WESTERN BIRDS

Volume 8, Number 1, 1977

BREEDING AVIFAUNA OF THE SOUTH SAN FRANCISCO BAY ESTUARY

ROBERT GILL, JR., California Department of Fish and Game, Sacramento, California 95814 (present address: U.S. Fish and Wildlife Service—Biological Services, Anchorage, Alaska 99501)

San Francisco Bay represents one of the largest estuarine areas on the Pacific Coast of North America. Its open waters, tidal flats, tidal marshes and solar evaporation ponds provide critical foraging, resting and breeding habitat for migratory and resident birds. The avifauna of San Francisco Bay has received considerable attention; however, little of it has been directed toward assessing the overall importance of the Bay as a nesting area. Works by Grinnell and Wythe (1927), Grinnell and Miller (1944) and Sibley (1952) are the only comprehensive studies of San Francisco Bay avifauna. These studies, while major contributions, are broad in scope as they relate to the breeding avifauna of the Bay's estuarine areas. Several studies by Johnston (1955, 1956a, b), Marshall (1948a, b), DeGroot (1927, 1931) and Zucca (1954) have concentrated on the breeding biology of individual species; however, much of the marsh reclamation and Bay fill has occurred since. The present breeding status of many resident and migratory birds is poorly known for San Francisco Bay. Included among these are three rare or endangered forms: California Black Rail, California Clapper Rail and California Least Tern. In addition, some species now found in the area represent recent breeding range extensions. This study, undertaken from March to September 1971 and including a few more recent data, presents a quantitative assessment of the present breeding bird populations in the South San Francisco Bay area.

STUDY AREA AND METHODS

The study was conducted on approximately 19,389 ha (47,900 acres) of the South San Francisco Bay estuary (Figure 1). Seven habitat types were delineated: solar evaporation ponds, 8,850 ha (46%); tidal flats, 5,506 ha (29%); open water, 2,645 ha (14%); salt marsh, 1,829 ha (9%); grassland, 285 ha (1%); freshwater marsh, 81 ha (<1%); and dikes and levees, 193 ha (<1%), about 320 km in length.

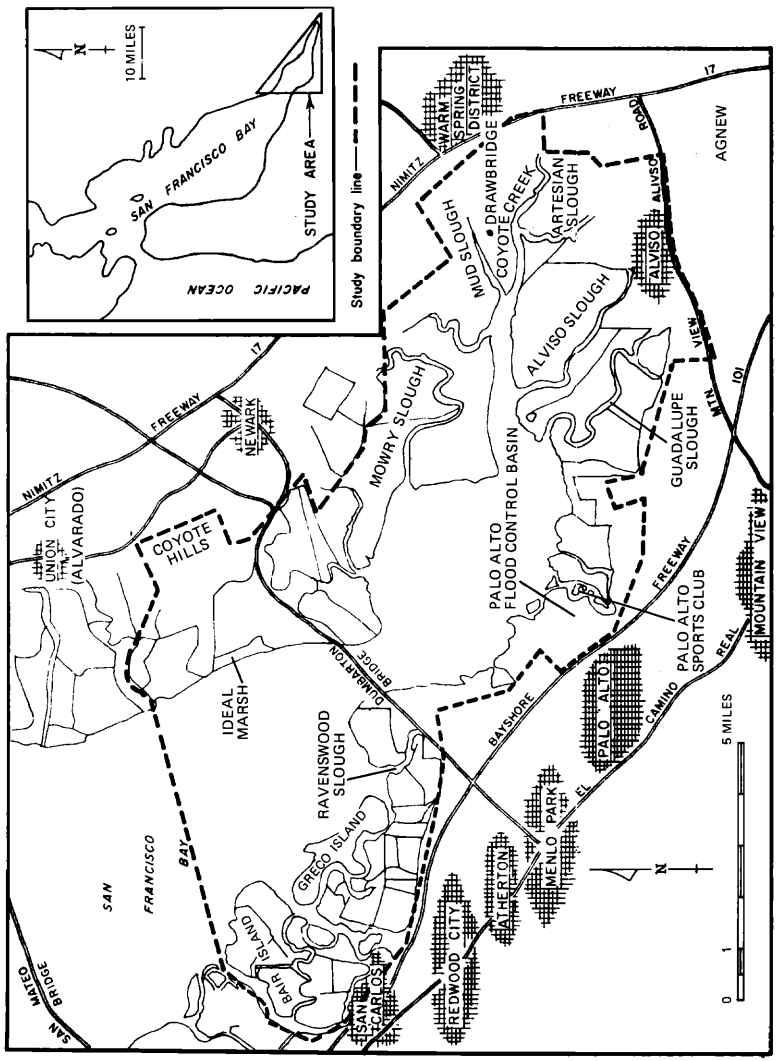

Figure 1. South San Francisco Bay study area.

Most of the nesting activity was located by direct field observation. Aerial surveys aided in locating large or isolated nesting species. Numerous nesting areas were located from historical information. Most colonies of terns, herons and egrets, as well as assemblages of avocets and stilts, were visited. A total of 2,561 young birds was banded in conjunction with nesting studies.

The following annotated list presents recent and historical data regarding habitat utilization, breeding populations, nesting requirements, laying dates, clutch sizes and, in several instances, hatching and fledging rates. Estimates of the amount of suitable nesting habitat and of the size of nesting populations are limited to the study area unless otherwise noted. Discussions on behavior, feeding habits, exact nesting locations, methods of population projections and management recommendations have been presented elsewhere (Gill 1972, 1973).

SPECIES ACCOUNTS

GREAT BLUE HERON *(Ardea herodias)*. Historically a widespread breeding species in the South Bay. The only active rookery located in 1971 was on Bair Island, San Mateo County. This colony (49 pairs) is thought to represent a bayward extension of a former tree nesting colony near Redwood City (Carriger and Pemberton 1908, Moffitt 1939). Anderson (pers. comm.) reported 30 nesting pairs at the Bair Island site in both 1967 and 1969. Nests are now placed in the tops of Coyote Bushes *(Baccharis pilularis)* 1 to 2 m tall growing on dredge spoils deposited on former salt marsh. First eggs were laid during the last week of February 1971. Mean clutch size for 49 active nests was 3.63. Hatching began on 1 April and peaked during the second week of May. Forty-nine clutches, totaling 178 eggs, produced 124 hatchlings (69.7%). Fledging began the second week of June and continued through August. Of eggs hatched, 105 fledged (84.7%). Only 30 active nests were counted during the 1973 season (Mattish pers. comm.).

BLACK-CROWNED NIGHT HERON *(Nycticorax nycticorax)*. First breeding record for the South Bay was in 1898 (Cohen 1900). Finley (1906) reported a large colony (700 pairs) near Alvarado, Alameda County in 1906. As of 1952, no active rookeries were known for the South Bay (Sibley 1952). Nesting has been restricted since 1967 to Bair Island, San Mateo County. This colony is one of the few known ground nesting colonies of this species. During 1971 nests were placed in gumplant *(Grindelia humilis)* and pickleweed *(Salicornia pacifica)*. Nesting was in progress on 4 March and peaked in mid-May 1971. Mean clutch size based on a sample of 684 nests taken on 4 May was 2.89. No data were taken on hatching or fledging success. During the 1973 season, 609 pairs nested on Bair Island (Mattish pers. comm.). Of these, 182 pairs were nesting in association with Great Blue Herons.

SNOWY EGRET *(Egretta thula)*. Nesting in South San Francisco Bay was first reported in 1969 (Anderson 1969). The 150 pairs on Bair Island in 1969 had increased to approximately 340 pairs by 1971. During 1971 Snowy Egrets nested in association with night herons and utilized similar vegetation for nest platforms; however, the egrets tended to restrict nesting to a few sites, whereas the night herons nested throughout the rookery. First nesting was found on 1 April. Peak nesting occurred around 1 June (340 active nests). Mean clutch size was 3.20. No

data were taken on hatching or fledging success. Mattish (pers. comm.) found 362 active nests on 24 May 1973. Like *Nycticorax*, a small number (86 pairs) of *E. thula* had abandoned the 1971 nesting site and moved within the Great Blue heron rookery. Nests at the new site were placed in Coyote Bushes. During the 1975 season, almost the entire colony of Snowy Egrets had moved within the heron rookery.

GREAT EGRET *(Casmerodius albus)*. Formerly nested near Agnew in Santa Clara County (Sibley 1952). Seventy-five active nests were found on Bair Island in 1967 (Anderson pers. comm.). Nesting was in association with Great Blue Herons. No nesting by this species in the South Bay has been reported since.

AMERICAN BITTERN *(Botaurus lentiginosus)*. This species was not found nesting during 1971. Grinnell and Wythe (1927) cite two nesting records for the San Francisco Bay area. Between March and June 1971 bitterns were flushed from suitable habitat near Palo Alto and Alviso; however, no nests were found and no birds were observed with white nuptial patches. Loss of a freshwater marsh fringe around the Bay is thought to be the cause of reduction in breeding numbers of this species.

WATERFOWL. Six waterfowl species nested in 1971: Pintail *(Anas acuta)*, 21 nests and/or broods; Gadwall *(A. strepera)*, 19; Mallard *(A. platyrhynchos)*, 8; Ruddy Duck *(Oxyura jamaicensis)*, 5; Cinnamon Teal *(A. cyanoptera)*, 4; Northern Shoveler *(A. clypeata)*, 1. Availability of freshwater appears to be the limiting factor in successful waterfowl nesting in the South Bay. Within the study

Bair Island, San Mateo County, California, 31 July 1973.

Photo by J. C. Fraser

area, freshwater marsh suitable for waterfowl nesting was limited to less than 100 ha. The majority of observed nesting, however, was found in salt marsh. Of 41 nesting attempts found in salt marsh, none was successful. Total estimated nesting populations for the six species of waterfowl during 1971 were: Pintail, 50-100 pairs; Gadwall, 100-150 pairs; Mallard, 100-150 pairs; Ruddy Duck, 50-100 pairs; Cinnamon Teal, 75-100 pairs; and Northern Shoveler, 1-5 pairs.

WHITE-TAILED KITE *(Elanus leucurus).* Resident in the South Bay and Santa Clara County. Populations have fluctuated greatly over the past 75 years (Sibley 1952, Pickwell 1932, Martin 1939, Waian and Stendall 1970). Seven kite nests were located within the study area during 1971. Nesting dates ranged from 14 April to 18 August. The latter date is unusually late for this species. Nesting site preference was shown for Bair Island, San Mateo County and Coyote Hills Regional Park, Alameda County. Clutch size averaged 3.50. The two nests followed to fledging produced 5 and 3 fledglings, respectively. Coyote Bushes were used as nesting platforms on Bair Island while *Eucalyptus* sp. were utilized at Coyote Hills. Three pairs of kites successfully nested on Bair Island in 1972 and 1975.

MARSH HARRIER *(Circus cyaneus).* This species is generally considered a winter visitor to the Bay Area; however, several nesting records do exist (Barlow 1900, Grinnell and Miller 1944, Sibley 1952). Five nests were located during 1971. Three nests were constructed in pickleweed, one in cordgrass *(Spartina foliosa)* and one on dredge spoils grown to annual grasses. Eggs were first located on 18 April 1971. Three nests contained 6 eggs, one contained 5 and one contained 4. Eighteen young (78%) fledged. Population projections for nesting Marsh Harriers were between 26 and 32 birds in 1971.

RING-NECKED PHEASANT *(Phasianus colchicus).* Nesting in 1971 was restricted to fields, adjoining levees and agricultural lands bordering marshlands in the extreme South Bay. Active nesting was recorded for the Palo Alto Flood Control Basin and northeast of Alviso, Santa Clara County. Nesting was first encountered on 12 April. Suitable nesting habitat was limited to approximately 161 ha. Nesting populations were projected at between 40 and 50 individuals.

CALIFORNIA CLAPPER RAIL *(Rallus longirostris obsoletus).* Studies of this endemic Bay Area race date back to the early 1890s (Taylor 1894, Adams 1900). Other nesting studies have been reported by Bryant (1915), DeGroot (1927), Applegarth (1938) and Zucca (1954). Rail investigations during 1971 were restricted to 1,829 ha of tidally influenced salt marsh. Nesting and population data were derived from visual counts during high tides, call counts, nest counts and ropedrags in appropriate habitats. A total of 87 nesting attempts was located in 1971. Active nesting was recorded from the middle of April to the end of July. Peak nesting occurred during the first two weeks of May. In 58 nests classified as active, clutch size ranged from 3 to 11 eggs. Mean clutch size was 6.83. Sixty-nine of 87 nesting attempts (79%) were located in cordgrass, 10 at the base of gumplant, 6 in pickleweed and 2 in mixed cordgrass-pickleweed. All nests were constructed from dried cordgrass stalks. Breeding populations varied according to habitat type and tide conditions during the census periods. Highest densities (2.51 rails/ha) were found in almost pure stands of cordgrass when censuses were conducted during medium-high tides (+5.0′ mllw). Population densities derived from visual counts during flood tide conditions (+6.5′ mllw) averaged 3.3 rails/ha for cordgrass marsh. Zucca (1954), using similar methods, reported a density of 3.01 rails/ha for cordgrass marsh. Population projections for 1971 were between 2,400 and 2,900 individuals. Follow-up investigations from 1972 to 1975 have revealed fluctuating rail populations (Gill MS) similar to those described by Ferrigno (1966) and Widjeskog (1974) for *R. l. crepitans* of New Jersey salt marshes.

VIRGINIA RAIL *(Rallus limicola).* This species exhibits a seasonal distribution in the San Francisco Bay area. Winter populations are commonly found on salt marshes, whereas nesting is confined to freshwater marsh areas. Previous nesting records for Virginia Rails in the South Bay were not found. No evidence of nesting was found during 1971. Breeding is suspect within the fresh and brackish water marshes of Coyote Hills Regional Park and the upper reaches of Coyote Creek and Artesian Slough in Santa Clara County.

SORA *(Porzana carolina).* This rail is considered a resident of Bay Area marshes with nesting restricted to freshwater marshes. No nesting was found during 1971. Nesting most likely occurred within the Coyote Hills area and the upper reaches of several sloughs in the extreme South Bay.

BLACK RAIL *(Laterallus jamaicensis coturniculus).* No nests or eggs of this species have been reported from the San Francisco Bay area; however, adults have been reported in April and birds of the year have been found in August (Orr 1947). More recently, Black Rails have been reported calling from the Olema Marsh, Marin County, in May and at Benicia State Park, Solano County, also in May (Robinson 1975). The latter two areas have been major wintering areas for Black Rails in the Bay Area. Considering this, and the recent confirmation of their occurrence in the Bay Area during what is generally considered the breeding season for this species, it seems likely that a limited number do breed in the area or remain as non-breeders through the summer.

AMERICAN COOT *(Fulica americana).* Four broods of young coots were found during 1971. First nesting evidence was encountered on 5 June near Coyote Hills. All broods were located in areas with strong freshwater influence. Additional sightings of 40 adults within the study area between April and August indicated that the minimum 1971 breeding population was probably between 50 and 75 pairs.

SNOWY PLOVER *(Charadrius alexandrinus).* Nesting records for this species in the Bay Area date from 1911 (Grinnell et al. 1918). South Bay records exist from Palo Alto (Martin 1939) and Alviso (Sibley 1952). Preferred nesting habitat was found to be salt pond levees accompanied by loose shell or small pebble deposits. Fifteen nesting attempts were recorded during 1971. First nesting was found on 8 May near Alviso. Nesting continued through July. Clutch sizes ranged from 1 to 3 eggs with the following distribution: 1 with 1 egg, 6 with 2 eggs and 8 with 3 eggs. Major nesting areas were located 0.3 km northwest of Alviso, Santa Clara County, and west of Coyote Hills, Alameda County. Observations of adults, in addition to those observed nesting, indicated a 1971 breeding population of about 150 pairs.

KILLDEER *(C. vociferus).* Only one nest, containing 3 eggs, was found. A second successful attempt was recorded on 11 June when 3 young were observed north of Alviso. Adult birds were seen throughout the breeding season and in association with every habitat type. Breeding population projections during 1971 were figured at between 350 and 400 pairs.

AMERICAN AVOCET *(Recurvirostra americana).* Status as a breeding species in the Bay Area was still in question in 1927 (Grinnell and Wythe 1927). There is, however, a record of a downy young (MVZ 2165) taken near Alvarado on 11 May 1926. By the early 1940s there were several reports of nesting in the South Bay (Parmenter 1937, Martin 1939, Kelly 1941). Sibley (1952) reported an assemblage of 26 pairs near Alviso in April 1950. A total of 160 avocet scrapes was located during 1971. Of these, 141 were considered active when found. All

scrapes were constructed on salt pond levees. The larger assemblages were located on levee fragments within salt ponds. Nesting was first observed on 23 April and continued through July. The mean clutch size was 3.52 (n=141 scrapes). Breeding density was determined for each type of levee and then projected to the available habitat type within the study area. The number of breeding pairs during 1971 was thus estimated at 1,800.

BLACK-NECKED STILT *(Himantopus mexicanus)*. Sibley (1952) lists the stilt as an uncommon summer resident and rare winter visitor to the South Bay. Nesting reports and winter sightings prior to 1952 refer to only small numbers, usually single pairs. The stilt has adapted readily to the salt pond environment of the South Bay, and numbers have increased steadily during the last twenty years. Fourteen nesting attempts were found in 1971. First nesting was found on 3 May when nine active scrapes were found near Alviso. Three additional nests were found on 9 June. Clutch sizes ranged from 1 to 4 eggs with the following distribution: 1 with 1 egg, 2 with 2, 6 with 3 and 3 with 4 eggs. Like avocets, stilts restricted nesting to salt pond levees. The total nesting population for 1971 was estimated at between 400 and 500 pairs.

LEAST TERN *(Sterna albifrons browni)*. Prior to 1943, the northernmost nesting colony of the California Least Tern was reported at Moss Landing, Monterey County (Grinnell and Miller 1944). Chandik and Baldridge (1967) reported three Least Tern nests at Alameda, Alameda County, in June 1967. Least Terns were also observed in South San Francisco Bay during August and September 1968. Sixty were counted on 1 September 1968. A breeding colony of 30 pairs was established on Bay Farm Island, Alameda County, in 1969. A smaller colony of 15 pairs was also reported from Bair Island, San Mateo County, that same year (Anderson 1970a). No nesting was found within the study area during 1971. The Bay Area population outside the study area during 1971 was estimated at between 85 and 105 pairs. Least Terns have since nested within the study area on Bair Island (1972-1975). A minimum of 14 active scrapes was found on Bair Island on 2 July 1975.

FORSTER'S TERN *(S. forsteri)*. Grinnell and Miller (1944) list this species as a migrant and winter visitor to San Francisco Bay. Forster's Terns were first reported nesting in the Bay Area in 1948, when 100 active scrapes were found near the eastern approach to the San Mateo Bridge, Alameda County, immediately north of the study area (Sibley 1952). Numbers have steadily increased. Six colonies, totaling 935 nesting pairs, were located during 1971. All colonies occupied small islands or discontinued dikes within salt ponds. Nesting was first observed on 23 April when 100 pairs were seen in various stages of courtship and nest building near the mouth of Alviso Slough. Egg laying in most colonies commenced during the last week of May. Mean clutch size for all scrapes was 2.60. Peak laying occurred between the first and second weeks of June. Volant young were seen on 21 June. The 1971 population was estimated at 1,200 pairs. Nesting was also found outside the study area during 1971. Mansfield (pers. comm.) found 10 colonies, totaling an estimated 2,000 pairs, within the study area in 1972.

CASPIAN TERN *(S. caspia)*. The first San Francisco Bay breeding record is for 1916 (Grinnell and Miller 1944). DeGroot (1931) reported a colony near the eastern approach to the Dumbarton Bridge, Alameda County, in 1922. This colony remained intact until 1966 (Chaniot 1970), but was abandoned sometime between 1966 and 1969. The two colonies studied in 1971 were probably offshoots of the original 1916 colony since neither of the present colonies had a history prior to 1967 (Anderson pers. comm.). Both colonies studied in 1971

occupied salt pond levees free from vegetation. The two colonies, located near Drawbridge, Alameda County, and on Bair Island, San Mateo County, had 200 and 350 pairs, respectively, in 1971. Active scrapes were first observed on 9 April. Peak nesting occurred on 6 June at Drawbridge and on 12 June on Bair Island. Mean clutch size for the Drawbridge and Bair Island colonies was 1.98 (n=176 scrapes) and 2.01 (n=304 scrapes), respectively. Chicks were first observed between 7-9 May at both colonies. No hatching or fledging success data were recorded. An estimated 500-600 pairs were found at the Bair Island site on 7 July 1975. This increase in colony size is attributed to the abandonment and absorption, at the Bair Island site, of a smaller colony outside but adjacent to the study area. The only other known Caspian Tern colony in the Bay Area is located on a salt pond levee in Napa County.

SHORT-EARED OWL *(Asio flammeus).* References to nesting in the Bay Area are limited (Grinnell and Wythe 1927, Grinnell and Miller 1944). Johnston (1956) states that this species may breed in the marshes bordering the Bay, but none have been reported doing so in recent years. During 1971, they were frequently flushed from Bair Island and the Palo Alto Flood Control Basin, but nesting was unconfirmed until 1972, when two nests were found within the flood basin. The first nest, containing two volant young and one about one week pre-fledging, was found on 15 April approximately 50 m from the first. During 1973, nesting was also confirmed for Bair Island; a nest with five eggs was found on 24 April at the base of a Coyote Bush near the northeast corner of the island.

BURROWING OWL *(Athene cunicularia).* Nesting was found at Alviso, Santa Clara County (3 pairs), and near Durham Road, Alameda County (10 pairs). Suitable nesting habitat was limited to approximately 170 ha. The nesting population was figured at between 12 and 16 pairs.

BARN OWL *(Tyto alba).* No nesting was found during 1971. A nest containing 4 eggs was located in 1972 in a dense stand of bulrush *(Scirpus acutus)* along the upper reaches of Artesian Slough, Santa Clara County.

BARN SWALLOW *(Hirundo rustica).* First nesting was observed on 8 April 1971. Peak nesting occurred during the second week of May. A total of 148 nests was located during 1971. The abandoned town of Drawbridge, Alameda County, represented the major nesting site within the study area. Other nesting areas included abandoned and active waterfowl hunting shacks, the underside of catwalks and other dwellings. The 1971 South Bay population was figured at between 300 and 500 pairs. No data were recorded on clutch sizes or hatching and fledging success.

CLIFF SWALLOW *(Petrochelidon pyrrhonota).* Nesting was first observed on 22 April 1971. A total of 850 nests was located. Nesting was in association with *H. rustica,* but in much greater densities. South Bay populations were projected at between 1,100 and 1,400 pairs during 1971.

LONG-BILLED MARSH WREN *(Cistothorus palustris).* Six active nests were found during 1971. An additional 32 nests were located, but were classified as dummy nests (Bent 1948) or nests from previous seasons. Of the active nests, 4 were placed in cordgrass and 2 were constructed in cattails *(Typha* sp.). Nesting was first observed on 5 May and continued through 5 June. Though most of the active nests were found in cordgrass, the greatest nesting densities were found in freshwater marsh areas, especially Coyote Hills. Other major nesting areas included the upper reaches of Alviso and Guadalupe sloughs, Coyote Creek and Mud Slough, and the Palo Alto Flood Control Basin. The projected breeding population for 1971 was between 1,000 and 1,200 pairs.

LOGGERHEAD SHRIKE *(Lanius ludovicianus).* A single nest, containing four eggs, was located in a Coyote Bush on Bair Island on 18 April 1971. Several other adult shrikes were sighted throughout the study area from April through July. Atkinson (1901) listed several nesting dates and locations for the Santa Clara Valley. Nesting populations for 1971 were projected at between 10 and 15 pairs.

SALT MARSH YELLOWTHROAT *(Geothlypis trichas sinuosa).* Nesting of this race is generally restricted to freshwater marsh areas with winter populations spreading into salt marsh (Grinnell and Miller 1944). Grinnell (1901) and Schussler (1918) have reported on early nesting studies of *G. t. sinuosa.* A single nest was located on 7 June 1971 at Coyote Hills. Several singing males were also observed at this site during the breeding season. A minimum breeding population for 1971 was estimated at between 25 and 30 pairs.

WESTERN MEADOWLARK *(Sturnella neglecta).* A single nest containing 3 eggs was found on 4 May 1971 on Bair Island, San Mateo County. Suitable nesting habitat within the study area was limited to approximately 330 ha. Bair Island, Palo Alto Flood Basin and a field northwest of Drawbridge, Alameda County, accounted for most grassland habitat within the study area. The 1971 breeding population was estimated at between 100 and 150 pairs.

RED-WINGED BLACKBIRD *(Agelaius phoeniceus).* Nesting was found in salt marsh, freshwater marsh and grassland habitats during 1971. Seventeen of 22 nests were found in salt marsh. Nesting was first encountered on 11 April and continued through 8 June. Populations for salt marsh, freshwater marsh and grassland were figured at 500, 350 and 300 pairs, respectively, during 1971.

TRICOLORED BLACKBIRD *(A. tricolor).* Nesting in 1971 was restricted to a colony of approximately 400 pairs at Coyote Hills Regional Park, Alameda County.

BREWER'S BLACKBIRD *(Euphagus cyanocephalus).* Nesting was recorded on three occasions within the study area during 1971. The preferred nesting habitat of this species was limited within the study area. Within the Coyote Hills area, stands of Monterey Pine *(Pinus radiata), Eucalyptus,* willow *(Salix* sp.) and Box Elder *(Acer negundo)* provided the majority of nesting cover. Additional nesting areas were afforded by man-made structures, including duck hunting blinds and pump houses associated with salt production. The 1971 breeding population approximated 700 pairs.

HOUSE FINCH *(Carpodacus mexicanus).* Thirty-one active nests were located during 1971. First nesting was found on 4 May. Nesting continued through July. Twenty-six of 31 nests were located during May. Almost all nests were found in association with man-made structures. Between 400 and 500 pairs were estimated to have nested during 1971.

SAVANNAH SPARROW *(Passerculus sandwichensis).* Eight nests were found during 1971. Dates ranged from 1 April to 22 June. Clutch size averaged 3.60. Preferred nesting habitat was levee tops grown to annual grasses and high pickleweed growing on levee banks. The 1971 nesting population was estimated at between 800 and 1,000 pairs.

SALT MARSH SONG SPARROW *(Melospiza melodia pusillula).* One of three races of Song Sparrows endemic to San Francisco Bay salt marshes, *M. m. pusillula* is restricted to the South San Francisco Bay. Major breeding and population works have been reported by Grinnell (1913), Grinnell and Miller (1944), Marshall (1948a, b), and Johnston (1955, 1956a, b). Seventeen nests were found be-

tween 12 March and 7 May 1971. Clutch sizes were distributed as follows: 1 nest with 1 egg, 1 with 2, 2 with 3, 4 with 4, 2 with 1 egg and 1 young, 2 with 3 young and 1 with 4 young. The projected population during 1971 was 1,800 pairs. This includes 960 pairs showing a nesting preference for pickleweed marsh and 840 pairs showing a preference for cordgrass marsh.

SUMMARY

The breeding biology, habitat requirements and relative abundance of 41 avian species nesting in the estuarine influence of South San Francisco Bay are discussed. Over 4,000 nesting attempts were recorded from March to August 1971. A few additional data from 1972 to 1975 are also included. Forster's Terns accounted for over 15% of all nesting attempts, followed by Cliff Swallows (850), Black-crowned Night Herons (684), Caspian Terns (500) and Snowy Egrets (340). The Salt Marsh Song Sparrow and American Avocet, with an estimated 1,800 pairs each, represented the most abundant breeding species within the study area. Song Sparrows were found to be the earliest nesting species (March), whereas the White-tailed Kite nested into August. Seven species are relatively recent additions to the recorded nesting avifauna of the South Bay area: California Least Tern (1967), Snowy Egret (1969), Black-necked Stilt (1952), Forster's Tern (1948), Snowy Plover (1911), American Avocet (1926) and Caspian Tern (1916). The conversion of tidal marsh to solar evaporation ponds and the creation of high ground with dredging spoils on former salt marsh habitat are responsible for these breeding range extensions. Conversely, populations of the California Clapper Rail, Salt Marsh Song Sparrow and Long-billed Marsh Wren have declined. The substantial reduction in fresh and brackish water marshes on the fringe of the Bay has severely reduced nesting of several species, including the American Bittern, Virginia Rail, Sora, Salt Marsh Yellowthroat and several species of waterfowl.

ACKNOWLEDGMENTS

I am indebted to the management of the Leslie Salt Company for providing the opportunity to conduct this study on much of their lands. I also thank the following employees of the California Department of Fish and Game: Howard Leach, Robert Mallette, Richard Forester, Robert Lassen, Bruce Elliott and Ron Jurek. Albert Mansfield and Richard Mattish are thanked for their field assistance during the study. I especially thank L. Richard Mewaldt for his guidance during this study and for his editing of this manuscript. This study was partially funded by the California Department of Fish and Game and was prepared as partial fulfillment of the requirements for a Master of Arts Degree in Biology at San Jose State University.

LITERATURE CITED

Adams, E. 1900. Notes on the California Clapper Rail. Condor 2:31-32.

Anderson, W. 1969. Seasonal distribution of water birds of San Francisco Bay. California Dept. Fish & Game, Yountville. 14 p. mimeo.

Anderson, W. 1970a The California Least Tern breeding in Alameda and San Mateo counties. California Fish & Game 56:136-137.

Anderson, W. 1970b. A preliminary study of the relationship of saltponds and wildlife—South San Francisco Bay. California Fish & Game 56:240-252.

Applegarth, J. H. 1938. The ecology of the California Clapper Rail on the south arm of San Francisco Bay. MA Thesis, Stanford Univ.

Atkinson, W. L. 1901. Nesting habits of the California Shrike. Condor 3:9-10.

Barlow, C. 1900. Some additions to Van Denburk's list of land birds of Santa Clara County, Cal. Condor 2:131-133.

Bent, A. C. 1948. Life histories of North American nuthatches, wrens, thrashers, and their allies. U. S. Natl. Mus. Bull. 195.

Bryant, H. C. 1915. California Clapper Rail breeds in Alameda salt marshes. California Fish & Game 1:192.

Carriger, H. W. and J. R. Pemberton. 1908. Some notes on the Great Blue Heron. Condor 10:78-81.

Chandik, T. and A. Baldridge. 1967. Nesting season. Middle Pacific Coast region. Aud. Field Notes 21:600-603

Chaniot, G. E., Jr. 1970. Notes on color variation in downy Caspian Terns. Condor 72:460-465.

Cohen, D. A. 1900. Casual observations on a colony of Black-crowned Night Herons. Condor 2:10-12.

DeGroot, D. S. 1927. The California Clapper Rail its nesting habits, enemies, and habitat. Condor 29:259-270.

DeGroot, D. S. 1931. History of a nesting colony of Caspian Terns on San Francisco Bay. Condor 33:188-192.

Ferrigno, F., Sr. 1966. They go up and down: population dynamics of the Clapper Rail. New Jersey Outdoors 16(8):3-9.

Finley, W. L. 1906. Heron at home. Condor 8:34-40.

Gill, R. E., Jr. 1972. South San Francisco Bay breeding bird survey. Calif. Dept. Fish & Game Admin. Rpt. No. 72-6.

Gill, R. E., Jr. 1973. The breeding birds of the South San Francisco Bay estuary. MA Thesis, Avian Biology Laboratory, San Jose State Univ. 145 p.

Grinnell, J. 1901. The Pacific Coast Yellowthroats. Condor 3:65-66.

Grinnell, J. 1913. Notes on the birds of the San Francisco Bay marshes. Univ. Calif. Publ. Zool. 10:191-194.

Grinnell, J., H. C. Bryant and T. I. Storer. 1918. The game birds of California. Univ. California Press, Berkeley.

Grinnell, J. and M. W. Wythe. 1927. Directory to the bird-life of the San Francisco Bay region. Pac. Coast Avif. No. 18.

Grinnell, J. and A. H. Miller. 1944. Distribution of the birds of California. Pac. Coast Avif. No. 27.

Johnston, R. F. 1954. Variation in the breeding season and clutch size in Song Sparrows of the Pacific Coast. Condor 56:268-273.

Johnston, R. F. 1955. Influence of winter high tides on two populations of Salt Marsh Song Sparrows. Condor 57:308-309.

Johnston, R. F. 1956a. Population structure in Salt Marsh Song Sparrows, part I. Environment and annual cycle. Condor 58:24-44.

Johnston, R. F. 1956b. Population structure in Salt Marsh Song Sparrows, part II. Density, age structure, and maintenance. Condor 58:254-272.

Kelly, J. W. 1927. Notes on Snowy Plover nesting in San Francisco Bay. Gull 9(6):3.

Kelly, J. W. 1941. Notes on American Avocet nesting near Dumbarton Bridge. Gull 23(9):34.

Marshall, J. T., Jr. 1948a. Ecologic races of Song Sparrows in the San Francisco Bay region, part I. Habitat and abundance. Condor 50:193-215.

Marshall, J. T., Jr. 1948b. Ecologic races of Song Sparrows in the San Francisco Bay region, part II. Geographic variation. Condor 50:233-256.

Martin, E. W. 1939. Notes from the Palo Alto Sports Club. Condor 41:124-125.

Miller, A. H. 1943. Census of a colony of Caspian Terns. Condor 45:220-225.

Moffitt, J. 1939. Notes on the distribution of herons in California. Condor 41:70-80.

Orr, R. T. 1947. Occurrence of Black Rail in San Francisco. Condor 49:41.

Parmenter, H. E. 1937. American Avocet nesting near Alvarado, Alameda County. Gull 19(9):4.

Pickwell, G. 1929. Notes on Barn Swallow nesting near Alviso, Santa Clara County. Wrentit 1(1):1.

Pickwell, G. 1932. Requiem for the White-tailed Kites of Santa Clara Valley. Condor 34:44-45.

Robinson, D. 1975. May and June field observations. Gull 57:88.

Schussler, G. W. 1918. The Salt Marsh Yellowthroats of San Francisco. Condor 20:62-64.

Sibley, C. G. 1952. Birds of the South San Francisco Bay region. San Jose State College, 44 p. mimeo.

Sibley, C. G. 1953. Forster Terns breeding on San Francisco Bay, California. Condor 55:278-279.

Taylor, H. R. 1894. Among the Clapper Rail. Nidologist 1:153-155.

Waian, L. B. and R. C. Stendall. 1970. The White-tailed Kite in California with observations of the Santa Barbara population. Calif. Fish & Game 56:188-198.

Widjeskog, L. 1974. Clapper Rail study. New Jersey Dept. Envir. Proj., Div. Fish & Shellfish. Prog. Rep. W-53-R-7. 12 p. mimeo.

Zucca, J. H. 1954. A study of the California Clapper Rail. Wasmann J. Biol. 12:135-153.

Accepted 11 January 1977