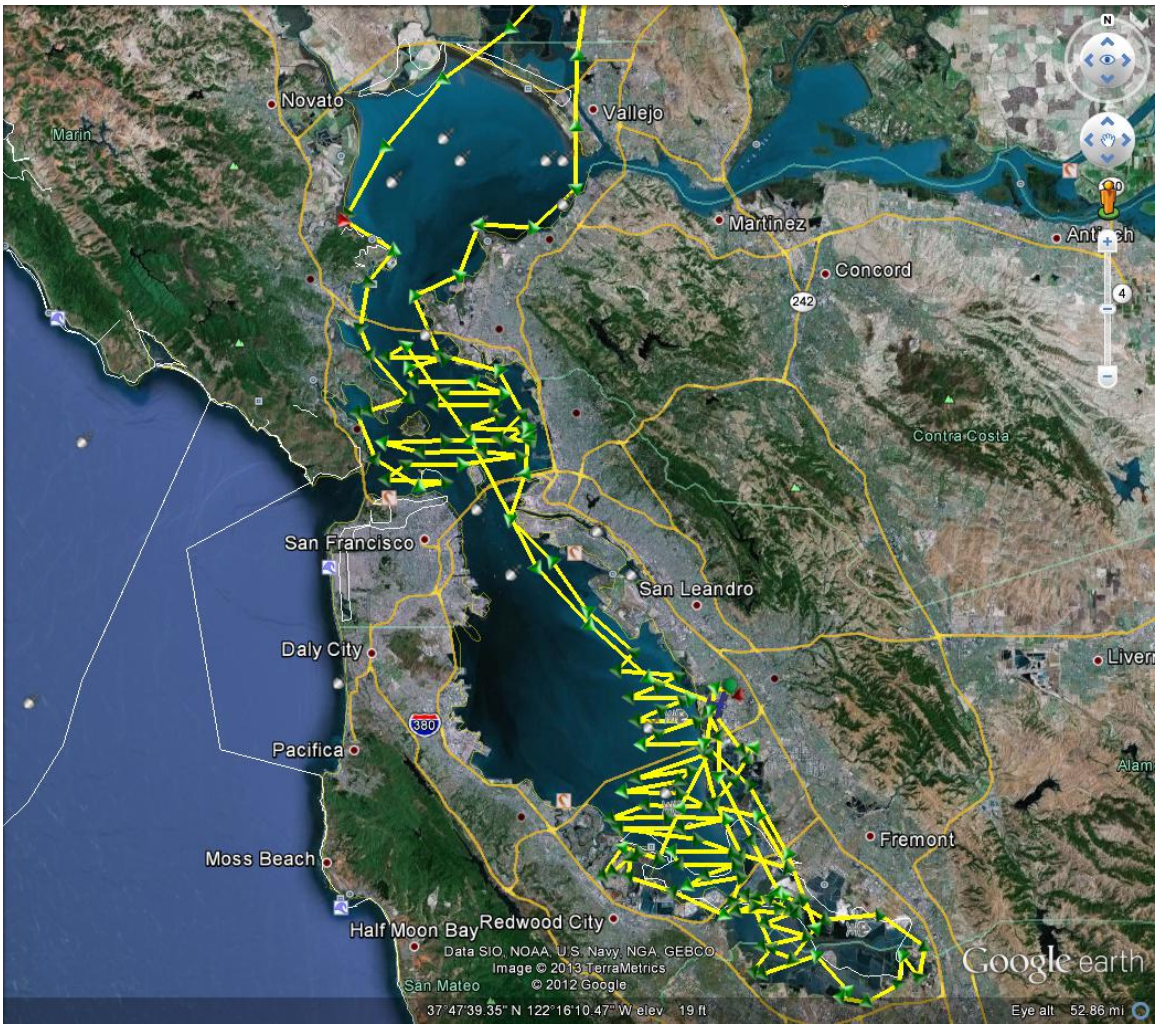

San Francisco Estuary Midwinter Waterfowl Survey: 2013- 2018 Summary Results

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April 25, 2019

Suggested Citation:
Strong, C.M. 2018. San Francisco Estuary Midwinter Waterfowl Survey: 2013-2018 Summary Results. U. S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex. Fremont, CA, USA.

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Executive Summary

Aerial and ground surveys of waterfowl and coots were conducted generally in the first half of January 2013 to 2018, in San Francisco Bay, Suisun Bay and selected coastal sites in Marin and Sonoma counties (hereafter 'SF Estuary') as part of the annual nationwide Midwinter Waterfowl Survey (hereafter 'MWS') organized by state and federal agencies. The purpose of the MWS is to assess the distribution of wintering waterfowl and to provide a long-term dataset for assessing population trends. In the SF Estuary survey area, the MWS assesses waterfowl use of wetlands including open bays, salt production ponds, managed ponds, sloughs, marshes, inlets, coastal lagoons and other near-coastal waters. Survey methods included a GPS-enabled aerial survey methodology (including a time stamp on each observation) as well as ground counts at selected ponds in the far South Bay.

Of the twelve MWS zones in the SF Estuary, the North Bay and South Bay salt production ponds and managed ponds (hereafter 'North Bay Ponds' and 'South Bay Ponds', respectively) consistently had the highest percentages of the waterfowl and coots counted in 2013-2016; except in 2018 when the North Bay Open Bay and South Bay Ponds had the highest percentages. Survey coverage varied by year from nearly complete coverage in 2018 to only select coastal sites in Marin and Sonoma counties, and in a few units in South Bay Ponds in 2017.

Key Words aerial transect survey, coots, dabbling ducks, diving ducks, geese, managed ponds, midwinter waterfowl survey, salt ponds, San Francisco Estuary, San Pablo Bay, sea ducks, stiff-tailed ducks, Suisun Bay, waterfowl

Introduction

At a national level, the MWS provides information on the distribution of wintering waterfowl and a long-term dataset for assessing population trends across the four major flyways. For the SF Estuary, the MWS is also used to assess the effects of environmental threats (e.g., development, ferry routes, oil spills) and conservation actions such as wetland restoration projects on wintering waterfowl and coots. This report is an update to the 2014 report on recent trends in waterfowl counts for selected species (Richmond et al. 2014) and provides a summary of MWS data from 2013-2018 in the SF Estuary. For a more complete background on the MWS and data trends from 1981-2012 in the SF Estuary, see Richmond et al. 2014. Some of the basic text in this report has been taken or modified from that comprehensive report.

Methods

The SF Estuary MWS was coordinated by the USFWS (coordinator Cheryl Strong of the San Francisco Bay National Wildlife Refuge Complex). USFWS coordinated and conducted aerial surveys for San Francisco Bay, Suisun Bay (open bay only, excluding Suisun Marsh and Grizzly Island) and the Outer Coast estuaries in Marin and Sonoma counties (Table 1). The U.S. Geological Survey (USGS) is a partner in this effort and did most of the in-air data collection. The San Francisco Bay Bird Observatory (SFBBO) contributed ground count data for a portion of the 67 South Bay salt production and managed ponds (hereafter 'ponds'), thus, these ponds were not surveyed by air. Not all South Bay salt production and managed ponds were counted due to accessibility and time constraints; however, the ponds with historically some of the highest concentrations of waterfowl were counted (De La Cruz et al. 2018).

The Pacific Flyway Study Committee typically schedules the MWS for the first or second week of January in each year; actual dates vary year to year due to weather conditions and logistical constraints.

Survey Area

The SF Estuary was divided into three survey regions: the Outer Coast, San Francisco Bay and Suisun Bay (Figure 1). These regions were then subdivided into 12 zones (Table 1 and Figure 1). The Outer Coast region includes Abbotts Lagoon, Bodega Bay, Drakes Estero, Rodeo Lagoon and Tomales Bay zones. The Suisun Bay region and zone includes the open waters of Suisun Bay but excludes Grizzly Island, Ryer Island and Roe Island. The North Bay Open Bay zone encompasses the open waters of San Pablo Bay. Its boundary with the upstream Suisun Bay region is the Carquinez Bridge. Downstream it abuts the Central Bay Open Bay zone on the western shore at Point San Pedro and on the eastern shore at Point San Pablo. The Central Bay Open Bay zone includes the main body of San Francisco Bay and extends along the western shore from Point San Pedro to the San Mateo Bridge, and along the eastern shore from Point San Pablo to the San Mateo Bridge. The South Bay Open Bay zone includes the southern-most portion of San Francisco Bay. It abuts the Central Bay zone on the western and eastern sides at the San Mateo Bridge. The North Bay Pond and South Bay Pond zones encompass salt production ponds, other managed ponds, sloughs, rivers and marshes (Figure 1).

The Outer Coast and Suisun Bay regions were surveyed using only aerial surveys. The San Francisco Bay region was surveyed using aerial surveys except for ponds in the South Bay Ponds zone where ground count data were used from an ongoing monitoring project conducted by SFBBO (Figure 1). Ground count data were used because this reduced the required flight time, and ground count data are considered to be more accurate than aerial count data (Pollock and Kendall 1987).

Figure 1. Map of San Francisco Estuary Midwinter Waterfowl Survey regions and zones, including aerial transects and ponds that were surveyed by ground in 2013-2018.

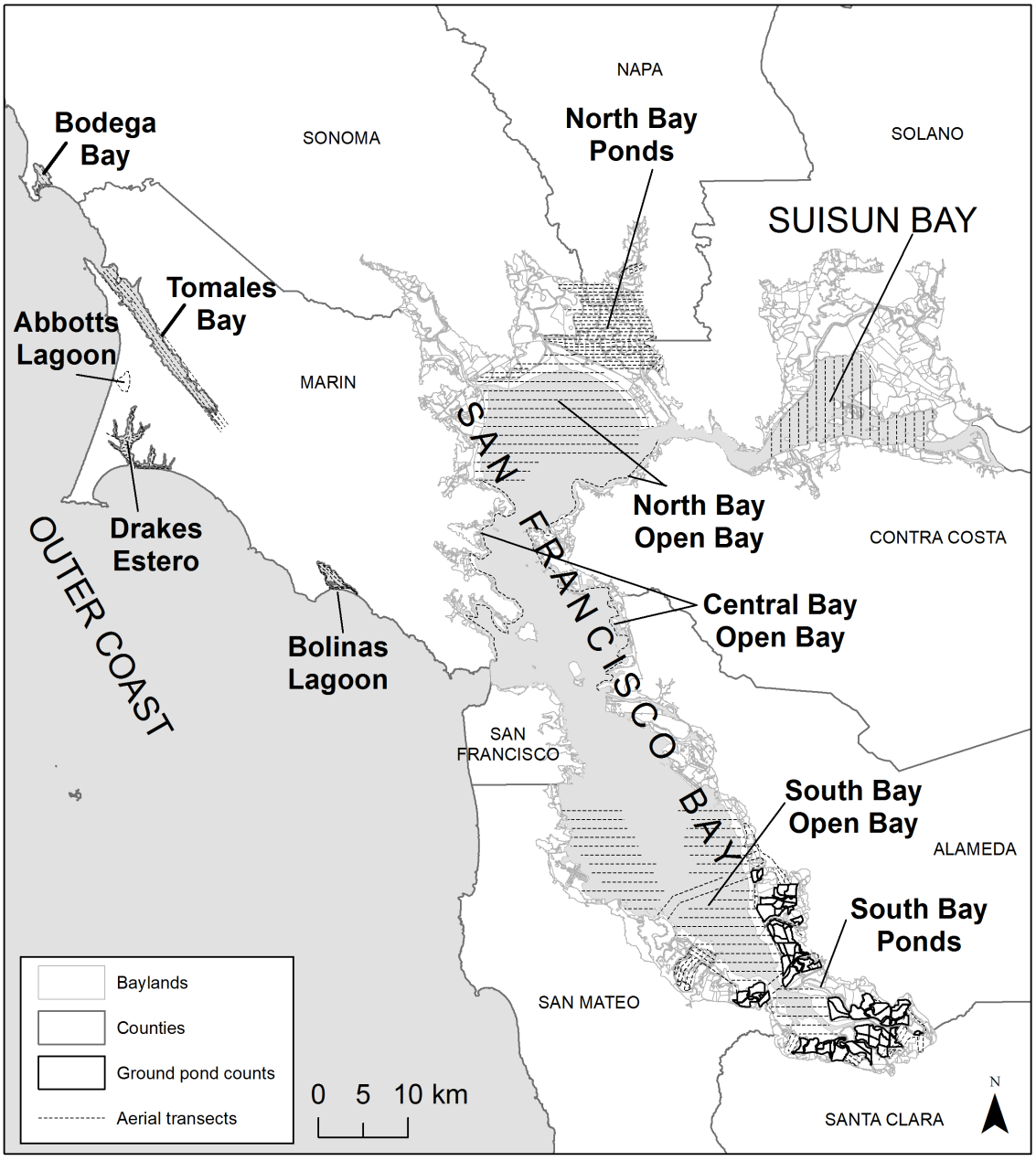


Table 1. Regions and zones for the San Francisco Estuary Midwinter Waterfowl Survey.

Region	Zone	Zone code
Outer Coast	Abbotts Lagoon	ABL
	Bodega Bay	BOB
	Bolinas Lagoon	BOL
	Drakes Estero	DRA
	Rodeo Lagoon	ROD
	Tomales Bay	TOM
San Francisco Bay	Central Bay Open Bay	CBAYOB
	North Bay Open Bay	NBAYOB
	North Bay Salt Ponds	NBAYSP
	South Bay Open Bay	SBAYOB
	South Bay Salt Ponds	SBAYSP
Suisun Bay	Suisun Bay	SUIS

Aerial surveys

Sampling Scheme

We used transects in the open bay zones and North Bay Ponds that had been established in 1987-1988 by Accurso (1992; Figure 1, Appendix A). Transects P3-P9 were extended in 2012 to encompass the newly restored Napa Plant Site along the Napa River. Selected ponds, sloughs, marshes, lagoons and bays in the North Bay Ponds, South Bay Ponds and Outer Coast are surveyed by air without fixed transects; these locations are indicated as short, unlabeled transects in Figure 1 and data is collected by site name rather than associated with a transect.

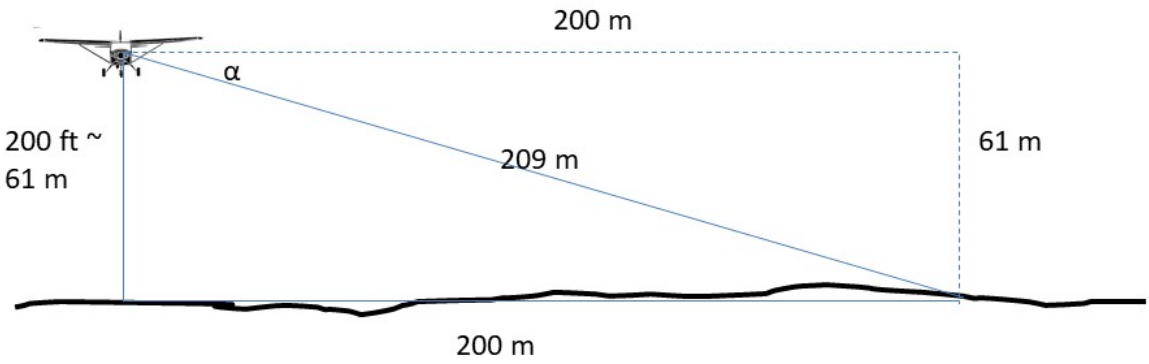
Note that differences in the survey area covered from year to year were not accounted for in the analysis of temporal trends in waterfowl and coot counts presented in the Results section.

A standard transect width of 400 m (200 m from each side of the plane) was marked using tape at observer eye level on the aircraft windows to ensure that observers are counting flocks out to the same distance and to reduce the probability of double counting (Smith 1995, Figure 2).

Figure 2. A standard transect width of 200 m from each side of the plane ensures that observers are counting flocks out to the same distance (after Smith 1995).

How to calculate the angle below horizontal (α) that an observer needs to use to get a transect width of 200 m assuming an altitude of 200 ft (61 m).

Tangent(α) = 61/200 = 0.3048
α = 16.95 degrees
Angle for window marking: 73



Aircraft

Our pilot for aerial surveys in the North Bay Open Bay, North Bay Ponds, Central Bay Open Bay, South Bay Open Bay and South Bay Ponds for years 2013-2015 was Barry Hansen and in 2016 Brad Busch, both from Aspen Helo (Aspen Helicopters, Oxnard, California, 805-985-5416) in a Partenavia twin-engine high-wing plane. In 2018, a Partenavia twin-engine high-wing plane was flown by USFWS pilot James Bredy for aerial surveys in the North Bay Open Bay, North Bay Ponds, Central Bay Open Bay, South Bay Open Bay and South Bay Ponds. A fixed-wing single-engine Cessna 182R was flown by Bob Van Wagenen (Ecoscan Resource Data, 143 Browns Valley Road, Watsonville, CA 95076; Phone: 831-728-5900) for aerial surveys of the Outer Coast region from 2013 to 2018. During surveys, both planes flew at altitudes of approximately 60 m (200 ft) at speeds of approximately 90 knots. Two aerial observers were used for each survey and sat in the second row of seats (behind the pilot; Table 2). A navigator sat in the front right seat next to the pilot for flights in the San Francisco and Suisun Bay regions (but not the Outer Coast region). The navigator is there to assist with navigation and detecting hazards using detailed paper maps of the survey routes. The navigators played a critical role by keeping the pilot on course and keeping the observers informed of the plane's location, especially in the more complex pond regions. A full Project Aviation Safety Plan can be found at: Z:\REFUGES & PROGRAMS\BIOLOGY\MidwinterWaterfowlSurvey\Documentation\Planning\Safety\PASP.

Table 2. Observers who participated in the 2013-2018 Midwinter Waterfowl Survey (name, affiliation, survey type, years participated).

Last name	First name	Affiliation	Survey type	2013	2014	2015	2016	2017	2018
Albertson	Joy	USFWS	Aerial	x	x		x		x
Clearwater	Iris	USGS	Ground	x					
DeLaCruz	Susan	USGS	Aerial	x		x			
DeLaCruz	Susan	USGS	Ground	x					
Dulava	Sharon	USFWS	Aerial		x	x			
Graham	Tanya	USGS	Aerial				x	x	x
Hawk	Luke	USGS	Aerial						x
Heyse	Victoria	San Francisco Bay Bird Observatory	Ground			x	x	x	x
Hill	Mason	USGS	Aerial					x	x
Hollander	Laura	USGS	Ground	x					
Liu	Len	PRBO Conservation Science	Aerial		x	x			
Marriott	Meg	USFWS	Aerial	x	x		x		
McChesney	Gerry	USFWS	Aerial			x	x		
Moskal	Stacy	USGS	Ground	x					
Pottier	Sara	USGS	Ground	x					
Richmond	Orien	USFWS	Aerial	x	x	x			
Schultz	Annie	USGS	Ground	x					
Sloop	Christina	San Francisco Bay Joint Venture	Aerial	x					
Spragens	Kyle	USGS	Aerial				x		
St. Pierre	Jason	San Francisco Bay Bird Observatory	Ground			x			
Strong	Cheryl	USFWS	Ground	x					
Tertes	Rachel	USFWS	Aerial	x	x	x	x		
Tokatlian	Karine	San Francisco Bay Bird Observatory	Ground	x	x				
Washburn	Natalie	San Francisco Bay Bird Observatory	Ground		x				

Waterfowl counts

Waterfowl numbers were determined with direct counts for smaller flocks or by estimation for larger flocks. We assumed that individual birds were not double counted or missed, although this assumption is likely violated to some degree because counts are spaced out over several days; in addition, the transects in the North Bay Ponds zone are quite close together (0.5 km), which could lead to double counting. No adjustments for detection probability or observer bias were made to count values. Counts were also not adjusted to account for birds present in unsampled parts of the SF Estuary.

Species identification

A list of the potential waterfowl and coot species found in the SF Estuary, including common names, scientific names, families, sub-families and tribes, are provided in Appendix B. Waterfowl, and coots were identified to species except for goldeneye, mergansers, scaup and scoter. Goldeneye were assumed to be predominantly common goldeneye, though Accurso (1992) found up to 1% Barrow's goldeneye. Mergansers included common merganser and red-breasted merganser. Scaup included greater and lesser scaup. Scoters were assumed to be predominantly surf scoters, though Accurso (1992) found up to 1% black and/or white-winged scoters. Waterfowl that could not be identified were recorded as unidentified (e.g., unidentified dabbler, unidentified diver, or unidentified duck). Grebes (*Aechmophorus* only) were not consistently recorded by all observers, so the counts should be interpreted with caution. When counted, western and Clark's grebes were lumped. Smaller waterfowl (such as cinnamon teal and blue-winged teal) that are found in more vegetated wetlands are not well accounted for in the MWS.

Data collection and transcription

From 2013-2018, aerial observers recorded all waterfowl seen from the aircraft using a GPS-enabled data recording system developed by John I. Hodges, U.S. Fish and Wildlife Service, Migratory Bird Management, 3000 Vintage Blvd., Suite 240, Juneau, AK 99801-7100. Each aerial observer had a Panasonic Toughbook 53 laptop running a software package called "Survey Programs" written by Hodges. Bird observations were verbally recorded using a Phillips SpeechMike USB dictation microphone connected to each laptop via a USB cable. Each laptop concurrently received position and temporal data from a GlobalSat BU-353S4 GPS receiver placed on the plane's dashboard. The GPS units and laptops were supplied with power via a DC to AC power inverter connected to the aircraft's electrical system. Voice recordings were saved to sound files (.wav format) that were linked to a position file containing location, date and time.

After the flights, each observer transcribed their data by playing back the sound files and entering species codes and counts for each observation using a custom transcription program written by Hodges. The transcription program produced an ASCII text file, each line of which

contained the species code, count, geographic coordinates, date, time (in seconds since midnight), observer code, observer position in aircraft and survey unit identifier. The system also recorded a "track file" consisting of a list of the aircraft's geographic coordinates every five seconds during flight. The data files were then imported into the MWS Access database maintained by Don Edwards San Francisco Bay National Wildlife Refuge staff (current database manager Cheryl Strong). Access queries were used to extract desired data for the production of maps, tables and other data products developed for this report.

Ground counts

SFBBO and USGS conducted ground counts in the South Bay Pond zone in January each year (Figure 1). During each survey, birds were counted by trained observers using spotting scopes and binoculars from the nearest drivable levee. Birds were identified at the species level whenever possible, with the exception of greater and lesser scaup, which were identified as scaup. When species identification was not possible, birds were identified to genus or foraging guild (e.g., diver vs. dabbler). Ground surveys were conducted exclusively during high tide, defined as a tide of 4.0 feet or greater at the Alameda Creek Tide Sub-Station (37° 35.7' 122°). Ground counts were summed by species for each pond for use in further analyses. For further description of these data see De La Cruz et al. (2018).

Data analysis

Data collected during aerial surveys included date, observer, region, zone, survey unit (pond, slough, marsh, lagoon, bay ID or transect ID), species, count, location (X-Y coordinates) and time. Data collected during ground counts included the same information, except bird counts were grouped by pond.

In this report, MWS counts are considered to be an imperfect index of waterfowl/coot abundance and were used to evaluate the contribution of the SF Estuary to Lower Pacific Flyway total counts.

Descriptive statistics such as total counts and percentages were used to summarize waterfowl use over time and by region. Distribution maps were generated using X-Y coordinates of individual birds or flocks for the aerial data and X-Y coordinates of pond centroids for ground count data, where counts for each species were summed for each pond.

Results

Summary

The 2013-2018 SF Estuary MWS were conducted in January as early as January 3rd and as late as January 26th (Table 3). Due to funding limitations, we did not survey the Outer Coast and Suisun regions in 2013 and 2014. Suitable conditions in 2015 allowed for all regions and zones to be

surveyed, except for Suisun, which was limited by heavy fog. Fog and time constraints of the pilot limited our ability to survey the Outer Coast region in 2016. Lack of a suitable pilot for flights over open water (requiring a twin-engine airplane) limited our survey in the SF Estuary overall in 2017. Only the Outer Coast region was surveyed by air, along with nine ponds ground-counted in the South Bay Ponds in 2017. Suitable weather, funding, and pilot conditions in 2018 allowed for all regions to be surveyed.

Table 3. Survey dates and zones from 2013-2018 for the SF Estuary midwinter waterfowl survey.

Year	Survey Dates	Zone areas surveyed
2013	1/7-1/11	CBAYOB, NBAYOB, NBAYSP, SBAYOB, SBAYSP
2014	1/6-1/10	CBAYOB, NBAYOB, NBAYSP, SBAYOB, SBAYSP
2015	1/7, 1/14-1/16	ABL, BOB, BOL, CBAYOB, DRA, NBAYOB, NBAYSP, ROD, SBAYOB, SBAYSP, TOM
2016	1/3-1/4, 1/7-1/8, 1/10, 1/12, 1/14	CBAYOB, NBAYOB, NBAYSP, SBAYOB, SBAYSP, SUIS
2017	1/6, 1/9, 1/11-1/13	ABL, BOB, BOL, DRA, SBAYSP, TOM
2018	1/9-1/14, 1/16-1/17, 1/26	ABL, BOB, BOL, CBAYOB, DRA, NBAYOB, NBAYSP, ROD, SBAYOB, SBAYSP, SUIS, TOM

Every year, some transect are cut short or skipped entirely due to air traffic control restrictions at one of the local airports (notable San Francisco International Airport in the Central Bay), due to weather, or due to other constraints. For example, the following locations were not surveyed in 2018:

North Bay Open Bay: The west side of N5, N6, N11, N12, N16, in the North Bay Open Bay all cut short by ~half mile due to close proximity of power lines.

North Bay Salt Ponds: Transects P2, P3, and P4 were all cut at the railroad tracks as habitat on the west side of the tracks is dry. The following transects were cut ~three tenths of a mile short: P10, P11, P12, P13, P14. The following transects were cut ~ half mile short: P15, P16, P17, P18 P19, P21. Transects P25, P26, P27 were not done.

Central Bay Open Bay: The west side of B00, B3, B6, B9, B11, B12 were cut short by two tenths of a mile, transect B4 was not surveyed; and transects B15, B16, B17 were cut short one mile in the South Bay Open Bay due to San Francisco International Airport traffic.

South Bay Open Bay: Transect A00 was cut short on the east side ~1.4 miles (out of ~6.5); on the west side transects A4, A5, A6 were all cut short ~half mile.

South Bay Salt Ponds: Within the South Bay Ponds zone the following areas were ground counted 2013-2018:

2013	A19	PAT	B7	R1	A9	2014	A2E	N2A
	A20	B1	B8A	R2	M1		A3W	N3A
	A21	B10	B9	A10	M2		AB1	A16
	A22	B12	N3A	A11	M3		AB2	A5
	A23	B13	N7	A12	N4		A1	A14
	N1A	B14	R3	A13	B3C		A2W	A9
	N8	B14B	R4	A14	RSF2		B3C	B1
	A1	B15B	A3N	A15	B6B		B9	B10
	A2E	B16B	A3W	A16	B8		N1A	
	A2W	B2	A4	A17		2015	A14	AB2
	BDC	B4	AB1	A5			A9	A16
	CRP	B5	AB2	A7			A1	A5
	N4AA	B6	M4	A8			A2W	
	N4AB	B6A	M5	A8S				
	N4B	B6C	N2A	A8W				

2016	A2W	A15	2017	A12	B8AE
	M4	B6B		A14	B8AW
	M5	B8AE		A9	A16
	A8S	B8AW		B2	A5
	A8W	B8XN		B4	
	N1	B8XS	2018	N3a	N4AB
	N4	B9		N4aa	N4B
	N5	E14		A14	N7
	N6	A5		A16	N8
	NPP1	A6S		A3N	A10
	M3	A7		A5	A11
	M6	A3W		AB2	A12
	A13	AB2		A3W	A9
	A14			B2	

Species counts and composition by region, with comparison to 2012 data

We counted a total of 17 species and 6 species groups of waterfowl and coots in the SF Estuary during the MWS in 2013-2018, excluding Suisun Marsh, Grizzly Island and the Delta (Appendix C). Total counts ranged from 53,072 in 2017 when few zones were counted, to 299,639 in 2018 when all zones were counted (Table 4). Diving ducks were consistently the most common guild

counted (46-66%); with dabbling ducks a consistent second (28-45%; Table 5). The two zones with the consistently highest counts of waterfowl and coots in the SF Estuary (excluding 2017 due to lack of survey in most zones) were the South Bay Ponds (65,232-139,961; 31-67%), and the North Bay Ponds (26,907-105,088; 13-38%), except for in 2018 when the North Bay Open Bay had a higher percentage (79,860; 27%; Table 6 and 7).

The North and South Bay ponds had fairly mixed species compositions with high representation of both diving and dabbling ducks, while the North, Central, South and Suisun Open Bays had less diverse species compositions more heavily weighted towards diving ducks (Figure 3). This is consistent with Richmond et al (2014).

Figure 3. Distribution of diving ducks, dabbling ducks, and coots counted during the Midwinter Waterfowl Survey, 2013-2018.

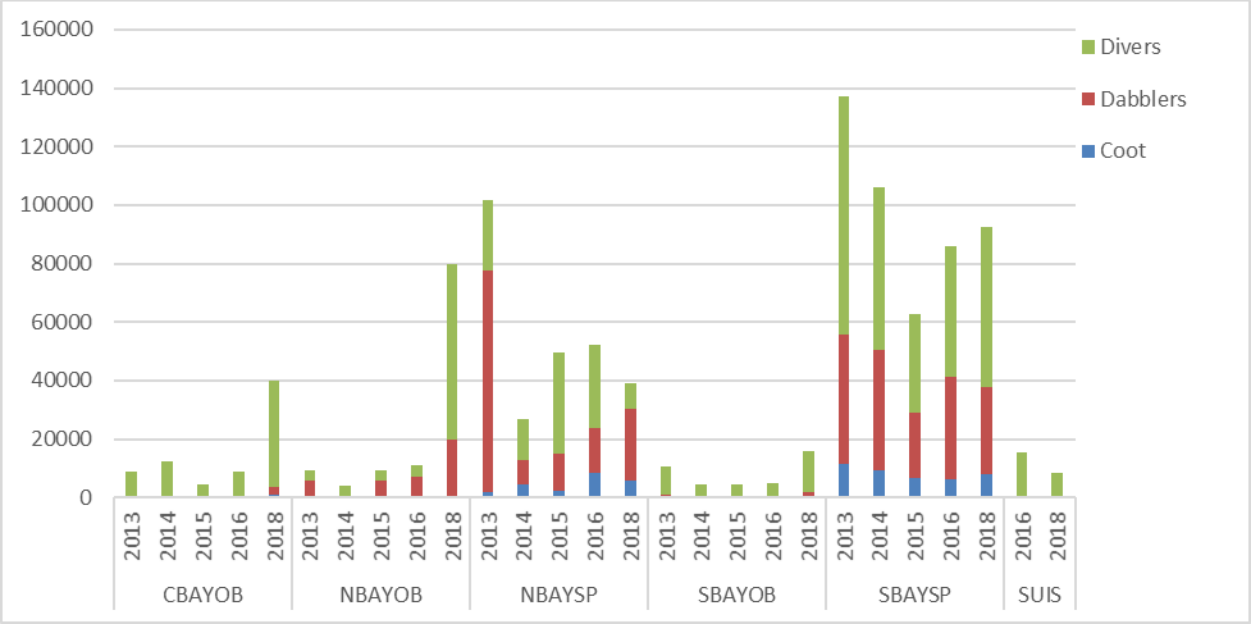


Table 4. Number of waterfowl and coots counted by year in the San Francisco Estuary Midwinter Waterfowl Survey in January 2013-2018.

Guild	2013	2014	2015	2016	2017	2018
Coot	13401	13928	9039	14963	7750	14861
Dabblers	126664	50297	43021	57945	16292	84262
Divers	127983	89605	85950	105899	25718	198185
Geese	1261	74	2237	190	3231	1321
Grebe	3951	2507	3084	924	61	956
Swan	0	0	25	35	0	44
Unidentified Duck	4590	986	3184	1019	20	10
Grand Total	277850	157397	146540	180975	53072	299639

Table 5. Percentages of waterfowl and coots counted by year in the San Francisco Estuary Midwinter Waterfowl Survey in January 2013-2018.

Guild	2013	2014	2015	2016	2017	2018
Coot	4.82	8.85	6.17	8.27	14.60	4.96
Dabblers	45.59	31.96	29.36	32.02	30.70	28.12
Divers	46.06	56.93	58.65	58.52	48.46	66.14
Geese	0.45	0.05	1.53	0.10	6.09	0.44
Grebe	1.42	1.59	2.10	0.51	0.11	0.32
Swan	0.00	0.00	0.02	0.02	0.00	0.01
Unidentified Duck	1.65	0.63	2.17	0.56	0.04	0.00
Grand Total	100	100	100	100	100	100

Table 6. Total number of waterfowl and coots counted by area in the San Francisco Estuary Midwinter Waterfowl Survey in January 2013-2018. Empty cells indicate no count.

Zone	2013	2014	2015	2016	2017	2018
Abbotts Lagoon			15		30	192
Bodega Bay			985		1303	1816
Bolinas Lagoon			704		586	1067
Central Bay Open Bay	10939	13902	6449	9305		40556
Drakes Estero			1797		5365	8185
North Bay Open Bay	10674	4691	9705	11620		79860
North Bay Salt Ponds	105088	26907	49976	52437		39371
Rodeo Lagoon			5		12	2
South Bay Open Bay	11188	5087	5036	5195		16214
South Bay Salt Ponds	139961	106810	65232	86896	37575	92553
Suisun Bay				15522		8566
Tomales Bay			6636		8201	11257
Grand Total	277850	157397	146540	180975	53072	299639

Table 7. Percentages of all waterfowl and coots counted by year in the San Francisco Estuary Midwinter Waterfowl Survey in January 2013-2018.

Zone	2013	2014	2015	2016	2018
Abbotts Lagoon	0.00	0.00	0.01	0.00	0.06
Bodega Bay			0.67		0.61
Bolinas Lagoon			0.48		0.36
Central Bay Open Bay	3.94	8.83	4.40	5.14	13.53
Drakes Estero			1.23		2.73
North Bay Open Bay	3.84	2.98	6.62	6.42	26.65
North Bay Salt Ponds	37.82	17.09	34.10	28.97	13.14
Rodeo Lagoon			0.00		0.00
South Bay Open Bay	4.03	3.23	3.44	2.87	5.41
South Bay Salt Ponds	50.37	67.86	44.51	48.02	30.89
Suisun Bay				8.58	2.86
Tomales Bay			4.53		3.76
Grand Total	100	100	100	100	100

Summaries below exclude 2017 due to lack of survey in most zones.

Dabbling ducks

Total counts for dabbling ducks included the sum of counts for American wigeon, Eurasian wigeon, cinnamon teal, gadwall, green-winged teal, mallard, northern pintail, northern shoveler and unidentified dabbling ducks. Total numbers of dabbling ducks ranged from 50,297 in 2014 to 126,664 in 2013 in the SF Estuary (Table 8, Appendix C and D). Dabbling ducks were distributed primarily in the North and South Bay Ponds, consistent with Richmond et al 2014 (Figure 3). Detailed results are presented below for the five most abundant dabbling ducks: American wigeon, gadwall, mallard, northern pintail and northern shoveler.

Table 8. Number of dabbling ducks counted by area in the San Francisco Estuary Midwinter Waterfowl Survey in January 2013-2018. Empty cells indicate no count.

Dabblers	2013	2014	2015	2016	2018
Abbotts Lagoon			10		192
Bodega Bay			1		2
Bolinas Lagoon			440		359
Central Bay Open Bay	175	13	29	2	2724
Drakes Estero			645		3005
North Bay Open Bay	5644	559	5195	7059	19836
North Bay Salt Ponds	75486	8217	12791	15337	24592
Rodeo Lagoon			5		0
South Bay Open Bay	1174	80	258	119	2060
South Bay Salt Ponds	44185	41428	22595	35299	29683
Suisun Bay				129	42
Tomales Bay			1052		1767
Grand Total	**126664**	**50297**	**43021**	**57945**	**84262**

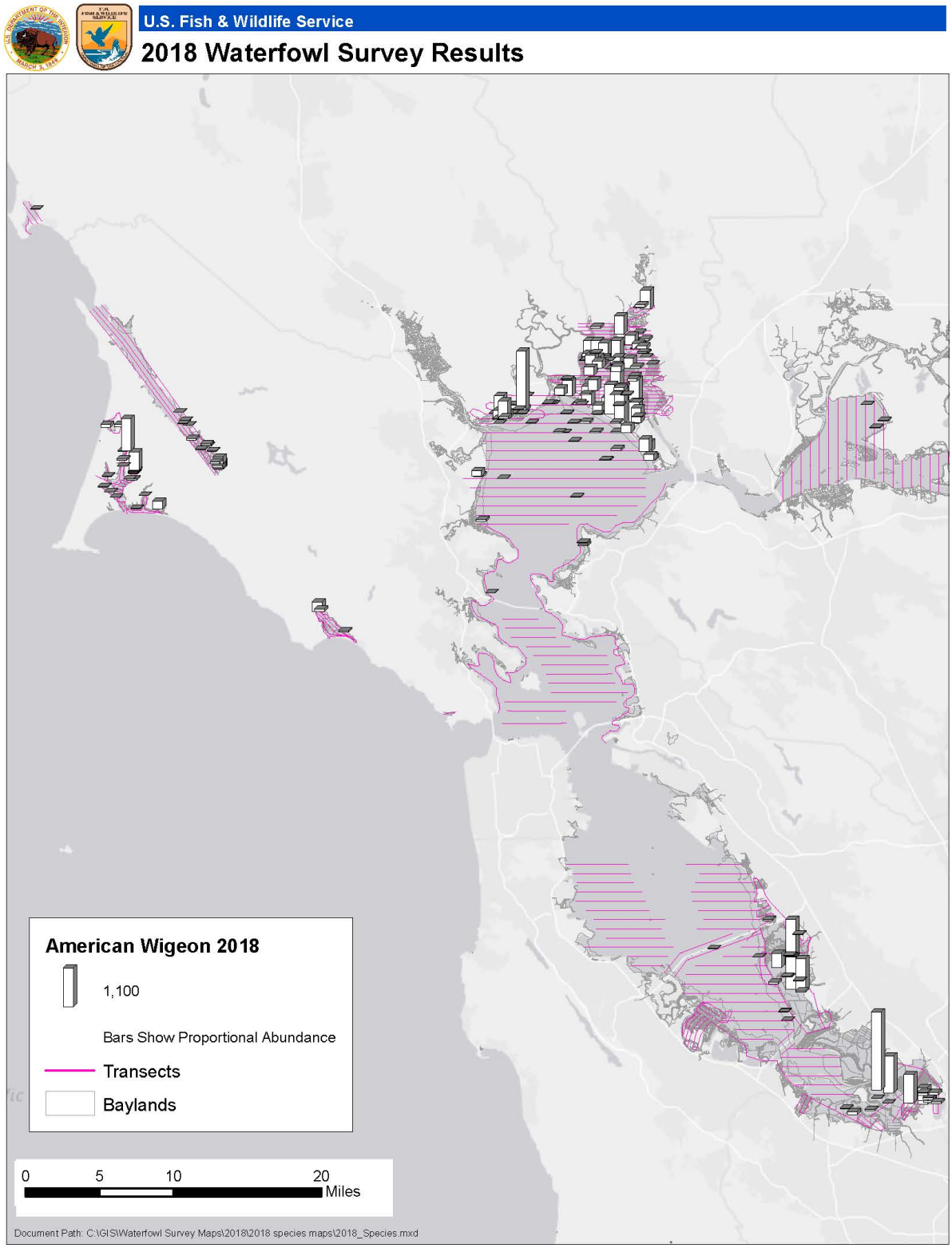
American wigeon

A range of 15,845-32,116 American wigeon were counted in the SF Estuary in January 2013-2018 (Table 9). American wigeon were distributed throughout the North and South Bay Ponds and on the Outer Coast (Figure 4). The largest concentrations were in the South Bay Ponds, except in 2013 when higher numbers were found in the North Bay Ponds (Table 9 and Appendix C and D). Richmond et al (2014) also found higher numbers in the South Bay Ponds.

Table 9. Number of American wigeon counted by area in the San Francisco Estuary Midwinter Waterfowl Survey in January 2013-2018. Empty cells indicate no count.

American Wigeon	2013	2014	2015	2016	2018
Abbotts Lagoon			0		150
Bodega Bay			0		2
Bolinas Lagoon			70		325
Central Bay Open Bay	155	5	22	2	105
Drakes Estero			204		1793
North Bay Open Bay	4220	205	1988	4699	12921
North Bay Salt Ponds	14636	3212	5948	4495	5770
Rodeo Lagoon			0		0
South Bay Open Bay	423	30	105	50	114
South Bay Salt Ponds	12682	13253	6483	12565	8307
Suisun Bay				100	23
Tomales Bay			665		817
Grand Total	**32116**	**16705**	**15485**	**21911**	**30327**

Figure 4. American wigeon distribution during the Midwinter Water Survey, 2018.



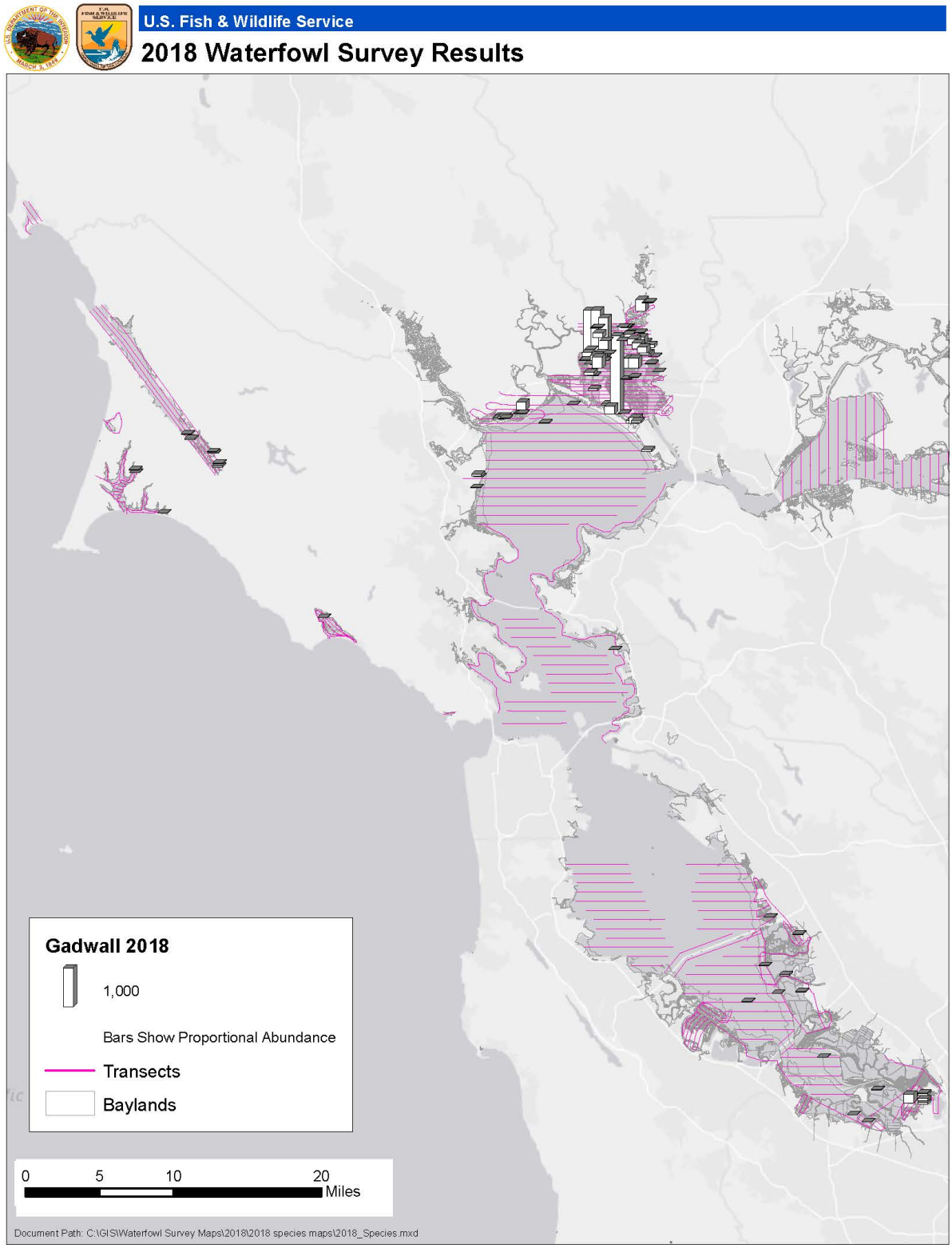
Gadwall

A range of 523-10671 gadwall were counted in the SF Estuary in January 2013-2018 (Table 10). Gadwall were distributed mainly in the North Bay Ponds and North Bay Open Bay (Figure 5). Richmond et al (2014) found highest concentrations to be in the North and South Bay Ponds.

Table 10. Number of gadwall counted by area in the San Francisco Estuary Midwinter Waterfowl Survey in January 2013-2018. Empty cells indicate no count.

Gadwall	2013	2014	2015	2016	2018
Abbotts Lagoon			0		0
Bodega Bay			0		0
Bolinas Lagoon			0		4
Central Bay Open Bay			3		4
Drakes Estero			0		17
North Bay Open Bay	277	0	74	327	3088
North Bay Salt Ponds	9876	393	211	1293	6739
Rodeo Lagoon			0		0
South Bay Open Bay		2	2	10	23
South Bay Salt Ponds	518	159	229	146	471
Suisun Bay				25	0
Tomales Bay			4		92
Grand Total	**10671**	**554**	**523**	**1801**	**10438**

Figure 5. Gadwall distribution during the Midwinter Water Survey, 2018.



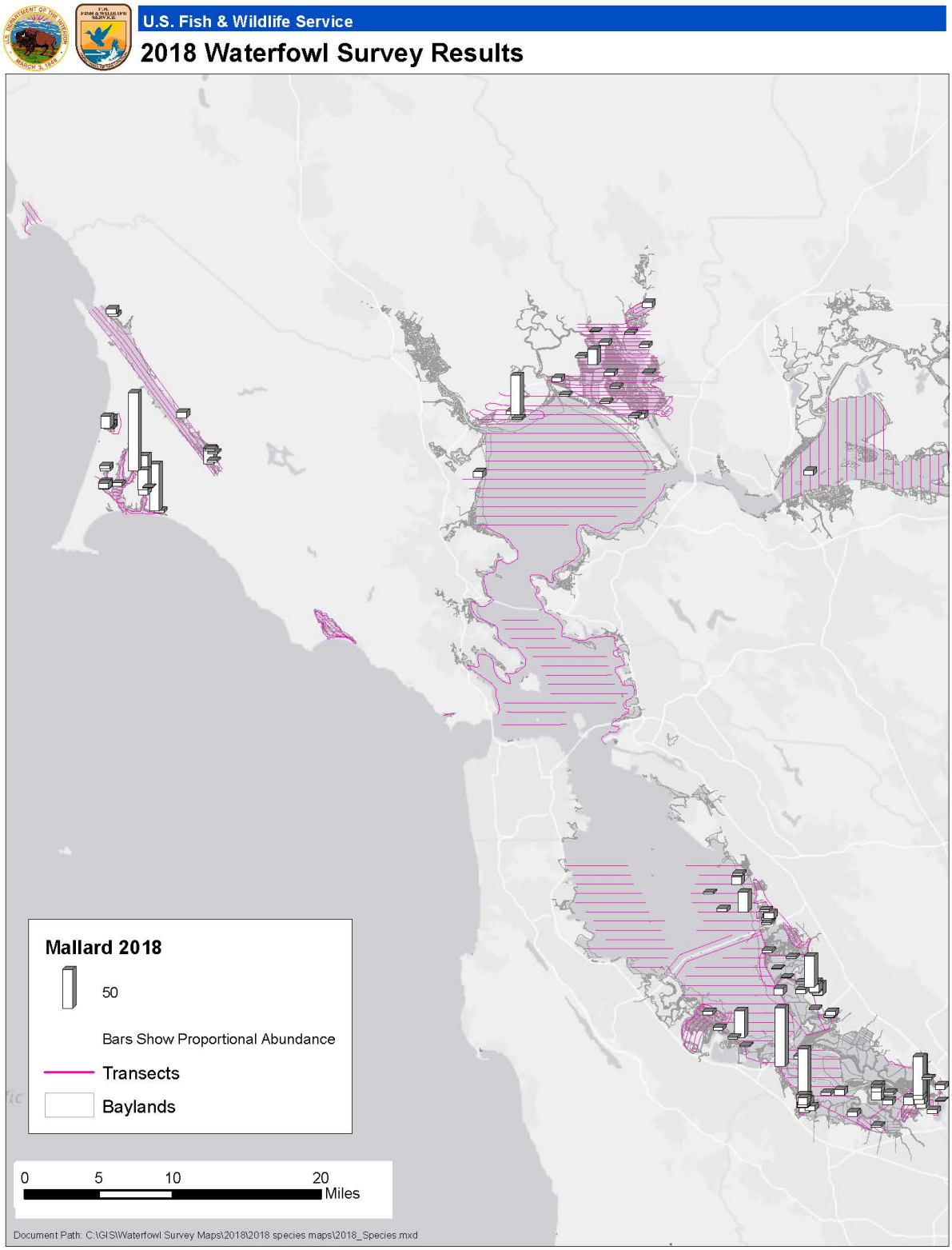
Mallard

Total numbers of mallards ranged from 224-2,888 in the SF Estuary in January 2013-2018 (Table 11). Mallards were distributed mainly in the North and South Bay Ponds (Figure 6). Few were found in the North Bay Open Bay, contrary to Richmond et al (2014).

Table 11. Number of mallard counted by area in the San Francisco Estuary Midwinter Waterfowl Survey in January 2013-2018. Empty cells indicate no count.

Mallard	2013	2014	2015	2016	2018
Abbotts Lagoon			10		39
Bodega Bay			1		0
Bolinas Lagoon			30		0
Central Bay Open Bay	0	8	4	0	43
Drakes Estero			4		268
North Bay Open Bay	34	61	90	36	67
North Bay Salt Ponds	2563	287	509	135	63
Rodeo Lagoon			0		0
South Bay Open Bay	0	9	7	4	59
South Bay Salt Ponds	291	656	193	47	642
Suisun Bay				2	6
Tomales Bay			63		45
Grand Total	**2888**	**1021**	**911**	**224**	**1232**

Figure 6. Mallard distribution during the Midwinter Water Survey, 2018.



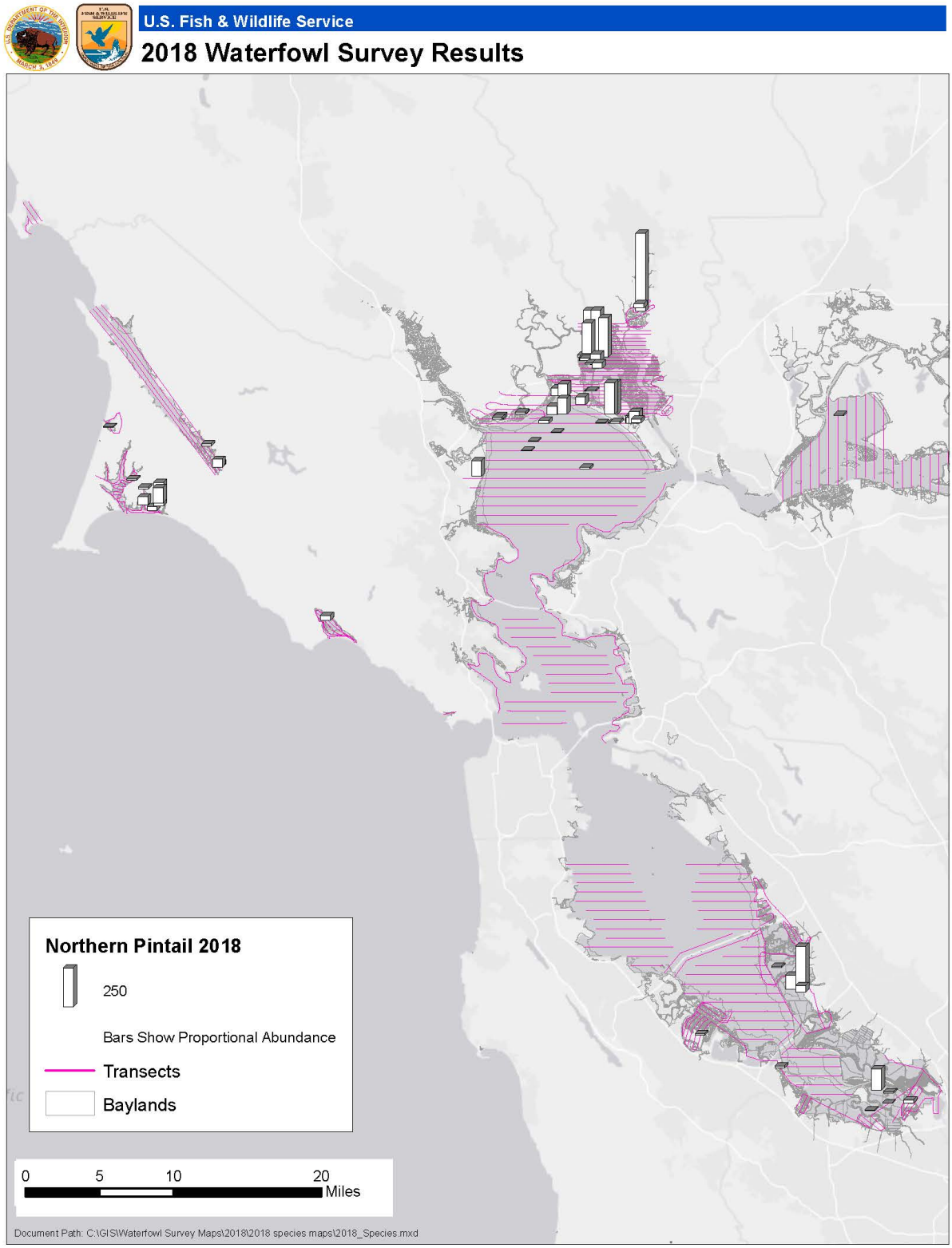
Northern pintail

A range of 2,361-12,150 northern pintail were counted in the SF Estuary in January 2013-2018 (Table 12). Northern pintail distribution varied year to year, with peaks in the North and South Bay Ponds and in the North Bay Open Bay region (Figure 7). This distribution is similar to that found by Richmond et al (2014).

Table 12. Number of northern pintail counted by area in the San Francisco Estuary Midwinter Waterfowl Survey in January 2013-2018. Empty cells indicate no count.

Northern pintail	2013	2014	2015	2016	2018
Abbotts Lagoon			0		3
Bodega Bay			0		0
Bolinas Lagoon			0		30
Central Bay Open Bay	0	0	0	0	0
Drakes Estero			1		340
North Bay Open Bay	766	252	2904	1042	1127
North Bay Salt Ponds	9813	408	900	1127	1798
Rodeo Lagoon			0		0
South Bay Open Bay	0	10	85	50	0
South Bay Salt Ponds	1571	5804	2326	142	609
Suisun Bay				0	6
Tomales Bay			0		90
Grand Total	**12150**	**6474**	**6216**	**2361**	**4003**

Figure 7. Northern pintail distribution during the Midwinter Water Survey, 2018.



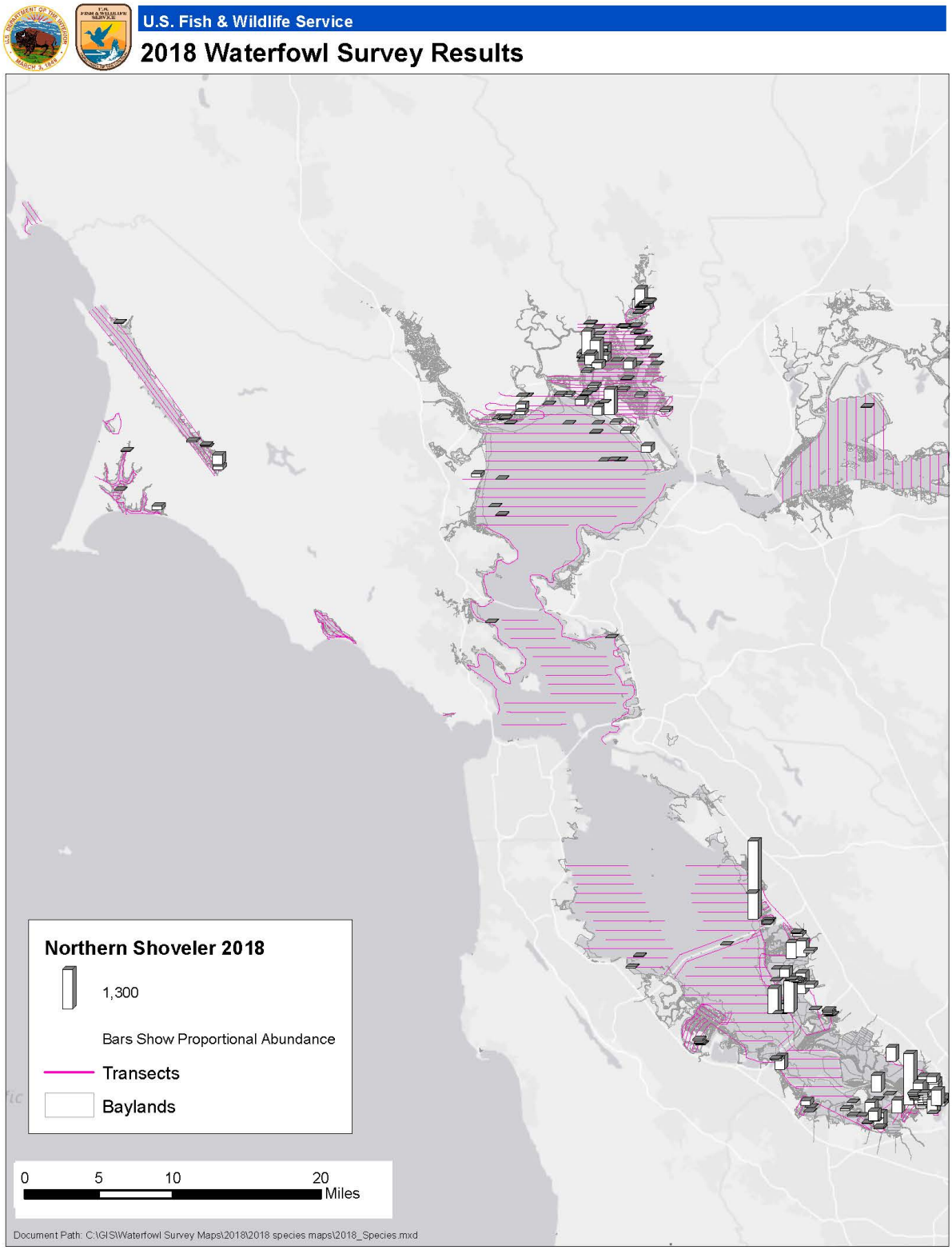
Northern shoveler

Between 15,742-56,933 northern shovelers were counted in the SF Estuary in January 2013-2018 (Table 13). Northern shovelers were distributed almost exclusively in the North and South Bay Ponds (Figure 8). As found by Richmond et al (2014), the largest concentrations were generally in the South Bay Ponds with the exception of 2013 when there were more counted in the North Bay Ponds.

Table 13. Number of northern shoveler counted by area in the San Francisco Estuary Midwinter Waterfowl Survey in January 2013-2018. Empty cells indicate no count.

Northern shoveler	2013	2014	2015	2016	2018
Abbotts Lagoon			0		0
Bodega Bay			0		0
Bolinas Lagoon			0		0
Central Bay Open Bay	20	0	0	0	2572
Drakes Estero			0		122
North Bay Open Bay	35		84	65	2454
North Bay Salt Ponds	32787	3583	4941	7641	7550
Rodeo Lagoon			0		0
South Bay Open Bay	751	29	59	5	1849
South Bay Salt Ponds	23340	19569	10658	21400	18904
Suisun Bay				2	7
Tomales Bay			0		473
Grand Total	**56933**	**23181**	**15742**	**29113**	**33931**

Figure 8. Northern shoveler distribution during the Midwinter Water Survey, 2018.



Diving ducks

Total counts for diving ducks included the sum of counts for bufflehead, canvasback, goldeneye spp., merganser spp., redhead, ring-necked duck, ruddy duck, scaup spp., scoter spp. and unidentified diver. Total numbers of diving ducks ranged from 85,950 in 2015, to 198,185 in 2018 in the SF Estuary (Table 14). Diving ducks were distributed primarily in the North and South Bay Ponds in most years; however in 2018 there were substantially more in the North Bay Open Bay than the North Bay Salt Ponds (Figure 3, Appendix C and D). Conversely, Richmond et al 2014 found diving ducks to be distributed more evenly in the SF Estuary. Detailed results are presented below for the five most abundant diving ducks: bufflehead, canvasback, ruddy duck, scaup spp. and scoter spp.

Table 14. Number of diving ducks counted by area in the San Francisco Estuary Midwinter Waterfowl Survey in January 2013-2018. Empty cells indicate no count.

Divers	2013	2014	2015	2016	2018
Abbotts Lagoon			5		0
Bodega Bay			97		1188
Bolinas Lagoon			166		701
Central Bay Open Bay	8859	12356	4588	8765	36570
Drakes Estero			741		5009
North Bay Open Bay	3791	3635	3815	3951	59853
North Bay Salt Ponds	24020	13934	34692	28560	9062
Rodeo Lagoon			0		0
South Bay Open Bay	9586	4328	4298	4841	13979
South Bay Salt Ponds	81727	55352	33599	44654	54531
Suisun Bay				15128	8481
Tomales Bay			3949		8811
Grand Total	**127983**	**89605**	**85950**	**105899**	**198185**

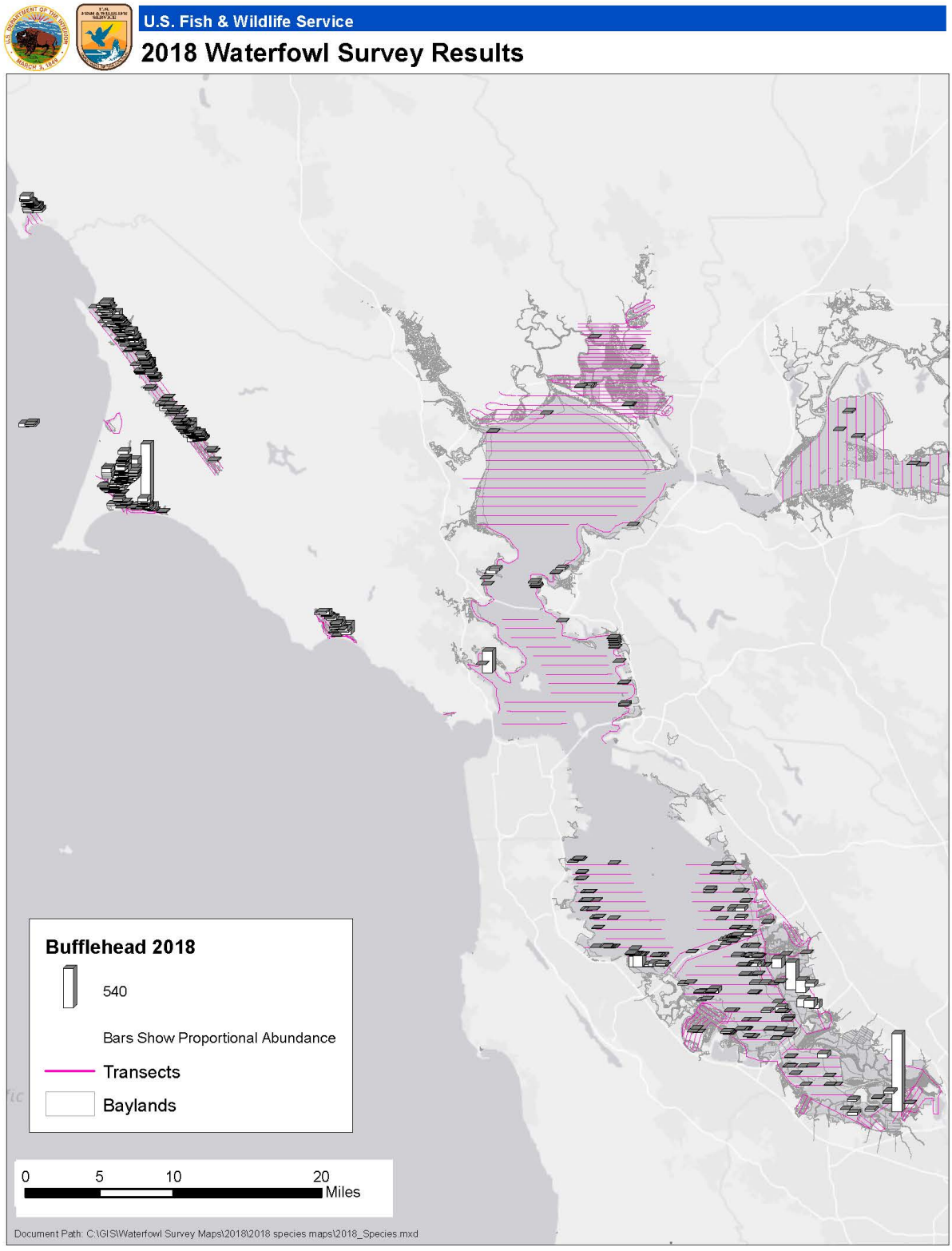
Bufflehead

A range of 2,945-13,649 bufflehead were counted in the SF Estuary in January 2013-2018 (Table 15). In 2012, bufflehead were distributed widely across the South Bay Salt Ponds, Central, North and South Open Bays with few counted on the Outer Coast (Figure 9). Richmond et al (2014) found the largest concentrations were in the Outer Coast, Central Bay Open Bay, and South Bay Open Bay.

Table 15. Number of bufflehead counted by area in the San Francisco Estuary Midwinter Waterfowl Survey in January 2013-2018. Empty cells indicate no count.

Bufflehead	2013	2014	2015	2016	2018
Abbotts Lagoon			0		0
Bodega Bay			11		781
Bolinas Lagoon			51		589
Central Bay Open Bay	3256	2982	1422	417	1537
Drakes Estero			383		4302
North Bay Open Bay	401	334	46	133	3
North Bay Salt Ponds	1474	436	549	466	90
Rodeo Lagoon			0		0
South Bay Open Bay	1308	936	579	359	960
South Bay Salt Ponds	4286	2851	735	1529	2408
Suisun Bay				41	28
Tomales Bay			1397		2951
Grand Total	**10725**	**7539**	**5173**	**2945**	**13649**

Figure 9. Bufflehead distribution during the Midwinter Water Survey, 2018.



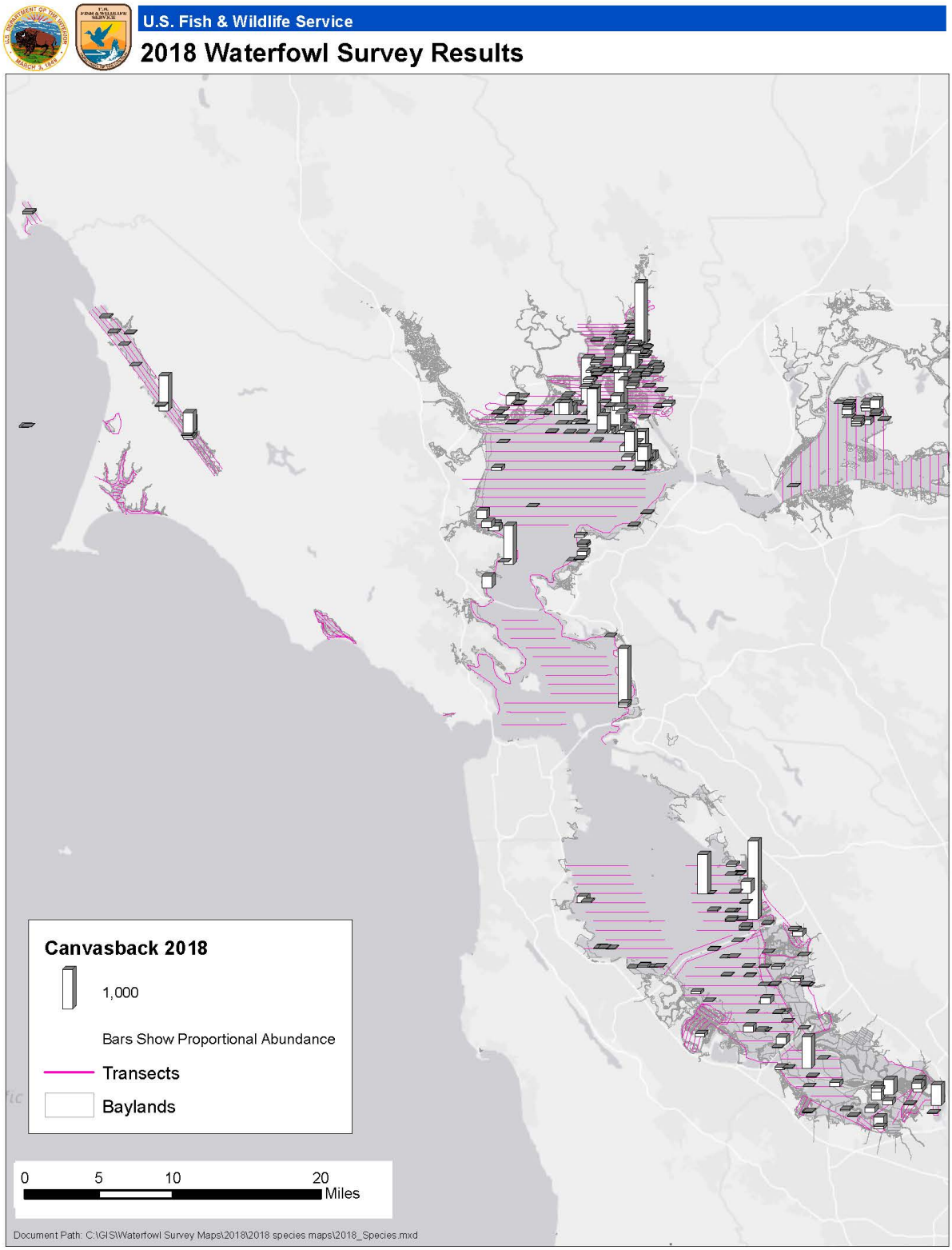
Canvasback

Canvasback numbers ranged from 14,373-32,915 in January 2013-2018 (Table 16). Similar to Richmond et al (2014), canvasback were distributed mainly in the North and South Bay Ponds however in 2018 there were substantially more in the North Bay Open Bay than the North or South Bay Salt Ponds (Figure 10).

Table 16. Number of canvasback counted by area in the San Francisco Estuary Midwinter Waterfowl Survey in January 2013-2018. Empty cells indicate no count.

Canvasback	2013	2014	2015	2016	2018
Abbotts Lagoon			0		0
Bodega Bay			0		104
Bolinas Lagoon			0		0
Central Bay Open Bay	179	145	12	120	7935
Drakes Estero			0		0
North Bay Open Bay	1090	630	988	858	11415
North Bay Salt Ponds	6922	7442	25725	8236	5086
Rodeo Lagoon			0		0
South Bay Open Bay	464	480	844	70	2030
South Bay Salt Ponds	7082	6769	2117	3508	3148
Suisun Bay				1581	1084
Tomales Bay			0		2113
Grand Total	**15737**	**15466**	**29686**	**14373**	**32915**

Figure 10. Canvasback distribution during the Midwinter Water Survey, 2018.



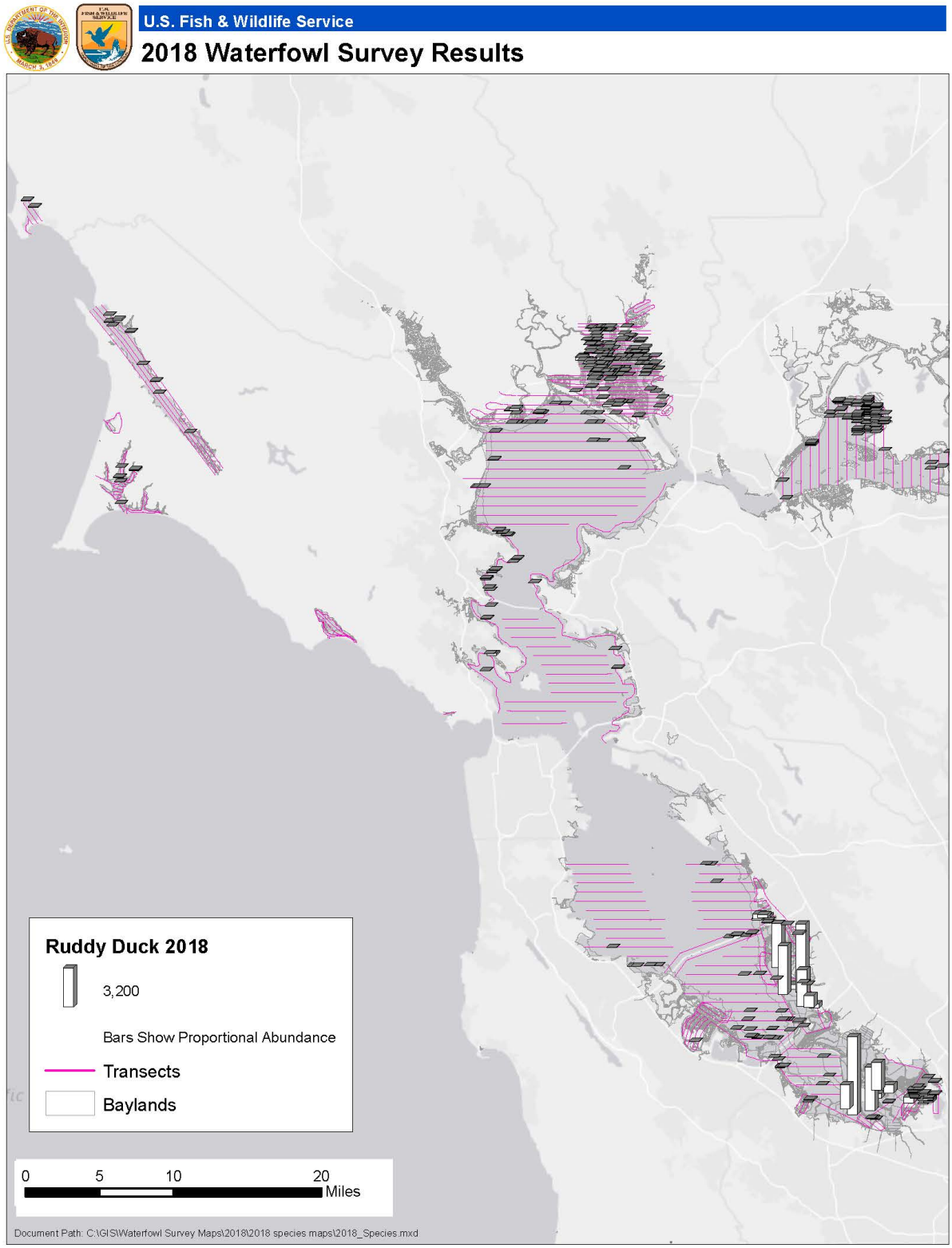
Ruddy duck

Number of ruddy ducks ranged from 31,427-49,263 in the SF Estuary in January 2013-2018 (Table 17). As found in Richmond et al (2014), ruddy ducks were mainly in the South Bay Salt Ponds (Figure 11).

Table 17. Number of ruddy duck counted by area in the San Francisco Estuary Midwinter Waterfowl Survey in January 2013-2018. Empty cells indicate no count.

Ruddy duck	2013	2014	2015	2016	2018
Abbotts Lagoon			5		
Bodega Bay			50		40
Bolinas Lagoon			3		
Central Bay Open Bay	215	165	186	197	553
Drakes Estero			65		103
North Bay Open Bay	321	496	618	962	454
North Bay Salt Ponds	4994	3437	4653	14318	3754
Rodeo Lagoon			0		0
South Bay Open Bay	120	20	30	43	171
South Bay Salt Ponds	43613	32970	25650	27127	36957
Suisun Bay				23	1477
Tomales Bay			167		171
Grand Total	**49263**	**37088**	**31427**	**42670**	**43680**

Figure 11. Ruddy duck distribution during the Midwinter Water Survey, 2018.



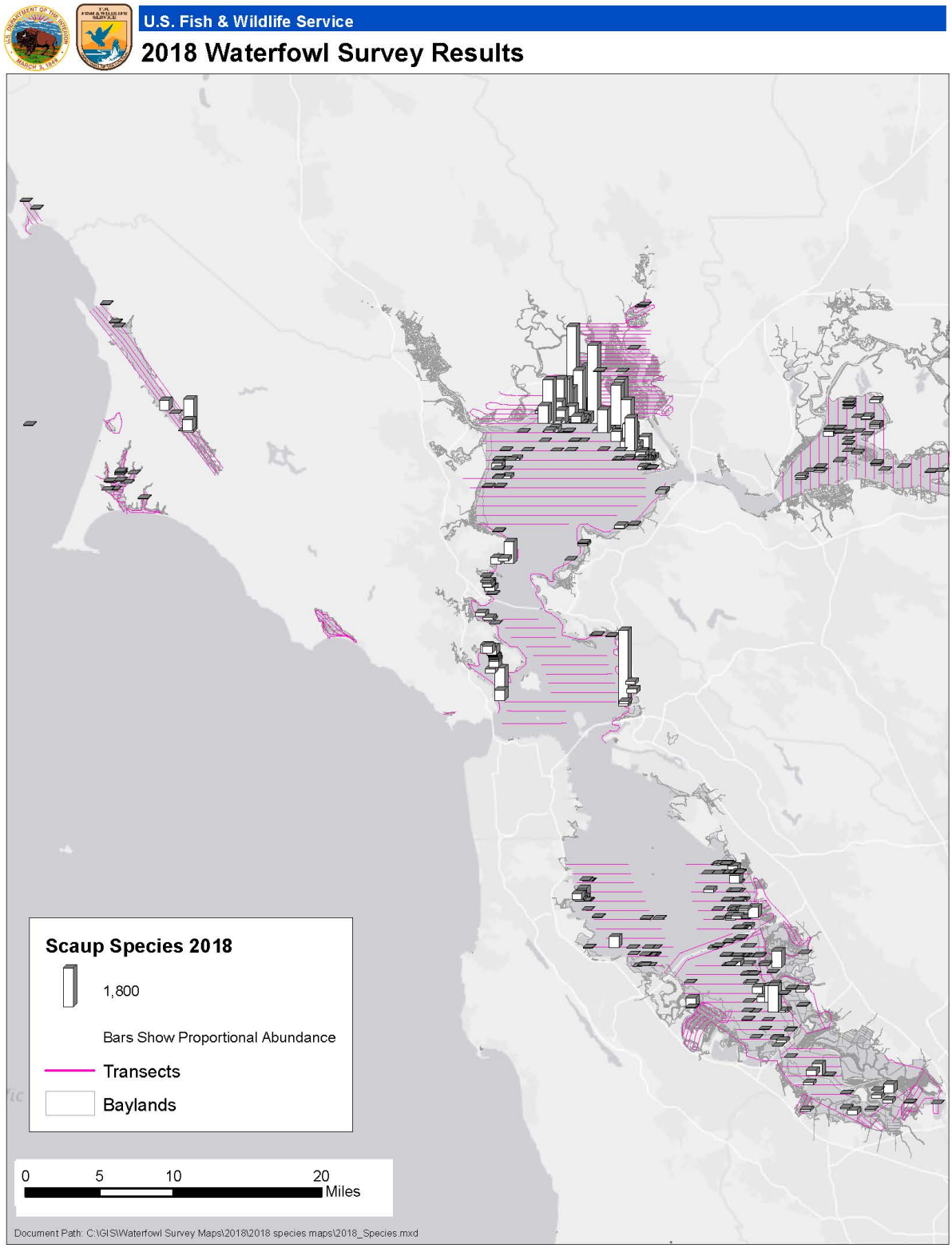
Scaup spp.

Numbers of scaup species ranged from 15,207-88,874 in the SF Estuary in January 2013-2018 (Table 18). Similar to Richmond et al (2014), scaup were distributed in the open bay areas of the Central, North and South Bays, and in the North and South Bay Salt Ponds (Figure 12). Notably, in 2018, over 45,000 scaup were counted in the North Bay Open Bay; this is more than the total number of scaup counted during the previous five surveys. In addition, in 2018, substantially more scaup were counted in the Central Bay Open Bay than in previous year or in either the North or South Bay Salt Ponds.

Table 18. Number of scaup spp. counted by area in the San Francisco Estuary Midwinter Waterfowl Survey in January 2013-2018. Empty cells indicate no count.

Scaup spp.	2013	2014	2015	2016	2018
Abbotts Lagoon			0		0
Bodega Bay			30		63
Bolinas Lagoon			26		
Central Bay Open Bay	4062	7837	1826	6402	17693
Drakes Estero			177		184
North Bay Open Bay	1755	1470	1420	1674	45211
North Bay Salt Ponds	9425	2592	3512	5042	45
Rodeo Lagoon			0		0
South Bay Open Bay	6353	1884	2122	3363	8782
South Bay Salt Ponds	18784	11783	4075	11750	2103
Suisun Bay				12853	1221
Tomales Bay			2019		2572
Grand Total	**40379**	**25566**	**15207**	**41084**	**77874**

Figure 12. Scaup distribution during the Midwinter Water Survey, 2018.



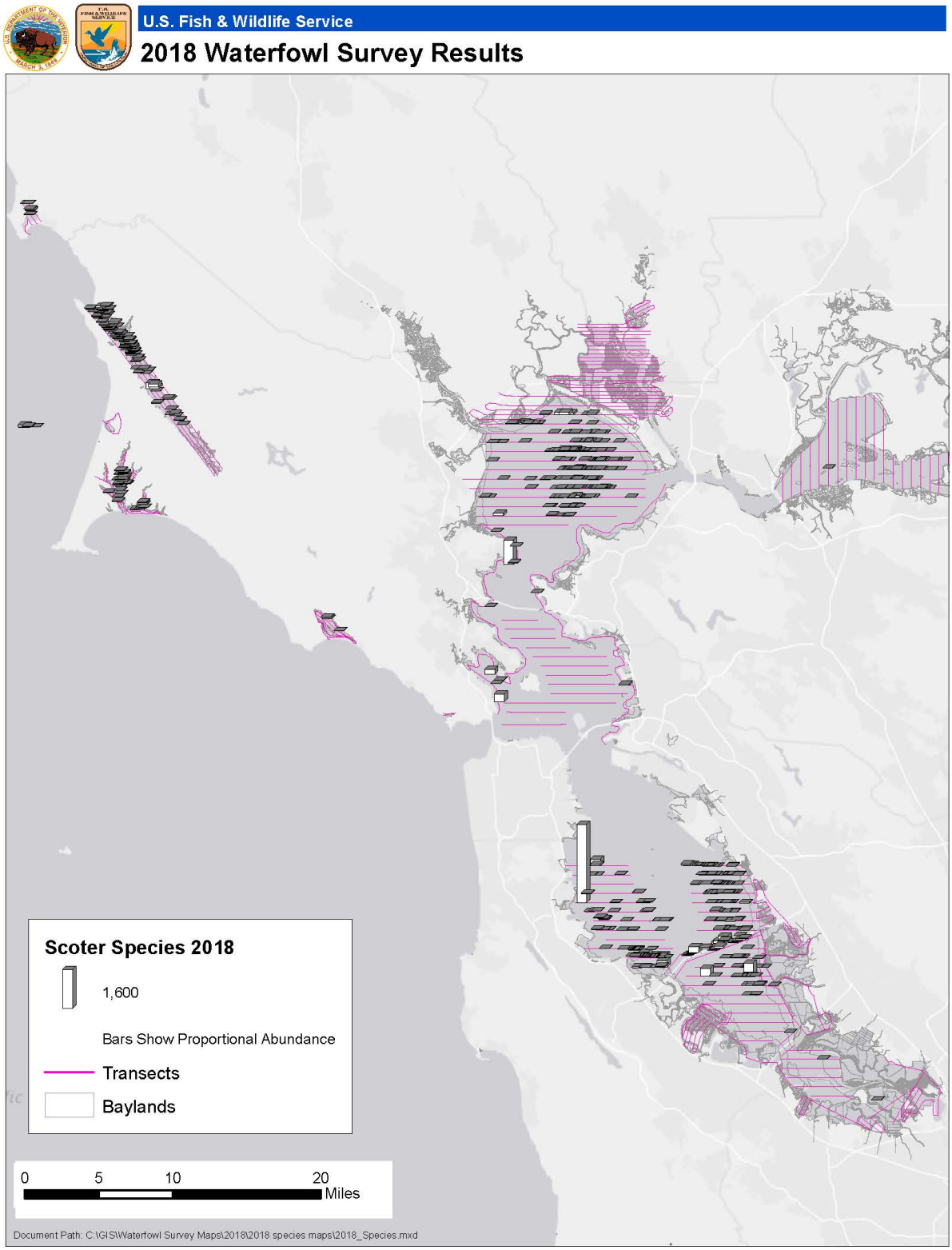
Scoter spp.

A range of 2,727-14,562 scoter spp. were counted in the SF Estuary in January 2013-2018 (Table 19). Highest numbers of scoters were found in the Central and South Open Bay (Figure 13). Richmond et al (2014) found the largest concentrations to be in North Bay Open Bay and Central Bay Open Bay. Notably in 2018, over 8,000 scoter were counted in the Central Bay Open Bay; this is more than the total number of scoter counted during the previous five surveys. In addition, substantially more were counted in 2018 in the North Bay Open Bay than in previous years. Unlike other divers, scoters are not counted in large numbers in the ponds.

Table 19. Number of scoter spp. counted by area in the San Francisco Estuary Midwinter Waterfowl Survey in January 2013-2018. Empty cells indicate no count.

Scoter spp.	2013	2014	2015	2016	2018
Abbotts Lagoon			0		0
Bodega Bay			6		154
Bolinas Lagoon			27		12
Central Bay Open Bay	1147	1226	1133	1602	8778
Drakes Estero			87		333
North Bay Open Bay	217	602	571	293	2720
North Bay Salt Ponds	0	3	31	0	0
Rodeo Lagoon			0		0
South Bay Open Bay	1341	1006	655	1005	1568
South Bay Salt Ponds	22	320	66	15	3
Suisun Bay				599	2
Tomales Bay			308		992
Grand Total	**2727**	**3157**	**2884**	**3514**	**14562**

Figure 13. Scoter distribution during the Midwinter Water Survey, 2018.



American coot

Between 9,039 and 14,963 American coots were counted in the SF Estuary 2013-2018 (Table 20). American coots were distributed almost exclusively in the North and South Bay Ponds, which is what Richmond et al 2014 also reported.

Table 20. Number of American coot counted by area in the San Francisco Estuary Midwinter Waterfowl Survey in January 2013-2018. Empty cells indicate no count.

American Coots	2013	2014	2015	2016	2018
Abbotts Lagoon			0		0
Bodega Bay			20		76
Bolinas Lagoon			0		0
Central Bay Open Bay	32	1	0	230	868
Drakes Estero			1		24
North Bay Open Bay	15	8	412	179	104
North Bay Salt Ponds	1990	4687	2091	8450	5590
Rodeo Lagoon			0		0
South Bay Open Bay	1	0	0	0	4
South Bay Salt Ponds	11363	9232	6515	6096	8126
Suisun Bay				8	40
Tomales Bay			0		29
Grand Total	**13401**	**13928**	**9039**	**14963**	**14861**

Geese and swans

A range of 74-1261 Canada geese, white geese, and swans were counted in the SF Estuary 2013-2018 (Table 21). Brant numbers varied for the two years of available data from 854 in 2018 to 1804 in 2015 (Table 22). All of the brant were counted in the Outer Coast and most of the Canada geese (which accounted for 93% of all geese and swans counted) were counted in the South Bay Ponds. Richmond et al (2014) found similar distributions.

Table 21. Number of geese and swans (excluding brant) counted by area in the San Francisco Estuary Midwinter Waterfowl Survey in January 2013-2018. Empty cells indicate no count.

Geese and Swans	2013	2014	2015	2016	2018
Abbotts Lagoon			0		0
Bodega Bay			796		511
Bolinas Lagoon			50		0
Central Bay Open Bay	0	0	9	6	0
Drakes Estero			300		93
North Bay Open Bay	21	0	0	19	40
North Bay Salt Ponds	50	0	81	49	117
Rodeo Lagoon			0		0
South Bay Open Bay	0	1	0	0	0
South Bay Salt Ponds	1190	73	147	151	210
Suisun Bay				0	2
Tomales Bay			879		392
Grand Total	**1261**	**74**	**2262**	**225**	**1365**

Table 22. Number of brant counted by area in the San Francisco Estuary Midwinter Waterfowl Survey in January 2013-2018. Empty cells (and missing years) indicate no count.

Brant	2015	2018
Abbotts Lagoon	0	0
Bodega Bay	727	450
Bolinas Lagoon	50	0
Central Bay Open Bay	9	0
Drakes Estero	224	82
North Bay Open Bay	0	0
North Bay Salt Ponds	0	0
Rodeo Lagoon	0	0
South Bay Open Bay	0	0
South Bay Salt Ponds	0	0
Suisun Bay	0	0
Tomales Bay	794	322
Grand Total	**1804**	**854**

Grebes

Grebe (*Aechmophorus* spp.) numbers varied from 924-3,951 in 2013-2018 in the SF Estuary (Table 23). The highest numbers of grebes were counted in the Central Bay Open Bay, contrary to Richmond et al (2014) who found the majority in the South Bay Ponds.

Table 23. Number of grebes counted by area in the San Francisco Estuary Midwinter Waterfowl Survey in January 2013-2018. Empty cells indicate no count.

Grebes	2013	2014	2015	2016	2018
Abbotts Lagoon			0		0
Bodega Bay			70		39
Bolinas Lagoon			8		7
Central Bay Open Bay	1873	1355	1703	268	394
Drakes Estero			92		54
North Bay Open Bay	203	347	208	381	27
North Bay Salt Ponds	102	16	45	41	10
Rodeo Lagoon					2
South Bay Open Bay	427	485	384	88	161
South Bay Salt Ponds	1346	304	185	61	3
Suisun Bay				85	1
Tomales Bay			389		258
Grand Total	**3951**	**2507**	**3084**	**924**	**956**

Discussion

Waterfowl and coot numbers and distribution varied year to year due to natural variation in populations, available wetlands due to rainfall, and weather. As noted before, MWS counts are an imperfect index of waterfowl and coot abundance and should be interpreted cautiously. The discussion below applies to counts from 2013-2018.

Some species appear to be using the same zones consistently over the years. For example, ruddy ducks have fluctuated in numbers over the years, but have consistently utilized the South Bay Salt Ponds far more than any other zone.

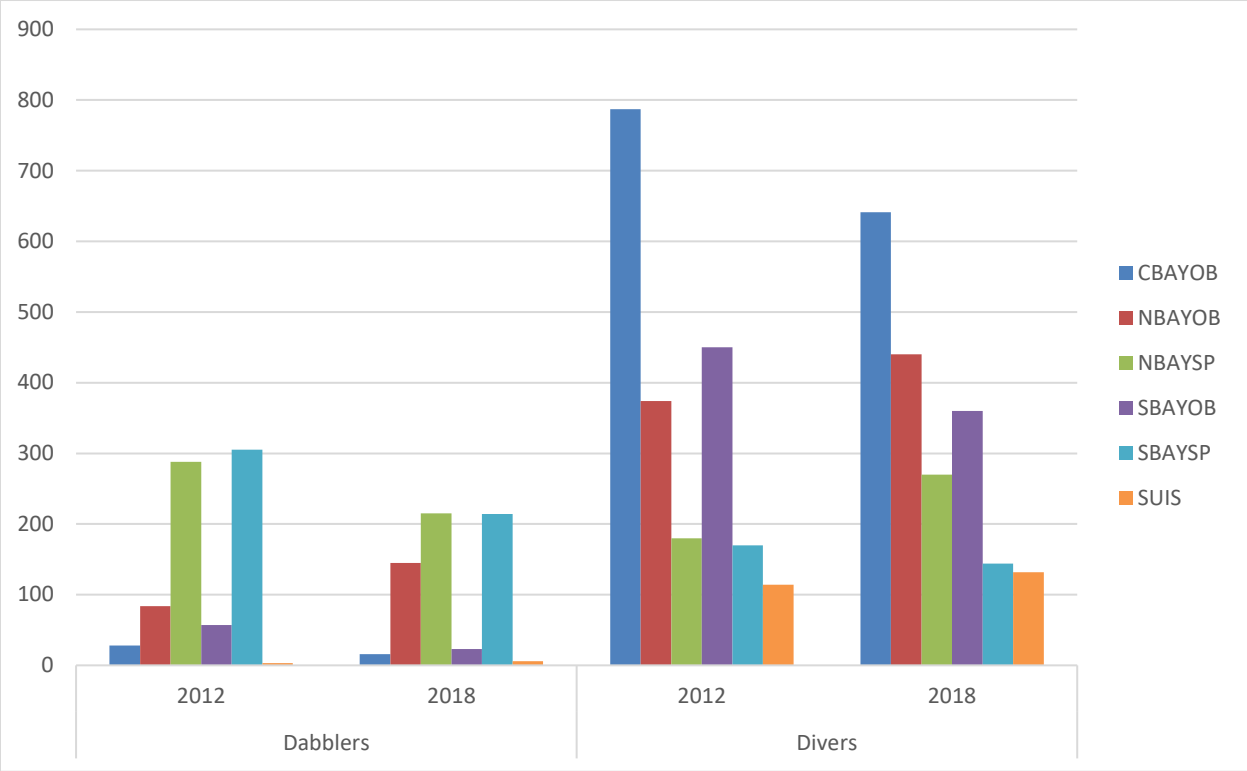
Other species, such as scaup (including greater and lesser scaup combined) appear to fluctuate in zone usage as well as in number. South Bay Salt Ponds (2013-2015), Suisun (2016), and North Bay Open Bay (2018) have all held the highest count of scaup.

South Bay Salt Ponds zone is consistently the peak location for northern shovelers and ruddy ducks, thus representing the importance of this zone to both dabbling and diving ducks. Between 2003 and 2004 most of the ponds in the South Bay Salt Ponds zone began being operated as managed ponds, managed for the benefit of waterbirds instead of the creation of salt. This increased the overall number of waterbirds using the ponds (DelaCruz et al 2018).

In comparing numbers and distribution of waterfowl from 2012 and 2018 (years for which maps are available, Richmond et al., 2014 and this report), there are some differences. In 2012, we counted 606,930 waterfowl of the top ten species; in 2018, we counted 477,366. Dabbling duck distribution is approximately the same, with the zones involving ponds (North Bay and South

Bay) holding the bulk of this guild. This is particularly evident in 2012, but in 2018 there were higher numbers of dabbling ducks in the North Bay Open Bay as well. Diving duck distribution was also roughly similar between the two years, although larger numbers of diving ducks were present in the North Bay Salt Ponds in 2018 (Figure 14). As restoration efforts continue in the North and South of the Estuary, it will be important to watch these numbers and distributions to determine if waterfowl are being negatively affected as ponds are returned to tidal marsh habitats.

Figure 14. Comparison of diving and dabbling duck numbers and distribution, 2012 and 2018.



Despite improvements to the SF Estuary survey methods since 2012, MWS count data for the SF Estuary should be interpreted carefully for the reasons articulated in Richmond et al (2014). Detection probability, high inter-observer variability due to differences in experience, training and ability to accurately estimate large flock sizes among observers, and variation in survey effort from year to year depending on funding and weather all add noise to the data and potentially skewing trend estimates. Thus, any management decisions made using data from this report should be made in consultation with local USFWS personnel who have knowledge of the specific limitations of this dataset.

Improvements to the sampling design and survey methods include (reiterated from Richmond et al., 2014):

1) Establish a working group to reevaluate the SF Estuary sampling design using a stratified design. Historical data should be analyzed to determine if less intensive sampling designs are feasible while still meeting objectives for population and distribution monitoring, minimizing risks to pilots and aerial observers, and to meet the needs of local applications (e.g., refuge-scale information needs). This revision of the sampling design should be carried out in coordination with the Pacific Flyway study committee, CDFW and the San Francisco Bay and Central Valley Joint Ventures.
2) A correction factor should be used to account for different survey methodologies (aerial surveys vs. ground counts; for example see Burns et al. 2013).
3) Double-observer surveys should be periodically conducted to estimate variation in detection probability between observers.
4) The high cost of coordinating and implementing the survey and the safety risks inherent to manned aerial surveys remain a significant challenge. The use of aerial photography/videography and Unmanned Aircraft Systems (UAS) should be investigated as alternative survey methods.

References

Accurso, L. 1992. Distribution and abundance of wintering waterfowl on San Francisco Bay, 1988-1990. Humboldt State University.

Burns, C., J. Scullen, and V. Tobias. 2013. Establishing baseline conditions to inform adaptive management of South San Francisco Bay salt ponds: A comparison of waterbird abundance from the 1980s to the 2000s.

De La Cruz, S.E.W., Smith, L.M., Moskal, S.M., Strong, C., Krause, J., Wang, Y., and Takekawa, J.Y., 2018, Trends and habitat associations of waterbirds using the South Bay Salt Pond Restoration Project, San Francisco Bay, California: U.S. Geological Survey Open-File Report 2018–1040, 136 p., https://doi.org/10.3133/ofr20181040.

Environmental Systems Research Institute. 2009. ArcMap version 9.3.1. Environmental Systems Research Institute. Redlands, CA.

Gill, F., and D. Donsker. 2013. IOC World Bird List (v 3.4).

Hodges, J., J. King, B. Conant, and H. Hanson. 1996. Aerial surveys of waterbirds in Alaska 1957-94: population trends and observer variability. National Biological Service Information and Technology Report 4.

Pollock, K., and W. Kendall. 1987. Visibility bias in aerial surveys: a review of estimation procedures. The Journal of wildlife management 51:502–510.

Richmond, O.M.W., Dulava, S., Strong, C.M. and Albertson, J.D. 2014. San Francisco Estuary Midwinter Waterfowl Survey: 2012 Survey Results and Trend Analysis (1981-2012). U. S. Fish and Wildlife Service, Pacific Southwest Region. National Wildlife Refuge System Inventory and Monitoring Initiative. Fremont, CA, USA.

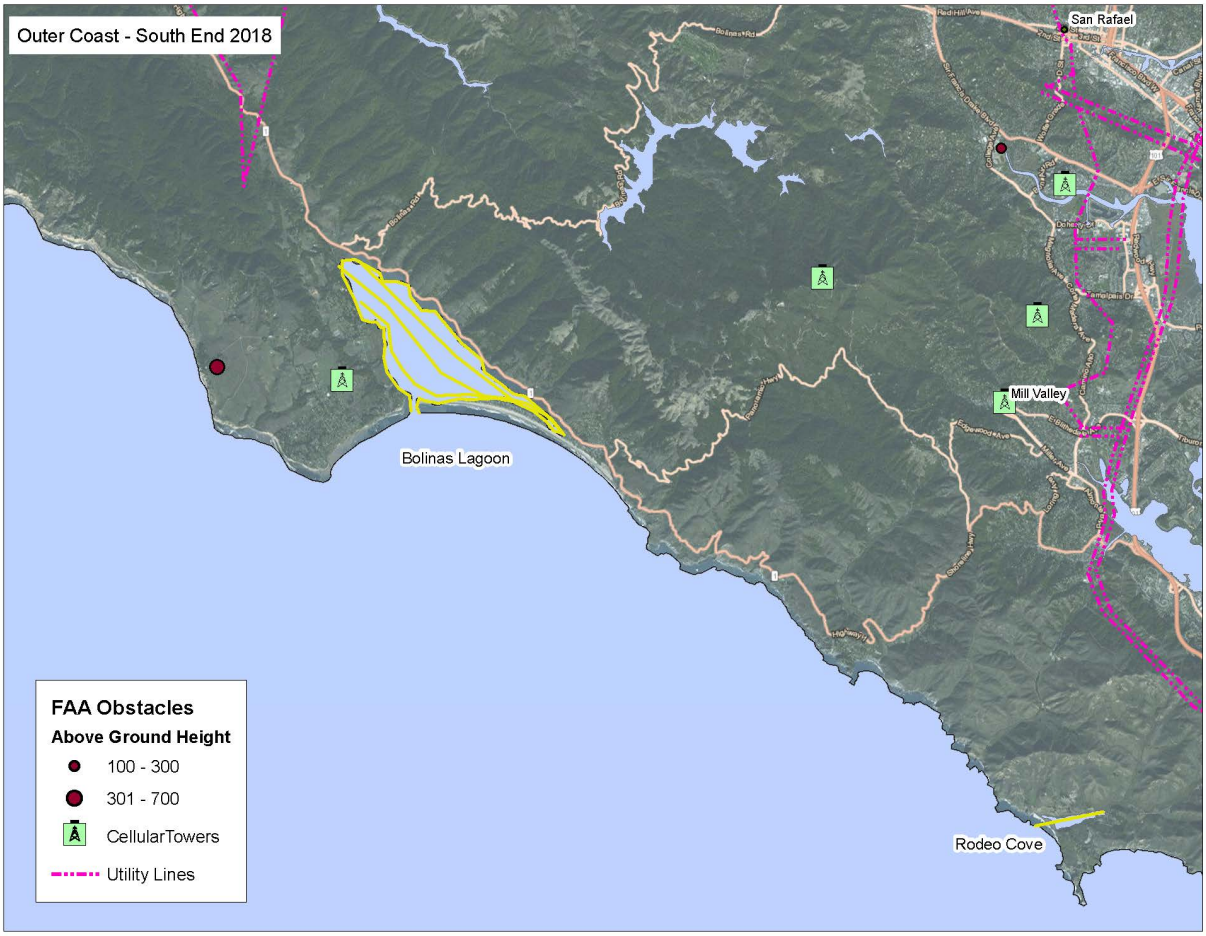
Smith, G. W. 1995. A critical review of the aerial and ground surveys of breeding waterfowl in North America. Biological Science Report 5. Science (New York, N.Y.). Volume 268.

Appendices

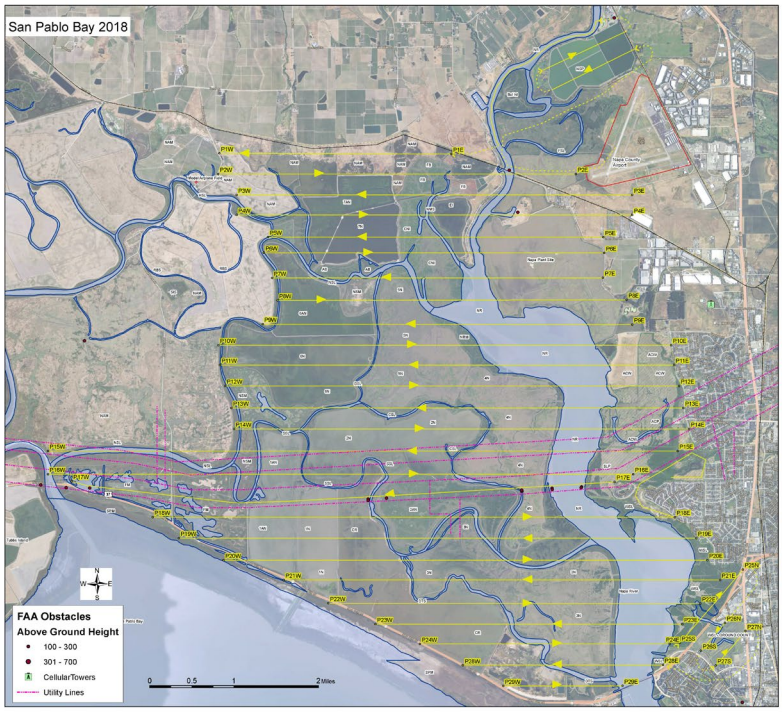
Appendix A. Survey units (ponds, sloughs and marshes) and aerial transects in the San Francisco Bay Estuary.

A. Outer Coast estuaries, north end.

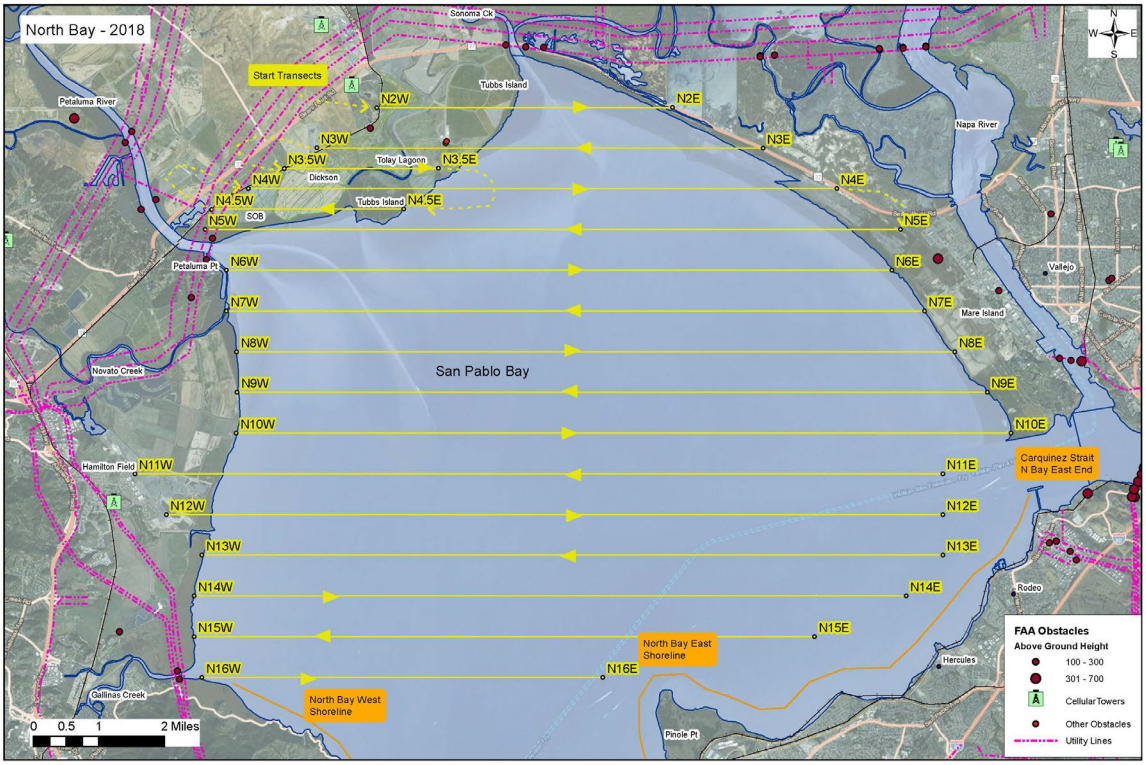
B. Outer Coast estuaries, south end.


Outer Coast - South End 2018
San Rafael
Mill Valley
Bolinas Lagoon
Rodeo Cove
FAA Obstacles
Above Ground Height
100 - 300
301 - 700
CellularTowers
Utility Lines

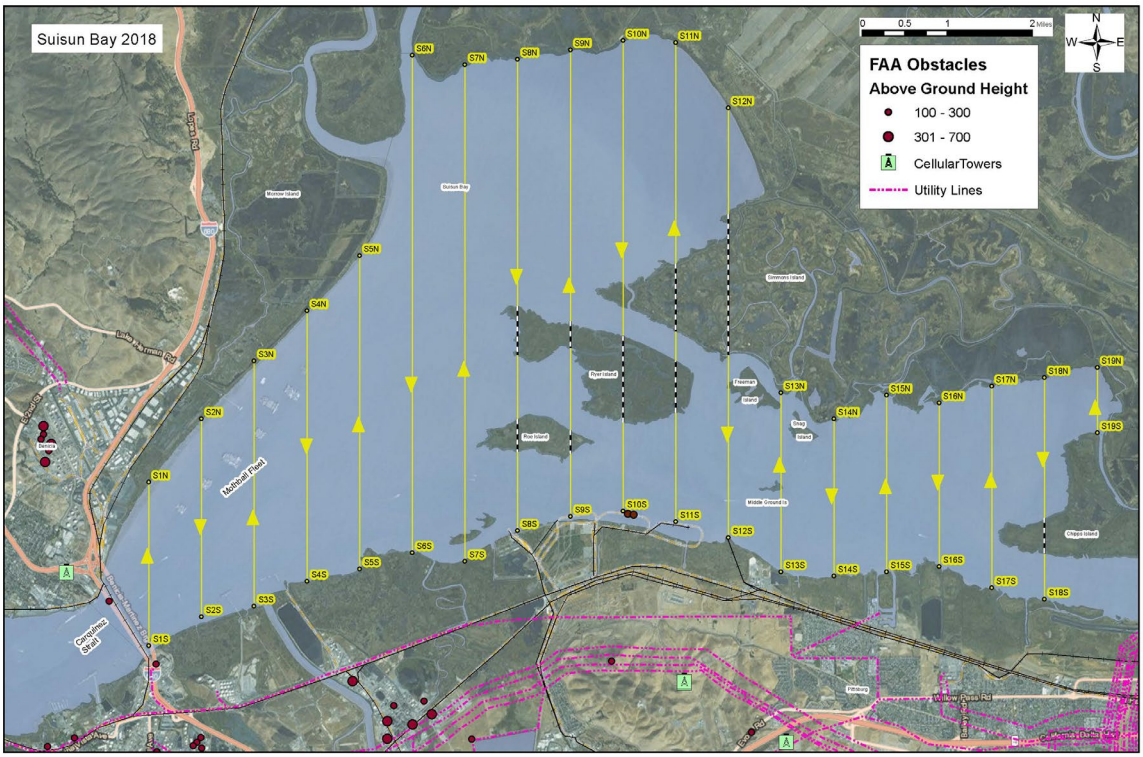
C. North Bay Salt Pond transects, ponds, sloughs and marshes.



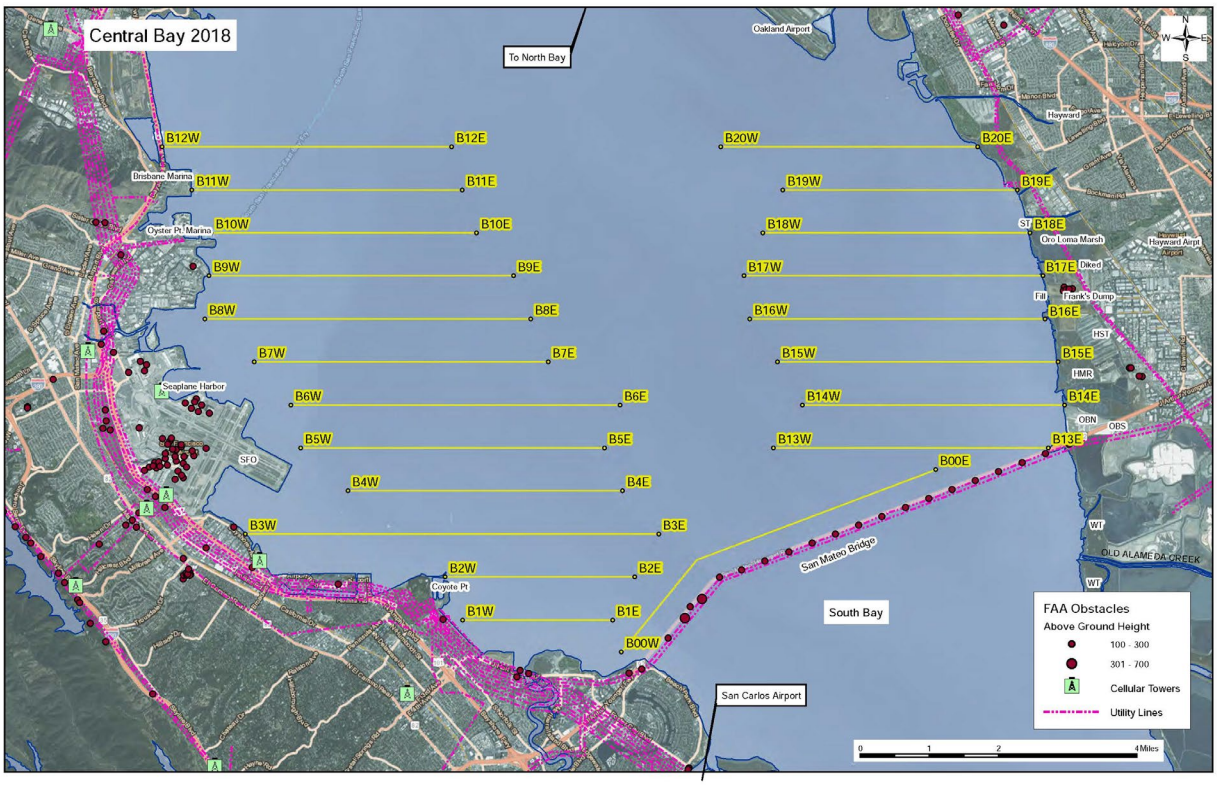
D. North Bay Open Bay aerial transects.



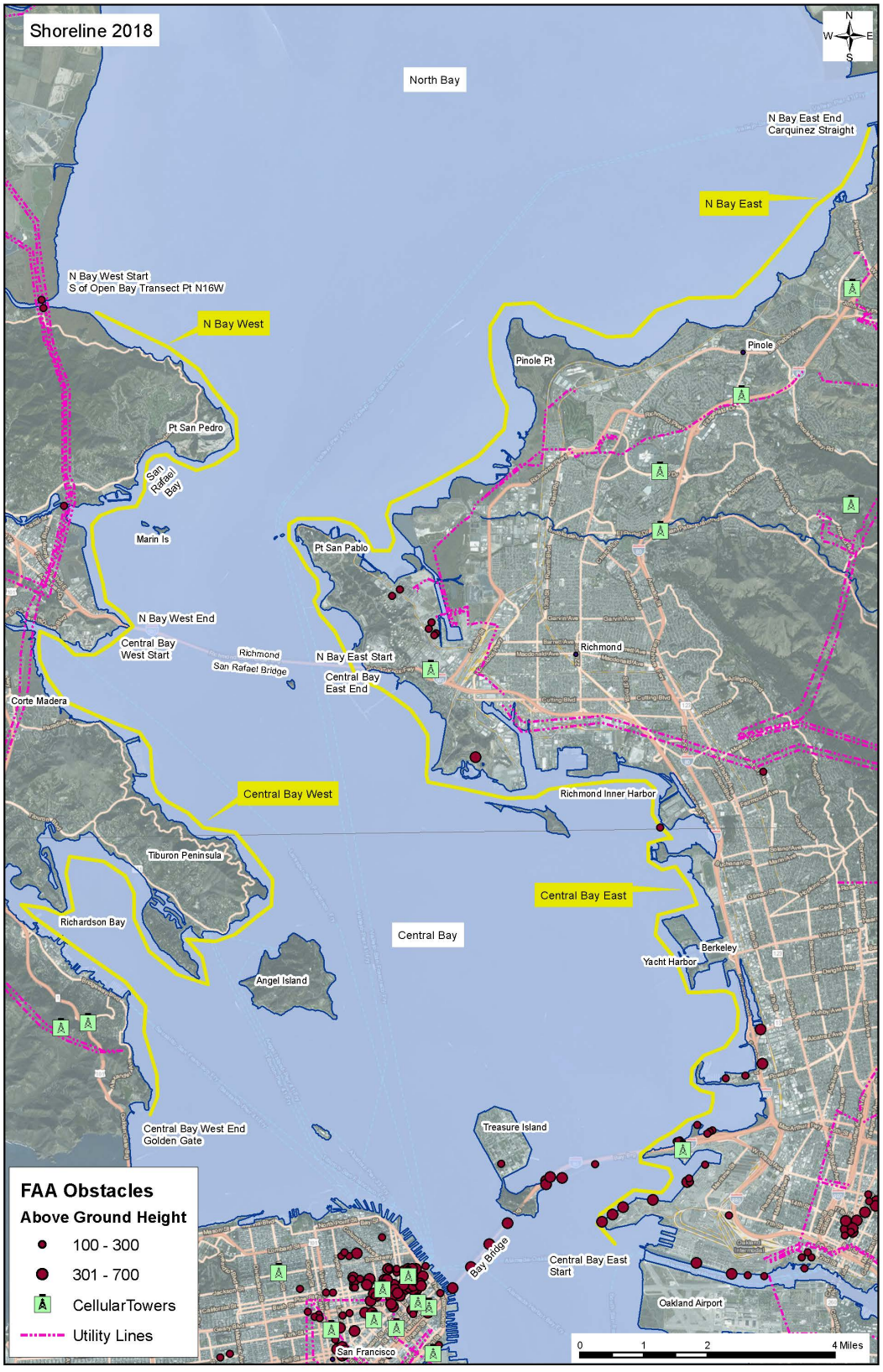
E. Suisun Bay aerial transects.



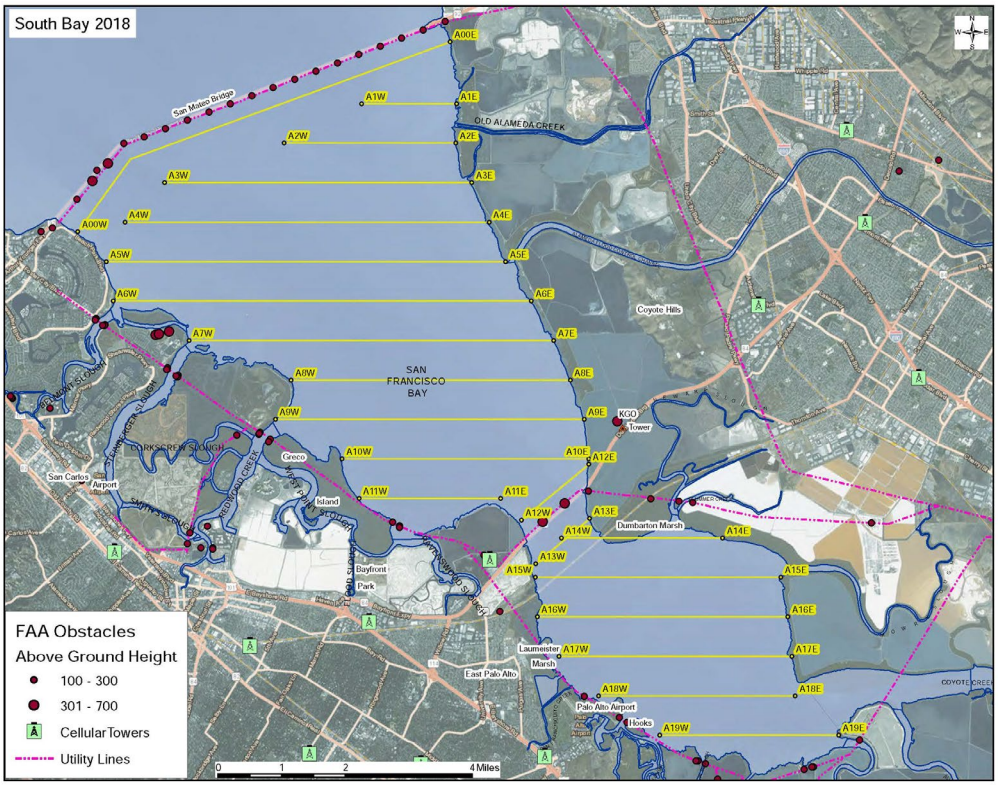
F. Central Bay Open Bay transects.



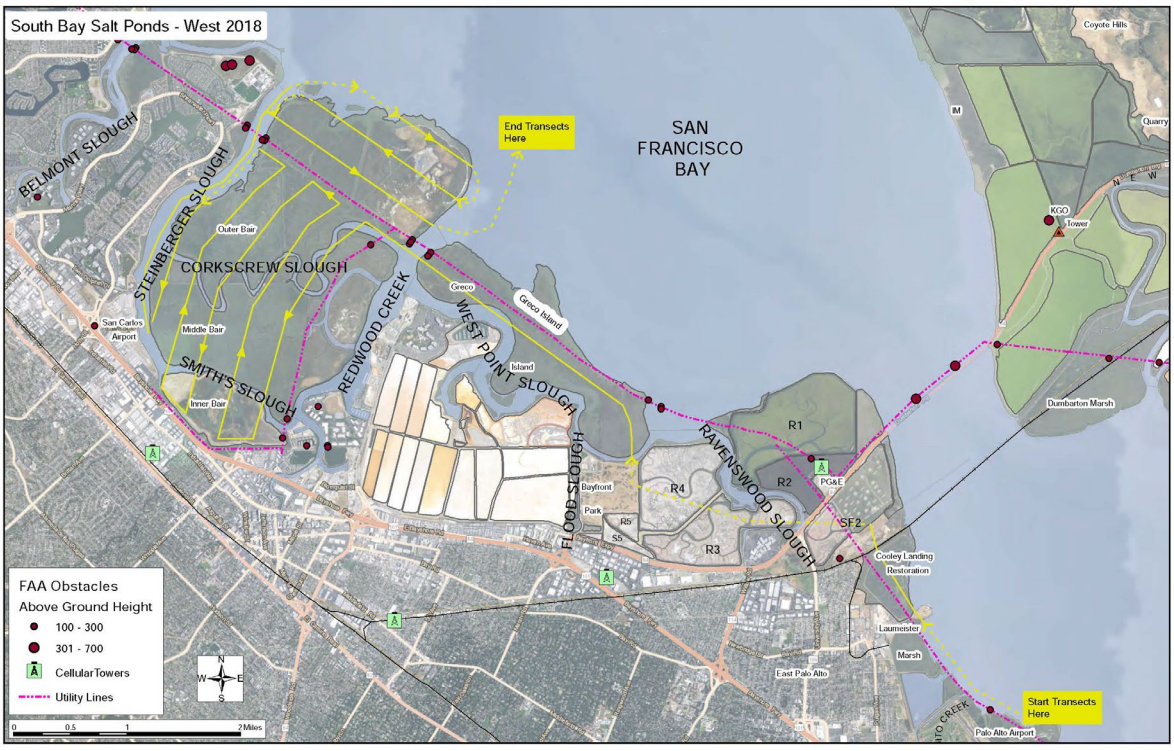
G. Central Bay Open Bay shoreline transects.



H. South Bay Open Bay aerial transects.

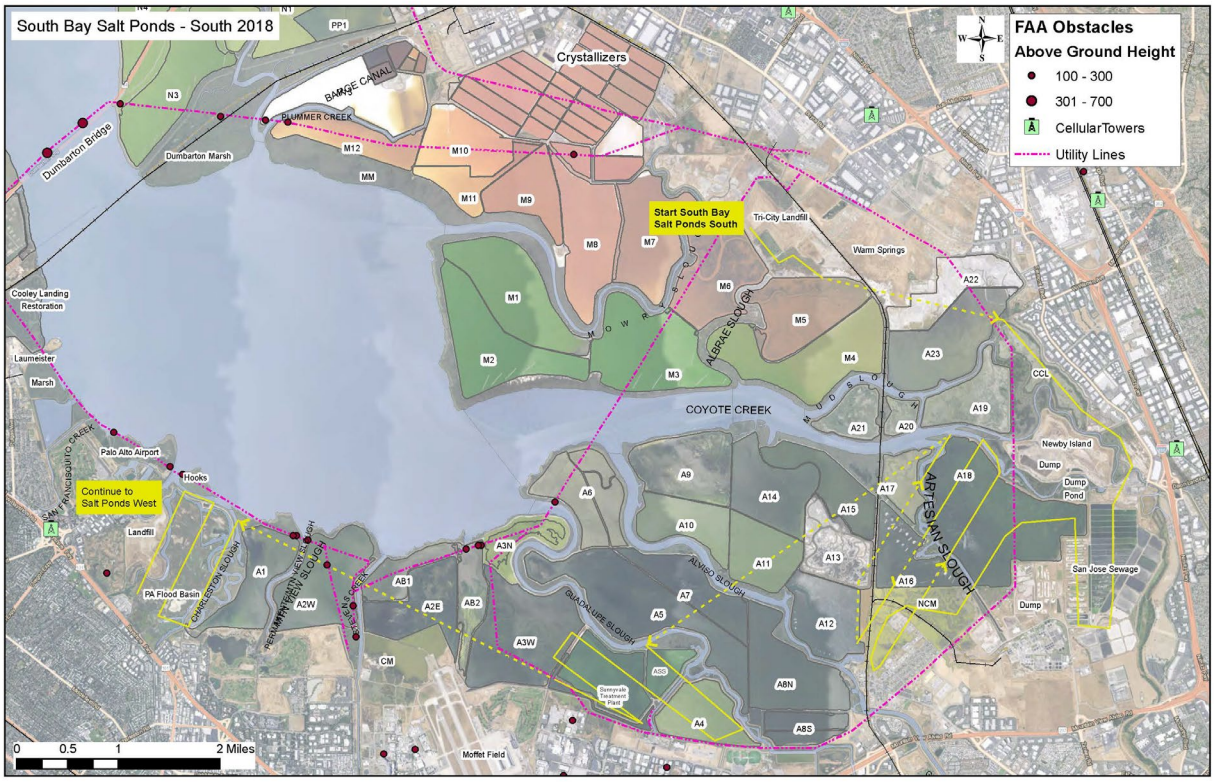


I. South Bay Salt Ponds transects, ponds, sloughs and marshes: west side of SF Bay.



J. South Bay Salt Ponds transects, ponds, sloughs and marshes: east side of SF Bay.

K. South Bay Salt Ponds transects, ponds, sloughs and marshes; south end of SF Bay.



Map Projection: North American Datum 1983 Universal Transverse Mercator Zone 10; Map Production Date: November 1, 2012; Source Data: Transects from Don Edwards San Francisco Bay National Wildlife Refuge, March 2012; Modern Baylands from San Francisco Estuary Institute EcoAtlas, August 2012.

Appendix B. Potential waterfowl and coot species present in the San Francisco Estuary, including common name, scientific name, name used in the SF Estuary Midwinter Waterfowl Survey, guild, family, subfamily and tribe[1,2].

Common name	Scientific name	Name used in MWS	Guild	Family	Subfamily	Tribe
American coot	*Fulica americana*	American coot	Coot	Rallidae		
American wigeon	*Anas americana*	American wigeon	Dabbler	Anatidae	Anatinae	Anatini
Barrow's goldeneye	***Bucephala islandica***	**Goldeneye**	**Diver**	**Anatidae**	**Anatinae**	**Mergini**
Black scoter	***Melanitta americana***	**Scoter**	**Diver**	**Anatidae**	**Anatinae**	**Mergini**
Blue-winged teal	*Anas discors*	Blue-winged teal	Dabbler	Anatidae	Anatinae	Anatini
Brant	*Branta bernicla*	Brant	Goose	Anatidae	Anserinae	Anserini
Bufflehead	*Bucephala albeola*	Bufflehead	Diver	Anatidae	Anatinae	Mergini
Cackling goose	*Branta hutchinsii*	Cackling goose	Goose	Anatidae	Anserinae	Anserini
Canada goose	*Branta canadensis*	Canada goose	Goose	Anatidae	Anserinae	Anserini
Canvasback	*Aythya valisineria*	Canvasback	Diver	Anatidae	Anatinae	Aythyini
Cinnamon teal	*Anas cyanoptera*	Cinnamon teal	Dabbler	Anatidae	Anatinae	Anatini
Clark's grebe	***Aechmophorus clarkii***	**Clark's/western grebe**	**Grebe**	**Podicipedidae**		
Common goldeneye	***Bucephala clangula***	**Goldeneye**	**Diver**	**Anatidae**	**Anatinae**	**Mergini**
Common merganser	***Mergus merganser***	**Merganser**	**Diver**	**Anatidae**	**Anatinae**	**Mergini**
Eurasian wigeon	*Mareca penelope*	Eurasian wigeon	Dabbler	Anatidae	Anatinae	Anatini
Gadwall	*Anas strepera*	Gadwall	Dabbler	Anatidae	Anatinae	Anatini
Greater scaup	***Aythya marila***	**Scaup**	**Diver**	**Anatidae**	**Anatinae**	**Aythyini**
Greater white-fronted goose	***Anser albifrons***	**Greater white-fronted goose**	**Goose**	**Anatidae**	**Anserinae**	**Anserini**

[1] Rows in bold indicate taxa that are not identified to the species level during the aerial portion of the Midwinter Waterfowl Survey.
[2] Taxonomy follows Gill and Donsker (2013).

Common name	Scientific name	Name used in MWS	Guild	Family	Subfamily	Tribe
Green-winged teal	*Anas crecca*	Green-winged teal	Dabbler	Anatidae	Anatinae	Anatini
Harlequin duck	*Histrionicus histrionicus*	Harlequin duck	Diver	Anatidae	Anatinae	Mergini
Lesser scaup	***Aythya affinis***	**Scaup**	**Diver**	**Anatidae**	**Anatinae**	**Aythyini**
Long-tailed duck	*Clangula hyemalis*	Long-tailed duck	Diver	Anatidae	Anatinae	Mergini
Mallard	*Anas platyrhynchos*	Mallard	Dabbler	Anatidae	Anatinae	Anatini
Red-breasted merganser	***Mergus serrator***	**Merganser**	**Diver**	**Anatidae**	**Anatinae**	**Mergini**
Northern pintail	*Anas acuta*	Northern pintail	Dabbler	Anatidae	Anatinae	Anatini
Northern shoveler	*Anas clypeata*	Northern shoveler	Dabbler	Anatidae	Anatinae	Anatini
Redhead	*Aythya americana*	Redhead	Diver	Anatidae	Anatinae	Aythyini
Ring-necked duck	*Aythya collaris*	Ring-necked duck	Diver	Anatidae	Anatinae	Aythyini
Ross's goose	***Chen rossii***	**Ross's goose**	**Goose**	**Anatidae**	**Anserinae**	**Anserini**
Ruddy duck	*Oxyura jamaicensis*	Ruddy duck	Diver	Anatidae	Anserinae	Oxyurini
Snow goose	***Chen caerulescens***	**Snow goose**	**Goose**	**Anatidae**	**Anserinae**	**Anserini**
Surf scoter	***Melanitta perspicillata***	**Scoter**	**Diver**	**Anatidae**	**Anatinae**	**Mergini**
Tundra swan	*Cygnus columbianus*	Tundra swan	Swan	Anatidae	Anserinae	Anserini
White-winged scoter	***Melanitta deglandi***	**Scoter**	**Diver**	**Anatidae**	**Anatinae**	**Mergini**
Western grebe	***Aechmophorus occidentalis***	**Clark's/western grebe**	**Grebe**	**Podicipedidae**		
Wood duck	*Aix sponsa*	Wood duck	Perching duck	Anatidae	Anatinae	Cairinini

Appendix C. Number of waterfowl and coots counted by area in the San Francisco Estuary Midwinter Waterfowl Survey in January 2013-2018 (a-f).

a) 2013 (no survey for Outer Coast)

Common Name	Central Bay Open Bay	North Bay Open Bay	North Bay Salt Ponds	South Bay Open Bay	South Bay Salt Ponds	Grand Total
American Coot	32	15	1990	1	11363	13401
American Wigeon	155	4220	14636	423	12682	32116
Barrow's/Common Goldeneye		7	28			35
Black/White-winged/Surf Scoter	1147	217		1341		2705
Bufflehead	3256	401	1474	1308	4286	10725
Canada Goose		21	10		1186	1217
Canvasback	179	1090	6922	464	7082	15737
Cinnamon Teal			2		4	6
Clark's Grebe					161	161
Clark's/Western Grebe	1873	183	102	427	557	3142
Common Goldeneye					739	739
Common Merganser					33	33
Common/Red-breasted/Hooded Merganser			2		138	140
Eurasian Wigeon					9	9
Gadwall		277	9876		518	10671
Greater/Lesser Scaup	4062	1755	9425	6353	18784	40379
Green-winged Teal		5	522		1245	1772
Mallard		34	2563		291	2888
Northern Pintail		766	9813		1571	12150
Northern Shoveler	20	35	32787	751	23340	56933
Red-breasted Merganser					38	38

Common Name 2013, continued	Central Bay Open Bay	North Bay Open Bay	North Bay Salt Ponds	South Bay Open Bay	South Bay Salt Ponds	Grand Total
Redhead			513		131	644
Ross's/Snow Goose			40		4	44
Ruddy Duck	215	321	4994	120	43613	49263
Surf Scoter					22	22
Unidentified diving duck			662		6861	7523
Unidentified duck		1000	3440		150	4590
Unidentified puddle duck		307	5287		4525	10119
Western Grebe		20			628	648
Grand Total	**10939**	**10674**	**105088**	**11188**	**139961**	**277850**

b) 2014 (no survey for Outer Coast)

Common Name	Central Bay Open Bay	North Bay Open Bay	North Bay Salt Ponds	South Bay Open Bay	South Bay Salt Ponds	Grand Total
American Coot	1	8	4687		9232	13928
American Wigeon	5	205	3212	30	13253	16705
Barrow's/Common Goldeneye			2			2
Black/White-winged/Surf Scoter	1226	602	3	1006	14	2851
Bufflehead	2982	334	436	936	2851	7539
Canada Goose				1	73	74
Canvasback	145	630	7442	480	6769	15466
Cinnamon Teal					15	15
Clark's/Western Grebe	1355	347	16	485	304	2507
Common Goldeneye					96	96

Common Name 2014, continued	Central Bay Open Bay	North Bay Open Bay	North Bay Salt Ponds	South Bay Open Bay	South Bay Salt Ponds	Grand Total
Common/Red-breasted/Hooded Merganser				2		2
Eurasian Wigeon					1	1
Gadwall			393	2	159	554
Greater/Lesser Scaup	7837	1470	2592	1884	11783	25566
Green-winged Teal			222		1971	2193
Hooded Merganser					1	1
Mallard	8	61	287	9	656	1021
Northern Pintail		252	408	10	5804	6474
Northern Shoveler			3583	29	19569	23181
Red-breasted Merganser					73	73
Redhead	1		22		89	112
Ruddy Duck	165	496	3437	20	32970	37088
Surf Scoter					306	306
Unidentified diving duck		103			400	503
Unidentified duck	177	142	53	193	421	986
Unidentified puddle duck		41	112			153
Grand Total	**13902**	**4691**	**26907**	**5087**	**106810**	**157397**

c) 2015

Common name	Central Bay Open Bay	North Bay Open Bay	North Bay Salt Ponds	Outer Coast	South Bay Open Bay	South Bay Salt Ponds	Grand Total
American Coot		412	2091	21		6515	9039
American Wigeon	22	1988	5948	939	105	6483	15485

Common name 2015, continued	Central Bay Open Bay	North Bay Open Bay	North Bay Salt Ponds	Outer Coast	South Bay Open Bay	South Bay Salt Ponds	Grand Total
Barrow's/Common Goldeneye	7					124	131
Black Brant	9			1795			1804
Black/White-winged/Surf Scoter	1133	571	31	428	655	66	2884
Bufflehead	1422	46	549	1842	579	735	5173
Canada Goose			58	203		147	408
Canvasback	12	988	25725		844	2117	29686
Cinnamon Teal						7	7
Clark's/Western Grebe	1703	208	45	559	384	180	3079
Common/Red-breasted/Hooded Merganser			2	2		4	8
Gadwall	3	74	211	4	2	229	523
Greater/Lesser Scaup	1826	1420	3512	2252	2122	4075	15207
Green-winged Teal		25	30	1		48	104
Mallard	4	90	509	108	7	193	911
Northern Pintail		2904	900	1	85	2326	6216
Northern Shoveler		84	4941		59	10658	15742
Red-breasted Merganser						106	106
Redhead			25			7	32
Ring-necked Duck			125				125
Ross's/Snow Goose				25			25
Ruddy Duck	186	618	4653	290	30	25650	31427
Unidentified diving duck	2	172	70	144	68	715	1171
Unidentified duck	120	75	276	426	96	2191	3184
Unidentified puddle duck		30	252	1100		2651	4033
Unidentified swan			23	2			25
Unknown grebe						5	5

Common name 2015, continued	Central Bay Open Bay	North Bay Open Bay	North Bay Salt Ponds	Outer Coast	South Bay Open Bay	South Bay Salt Ponds	Grand Total
Grand Total	**6449**	**9705**	**49976**	**10142**	**5036**	**65232**	**146540**

d) 2016

Common Name	Central Bay Open Bay	North Bay Open Bay	North Bay Salt Ponds	South Bay Open Bay	South Bay Salt Ponds	Suisun Bay	Grand Total
American Coot	230	179	8450		6096	8	14963
American Wigeon	2	4699	4495	50	12565	100	21911
Barrow's/Common Goldeneye	27	31	440	1	6	30	535
Black/White-winged/Surf Scoter	1601	293		1005		599	3498
Bufflehead	417	133	466	359	1529	41	2945
Canada Goose	6	19	14		151		190
Canvasback	120	858	8236	70	3508	1581	14373
Clark's/Western Grebe	262	381	40	88	61	73	905
Common Goldeneye					504		504
Common Merganser					4		4
Common/Red-breasted/Hooded Merganser			1			1	2
Eurasian Wigeon					4		4
Gadwall		327	1293	10	146	25	1801
Greater/Lesser Scaup	6402	1674	5042	3363	11750	12853	41084
Green-winged Teal		890	646		436		1972
Mallard		36	135	4	47	2	224
Northern Pintail		1042	1127	50	142		2361
Northern Shoveler		65	7641	5	21400	2	29113

Common Name 2016, continued	Central Bay Open Bay	North Bay Open Bay	North Bay Salt Ponds	South Bay Open Bay	South Bay Salt Ponds	Suisun Bay	Grand Total
Red-breasted Merganser					103		103
Redhead			57		87		144
Ring-necked Duck					4		4
Ruddy Duck	197	962	14318	43	27127	23	42670
Surf Scoter					15		15
Unidentified diving duck					17		17
Unidentified duck	34	31		147	635	172	1019
Unidentified puddle duck					559		559
Unidentified swan			35				35
Western Grebe	6		1			12	19
White-winged Scoter	1						1
Grand Total	**9305**	**11620**	**52437**	**5195**	**86896**	**15522**	**180975**

e) 2017 (no survey for Central Bay, North Bay, or South Bay Open Bays, North Bay Salt Ponds; South Bay Salt Ponds ground counted only at select ponds)

Common name	Outer Coast	South Bay Salt Ponds	Grand Total
American Coot	121	7629	7750
American Wigeon	1772	9437	11209
Barrow's/Common Goldeneye	942		942
Black Brant	2743		2743
Black/White-winged/Surf Scoter	228		228
Bufflehead	3201	471	3672
Canada Goose	430	58	488

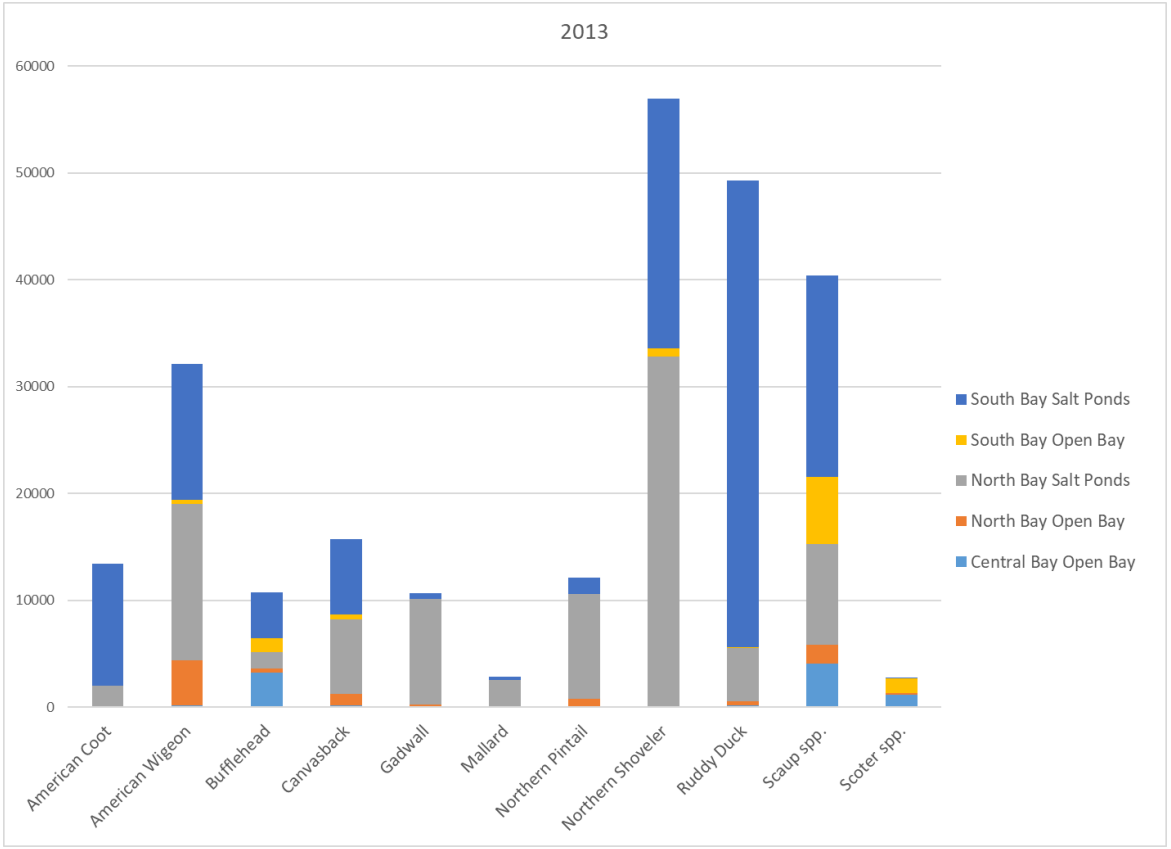
Common name 2017, continued	Outer Coast	South Bay Salt Ponds	Grand Total
Canvasback	410	1016	1426
Clark's/Western Grebe	61		61
Common Goldeneye		108	108
Eurasian Wigeon		5	5
Gadwall	98	197	295
Greater/Lesser Scaup	3174	2270	5444
Green-winged Teal	387	82	469
Mallard	298		298
Northern Pintail		279	279
Northern Shoveler		1294	1294
Red-breasted Merganser		44	44
Redhead		974	974
Ruddy Duck	674	11040	11714
Surf Scoter	88	2	90
Unidentified diving duck		1076	1076
Unidentified duck	20		20
Unidentified puddle duck	850	1593	2443
Grand Total	**15497**	**37575**	**53072**

f) 2018

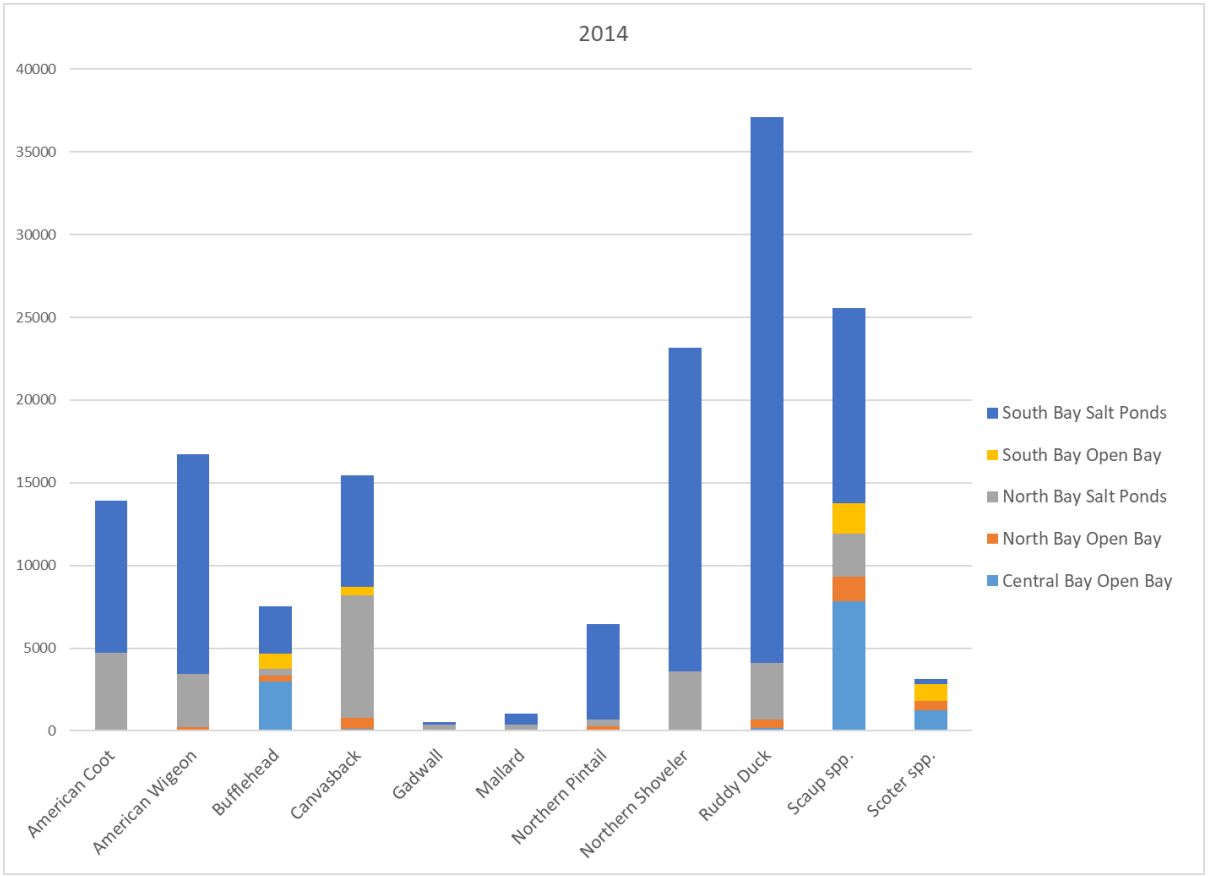
Common name	Central Bay Open Bay	North Bay Open Bay	North Bay Salt Ponds	Outer Coast	South Bay Open Bay	South Bay Salt Ponds	Suisun Bay	Grand Total
American Coot	868	104	5590	129	4	8126	40	14861
American Wigeon	105	12921	5770	3087	114	8307	23	30327
Barrow's/Common Goldeneye	74	50	87	142	1		4669	5023
Black Brant				854				854
Black/White-winged/Surf Scoter	7622	2720		1491	930		2	12765
Bufflehead	1537	3	90	8623	960	2408	28	13649
Canada Goose		40	79	140		208		467
Canvasback	7935	11415	5086	2217	2030	3148	1084	32915
Cinnamon Teal						13		13
Clark's/Western Grebe	388	21	5	83	161	3	1	662
Common Goldeneye						849		849
Common Merganser						20		20
Common/Red-breasted/Hooded Merganser				103				103
Eurasian Wigeon						1		1
Gadwall	4	3088	6739	113	23	471		10438
Greater Scaup						2		2
Greater/Lesser Scaup	17693	45211	45	2819	8782	2042	1221	77813
Green-winged Teal		179	2672	715	15	666		4247
Hooded Merganser						1		1
Lesser Scaup						59		59
Mallard	43	67	63	352	59	642	6	1232
Mute Swan						2		2
Northern Pintail		1127	1798	463		609	6	4003

Common name 2018, continued	Central Bay Open Bay	North Bay Open Bay	North Bay Salt Ponds	Outer Coast	South Bay Open Bay	South Bay Salt Ponds	Suisun Bay	Grand Total
Northern Shoveler	2572	2454	7550	595	1849	18904	7	33931
Red-breasted Merganser						138		138
Redhead						4903		4903
Ring-necked Duck						1		1
Ruddy Duck	553	454	3754	314	171	36957	1477	43680
Surf Scoter	1156				638	3		1797
Unidentified diving duck					467	4000		4467
Unidentified duck					10			10
Unidentified puddle duck						70		70
Unidentified swan			38	2			2	42
Unknown grebe	6	6	5	277				294
Grand Total	**40556**	**79860**	**39371**	**22519**	**16214**	**92553**	**8566**	**299639**

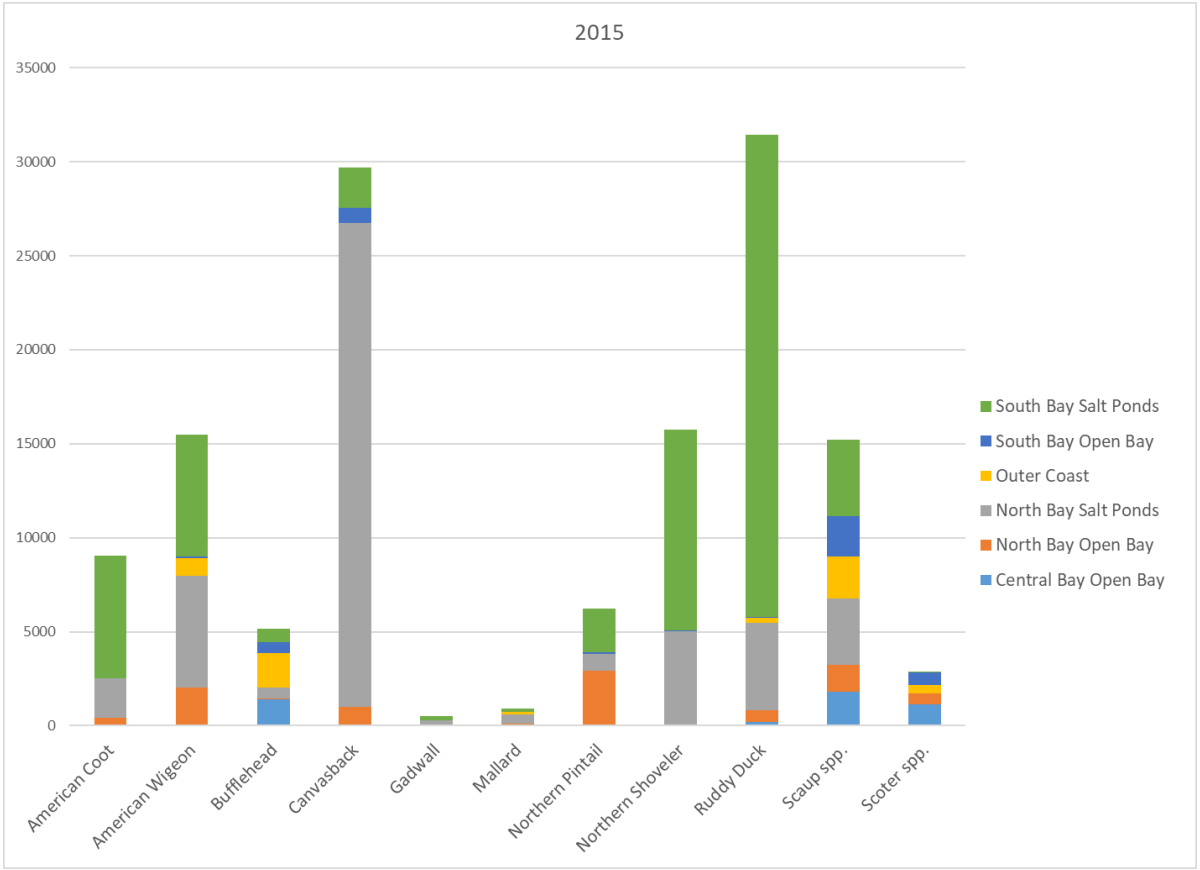
Appendix D. Regional distribution of ten waterfowl species and American coots in the San Francisco Estuary in January 2013-2018. Zones without surveys for that year are not depicted; 2017 is not depicted as few surveys were done that year.



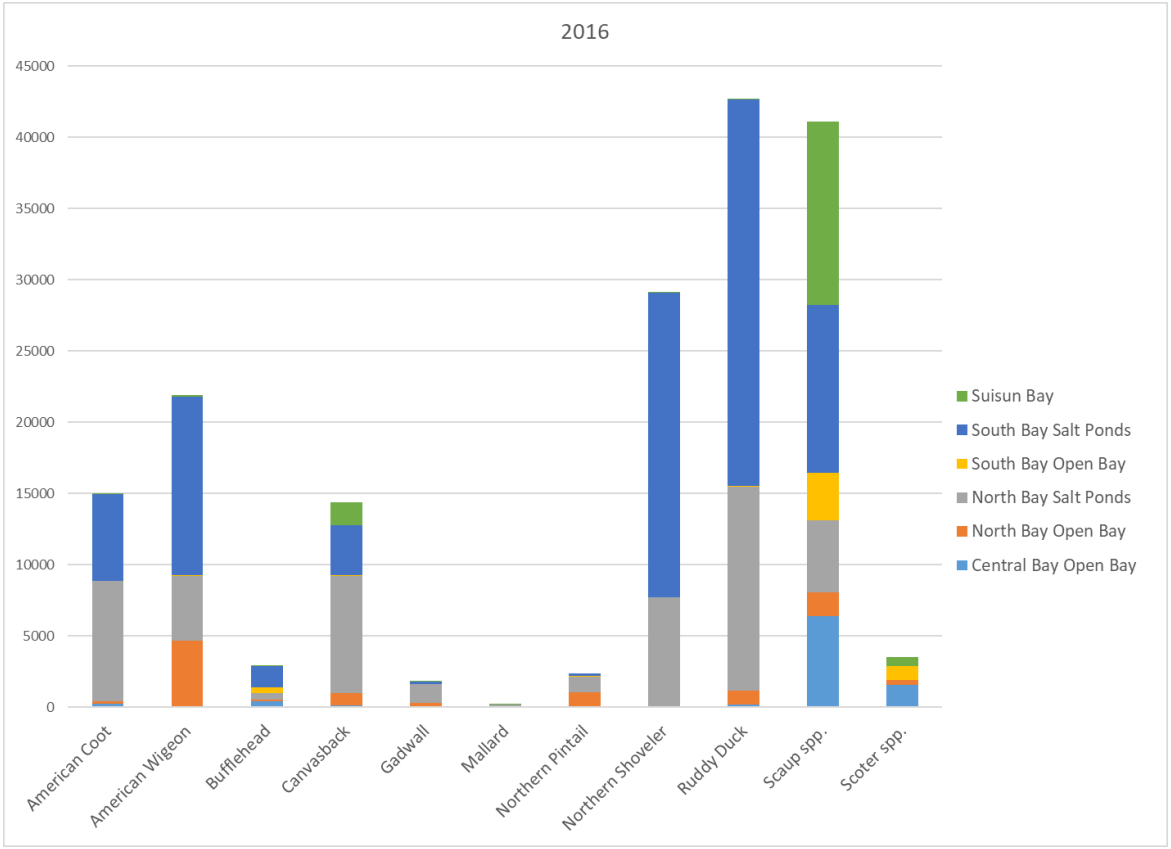
San Francisco Estuary Midwinter Waterfowl Survey 2013-2018



San Francisco Estuary Midwinter Waterfowl Survey 2013-2018



San Francisco Estuary Midwinter Waterfowl Survey 2013-2018



San Francisco Estuary Midwinter Waterfowl Survey 2013-2018