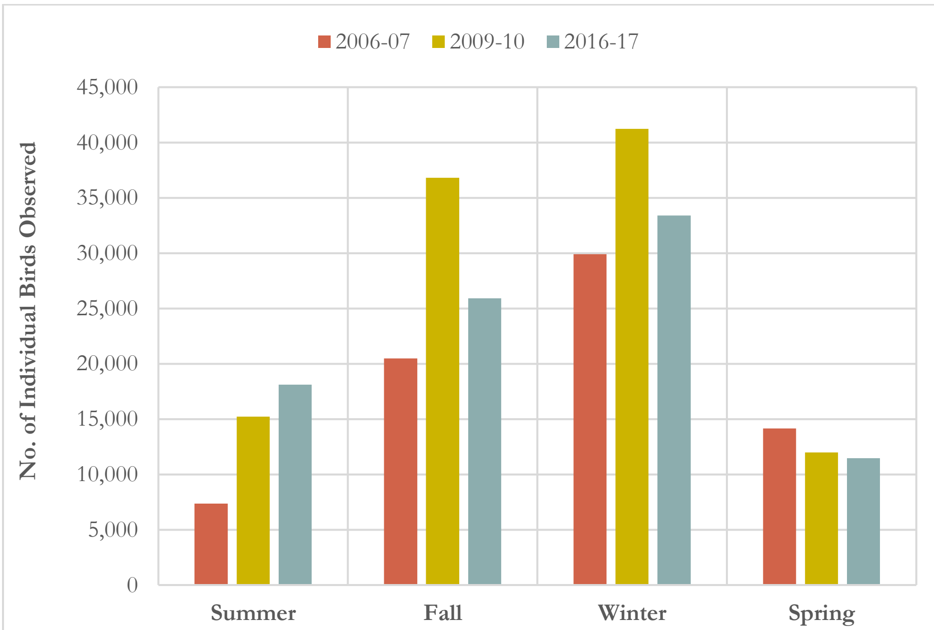


Figure 3-7. Number of individual birds observed during point count surveys n 2006-07, 2009-10, and 2016-17.

Table 3-17. Total number of individual birds observed at point count stations in 2006-07, 2009-10, and 2016-17. Stations where the 2016-17 total differed from 2006-07 by at least +500 or -500 birds are shown in bold. Stations where the percent change from 2006-07 to 2016-17 was at least +25% or -25% is also shown.

Station ID	Location	2006-07[1]	2009-10	2016-17	Difference 2016-17/2006-07	Percent Change
1	North Island South Beach	2,440	3,934	898	**-1,542**	**-63.2**
2	North Island South	1,121	1,387	597	**-524**	**-46.7**
3	Point Loma	1,559	1,605	5,613	**4,054**	**+260**
4	North Island North	833	682	535	-298	**-35.8**
5	Harbor Island	344	498	412	68	+19.8
6	Coast Guard Station	578	684	399	-179	**-31.0**
7	Embarcadero	489	481	586	97	-19.8
8	Convention Center	481	1,107	437	-44	-9.1
9	Terminal Street	306	278	235	-71	-23.2
10	Coronado Bridge	940	1,337	696	-244	**-26.0**
11	Glorietta Bay	650	896	258	-392	**-60.3**
12	Delta Beaches-North	1,716	3,839	1,656	-60	-3.5
13	Silver Strand	1,099	3,260	1,071	-28	-2.5
14	Delta Beaches-South	3,856	6,330	2,150	**-1,706**	**-44.2**
15	Terminal Avenue	908	431	904	-4	-0.4
16	D Street Fill	6,575	11,840	9,656	**3,081**	**+46.9**
17	Chula Vista North	4,003	6,920	4,851	**848**	+21.2
18	Chula Vista Mudflats	16,593	9,262	9,328	**-7,265**	**-43.8**
19	Chula Vista Wildlife Reserve	1,326	1,953	5,596	**4,270**	**+322.0**
20	Emory Cove	11,263	14,579	-	-	-
21	Salt Ponds North Shore	14,432	32,836	39,235	**24,803**	**+171.9**
22[2]	NRRF	-	1,100	1,262	162	+14.7
23[2]	Shelter Island	-	-	1,447	-	-
24[2]	Gran Caribe Isle	-	-	1,072	-	-
	Total	**71,512**	**105,239**	**88,894**	**17,382**	**+24.3**

[1] Several stations in 2006-07 were not surveyed at peaking tide instead of ebbing tide. Where ebbing tide data were not available, peaking tide was used to complete the data set for that station.
[2] Station 22 was established in 2009. Stations 23 and 24 were established in 2016.


Short-Billed Dowitchers. © Timothy Burr, 2017.

4.0 Discussion and Recommendations

4.1 Survey Limitations

The counting of active, mobile birds can often be influenced by animals moving around within complex environments, where obstacles such as docks, piers, anchored boats, and waves can obscure visibility. Such factors could result in either over or undercounting. For example, roosting waterbirds during peaking tide surveys may be undercounted if they are in areas of reduced visibility; they can be in densely packed flocks where discernment of individuals is difficult. Similarly, individuals in densely packed foraging flocks during ebbing tide surveys may be undercounted. It is also possible that observers counted individual birds or groups moving between cells more than once. Although observers make every effort to avoid double-counting of birds that may be moving around during the survey, it is not always possible to do so. For this reason, adding the results from multiple cells or throughout the study area can yield an inflated total number of observations. Count results within each cell present the abundance of individual birds observed within that cell, but any combined number of observations from multiple cells should be interpreted as an index that approximates the abundance of individual birds in those cells, rather than an accurate measure of bird numbers.

These surveys were not designed to detect secretive marsh bird species, which often conceal themselves in vegetation and require specific, auditory sampling methodology. Conspicuous marsh species, such as egrets, were recorded in greatest abundance while more secretive species were likely undercounted. And while the survey methods were also not designed to detect songbirds, the native Belding's Savannah Sparrow was the songbird recorded in the greatest numbers.

4.2 Shoreline and Mid-Water Surveys

The total number of individual birds observed in 2016-17 was greater than previous surveys have recorded, in part due to two additional months of effort (May and June) this time (budget constraints were the reason behind earlier deletions of survey months). The distribution and seasonality of the total numbers remained very similar to previous patterns, with fall and winter the peak seasons for abundance and richness. San Diego Bay is important for wintering species and holds significant non-breeding concentrations of several species, including Surf Scoter, Red Knot, Willet, and Black-necked Stilt. As in both previous survey years, the salt ponds, south bay, and north bay (particularly around the bait barge) consistently rank highest in abundance and richness.

The decline in numbers of waterfowl observed during the 2009-10 mid-water surveys, compared to 2006-07, continued in 2016-17, dropping to less than half of what had been recorded in 2009-10. The halving of the Surf Scoter count was a major contributor to the decline. Despite the drop-off in the number of individuals seen, the species makeup remained consistent during the mid-water surveys, with the only large-scale patterns being a slight increase in certain waterfowl (scaup [*Aythya* sp.] and Redhead [*Aythya americana*]) and the large decrease in Surf Scoter observations. The cause of the decline in Surf Scoter in San Diego Bay and elsewhere is currently unknown, although Unitt suggests the possibility of boat traffic being a factor (Unitt 2012). However, the survey results are consistent with observations of declining scoter populations throughout western North America since the 1950s (Anderson et al. 2015; Unitt 2012; Pitkin and Wood 2011). The number of Surf Scoters detected on Alaska breeding surveys also appears to have declined from 1993-2012 (Bowman et al. 2015). On the Pacific Coast, the wintering population is estimated at approximately 225,000 Surf Scoters, based on compilation of results from a variety of independent surveys (J. Hodges, unpublished; Sea Duck Joint Venture 2015).

When compared to previous avian studies in San Diego Bay, similar rankings for the most abundant species observed are found. Past studies had different objectives in terms of bay subregion emphasized, habitat areas that were focused on, and methods due to whether the interest was shorebirds, waterfowl, or all bay birds. These past studies include those of Ogden Environment & Energy Services (1994, 1995) and USFWS (1994, 1995). Their results are provided as a reference to the earliest quantitative data available from Port- and Navy-funded projects. The joint Port-Navy studies since 2006 are the first comprehensive survey of avian species in that methods are designed to detect all species groups across the whole bay in all habitat types (except marsh birds in marshes which require calling methods to detect birds with secretive behavior). Those rankings since 2006, therefore, are the most directly comparable. Comparisons of the most abundant species observed during avian surveys from historical to present are shown below in Table 4-1.

Table 4-1. Comparison of most abundant species observed during avian surveys from historical to present. Previous surveys include those of Ogden Environment & Energy Services (1994, 1995) and USFWS (1994, 1995). Rankings are ordered top-to-bottom from highest to lowest for each species group.

	Previous Bay Studies	2006-07 Surveys	2009-10 Surveys	2016-17 Surveys
Waterfowl	▪ Surf Scoter ▪ Eared Grebe ▪ Scaup (lesser & greater)	▪ Surf Scoter ▪ Western Grebe ▪ Eared Grebe	▪ Surf Scoter ▪ Eared Grebe ▪ Western Grebe	▪ Surf Scoter ▪ Eared Grebe ▪ Brant
Shorebirds	▪ Western Sandpiper ▪ Red-necked Phalarope ▪ Peep sp.	▪ Western Sandpiper ▪ Peep sp. ▪ Marbled Godwit	▪ Western Sandpiper ▪ Peep sp. ▪ Marbled Godwit	▪ Western Sandpiper ▪ Peep sp. ▪ Black-bellied Plover
Seabirds	▪ Brown Pelican ▪ Elegant Tern ▪ Heermann’s Gull	▪ Western Gull ▪ Elegant Tern ▪ Double-crested Cormorant	▪ Western Gull ▪ Elegant Tern ▪ Brandt’s Cormorant	▪ Elegant Tern ▪ Western Gull ▪ California Gull
Marshbirds	▪ Great Blue Heron ▪ Snowy Egret ▪ Great Egret	▪ Snowy Egret ▪ Belding's Savannah Sparrow ▪ Great Blue Heron	▪ Belding's Savannah Sparrow ▪ Snowy Egret ▪ Great Egret	▪ Belding's Savannah Sparrow ▪ Snowy Egret ▪ Great Blue Heron

Western Grebes (*Aechmophorus occidentalis*), which had placed sixth in previous efforts, have been very common more recently. Similarly, the Brown Pelican (*Pelecanus occidentalis californicus*) remains a common species, but not as common as Western Gulls and Brandt's Cormorants. Western Gulls, which were the most numerous of the seabirds during these surveys, placed seventh in previous efforts. This common gull was likely undercounted in past surveys as previous researchers often did not distinguish gulls to species (Ogden Environment & Energy Services 1994, 1995; USFWS 1994, 1995). The peeps listed in Table 4-1 are small, indistinguishable shorebirds, usually sandpipers that are difficult to differentiate to species from a distance. Many of the birds counted in this category are most likely Western Sandpipers, which would add even more individuals to the count of this abundant species.

Some bird movement patterns occur in concert with tidal cycles, as shown in Map 3-3. Sandpipers and plovers were the most numerous of the shorebird group and the differences in their locations between tides indicated their use of different habitats. For example, numbers in the interior salt works during peaking tide are high, with a shift to the tidal flats and western ponds during the ebbing tide as foraging opportunities become available. In August, migrant phalaropes are common in the non-tidal, interior salt works regardless of tide, along with Eared Grebe, stilt, and avocet. Eared Grebes, stilts, avocets, and phalaropes are known to rely on the brine fly and shrimp prey base of the interior salt ponds (SDNHM and Avian Research Associates 2014), and a similar feeding pattern has been noted in salt ponds of San Francisco Bay (Stenzel et al. 2002; Warnock et al. 2002). The importance of non-tidal salt ponds to foraging shorebirds and the possibility of higher foraging value in non-tidal salt ponds than in tidal habitats has been noted as well (Masero and Perez-Hurtado 2001; Warnock et al. 2002; Warnock and Takekawa 1995).

Previous monitoring has demonstrated the establishment of high tide roosting flocks of shorebirds along ocean-facing beaches and the shifting of those flocks to flats of the bay as they become exposed as tides ebb (Copper, Patton, Wolf, unpublished data 2014). Terns and skimmers showed a tendency to roost within the salt works during high tide and disperse to roost and forage in tidal areas during ebbing tide. Seabirds staged in the salt works often forage offshore. The ocean-side beaches of the Silver Strand (see Map 1-2) and the enhancement islet "Homeport Island" (south of Naval Amphibious Base), however, show heavy bird use regardless of tide. The width of the Silver Strand western beaches likely contributes to a longer duration of forage time when bayside foraging areas are flooded. At peaking tide, roosting areas remain available as well as some foraging opportunities, such as invertebrates associated with wrack line debris, for certain species. The availability of both food and resting areas throughout the day greatly contributes to the biodiversity seen in the bay. In addition, the apparent concentration and availability of prey within non-tidal salt ponds at times can also result in birds not shifting with the tides as expected.

Seasonally, seabirds have a reverse cycle compared to migratory shorebirds and waterfowl. The seabirds arrive from the south to breed in San Diego Bay and are highest in abundance in late summer. In 2017, a spike in abundance began on mudflats in April reflecting arriving migrant Elegant Terns, with 41,813 individual observations by summer's end. These and other seabirds stage from the salt ponds to forage offshore. The flocks roost, bathe, and show courting behavior in April, then nest and fledge young through the summer months. Observers at the salt ponds noted the arrival of cormorants, terns, and skimmers establishing nesting colonies on the levees in April, with those numbers boosted in late summer by pelicans and gulls.

The increase in numbers of birds at the salt works is likely a result of habitat restoration efforts to re-open some of the ponds to tidal flushing, providing additional foraging opportunity for birds. The South San Diego Bay Wetland Restoration Project is a long-term restoration and enhancement project of the San Diego Bay National Wildlife Refuge. Three salt evaporation ponds (10, 10A, and 11) totaling 585 ha (1,450 acres) on the west side of the salt works were converted to intertidal wetlands between late 2010 through September 2011. Tidal flow was restored by excavating channels within ponds 10 and 11 and breaching of the outer dikes (SDNHM and Avian Research Associates 2014). Planting of salt marsh vegetation extended through December 2011. By the time these 2016-17 surveys took place, much of the area had converted to salt marsh vegetation.

4.3 Point Counts

The point count results showed similar species richness and abundances as the shorebird surveys, though all measures were slightly lower, as would be expected with this method, which is conducted for a short 15-minute period and in a defined survey area (500-meter radius, usually as a subset of the routes). The consistency of species makeup and diversity between point count surveys and shorebird surveys indicates that this methodology can capture much of the diversity of the bay in a short amount of time.

To evaluate how well the point count abundance results represented the other methods, we conducted simple regressions comparing the annual total point count results for each station with the combined totals for both shoreline and mid-water surveys for grids within the 500-meter recording area of the station. We looked at August 2016, a low abundance month for birds, and January 2017, a high abundance month. Both showed a high correlation between point count results and the other combined survey methods (R^2 for August = 0.91 and R^2 for January = 0.98). This suggests that conducting point counts in interim years between the comprehensive survey events would produce robust results which could be a valuable index of both abundance and diversity, with highly correlated but generally lower numbers compared to the comprehensive survey events every five years.

As stated in the Methods section (Chapter 3), the point count Station 24 at Gran Caribe Isle was a timed walking route rather than a stationary count, to improve visibility for the observer. This site is of management interest to the Port as a future mitigation opportunity, and this station represents a baseline condition assessment for avian use of the area. Despite the adjustment in methods, these results can be combined with those of other point count locations because all are considered "moment-in-time" records. For other point counts where visibility was obstructed or urban hardscape formed a high proportion of the 500-meter circle, density calculations excluded the obstructed and much of the hardscape areas; for Gran Caribe Isle, a work-around to this problem by walking the site was the best solution.

4.4 Trends 2006-07 to 2016-17

This report's Appendix F provides survey results in a conveniently extractable format, for all survey years by grid or grid group, which can be distributed by the Port or Navy to support environmental baseline and impact studies. The point count results (Appendix E) are also presented in a way that the Navy and Port can easily extract for site-specific project needs.

Species-by-species trends for all three survey events are shown graphically in Appendix G, also to support environmental documentation needs of the project sponsors, and the management and conservation of the bay's birds. One of the key objectives of these surveys is to observe long-term trends of waterbirds that use San Diego Bay. Some species were identified (see Table 3-5) with a greater than 20% decline in observations between the 2006-07 and the 2016-17 surveys. These trends are large and likely overcome any observational bias or error in method. While statistical analyses of trend are beyond the scope of this report, a relatively straightforward analysis could be performed using the variability of observations among grids, species by species, to evaluate whether these large trends are significant.

A comparison of San Diego Bay results to regional, flyway, and national records for each species or species group provides context for interpreting the cause behind trends and, therefore, any management implication. This context helps determine if a decline or increase is local or a bigger picture than the bay. Understanding a species' geographic range, life history, and population status also provides valuable context. For instance, Red-necked Phalarope observations declined by over 90% in this survey compared to 2006-07. This species has an extremely large range and the population size is extremely large as well. Despite that the population trend appears to be decreasing on a broad scale (Manomet Bird Observatory 2018), the decline is not believed to be sufficiently rapid to make the species vulnerable. For these reasons this species is evaluated as Least Concern by the Manomet Bird Observatory (2018).

An overall downward trend in counts of North American shorebirds could be reversing since the late 1990s, according to almost 40 years of data from the International Shorebird Survey (1974-2009) published by the Manomet Bird Observatory. Despite these overall up trends, declines appear to be ongoing for 23 species. The declines were statistically significant for the geographic range of five of these species, including some already recognized to be of conservation concern, such as the Red Knot, Long-billed Curlew (*Numenius americanus*), and Black-bellied Plover (Manomet Bird Observatory 2018).

For ducks, conditions in breeding landscapes of the prairies and the boreal forest are key to their population status. According to the USFWS Waterfowl Population Survey (USFWS 2017), most duck populations are above long-term averages. However, they still identified pintails and scaup as a concern.

4.5 Recommendations for the Future

4.5.1 Data Acquisition, Sharing, and Distribution

Between the 2006-07 and 2016-17 surveys, improvements were made in how data collection was managed, leading to a more timely and accurate data set. These improvements have cut down on the time needed to collate the incoming records and enabled quicker identification and resolution of questions about the records when an observer's memory is still fresh. Use of the ESRI Collector application by most of the field crews greatly facilitated data acquisition by eliminating the time-consuming data entry required when data are recorded on paper. Continued use of the ESRI Collector or similar application would further streamline data acquisition efforts in the future.

The survey results collected should be provided to centralized clearinghouses for avian data so that conservation organizations can interpret the status and trend of each species for its regional and geographic range. A key data center is the Avian Knowledge Network (AKN), which is a network of people, institutions and government agencies supporting the conservation of birds and their habitats in the western hemisphere. The partners aim to improve the conservation of birds and their habitats through best available science and open, collaborative partnerships. To facilitate data exchange, the AKN developed a data standard called Bird Monitoring Data Exchange (BMDE), and each contributor (node) to the AKN has built tools to accept in and transform data into the BMDE form (AKN 2018). eBird is a contributing node to the AKN, managed by the Cornell Lab of Ornithology (an AKN partner). eBird is the largest biodiversity-related citizen science project (eBird 2018). The California Avian Data Center is a regional node of the AKN, hosted by Point Blue Conservation Science. With the support of 2010 California Landscape Conservation Cooperative funding, Point Blue developed and launched an on-line data portal for wintering shorebird monitoring as part of the Pacific Flyway Shorebird Survey. Their interactive data summary application is a place the Navy and Port can find context for bird numbers and trends at user-defined scales. The Pacific Flyway Shorebird Survey is a coordinated multi-partner monitoring program led by Point Blue targeting the management and conservation of wintering shorebirds on the Pacific Flyway. In comparison with other locations reporting to these networks, avian use of San Diego Bay may be more strongly representative due to the year-long and comprehensive nature of the surveys, whereas many locales only report twice per year: in winter and breeding season.

Many combinations of factors (seasonality, bird species, bird group, tide, location, region, habitat substrate, etc.) can be analyzed with the current data set. In-depth statistical and other analyses of the data that are not appropriate for a general report may be of great interest to project proponents in certain jurisdictions of the bay. Allowing outside access to the data for further in-depth analysis should be a key component of the overall survey program. It is recommended that the Port and Navy outreach to local or regional research organizations to take advantage of these data for special studies to enhance understanding of trends and implications for management for their respective needs, and for the greater good of avian conservation region-wide.

An important opportunity exists to correlate the Port-Navy sponsored fish abundance surveys with avian productivity of the bay, in the context of available food and climate cycles, and climate change.

The scope of these surveys also does not cover a detailed analysis of trend in relation to weather cycles and other regions—this should be done through grant or other opportunities. Analysis of trend in bird densities should be interpreted separately for each species or species group (such as small, medium, and large shorebirds; dabbling ducks; sea ducks; etc.). Certain statistics are straightforward and routine, while other will require a statistician's expertise. Nonparametric methods should be used, such as locally estimated scatterplot smoothing Local Polynomial Regression, a method used by others for avian trends for fitting a smooth curve between two variables, or fitting a smooth surface between an outcome and up to four predictor variables (Cleveland 1979; Cleveland and Devin 1988).

It is recommended that the Port and Navy adopt a set of indicators to report on bay health in relation to bird populations. The status of San Diego Bay's birds is one of multiple indicators that can be used, in combination, to portray health of the bay; however, bird status cannot be used in isolation. For example, the San Francisco Estuary Partnership (2015) uses 33 indicators of ecosystem health to publish a "report card" of the San Francisco Bay and Sacramento-San Joaquin River Delta. The Partnership is one of 28 National Estuary Programs in the country, which has required the use of ecosystem indicators as recommended by U.S. Environmental Protection Agency's Science Advisory Board (2002). The avian trends reported on as a part of ecosystem health in the San Francisco Bay/Delta could be a basis for considering for periodically reporting on populations in San Diego Bay as well. They are:

- Wintering waterfowl abundance, separating dabbling and diving ducks.
- Breeding waterfowl abundance.
- Shorebird abundance, separating large, medium, and small shorebirds.
- Heron and egret nest density, nest success in terms of fledged chicks, and brood size.
- Tidal marsh bird densities.
- Ridgway's Rail (*Rallus longirostris levipes*) population.
- Three birds of concern: Tri-colored Blackbird (*Agelaius tricolor*), California Black Rail (*Laterallus jamaicensis coturniculus*), and Sandhill Crane (*Grus canadensis*).
- Breeding success of Brandt's Cormorants (an indicator of fish as food).

4.5.2 Future Surveys

One of the original purposes of the point count stations was to provide an inexpensive yet quantitative method for conducting avian surveys each year, in the interval between major survey events. To date, this recommendation has not risen to the level of a funding priority for the Navy and Port, since it is not a direct environmental compliance mandate. An annual effort would help to better separate actual trends as distinct from inter-annual weather variation. Extending the point count surveys to additional years could also allow answers to more specific questions about substrate use, and how the bay is used by conservation planning species of interest. These species or species functional groups (i.e., trophic niche birds such as long-legged shorebirds, or resident songbirds) are endemic or dependent on the bay and can add an important level of detail to a program of successful habitat enhancement or assessing bay health trends. Examples of such use can be found in the San Francisco Bay Estuary Program (see Thompson & Gunther 2004; Pitkin & Wood 2011) and other national estuary programs. Conservation planning species are discussed in the San Diego Bay INRMP (Port and Navy 2013) and the Chula Vista Bayfront Master Plan NRMP (Port 2016). It is recommended that grant funding be sought in the interim years to conduct annual point counts and one mid-water survey, to augment the interpretability of the comprehensive survey events. Grant funding could overcome the challenge of prioritizing these surveys when environmental compliance budgets are constrained.

Future comprehensive avian species surveys should be conducted at least every five years to support project analysis and environmental documentation under the California Environmental Quality Act and National Environmental Protection Act. These periodic surveys can be cost-effective as special studies on avian use may not be necessary as projects arise. Appendices E and F are designed to be extractable for site-specific questions, and Appendix G for species-specific questions. The repeat nature of the surveys allows interpretation of trends within long-term weather cycles and assess management implications of the bay's human use and development. This interval would help keep the budget manageable while providing sufficient frequency to support environmental documentation needs of Port and Navy projects. It is recommended that future avian surveys coincide with periodic fish surveys, as well, so that any ties can be assessed between; for example, the success of seabird nesting and fish abundance that fluctuates with the El Nino cycle. These major survey events are designed to answer general questions about the bay, including the abundance and distribution of species through a tidal cycle and through seasons, high bird use versus low bird use habitats, and how abundance trends may change through time. Three distinct datasets are now available from which to build upon, making this one of the longer-term quantitative data sets on the west coast for tracking the status of coastal birds. Future surveys can improve and strengthen understanding of not only the bay's important benefit to birds, but broader-scale interpretation of trends along migratory pathways. The rich data set provided by these surveys can enhance the work of many other programs locally, such as the Bird Atlas work of the SDNHM, and the avian status and trend work of many conservation organizations in the west.

Great Blue Heron. © Timothy Burr, 2017.

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