State of California
The Resources Agency
Department of Fish and Game

COMMON EGRET AND GREAT BLUE HERON NEST STUDY INDIAN ISLAND, HUMBOLDT COUNTY, CALIFORNIA

1971-1972 1/

by

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ABSTRACT

At the Indian Island rookery, Humboldt Bay, Humboldt County, California, there were 440 nesting attempts by common egrets, 136 by great blue herons, and 101 nesting attempts by black-crowned night herons during the 1971 and 1972 breeding seasons. Of these attempts, there were 368 nesting successes by common egrets, 116 by great blue herons, and 88 attempts by black-crowned night herons were successful. Seven hundred and eleven common egret, 232 great blue heron, and 139 black-crowned night heron young were fledged during the two years.

Average clutch size for 30 common egret nests was 3.13 eggs per nest. A production of 1.94, 2.00, and 1.57 young per successful nest was determined for the common egret, great blue heron, and black-crowned night heron respectively. During 1972, 3 snowy egrets nested in a Himalaya berry patch adjacent to the rookery, and successfully fledged 6 young.

Broken common egret shells averaged 15.6 percent thinner than eggs collected before 1947, and great blue heron broken shells were 16.6 percent less than the pre-1947 shell measurements. Residues of DDT and its metabolites were found in varying amounts in eggs and nestlings collected.

1/ Wildlife Management Branch Administrative Report No. 72-9 (November 1972). Supported by Federal Aid in Wildlife Restoration, Project W-54-R, "Special Wildlife Investigations."

Indian Island Rookery, Humboldt Bay, Humboldt County, California.

RECOMMENDATIONS

In order to insure perpetuation of the heron rookery on Indian Island, it is recommended that:

1. Indian Island be incorporated into the Humboldt Bay National Wildlife Refuge.
2. A management plan be developed to provide needed protection.
3. An annual survey be made each year in May to determine rookery production and colony size.
4. Pesticide residues in eggs and nestlings be periodically monitored.

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INTRODUCTION

The common egret (Casmerodius albus) is relatively abundant throughout much of the coastal United States, but only fragmentary data exist on its life history. Recent work by Pratt (1970) has provided information on nesting success, mortality of young, and nesting season duration. On Humboldt Bay, California, Yull (1972), determined daily and seasonal movements, with emphasis on roost and nest areas around the bay. Teal (1965), studied the nesting success of egrets in Georgia. More information exists on the great blue heron (Ardea herodias). In California, Pratt (1970) studied the overall breeding biology, while Wilburn (1971) and Page (1971) both provided information on clutch sizes, hatching success, mortality of young, while also considering the importance of disturbance factors to productivity.

During the past five years, studies have shown reproductive distress in various marine-associated avian species. Gress (1970), indicated nesting failures in the California brown pelican (Pelicanus occidentalis californicus) due to eggshell thinning, while Anderson, et al.(1969), implicated DDT with nesting failures of the double-crested cormorant (Phalacrocorax auritus). Only recently has research dealt with the presence of chlorinated hydrocarbons in egrets and herons. Henny, et al.(1971), Faber, et al. (1972), and Vermeer, et al. (1970), all determined the presence and implications of chlorinated hydrocarbons and other chemical pollutants on the reproductive performance of great blue herons, while Faber, et al. (1972) related DDE with a high incidence of nesting failures and eggshell thinning with the common egret.

Objectives

This report summarizes findings of a two-year study of the reproductive biology of a population of common egrets and great blue herons on Indian Island, Humboldt County, California. Primary objectives of the study were to: (1) record life history information of the common egret and great blue heron, (2) determine reproductive status of nesting common egrets, great blue herons, and black-crowned night herons (Nycticorax nycticorax), (3) collect eggs and nestlings for pesticide analysis, and (4) evaluate the impact of a bridge recently constructed near the rookery.

STUDY AREA

History

Prior to 1966, there is little information pertaining to the existence of a heron rookery on Indian Island. Grinnell (1944) reports that the great blue heron was a known nester in the Humboldt Bay area in the early part of this century. Local oologist Charles Clay (1939) collected heron eggs in "a Eureka rookery" in 1909, but made no mention of herons nesting on Indian Island. Early reports suggest that the common egret was an infrequent visitor to the Humboldt Bay region as late as 1939 (Fraser, 1931; Clay, 1939). No data exist as to the first nesting of common egrets in Humboldt County or at the Indian Island rookery. According to Smith (1965), the abandoned Gunther mansion stood in the cypress grove at the site of the present rookery until 1958, at which time it was razed. It is unknown if herons or egrets nested there prior to that time.

Since 1966, however, three studies have provided estimates of the number of nesting egrets and herons on Indian Island (Table 1).

Gerstenberg (1966), Burton (1972), and Yull (1972), all indicated 60 to 70 breeding pairs of common egrets, 20 to 30 pairs of great blue herons, and 10 to 15 pairs of black-crowned night herons from 1966 to 1969. No studies on productivity were carried out.

TABLE 1

Number of Nests,
Indian Island Rookery
Humboldt County, California
1966-1972

Year	Common egret	Great blue heron	Black-crowned night heron	Snowy egret
1966 1/	65	20	13	- 5/
1967 2/	70-75	25	-	-
1968 2/	65	25-30	-	-
1969 3/	60-70	20-30	10-15	-
1970 4/	65	20	45	-
1971	184	55	62	-
1972	251	87	133 6/	2

1/ Gerstenberg (1966)

2/ Yull (1972)

3/ Burton (1972)

4/ Calif. Dept. of Fish and Game (1971)

5/ No counts available in years marked by dash

6/ Eighty-two nests were located in Himalaya berry patch. Productivity was determined only on 51 nests in cypress groves.

on productivity were carried out.

Description

Climate

Humboldt Bay area climate is considered maritime, with high humidity the entire year. Average annual precipitation ranges from 24 to 53 inches, with a mean of 39 inches. Temperatures are moderate, with a daily temperature averaging 56 degrees in the summer months and 47 degrees in the winter (U. S. Department of Commerce, 1972).

Physical and Vegetative Features

Indian Island, a 273 acre island on north Humboldt Bay, Humboldt County (R1W, T5N, Sec. 15, Humboldt Base Meridian), is situated between the city of Eureka on the south and the town of Samoa on the north (Figure 1). Island is of low relief, 0 to 15 feet above mean low tide (Burton, 1972), with the majority of the island 3 to 6 feet above that mean. It is transected by numerous natural and manmade sloughs which are periodically exposed and flooded by the tidal action (Figure 2).

Vegetation on the island consists of five plant communities: Salt Marsh, Dune, Willow, Coyote Bush, and Cypress. The Salt Marsh Plant Community makes up approximately 200 acres, 74 percent of the total land area and represents the only native plant community found on Indian Island (Burton, 1972). All other communities occur as a result of man's influence. Principal plant species present in the Salt Marsh Community are pickleweed (*Salicornia virginica*), cord grass (*Spartina foliosa*), and salt grass (*Distichlis spicata*).

Principal plant species in the Cypress Community are Monterey cypress (*Cupressus macrocarpa*), eucalyptus (*Eucalyptus* sp.), Sitka spruce (*Picea*

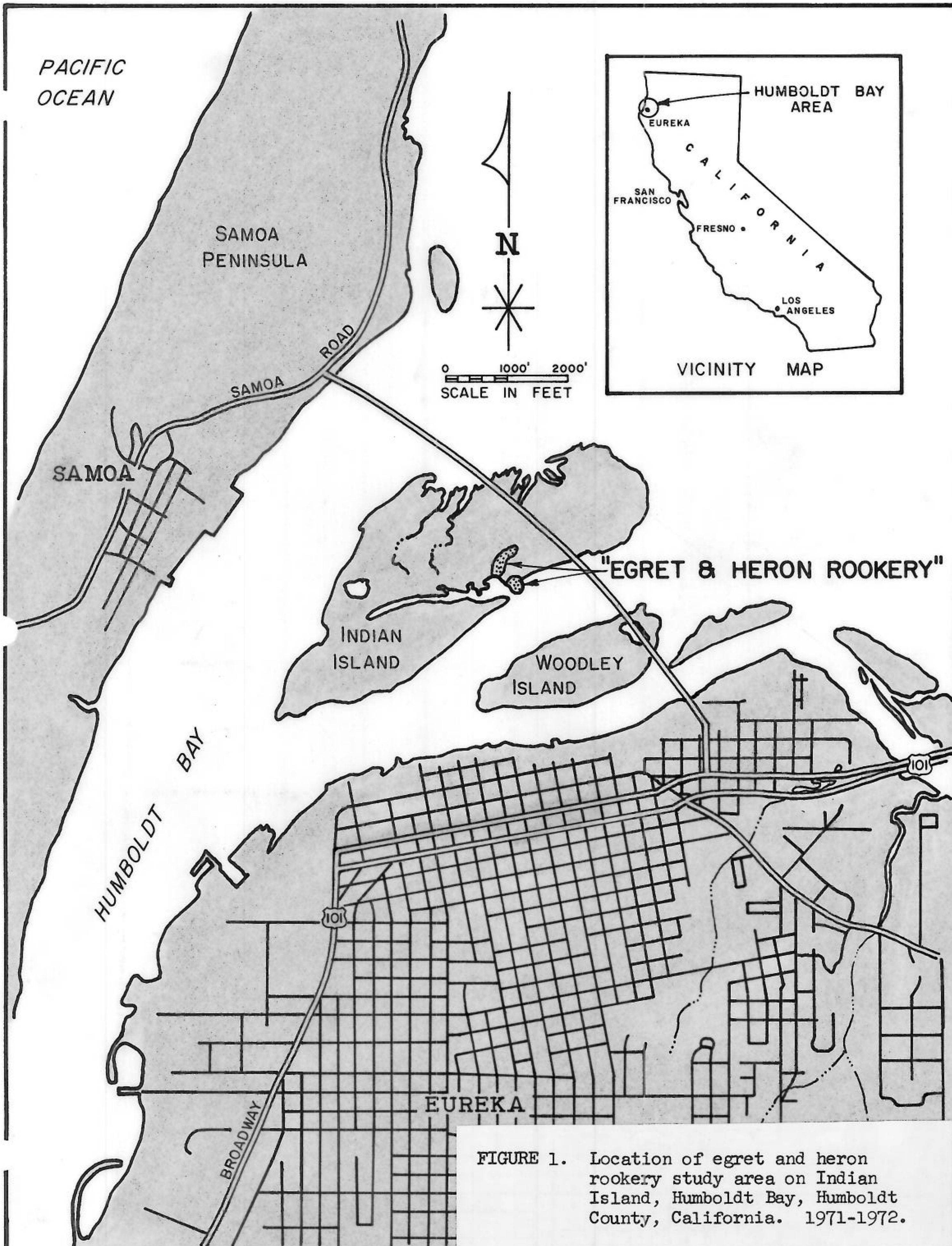

FIGURE 1. Location of egret and heron rookery study area on Indian Island, Humboldt Bay, Humboldt County, California. 1971-1972.

sitchensis), Aarrons beard (Hypericum calycinum), English ivy (Hedra helix), and Himalaya berry (Rubus procerus). These were ornamental plants which remained after the Gunther mansion was razed.

Nesting Sites

The major portion of the rookery is located in the Cypress Plant Community, near the middle of the island (Figure 2). Eucalyptus, Sitka spruce, and cypress trees vary in height from 25 to 75 feet and are the only trees utilized for nesting by common egrets and herons. Black-crowned night herons nested in all three species of trees and the Himalaya berry patch nearby.

Approximately 100 yards from the main cypress grove is a 200' x 230' patch of Himalaya berries and willows (Salix sp.) which is periodically utilized for nesting by black-crowned night herons, and only recently by snowy egrets (Leucophoyx thula) (Figure 2). This nesting site consists of berry vines, 4 to 8 feet above the ground, interspersed with willows, Scotch broom (Cytisus scoparius), and acacia (Acacia longifolia). A majority of the black-crowned night heron nests were situated in the Himalaya berry vines, with only 8 of 82 nests occurring in the willows and acacia. All snowy egret nests were restricted to the Himalaya berry patch.

Black-crowned night herons have been known to nest in the berry thicket prior to the start of this project. An estimated 13 pair utilized the area in 1966, and shifted to a willow grove on nearby Woodley Island during 1967 and 1968. No estimate of nesting pairs was made in 1971 in the Himalaya berry patch portion of the rookery.

Prior to this study, snowy egrets were seen in 1966, 1967, and 1968 on or near the Indian Island rookery although they were never observed to successfully nest.

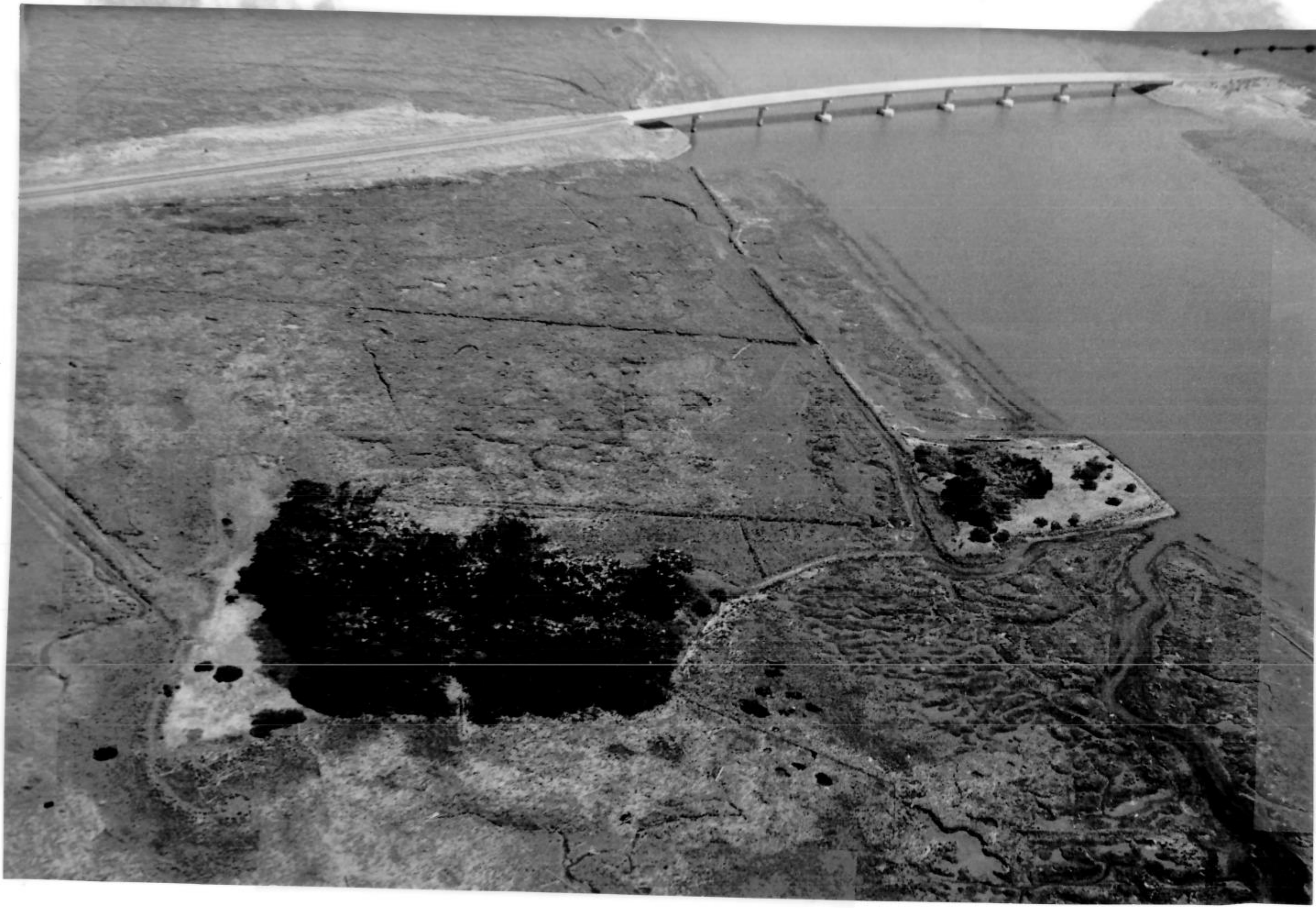

FIGURE 2. Aerial view of the Indian Island rookery showing a portion of Samoa Bridge, Indian Island, Humboldt County, California.

METHODS

Nest Survey

Prior to each nesting season, all trees in the rookery containing nest structures were numbered and mapped. Because of the large number of trees and the difficulty distinguishing one from another at a distance, all trees on the periphery of the grove were marked so numbers were visible from observation points situated around the rookery. Trees in the center of the grove were also numbered and mapped. Nest trees which were not visible from peripheral observation points were observed from within the rookery.

As nests were occupied by the great blue herons and common egrets, locations of nests were plotted on an outline form of the tree. The chronology and fate of each nest was then followed throughout the nesting season by using a 20 power spotting scope and a pair of 7 x 50 binoculars. Weekly checks were made of each nest to determine onset of incubation, hatching, number of young per nest, and fledging.

Nests were classified as occupied only when attended by a pair of egrets or herons. Nests utilized by displaying males did not always constitute occupied nests.

In 1972, one tree containing 15 egret nests was climbed and the nests labeled for future ground observations and clutch counts. The contents of these 15 nests were inspected 4 times during the nesting season to determine egg laying, hatchability, and hatching dates. On each visit, eggs at 7 nest sites were marked with a rapidograph pen, and the length and breadth of new eggs measured with vernier calipers. Loss, replacement, or addition of eggs was noted. Clutch counts of nests in neighboring trees were made where possible.

Collection of Material

Tissue and Eggs

During 1971 and 1972, whole eggs and dead nestlings found beneath the rookery were collected and preserved by freezing for pesticide analysis. These were found by checking beneath the nest trees at least once a week throughout the nesting season.

In 1971, five whole common egret eggs, two nestlings, and one adult bird were collected as well as one great blue heron egg and two nestlings.

During the 1972 nesting season, three-quarter inch mesh nets were stretched beneath selected trees to collect whole eggs, young which had fallen from nests, and hatched or broken eggshells. Broken shells found in the nets were assumed to have been broken on the nest and tossed out by the adult. Collected for analysis were 6 whole common egret eggs, 5 great blue heron eggs, 1 sub-adult bird, and 4 nestlings. Two trees were climbed late in the season to retrieve addled eggs for chemical analysis.

Great blue heron and common egret eggshells were collected during the 1971 and 1972 nesting seasons. This was done by checking beneath the nest trees at least once a week until the first week of June at which time hatching had been largely completed. Identification of eggshells as great blue heron or common egret was made on the basis of the criteria used by Faber, et al. (1972) and hatching period. The staggered egg laying and hatching intervals of the great blue heron, common egret, and black-crowned night heron greatly facilitated identification. Great blue herons were the earliest nesters, followed by the common egret and black-crowned night heron (Figure 3). Determination of shells as "hatched"or "broken" was also made using the methods of Faber, et al. (1972).

Eggshell Measurement

Eggshell thickness measurements was done using the method of Anderson and Hickey (1970). Shell thickness data of eggs collected prior to 1947 were obtained from specimens in the California State University, Humboldt collection, and from Anderson (In Henny, et al. 1971) and Faber, et al. (1972). Hatched and broken shells were measured to the nearest 0.01 mm. using a Starrett micrometer.

RESULTS

Life History

Territorial Behavior

Great blue herons occupied the rookery as a roosting area at night throughout much of the winter, and fed in the marsh flats west of the rookery during the day. During early January and February, it was common to flush 100 to 150 herons from their feeding areas. On February 10, 1971, and February 19, 1972, adult great blue herons were first observed occupying and defending old nest platforms and carrying nest material. Figure 3 illustrates the chronology of heron nesting on Indian Island.

In 1971, common egrets began occupying the rookery in large numbers on March 4, while in 1972, utilization of the rookery began March 8, well after the majority of great blue herons had established territories and were laying eggs. Intraspecific competition for prime nesting sites in the southern portion of the rookery was intense, with threat displays, chases, and bill

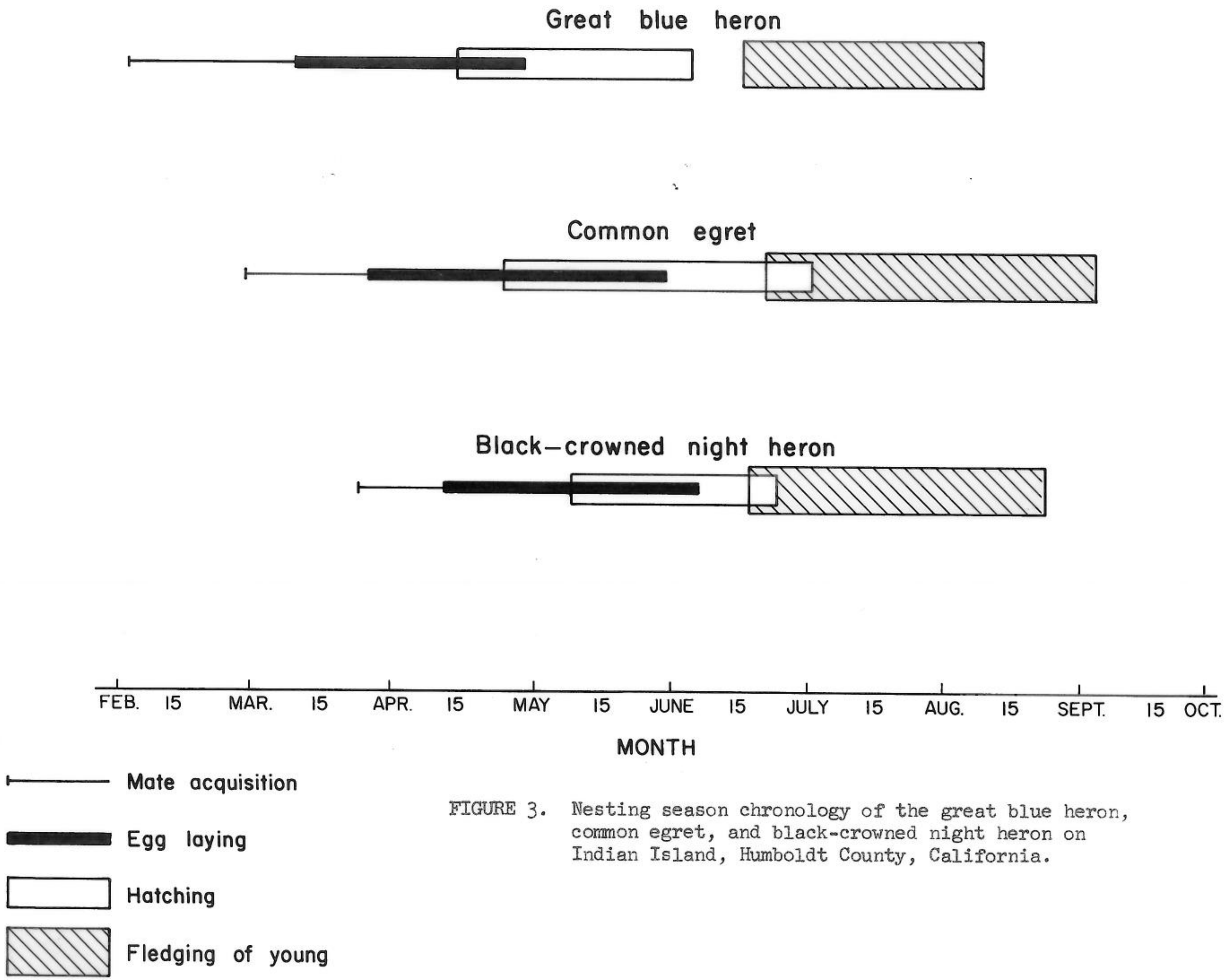

FIGURE 3. Nesting season chronology of the great blue heron, common egret, and black-crowned night heron on Indian Island, Humboldt County, California.

sparring common. During both years, the numbers of breeding pairs increased steadily through March, April, and May.

Incidence of threat displays and intraspecific interaction diminished greatly after early June, becoming restricted to late nesters and nonbreeding birds landing in occupied territories.

During the period of nestling, brooding and feeding, interaction between young on different nest sites became common as they grew up and were able to move off the nests and onto adjacent branches. Nestlings often defended the nest site by physically attacking both intruding adults and other young.

Courtship Behavior

Courtship among great blue herons began during the middle of February and lasted until the second week in March. Behavior included neck crossing, neck stretching accompanied by a downward bobbing motion, and extensive vocalization which is believed to be a key form of mate recognition (Etkin, 1964). As found by Pratt (1970), and Cotrille (1958), sudden flights by the herons were observed, all with no apparent disturbance.

Common egret courtship displays were of greater duration and variability than those of the great blue heron. The long aigrettes, characteristic of adult breeding plummage, were erected forming a peacock-like fan over the tail. Accompanying this plumage display were a series of bobs, neck stretches, and stroking of the breast and primary feathers.

Stick-Carrying Behavior

With both the common egrets and great blue herons, stick-carrying was found to be a behavior pattern associated with (1) securing a mate, (2) copulation, and (3) incubation.

Prior to pair-bonding, the male induced the female into his territory by collecting nesting material and beginning nest construction. Stick-carrying was more often observed as a post-copulatory behavior. During this time, the male secured nesting material, returned to the nest and presented it to the female. In virtually all cases, only the male collected material.

Stick-carrying after egg laying was observed to be a common occurrence, probably serving to strengthen the pair-bond relationship (Noble, et al. 1938).

Incubation and Brooding of Young

Incubation and brooding duties were performed by both sexes of all four species. After feeding, mates would return to the nest site to replace its mate.

Depending upon weather conditions, brooding of hatched chicks was nearly continuous until $1\frac{1}{2}$ to 2 weeks of age. After the chicks reached this age, the adult attending the nest would move to the edge to preen or loaf until replaced by the mate. After nestlings were 4 weeks of age, it was common for both adults to be away from the nest up to 4 hours.

Feeding of Young

During the early stages of brooding, adult egrets remained on the nest 5 to 6 hours, feeding the young with regurgitated food acquired from an earlier feeding trip. After nestlings were three weeks of age, it was common for adult egrets to return to the nest after acquiring food, feed the young, and immediately leave the nest site. As young increased in size, time spent at the nest by the adult became shorter because of increased harassment and/or food requirement of the young.

Feeding styles differed significantly as the young increased in age. With chicks younger than 2 to $2\frac{1}{2}$ weeks of age, the adult regurgitates food directly onto the nest floor, with little physical stimulation from the young. When older, nestlings will grasp the bill of the adult, usually just below the eyes, and induce the adult to regurgitate. Food often passes directly from the adult into the mouth of the young.

Great blue heron feeding methods differed only slightly from the common egret.

Nest Description

Platforms

Great blue heron nests were bulky platforms $2\frac{1}{2}$ to 3 feet in diameter and 1 to $1\frac{1}{2}$ feet in depth. Depending on the location of the structure, nests remaining intact from previous years tended to be the largest and most stable due to accumulation of nesting material. Nests constructed and used the first year were generally of poorer construction and sustained higher egg losses and nesting mortality.

Common egret nests were characteristically smaller and flimsier, rarely lasting from one nesting season to the next. Nest platforms tended to be 1 to $1\frac{1}{2}$ feet in diameter with a depth of 2 to 3 inches. Many lacked depressions and appeared almost flat. As a result, egg losses were high.

Both great blue herons and common egrets constructed their nests primarily of eucalyptus and cypress sticks procured from beneath the rookery or hanging dead on the trees, but often used vegetation from the salt marsh and willow habitats.

Site Preference

All three species nesting in the Cypress Community showed nest site specificity. Great blue herons nested in eucalyptus, cypress and Sitka spruce, with nest platforms usually located 5 to 20 feet higher in the trees than those of the egrets, but in some cases egrets and herons were nesting within a 5-foot radius of each other. In general, great blue herons were more randomly dispersed throughout the grove, but had a definite preference for the taller eucalyptus and Sitka spruce.

In contrast, common egrets were most selective, nesting in greater density in cypress and Sitka spruce, predominantly on the south side of the grove (Figures 4 and 5). Only one egret nest was located in a eucalyptus tree, and that nest was occupied earlier by great blue herons and abandoned in April.

Similarly, black-crowned night herons nested in eucalyptus, cypress, and Sitka spruce, but were less selective on height of the nest above the ground.

Population

Breeding population estimates since 1966 are shown in Table 1. An increase in the number of birds utilizing the rookery is evident. Estimates by earlier observers are considered low since no attempts were made to count nests other than along the grove periphery.

Marked increases in numbers of common egrets and great blue herons breeding between 1971 and 1972 may be due to: (1) shifting of birds from other rookeries, or (2) recruitment of juvenile birds into the breeding population.

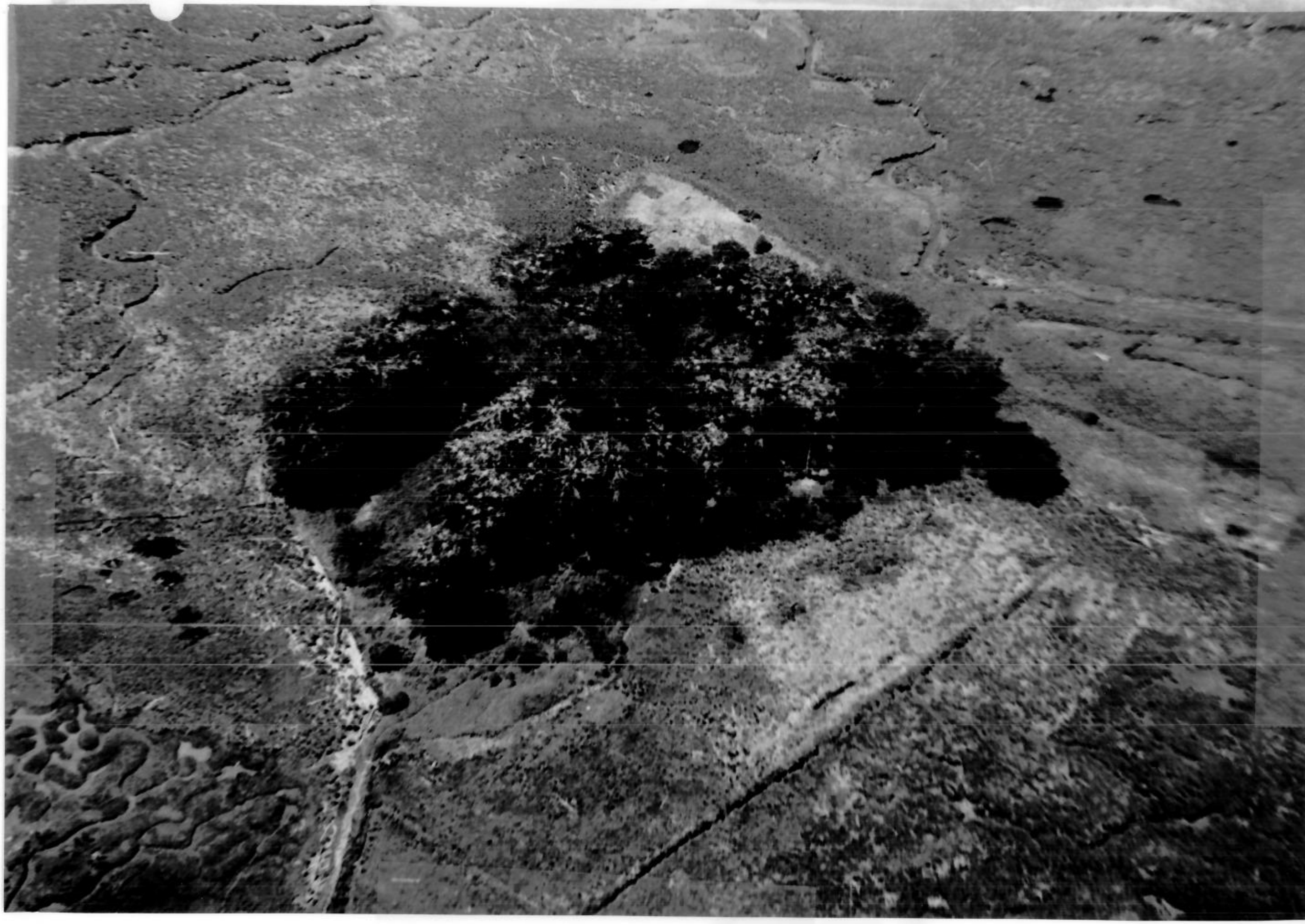

FIGURE 4. Aerial View Showing Nest Density at Indian Island Rookery, Humboldt Bay, Humboldt County, California.

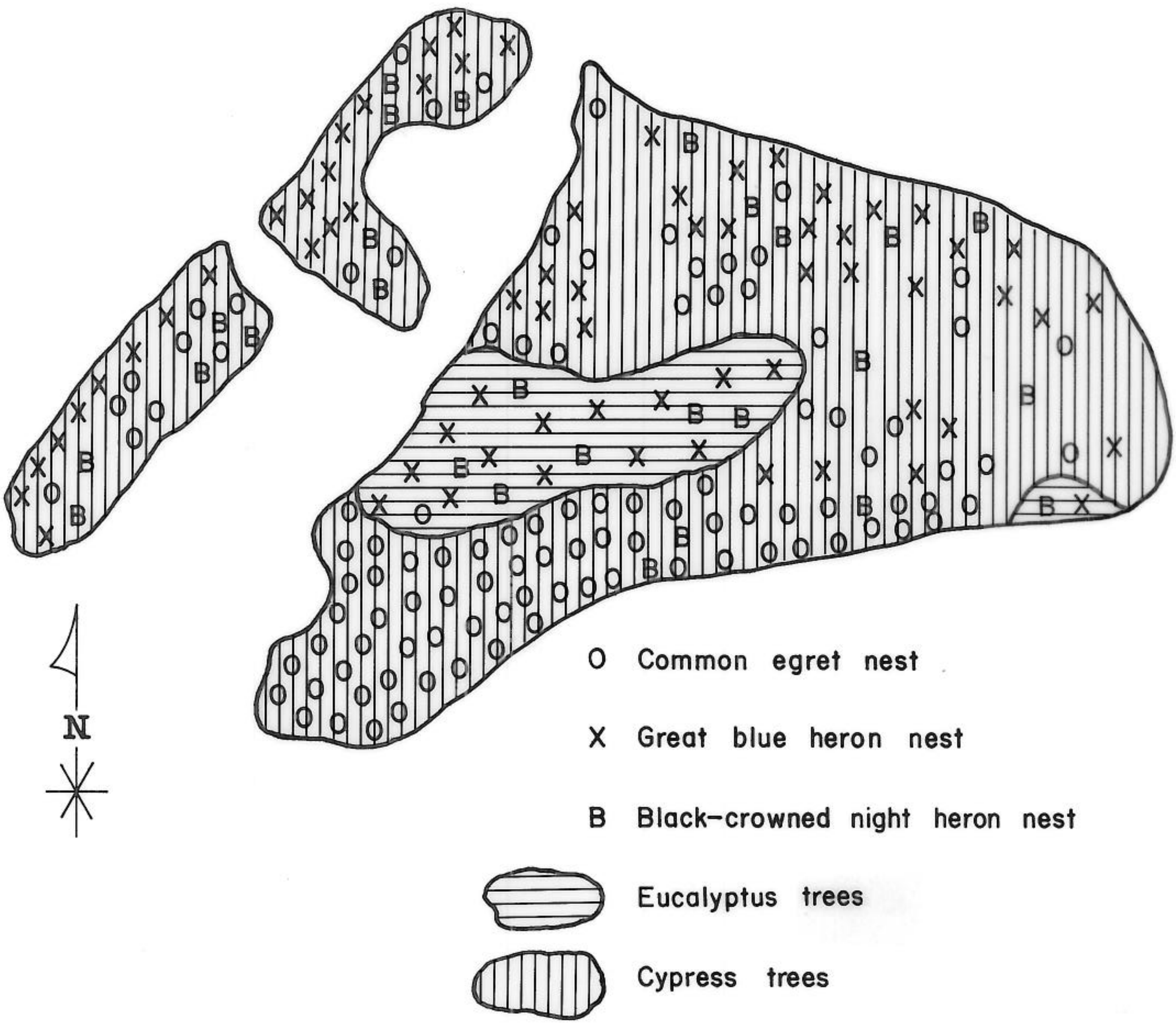

FIGURE 5. General distribution of common egret, great blue heron, and black-crowned night heron nests in the cypress and eucalyptus grove on Indian Island, Humboldt County, California. 1971-1972.

Reproductive Sucess

Egg Laying and Clutch Sizes

Great blue heron: During 1971 and 1972, a majority of great blue heron laid eggs from approximately March 9 to April 23. These dates were derived by back dating from time of hatching and from observation of first sitting of the females. Late nesters and renesting attempts extended egg laying until June 22, 1971 and June 27, in 1972.

Clutch size in four great blue heron nests averaged 4.0 eggs as compared to 3.38 eggs per clutch reported by Page (1971) in the San Joaquin Valley and 4.19 eggs per clutch by Henny, et al. (1971), in Western Oregon (Table 2).

Common egret: Common egret laying dates were from March 25 until May 20. Renesting attempts extended the laying time until June 27. In both years approximately 75 percent of the productive clutches were laid by May 31.

In 30 common egret nests checked in 1971 and 1972, the clutch size averaged 3.13 eggs. During 1972, study tree number 74 was climbed on April 21, May 2, and May 18 to check addition, loss, and hatching success of eggs. As the season progressed, clutch sizes increased. Therefore, the May 18 counts probably represent full clutches.

Four nests contained clutches of 2 eggs, 19 contained clutches of 3 eggs, 6 had 4 eggs, and 1 nest had 5 eggs. Comparative data are generally lacking, but Simmons (In Palmer, 1962), indicated an average of 2.94 eggs per clutch in a sample of 63 nests in Louisiana.

Black-crowned night heron: During the 1972 season, more detailed data were collected on black-crowned night herons nesting in the Himalaya berry community. Twenty-eight nests were located and marked on May 6. The number of

TABLE 2

Reproductive Performance of Great Blue Herons and
Common Egrets at Selected Rookeries in California and Western Oregon

Location and Year	No. Nesting Attempts (A)	No. Successful Nests (B)	Percent Nesting Success (A/B)	Clutch Size	No. Fledged (C)	No. Fledged Per Successful Nest (C/B)	No. Fledged Per Nesting Attempt (C/A)
Great Blue Heron							
Bolinas, CA 1/							
1967	61	34	56	3.66	75	2.21	1.23
1968	69	50	73	-	105	2.10	1.52
1969	55	48	87	-	110	2.29	2.00
1970	58	38	66	-	72	1.89	1.24
1971	56	30	54	-	68	2.00	1.07
1972	50	36	72	-	78	2.20	-
Indian Island, CA 2/							
1971	55	46	84	-	92	2.00	1.67
1972	81	70	86	4.00	140	2.00	1.73
San Joaquin, CA 3/							
1971	60	31	52	3.38	58	1.87	0.96
Lincoln, CA 4/							
1971	23	19	82	-	43	2.26	1.87
Western Oregon 5/							
1970	23	18	78	4.19	47	2.61	2.04
S. San Francisco Bay, CA 6/							
1971	49	42	86	3.63	105	2.50	2.14
Common Egret							
Bolinas, CA 1/							
1967	96	50	52	3.20	105	2.10	1.09
1968	109	41	38	-	74	1.81	0.67
1969	120	40	33	-	92	2.30	0.76
1970	154	43	28	-	82	1.91	0.53
1971	124	49	40	-	93	1.89	0.75
1972	114	63	55	-	144	2.00	1.35
Indian Island, CA 2/							
1971	184*	155	84	3.13	308	1.99	1.67
1972	256*	213	83	-	403	1.89	1.57
San Joaquin, CA 3/							
1970	50	30	60	3.20	78	2.60	1.56

1/ Pratt (1971)

2/ This Study

3/ Page (1970 and 1971)

4/ Wilburn (1970 and 1971)

5/ Henny et al. (1971)

6/ Gill (1972)

* - includes renest attempts

eggs found ranged from 1 to 4 and the mean clutch size in 23 nests was 2.87 eggs. Because egg and nest loss was commonplace, clutch size varied on each visit. Counts on May 18 indicated 1 nest containing 1 egg, 3 nests containing 2 eggs, 17 with 3 eggs, and 2 nests with 4 eggs.

Hatching Dates

Since great blue heron young were difficult to observe when small, hatched shells were collected as an index of hatching dates. Hatching of great blue heron eggs extended from April 21 to May 10 in 1971, and from April 14 to June 4 in 1972. Often variation in hatching dates occurs. Wilburn (1971) determined March 7 to April 18, 1970, and February 25 to May 27, 1971, to be the ranges of hatching dates at the Lincoln rookery, Placer County, while Page (1971) found hatching to occur in the San Joaquin River rookery, Merced County, from March 6 to June 6, 1970, and from March 12 to June 4, 1971. These variations are often due to weather conditions (Pratt, 1970).

Hatching dates of egret young were determined by back-dating from estimated age of nestlings when first observed. Young hatching early in the season were often observed one to three days after hatching, as there were few nesting birds and observation was easier. Common egret hatching extended from April 14 to July 21 in 1971, and from April 28 to July 4 in 1972.

Hatching Success

Great blue heron: No data were gathered on hatchability of great blue heron eggs because of the inaccessibility of the nests in high trees. Pratt (1970) observed 84 percent hatching success at Audubon Canyon Ranch rookery of 25 eggs in 7 nests. Gill (1972) at Bair Island, South San Francisco Bay, determined 70 percent hatching success, while Page (1971) found evidence of hatching failures at the San Joaquin rookery where only 28 percent of 152 eggs in 45 nests successfully hatched. At Indian Island, in 1971, great blue herons in 51 nests hatched 136 young for an average of 2.7 young hatched per nest. This compares to 2.4 young per nest (169 young) in 71 nests in 1972. Of these 51 nests in 1971 and 71 nests in 1972, 46 and 70 respectively were successful.

Common egret: Twenty-one common egret nests were checked in 1971 and 1972 to determine hatching success. Although these nests were checked only 4 times, some indication of hatchability could be determined. Of 68 eggs seen in the 21 nests, 51 of these hatched for a 75 percent success. Data are lacking on extent of egg loss, egg replacement, incidence of egg breakage, and hatching failure.

Results indicate that in 1971, 386 common egret young were hatched from 165 nests for an average of 2.34 young per nest. In 1972, 232 nests hatched 488 young for a 2.10 average per active nest. Of the 165 nests in 1971, 155 were successful. In 1972, 213 nests were successful in hatching 232 young (Table 2).

Fledging Success

Table 2 summarizes heron reproduction for selected rookeries in California and Oregon.

Of the 136 nesting attempts in 1971 and 1972 by great blue herons, 116 were successful, fledging 232 chicks for an average of 1.70 fledglings per attempted nest and 2.00 per successful nests. These results compare favorably with fledging success in other rookeries throughout California, and with the 1.91 young fledged per breeding pair which is estimated by Henny, et al. (1971) to be necessary to maintain population stability.

During the 1971 and 1972 nesting season, 368 common egret nests fledged 711 young for an average of 1.62 fledglings per nesting attempt or 1.94 young per successful nest. Egret young first began flying approximately June 29, 1971, and July 1, 1972.

Black-crowned night herons within the cypress rookery produced 88 successful nests fledging 139 young for an average of 1.57 young per successful nest.

In 1972, 82 breeding pairs of black-crowned night herons and 3 pairs of snowy egrets nested in the Himalaya berry willow thicket and successfully fledged 143 and 6 young respectively. This was the first authenticated successful nesting of snowy egrets in Humboldt County.

Factors Influencing Reproductive Success

Mortality factors affecting great blue heron and common egret nesting success at Indian Island shown in Figures 6 and 7 are discussed below.

Accidental Mortality

Great blue heron: The incidence of great blue heron egg loss due to poor nest construction was low in comparison to common egret egg loss. Conversely, nestling deaths were high, with accidents the major mortality factor. During the two nesting seasons, 31 nests lost 36 young, 12% of the young hatched. This accounted for 49% of the total mortality among great blue heron young.

Common egret: Accidental loss of both eggs and nestlings was commonplace with the common egret. Poor nest construction accounted for eggs slipping through or rolling out of the nest bowl. Nestling loss due to accidental death was the greatest single factor accounting for mortality among young.

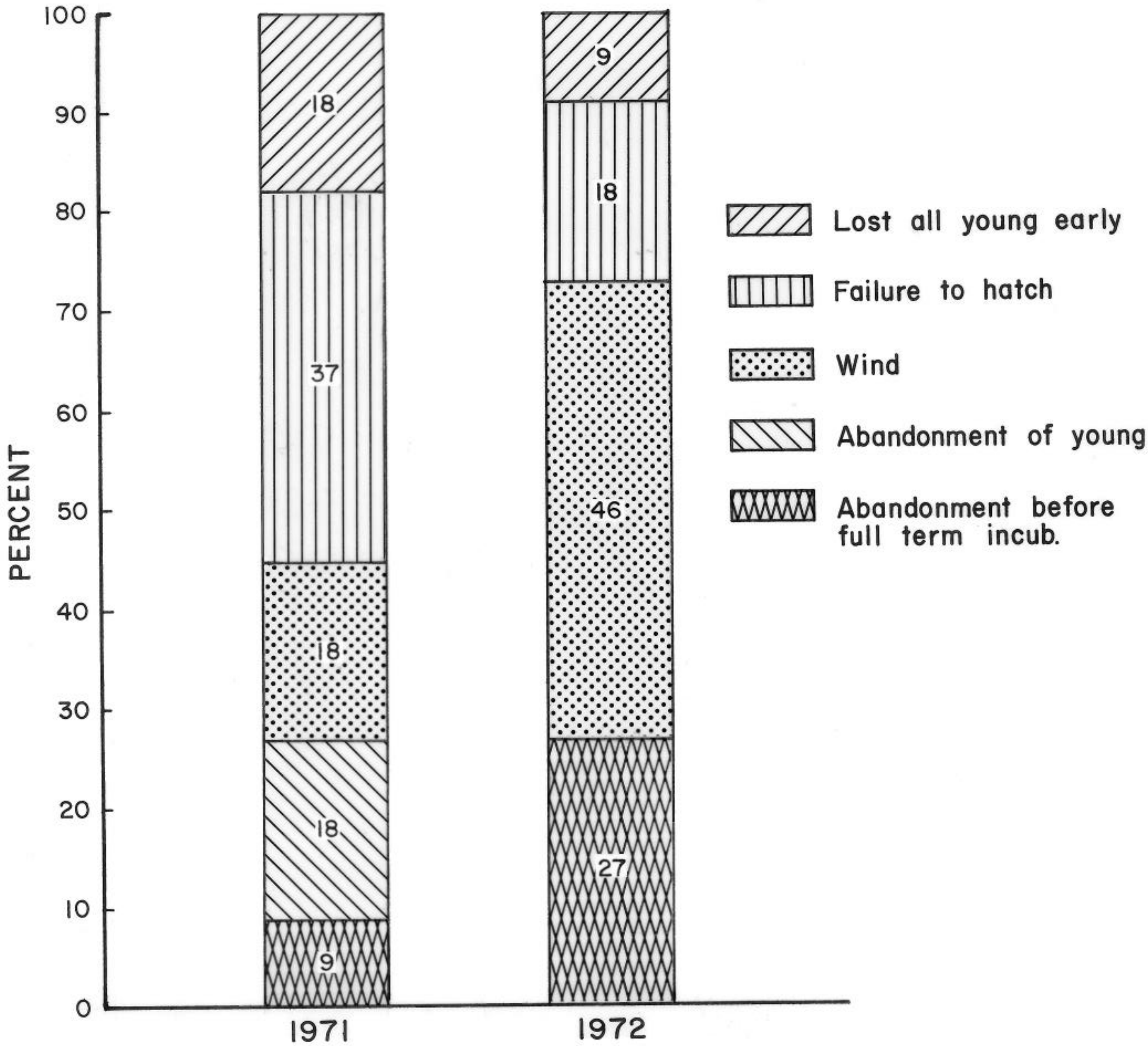

FIGURE 6. Great blue heron nest failures at Indian Island, Humboldt County, California. 1971-1972.

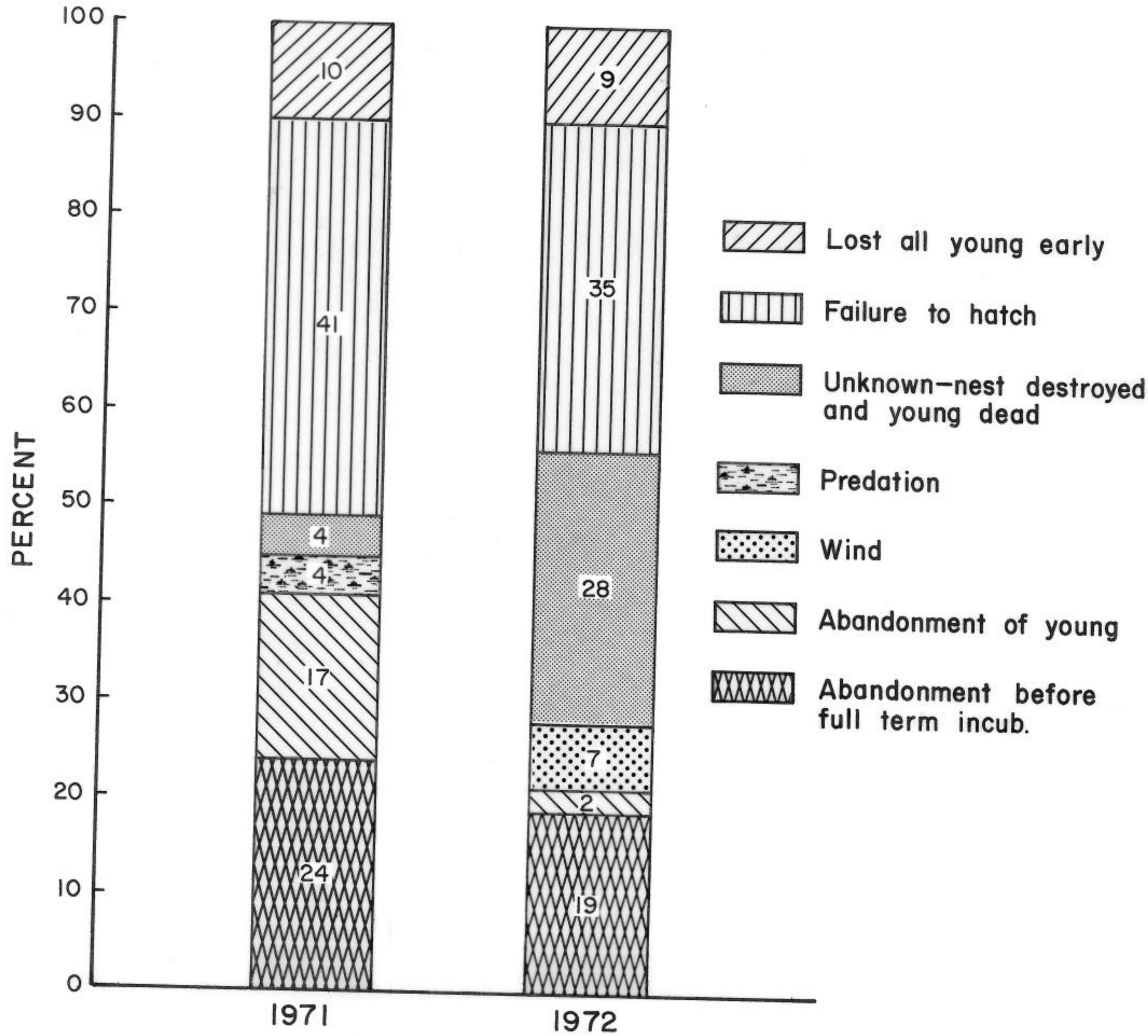

FIGURE 7. Common egret nest failures at Indian Island, Humboldt County, California. 1971-1972.

Deaths resulted from: (1) poor nest construction, (2) feeding interactions, and (3) prefledging activities of nestlings. During the 2 years, 73 common egret nestlings, 8.4% of the young hatched, died of accidental deaths, accounting for 48.5% of the total mortality.

Renesting

Great blue heron: Apparently, renesting occurred with great blue herons, but did not appear as persistent as the common egret. Specific data on great blue herons renesting are lacking as nesting activities were difficult to follow.

Common egret: Renesting among egrets was commonplace if loss of eggs or young occurred early in the season. During 1971, 1 pair losing young on June 26 attended the nest until July 19 before abandoning it. Eight other nests were attended from early May until early July before being abandoned. Of these 9 nests, where renesting occurred, 4 produced 8 young and 5 were unsuccessful, because of egg loss.

Although no adult birds were banded or color marked, it is unlikely that the first nesting efforts were attempted by one breeding pair and the second by another. In no instances were breeding displays or mate acceptance activities seen on any of the renesting sites after initial acquisition.

Nest Abandonment

Great blue heron nest abandonment was slightly less than that of the common egret. Of 136 nesting attempts, great blue herons at 6 nests were unsuccessful in hatching the eggs, while 2 nests with young were abandoned. One of these nests abandoned early in the year was attended by only 1 adult. This suggested an inability for the female to successfully raise young. Although 4 young were hatched, 2 died early probably of starvation, and the remaining 2 died after 4 weeks of age.

A significant percent of occupied egret nests were abandoned by adults, either leaving after an unsuccessful attempt to hatch eggs, or abandoning nestlings. Of 440 nesting attempts, common egrets at 27 nests were either unsuccessful at laying or hatching eggs. In 19 of those 27 nests, females attended the nest site from early May until late July without successfully hatching eggs.

Incidence of adult egrets abandoning young was considerably higher with those pairs nesting late. Of 6 abandoned nests, 5 hatched young after July 1. This suggested a diminished urge for the adults to brood and feed young.

Weather

Loss of eggs, nests and nestlings during both years of the study were attributed to adverse weather conditions. During March, April and May in 1971, over 20 days were recorded with winds exceeding 15 m.p.h. Two great blue heron nests accounting for 18% of nest losses were destroyed by wind. During 4 days in April 1972, winds exceeding 35 m.p.h. resulted in the destruction and abandonment of 5 great blue heron nests. This consisted of 46% of nesting losses in 1972 (Figure 6).

Numerous common egret eggs were lost from nests because of high winds. Renesting was commonplace making it difficult to determine the extent of losses to winds (Figure 7).

Human Disturbance

Bridge construction: In 1966, plans were formulated to construct a bridge across Humboldt Bay, Humboldt County, connecting the city of Eureka to the town of Samoa to the north. Preliminary plans indicated that of 6 possible routes, 4 would cross Indian Island. Public opposition to a Humboldt Bay bridge became centered about Indian Island and its future. In view that the bridge would permit access to the Island, there was alarm that industrial development would follow. Because the route selected was to pass within 400 feet of the rookery, additional public concern was expressed that the close proximity of the highway would create enough disturbance to cause abandonment of the rookery. Since the Division of Highways refused to consider an alternate route, requests were made by a Citizens' Committee to (1) realign the bridge to at least 800-1,000 feet from the rookery, (2) prohibit construction of the bridge during the April to July nesting season, and (3) restrict any access to the Island from the bridge. Eventually, the California Division of Highways agreed to the terms proposed by the Citizens' Committee, and bridge construction began February, 1969.

Considerable field time was spent observing heron and egret behavior during construction of the Samoa bridge. During February and March, great blue herons setting up and defending territories, showed no effect from distant, constant, or sudden noise. Birds flying over the construction site often changed flight direction and altitude. However, no disturbance to displaying or nesting birds was ever observed which could be directly related to construction activities. Because of restrictions placed on walking, bicycling, and stopping on any part of the bridge, the incidence of disturbance is now minimal.

Considering that bridge construction began in early 1969 and extended through 3 nesting seasons with an apparent increase in the number of nesting birds, it is improbable the bridge had or will have any adverse effect on the status of the rookery directly. However, because the bridge now provides easy access to Indian Island, development may take place which will cause the egrets and and herons to abandon the rookery.

Other disturbance: On 1 known occasion, 3 people crossed the bridge on foot, climbed over the fence, and camped in the cypress grove for 5 days. This disturbance occurred from March 18 to March 23, 1972, during the time of great blue heron egg laying and incubation, and the beginning of common egret nest acquisition and defense. Three great blue heron nests were abandoned as a direct result of this interference.

On numerous occasions, the Indian midden beneath the nesting grove was excavated during the nesting season. This appears to be the major form of human disturbance as it occurred periodically throughout the nesting season. Yull (1972) also indicated problems with people excavating and camping under the rookery during the nesting season.

Predation

Incidence and significance of predation appears light. Marsh hawks (*Circus cyaneus*), red-tailed hawks (*Buteo jamaicensis*), short-eared owls (*Asio flammeus*), common ravens (*Corvus corax*), and turkey vultures (*Cathartes aura*) were often seen, while sparrow hawks (*Falco sparverius*) were less common. During 1971, interspecific interaction between ravens and the nesting birds was common. Ravens may have attributed to egg predation earlier in the season as they were nesting within the grove itself. On one occasion, a red-tailed hawk was observed to stoop three times on the rookery, each time swooping into the trees but with no apparent success.

Pesticide Contamination

Residue analysis: Pesticide residue data for great blue heron and common egret tissues collected at the Indian Island rookery and fish tissues collected from Humboldt Bay are summarized in Table 3. Levels of DDT and metabolites

TABLE 3

Pesticide Residues in Common Egrets, Great Blue Herons, and Fish Tissues Collected at Indian Island, Humboldt County, California

Year	Sample Description	No. in Sample	Sample Weight (Gm.)	Residues Expressed as ug/gm Sample (ppm) pp'DDE	op'DDT	op'DDE	pp'DDD	pp'DDT	Dieldrin	Total DDT and Metabolites	PCB
1971	Common Egret Whole Eggs Cracked	1	32.0	0.71	-	-	0.11	0.07	-	0.89	-
	Embryo (near term)	1	-	0.48	-	-	0.14	0.07	-	0.69	-
	Dessicated	1	27.6	0.33	-	-	0.10	0.04	-	0.47	-
	Addled	1	37.75	0.90	-	-	0.20	0.11	-	1.21	-
	Cracked	1	30.92	0.80	-	-	0.11	0.09	-	1.00	-
	Nestling Whole Body**	1	18.80	0.16	0.01	-	0.24	0.01	-	0.42	-
	Flesh	1	-	0.34	0.01	-	0.20	0.01	-	0.56	-
	Adult Flesh	1	-	2.01	-	-	1.56	0.03	-	3.60	+
	Great Blue Heron Whole Eggs Fresh	1	64.6	2.24	-	-	0.25	0.20	-	2.69	+
	Nestling Whole Bird	1	104.9	0.11	0.01	-	0.10	tr	-	0.22	-
	Whole Bird	1	92.3	0.21	0.02	-	0.22	0.01	-	0.46	-
1972	Common Egret Eggs *Embryo (near term)	1	50.4	5.50	-	0.43	-	-	-	5.93	+
	*Embryo (near term)	1	50.5	5.46	-	0.53	-	-	-	5.99	+
	Embryo (near term-broken egg)	1	23.75	0.59	-	-	-	-	-	0.59	4.50
	Whole Egg	1	52.01	7.49	-	-	-	1.01	-	8.50	3.79
	*Addled Egg	1	42.9	1.11	-	-	0.21	0.08	-	1.40	4.06
	*Addled Egg	1	43.8	0.51	-	-	0.07	0.01	-	0.59	2.17
	Nestlings Whole Bird	1	22.51	0.43	-	-	-	-	-	0.43	4.60
	Whole Bird	1	54.83	7.48	-	-	-	-	0.75	8.23	+
	Whole Bird	1	204.4	0.07	-	-	-	-	+	0.77	0.71
	Whole Bird	1	168.7	0.12	-	-	-	-	+	0.12	1.03
	Subadult Flesh	1	-	0.04	-	-	-	-	0.07	0.11	+
1972	Great Blue Heron Whole Egg	1	74.94	1.65	-	-	-	-	-	1.65	11.31
	Whole Egg	1	78.04	3.53	-	-	-	-	-	3.53	11.71
	Whole Egg	1	82.05	1.19	-	-	-	-	-	1.19	5.99
	Whole Egg	1	67.33	1.48	-	-	-	-	-	1.48	4.02
	Whole Egg	1	73.41	1.92	-	-	-	-	-	1.92	6.88
1972	Fish Samples from North Humboldt Bay Anchovies (whole fish)	12	-	0.01	-	-	-	-	+	0.01	+
	Shiner Perch (whole fish)	17	-	0.03	-	-	-	-	0.01	0.04	+

-= Not Detected or not quantitated
+= Detected but not quantitated
*= Same nest
**= Whole body - whole carcass minus feet, wings & bill

in 6 great blue heron eggs collected in 1971 and 1972 indicated a range of 1.19 to 3.53 ppm of p,p'DDE, while two nestlings collected and analyzed had levels of contamination of 0.11 and 0.21 ppm of p,p'DDE.

Table 4 summarizes pesticide residues from selected locations in western North America. There are no comparable data for residues in eggs from elsewhere in California; however, great blue heron nestlings collected by Faber, et al. (1972) at Bolinas, California showed low levels of p,p'DDE (0.16 to 1.18 ppm). Great blue heron nestlings sampled at Lincoln, Placer County and at the San Joaquin rookery, Merced County, exhibited varying levels of DDE in brain tissues, fat, breast muscle and livers.

Common egret eggs collected at Indian Island in 1971 and 1972 had levels of p,p'DDE ranging from 0.33 to 7.49 ppm, on a wet weight basis. Total p,p'DDT and metabolites present in these samples ranged from 0.47 to 8.50 ppm. Samples collected during 1972 showed substantially higher concentrations of p,p'DDE than in 1971 samples. The reasons for this increase are not known. Two egret eggs collected from the same nest exhibited nearly identical levels of 5.50 and 5.46 ppm of p,p'DDE. Four of 5 nestlings analyzed for both years exhibited significantly lower levels of p,p'DDE (0.07 to 0.43 ppm) than residues found in whole eggs; however, a fifth chick had levels of 7.48 ppm p,p'DDE. The estimated age of this chick was 1 to 2 days, suggesting that it was not yet feeding from a local food source and still absorbing nourishment from the yolk. The 4 chicks having a low residue level were all older than 2 weeks of age and were receiving food from a local supply. Six nestlings, collected from Bolinas, had low levels of DDE (0.55 to 4.00 ppm). The nestling showing the highest DDE residues (4.00 ppm) was also the youngest (5 to 6 days old).

TABLE 4

Range of DDE Residues in ppm Wet Weight in Samples of Great Blue Heron and Common Egret Eggs, Nestlings and Adults

Species & Sample	Location	Sample Size	Residue Range of DDE	Mean (ppm)
GREAT BLUE HERON				
Eggs	Indian Island, CA	6	1.19-3.53	2.00
	Belly River, Alberta 2/	10	1.50-24.0	9.95
	Battle River, Alberta 2/	10	1.4-13.5	5.71
	Jamieson Lake, Alberta 2/	10	1.0-31.8	6.61
	Chip Lake, Alberta 2/	10	0.7-234.4	37.01
	Albany, OR 3/	2	3.3-4.5	3.90
Nestlings Whole bird	Indian Island, CA	2	0.11-0.21	0.16
	Bolinas, CA 1/	3	0.16-1.18	0.61
	San Joaquin, CA 4/	2	5.22-17.74	11.48
	Albany, OR 3/	1	-	10.10
Brain	Lincoln, CA 5/	1	-	1.09
	San Joaquin, CA 4/	4	0.12-0.39	0.27
Fat	San Joaquin, CA 4/	2	14.38-34.73	24.56
Breast muscle	San Joaquin, CA 4/	2	0.22-0.43	0.33
Adult Brain	Lincoln, CA 5/	1	-	1.82
Fat	" "	1	-	338.74
Breast	" "	1		11.67
Liver	" "	1		5.76

TABLE 4 (Cont'd)

Range of DDE Residues in ppm Wet Weight in Samples of Great Blue Heron and Common Egret Eggs, Nestlings and Adults

Species & Sample	Location	Sample Size	Residue Range of DDE	Mean (ppm)
COMMON EGRET				
Eggs	Indian Island, CA	11	0.33-7.49	2.17
Nestlings				
Whole bird	Indian Island, CA	5	0.07-7.48	1.65
Breast	Indian Island, CA	1	-	0.34
Whole bird	Bolinas, CA 1/	6	0.55-4.00	2.01
Subadult				
Breast muscle	Indian Island, CA	1	-	0.04
Adult				
Breast	Indian Island, CA	1	-	2.01
	Bolinas, CA 1/	5	1.1-193	93.9
Brain	Bolinas, CA 1/	5	1.0-93.4	59.7
Liver	Bolinas, CA 1/	5	28.4-239	124.3

1/ Faber, et al. (1972)

2/ Vermeer, et al. (1970)

3/ Henny, et al. (1971)

4/ Page, (1971)

5/ Wilburn, (1971)

Similarly, Henny, et al. (1971) found a day-old great blue heron chick (whole body) with 10.1 ppm p,p' DDE from a rookery in Albany, Oregon.

Faber, et al. (1972) hypothesized that adult egrets at the Audubon Canyon Ranch probably acquired heavy contamination of p,p' DDT from wintering areas as analyses of shiner perch (Cymatogaster aggregata) and walleye surf-perch (Hyperprosopon argentium) collected from Bolinas Lagoon, showed very low levels of contamination (0.012 and 0.025 ppm p,p' DDE respectively). Similarly, samples of shiner perch and anchovies (Engraulis mordax) collected during this study from Humboldt Bay, displayed equally low residues (0.03 and 0.01 ppm of p,p' DDE respectively), suggesting that adult egrets obtained contamination elsewhere.

Eggshell Thickness

Broken and hatched great blue heron and egret eggshells collected from Indian Island were measured using a Starrett micrometer, accurate to 0.01 mm. Eight broken and 52 hatched great blue heron eggshells measured had mean thicknesses of 0.327 mm. and 0.377 mm. respectively (Table 5). When these values were compared with the average shell thickness of 0.392 mm. for eggs collected in Northern California prior to 1947, measurements of broken shells indicated a 15.9 percent decrease in thickness from the pre-1947 standards.

Since commen egrets were prone to have higher egg loss at Indian Island than great blue herons, the sample size of broken eggs was larger than the sample size for the great blue herons. Seventy broken, and 81 hatched shells were measured and found to have a mean thickness of 0.249 mm. and 0.289 mm. respectively. Anderson (in Faber, et al. 1972) determined a pre-1947 mean shell thickness of 0.295 mm. Using this as a control for comparative purposes, results indicated a 15.6 percent decrease in shell thickness among broken common egret shells collected in this study, and 2.0 percent thinning among hatched shells (Table 5).

TABLE 5

Egg Shell Thickness Data of Great Blue Herons and Common Egrets from California Rookeries

Category & Location	Sample Size	Egg Shell thickness	% Decrease
Great Blue Heron			
pre-1947 1/	201	0.392 mm	-
Hatched Shells			
Bolinas 2/	42	0.365 mm	-6.9%
Indian Island	52	0.377 mm	-3.8%
Lincoln Rookery 3/	122	0.352 mm	-10.2%
San Joaquin Rookery 4/	23	0.345 mm	-12.0%
Broken Shells			
Bolinas 2/	17	0.328 mm	-16.3%
Indian Island	8	0.327 mm	-16.6%
Lincoln Rookery 3/	8	0.259 mm	-33.9%
San Joaquin Rookery 4/	18	0.343 mm	-12.5%
Common Egret			
pre-1947 1/	235	0.295 mm	-
Hatched Shells			
Bolinas 2/	13	0.272 mm	-7.8%
Indian Island	81	0.289 mm	-2.0%
Broken Shells			
Bolinas 2/	51	0.244 mm	-17.3%
Indian Island	70	0.249 mm	-15.6%

1/ Anderson, D.A., & Hickey, (1970) plus samples from California State University at Humboldt collection. All samples were from northern California.

2/ Faber et al. (1972)

3/ Wilburn (1971)

4/ Page (1971)

It is well realized that many of the egret eggs found broken were of "normal" thickness and would probably have hatched but fell from nests. According to Ratcliffe (1970) eggshell breakage in some avian species occurs when shell thickness decreases 15% or more. The thinnest hatched shell found (0.250 mm.) was 15.2% thinner than the control (0.295 mm.), suggesting that this is near the minimum allowable thickness for hatched eggs before breakage occurs in egrets. Although no hatched shells were found thinner than 0.250 mm., 48.5% of the broken shells measured, or 22.7 percent of all shells measured, had values less than 0.250 mm.

It is unknown what percent of the egret nests at Indian Island suffered egg loss, but Faber, et al. (1972), determined that 30 to 54% of the egret nesting attempts at Audubon Canyon Ranch from 1967 to 1970 lost eggs during incubation. It appears then that eggshell thinning and subsequent breakage is a definite cause of reproductive failure among common egrets; however, renesting by common egrets has resulted in maintaining a mean fledging success of 1.5 to 1.7 young per successful nest.

Other Factors

A significant portion of nestling mortality in both the common egrets and great blue herons occurred on the nest, suggesting: (1) death from starvation, (2) disease or parasites, or (3) competition among siblings. Starvation often occurred on heron and egret nests containing more than 2 young. Distinct size dimorphism placed younger, weaker birds at a disadvantage during feeding as they could not compete successfully with older siblings.

Observations indicate that competition for food among siblings resulted in subordinate nestlings becoming weakened and often physically driven off nest sites by the larger nestlings. Subsequently, this "peck order" situation lead to starvation or accidents to the weaker individuals.

DISCUSSION

The reproductive trend of the great blue heron breeding population on Indian Island has remained stable over the two-year study. During 1971 and 1972, great blue herons fledged 2.0 young per successful nest. This is lower than fledging success in San Francisco Bay (2.50 per successful nest) where great blue herons nested in coyote bush and had low nestling mortality, and is comparable with results from Bolinas. According to Henny (in press), 1.91 young must be fledged per breeding pair in the northern United States (43.4°N latitude) to maintain a stable population. In comparison, the number fledged per breeding pair at Bolinas has varied from 1.3 to 2.0 from 1967 to 1972 with 1969 being the only year during which the 1.9 level was attained (Pratt, 1972 and unpublished). At the San Joaquin River rookery, only 31 nests (52%) successfully fledged young of the 60 nests studied (Page, 1971). There was also an abnormally low hatching success (28%) of the eggs studied. The number of young fledged per breeding pair was not specifically determined by Page, but it was estimated to be below 1.0 young per pair. In the Indian Island study, the number of young fledged per breeding pair was estimated at 1.75 to 1.80. These low levels of production below the "stability level" of 1.91 have been attributed to egg breakage on the nests (Pratt, 1972), wind (Page, 1971 and this study) and/or disturbance by man (Page, 1971 and this study).

Common egret fledging success throughout California has been variable. At the Indian Island rookery, 1.99 young fledged per successful nest in 1971, and 1.89 in 1972. At Bolinas, Marin County, productivity has fluctuated between 1.81 and 2.3 young per successful nest and 1.0 to 1.5 per breeding pair.

Kahl, (1963) determined from band returns that 2.92 young egrets must be fledged from each nest in order to maintain population stability. Considering that the mean clutch size of common egrets is only 3.1 to 3.2 eggs per nest, it seems unlikely that 2.92 young can possibly be fledged per nest. Pratt (1972) suggests that only 1.0 to 1.1 young may be necessary to maintain population stability as her studies have shown the breeding population to remain stable over a six-year period.

The question of what effect chlorinated hydrocarbons have on common egret productivity still remains unanswered as not enough data have been collected to determine an eggshall thickness index and correlation with pesticides residues. However, evidence collected during this study and by Faber, et al. (1972) indicate significant decreases in eggshell thickness and occurrence of DDT and metabolites in eggs, young and adults, but there is a need for a more thorough evaluation of the role of egg breakage as a percent of total egg losses and the possible compensation by renesting.

ACKNOWLEDGMENTS

I thank Bob Mallette and Howard Leach, of the California Department of Fish and Game, for their time and effort given in all facets of this study and report production, and to Doctors Dan Anderson, Stanley Harris and James Koplin for their aid in reviewing this project. I am also very grateful to William High for his help collecting data and providing information on nesting black-crowned night herons. I extend thanks to the California Department of Fish and Game for all pesticides analyses done, and to the Eureka City Council for allowing for access to the study area.

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APPENDIX I

Nesting Success of Common Egrets in Study Tree Number 74, Indian Island Rookery, Humboldt County, California - 1972

Observation Dates

Nest no.	April 21		May 2		May 18		June 1		June 19		July 1		July 18		No. Fledged
	eggs	young	eggs	young	eggs	young	eggs	young	eggs	young	eggs	young	eggs	young	
1	3		2	1	1	2		2		2		2	fledged		2
2	3		3		3			3		3		3		3	3
3	2		2		1	1		2		2		2	fledged		2
4	1		3		3		3			3		3		3	3
5	4		4			4		4		3		3		3	3
6	1		3		3		3			3		3		3	2
7	3		3		1	2		3		3		3		2	2
8	2		3		3		1	2		2		2		2	2
9	empty		1		3		2			1		2		2	2
0	2		4		3		-Destroyed-			-		-		-	0
11	empty		3		3		3			2		2		2	2
12	empty		3		3		3			3		3		3	2
13	empty		2		3		3			2		2		1	1
14	empty		3		3		2			2		2		2	2
15	empty		empty		2		2			1		0		0	0

Means:	Clutch size	Hatched/nest	fledged/nest
	3.00	2.27	1.87

APPENDIX II

Common Egret Egg Measurements, Indian Island,
Humboldt County, California
1971-1972

Tree	Nest	Egg	Weight (grams)	Length (mm)	Breadth (mm)
74	1	1	-	53.0	39.0
		2	-	54.2	40.3
74	2	1	-	59.0	38.3
		2	-	58.0	39.1
		3	-	53.0	40.2
74	3	1	-	55.7	42.5
74	7	1	-	58.3	41.0
		2	-	58.0	38.9
56	2	1	50.44 gr.	60.0	41.2
		2	50.50 gr.	62.0	42.0
		-	46.40 gr.	59.5	37.5
		-	-	55.0	39.0
		-	-	58.2	36.0
		-	-	60.0	43.5
		-	-	62.3	42.1
		-	-	59.4	39.5
		-	-	58.5	40.0
		-	-	55.6	41.0
		-	-	57.0	41.5
		-	-	59.0	41.0
		-	52.01 gr.	58.5	41.5
		-	-	57.0	42.0
57	5*	1	43.93 gr.	57.5	40.5
		2	43.02 gr.	57.7	41.0
Total number eggs			6	24	24
Means			47.72 gr.	57.8 ± 2.30	40.4 ± 1.69

* Unsuccessful hatching attempt.