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REPRODUCTIVE STATUS OF THE CALIFORNIA BROWN PELICAN IN 1970, WITH NOTES ON BREEDING BIOLOGY AND NATURAL HISTORY

by

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ABSTRACT

Recent evidence of reproductive failures of the brown pelican in California prompted a study of the Anacapa Island population in 1970. From February to August reproductive success and breeding biology were studied. There were 552 nesting attempts in two colonies established on Anacapa in 1970, with but one young produced. Reproductive failure was attributed to thin eggshells which collapsed during incubation. Aberrant behavior associated with reproduction was also observed. In a survey of all traditional breeding sites in California, no other nesting was reported. Thus, in the State of California, only one young pelican was hatched in 1970. Double-crested cormorants nesting on Anacapa suffered the same fate as the pelicans. In at least 50 nesting attempts, only one nest producing three young cormorants was successful.

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INTRODUCTION

The continued existence of the brown pelican (Pelecanus occidentalis californicus) in California is in peril. Though still commonly seen in bays and lagoons along the Pacific Coast from June through January, there has been a great decline of successful breeding in recent years (Schreiber and DeLong, 1969). Because pelicans are long-lived and range extensively after the breeding season, a decrease in their numbers has not been apparent. Thus documentation of reproductive failures did not occur until several years after the symptoms probably first existed.

Since the mid-1950's brown pelicans have virtually disappeared as breeding birds along the Atlantic and Gulf of Mexico coastlines, with the exception of Peninsular Florida (A.O.U., 1968; Williams and Martin, 1969). There has been no successful breeding even in Louisiana, where the brown pelican is the state bird and has been incorporated into the state seal, since 1961 (Williams and Martin, 1968). Pelicans were once so numerous along the Gulf coast that during World War I they were considered a pest and a threat to the commercial fisheries. In the words of Oberholser (1938), "...it being no exaggeration to claim that from 75,000 to 85,000 adults nest along the coast every year." Now the brown pelican is rarely seen in many of these areas.

There was evidence that declining populations of many species of raptorial and fish-eating birds both in Europe (Ratcliffe, 1967) and North America (Hickey and Anderson, 1968) were associated with reproductive failures caused by thin-shelled eggs. Reduced shell thickness in afflicted populations was attributed to chlorinated hydrocarbon pesticides, particularly DDT and its metabolic derivatives, in the environment. Significant inverse correlations had also been found between the p,p'-DDE content in eggs and the thickness of the shell in herring gulls (Larus argentatus) (Hickey and Anderson, 1968), white pelicans (Pelecanus erythrorhynchos), and double-crested cormorants (Phalacrocorax auritus) breeding in the mid-West (Anderson, et al., 1969); in other words, eggs with the highest levels of DDE had the thinnest shells. In each of the latter species a minimum effective level of the concentrations of these residues in relation to shell thinning was not apparent. The absence of a no-effect range indicated that even very low concentrations of DDE were related to shell-thinning (Anderson, et al., 1969).

The decline of pelican populations from the northern Gulf of Mexico coast, the discovery that thin eggshells had been produced by pelicans from the Gulf during the 1950's (Anderson and Hickey, 1970), and the findings of exceptionally high levels of p,p'-DDE (the principal metabolite of DDT and perhaps the most abundant synthetic pollutant) in many fish and marine bird species of the Southern California coastal waters (Risebrough et al., 1967; Risebrough, 1969) led to concern that the reproduction of brown pelicans in California might also be impaired.

In 1968 the Smithsonian Pacific Ocean Biological Survey Program failed to find active pelican nests in their survey of traditional pelican breeding areas in the Channel Islands, off the coast of Southern California, and Islas Los Coronados, near the Mexico-U.S. border (Schreiber and DeLong, 1969). This prompted a group of biologists from various universities to undertake studies of the brown pelican in California and Florida (results of these studies will be published in the near future). As a result, in 1969, it was found that the pelicans had suffered

disastrous reproductive failures on Anacapa Island, the only important brown pelican breeding area in California in recent years (Risebrough et al., 1970). Crushed, discarded eggshells were found scattered throughout the colony. The shells were abnormally thin and had apparently collapsed under the weight of the incubating adults. Only a few still intact eggs were present in nests; most of these eventually broke. Nearly total reproductive failure had occurred (Risebrough, et al., 1970).

In one of the studies resulting from the discovery of these reproductive failures, Keith, et al., (1970), found that lipids in the tissue of six adult pelicans collected on Anacapa Island in 1969 contained residues of DDE ranging from 738 to 2603 ppm. They also reported that most pelicans nesting in the colonies of the Gulf of California laid eggs of near normal thickness that contained relatively low amounts of DDE. Studies relating chlorinated hydrocarbon residues to shell-thinning and resultant reproductive failures in the 1969 Anacapa colony will soon be published.

The reproductive failures of the brown pelican in California and the graphic evidence of the consequences of man's pollution have by now become well-publicized. The ecological causes and significance have yet to be fully researched. It is becoming increasingly more important to obtain basic data concerning ecology and breeding biology of marine organisms if we are to understand how man-made pollutants are affecting marine ecosystems.

OBJECTIVES AND SCOPE

The objectives of the present study were to determine the current status of the brown pelican as a breeding bird in California (including an historical account), to determine reproductive success on Anacapa Island, and to make behavioral and ecological observations which might lead to a further understanding of the pelican reproductive failures.

This study was initiated on February 15, 1970 by the California Department of Fish and Game, Special Wildlife Investigations, through a contract with the author. By interagency agreement between the Department of Fish and Game, Bureau of Sport Fisheries and Wildlife, and National Park Service, only one researcher was to conduct the study and be allowed access to the Anacapa Island pelican colony. Other workers or individuals wishing to observe, photograph, or study the Anacapa pelicans could do so only in conjunction with the researcher's study and at his discretion. In this way it was hoped that disturbance would be kept to a minimum.

SYSTEMATICS

The California brown pelican was first described as a separate species Pelecanus californicus by Ridgway (Baird, Brewer, and Ridgway, 1884). Prior to this it was known both as P. occidentalis Linnaeus and P. fuscous Gmelin. Ridgway actually listed it as Pelecanus (fuscous?) californicus, but the common usage in the early literature was P. californicus. Despite an attempt by Oberholser (1918) to consider the California brown pelican as a subspecies of occidentalis, P. californicus was used widely throughout the literature

until 1931 (although Bent, in 1922, used P. o. californicus). Peters (1931) and the Fourth Edition of the A.O.U. checklist (1931) listed all brown pelicans as a single species with the California subspecies as P. o. californicus.

The population on the Galapagos Islands and Ecuador was at one time attributed to californicus, but Murphy (1936) and Wetmore (1945) both considered this population a distinct subspecies. P. o. californicus Ridgway is presently attributed only to the populations along the Pacific Coast of the United States and Mexico (A.O.U., 1957).

DISTRIBUTION

The current breeding range of P. o. californicus extends from the Channel Islands (principally Anacapa Island), occasionally north to Bird Island off Point Lobos, Monterey County, California, and south, including the several islands along the coast of Baja California and in the Gulf of California, to Isabel Island and the Tres Marias Islands off Nayarit, Mexico (A.O.U., 1957).

Brown pelicans wander extensively along the coast between nesting seasons with the movement north occurring primarily in June and July. The pelican's "wintering" range extends as far north as southern British Columbia (Vancouver Island) and south along the west coast of Mexico to Colima. An occasional straggler has been reported on Guadaloupe Island off the coast of Baja California, and inland in British Columbia, California, Utah, Nevada, and Arizona (A.O.U., 1957; Palmer, 1962).

HISTORIC BREEDING RECORDS

Breeding pelicans in California were first reported on Anacapa Island in 1898 (Holder, 1899). They were then nesting on all three islands in the Anacapa group. Willett (1910) was the first to give any data or detailed information on this colony. He found 500 nests on the east island in 1910. The records are obscure, but breeding on the east island has probably not occurred since the late 1920's (Bond, 1942). It was about this time that the lighthouse presently standing on the east island was constructed.

Numbers of pelicans breeding on Anacapa have fluctuated greatly from year to year. From the records available, the numbers ranged from 200 to 2,000 or more pairs, with no nesting occurring at all in some years (Bond, 1942; Anderson and Hickey, 1970). As an example of these year-to-year fluctuations, 500 nests were reported in 1910 (Willett, 1910), while there apparently was no nesting in 1911 (Willett, 1912; 1933) or in 1912 (Wright and Snyder, 1913). Peyton (1917) estimated 1,500 pairs nesting on the island in 1916 and 2,000 pairs in 1917. In 1930 Ashworth and Thompson (1930) noted about 200 nests containing eggs and young.

The number of breeding pelicans on Anacapa probably increased during the 1920's (Bond, 1942). It was during this time that Williams (1927) first reported nesting as far north as Monterey County, thus indicating a possible period of population increase.

Breeding records for Anacapa in subsequent years are scant and give little indication of population trends. In 1936 Stevens, on an egg-collection data slip, estimated over 2,000 pairs (Anderson and Hickey, 1970), while Bond (1942) reported at least 2,000 pairs nesting in 1939. In 1940 Bond (1942) reported to have banded 450 young pelicans. Thereafter, there are no published records until the early 1960's when Banks (1966) reported that, in 1963 and 1964, there was probably little change in the size of the population on Anacapa since the earliest reports. This indicates that reproduction was apparently normal, at least until 1964.

Santa Barbara Island could be considered as the second most important pelican breeding area in California. Data on numbers of birds breeding there is generally lacking. Willett (1912) reported about 25 pairs in 1911. In July 1912, 300-400 birds were breeding there. This was one of the years in which no nesting occurred on Anacapa (Wright and Snyder, 1913). There are no published breeding records from Santa Barbara Island since. Schreiber and DeLong (1969) report that National Park Service personnel took pictures of birds nesting there in 1967, but there is no indication of the extent of breeding. The Smithsonian Pacific Bird Project found no evidence of nesting on Santa Barbara Island in 1968 (Schreiber and DeLong, 1969).

Nesting on Santa Cruz Island and Prince Island (an outlying islet of San Miguel Island) was reported in 1909 and 1910 (Willett, 1910, 1912; Howell, 1917). Nesting on these islands has been irregular and confined to a few nests only. No nesting has been reported there in recent years.

The pelican breeding range has extended as far north as the Monterey Bay area where nesting has occurred irregularly. Williams (1927) first reported nesting pelicans on Bird Island, a small island off Point Lobos, in 1927. For two years he suspected that nesting was occurring there, but he was unable to find transportation to the island until 1927. There was no nesting in 1928, but in 1929 he reported 55 active nests with 78 young (Williams, 1931). Thereafter, apparently, throughout the 1930's (no data available from 1938 to 1948), nesting occurred infrequently. The last successful nesting attempt was in 1959 (Baldridge, pers. comm.).

STUDY AREA AND METHODS

Study Area

The field work for this study took place on West Anacapa Island. The Anacapa Island complex, which is part of the Channel Island National Monument, is made up of three islands stretched out for five miles in an east-west direction. The west island is the largest of the group; it is approximately one mile long and three-fourths mile wide at its widest point. The island lies about 15 miles southwest of the city of Ventura (Figure 1).

The west island is considerably higher in elevation than the east or middle island. Its highest point, "Anacapa Peak," is 980 feet above sea-level and is skewed toward the south side of the island. The summit drops off abruptly to the shoreline on the south side and more gradually to a series of bluffs on the island's north side. The west face of Anacapa Peak forms three broad

flat plateaus, one above the other in stair-step fashion. The lower plateau narrows to a point on the west end of the island ("West Point") where one can descend a rocky incline to the water's edge. The second highest point (which I refer to as "East Peak") is east of Anacapa Peak and is about 700-750 feet above sea level. From the high bluff north of East Peak to the lower, flatter bluffs northwest of Anacapa Peak, is a series of seven bluffs with steep canyons intersecting them in a north-south direction. I have numbered these bluffs from 1-7 (from east to west) for field identification in order to more accurately identify landmarks and nesting localities on the island. It is on the slopes of these bluffs that pelicans generally nest (Figure 2).

Except for the climb from West Point, which can only be approached when the sea is calm, the only other access to the upper part of the island is the difficult ascent along the razorback ridge from Frenchey's Cove on the east end of the island to the summit of East Peak, or up a steep gully on the north side immediately east of East Peak.

Methods

Because of the difficulty of getting to the upper part of the island with equipment and enough provisions and water for several days, it was necessary to use a helicopter for transportation. Such access was provided by Rotor Aids, Inc., a helicopter service based at Ventura Marina. Landing points and approaches were selected away from the nesting site to avoid disturbance.

Since the colony could not be viewed in its entirety from the island, it was necessary to do some of the reconnaissance and census work from a boat. The California Department of Fish and Game patrol boat, Yellowtail, berthed in Port Hueneme, was made available on a number of occasions by Lt. Henry Hoover for this purpose.

It was my original intention to spend at least four or five days on the island every other week. A set schedule, however, became impossible to maintain due to the delay and cancellation of several trips caused by logistic and weather problems.

The field work took place on West Anacapa Island on the following dates:

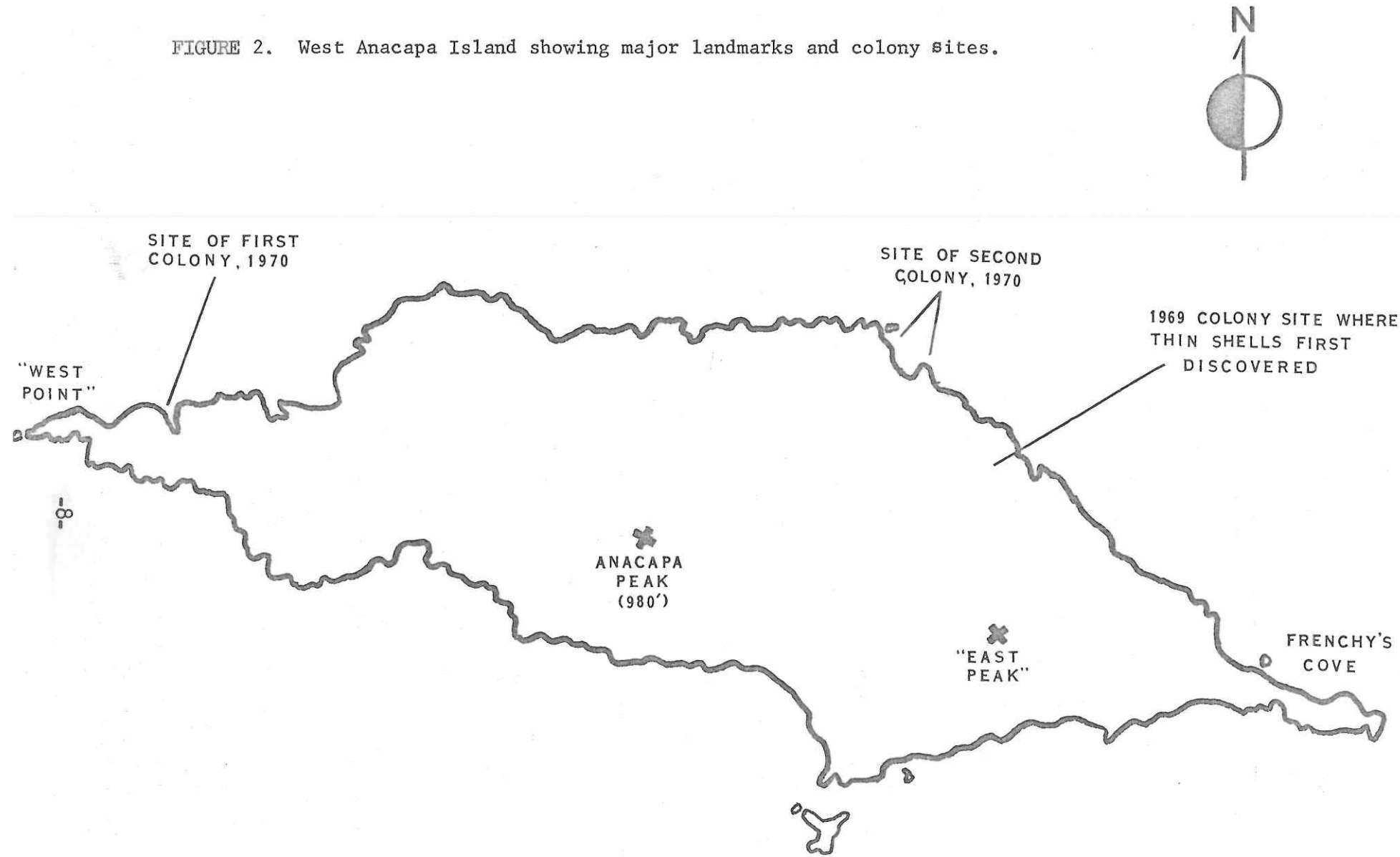
February 21-24	April 20-23	June 1-5
March 7-10	April 27-29	June 20-24
March 29-April 1	May 10-13	July 29
		August 13

Three trips, March 14-19, April 13-15, and May 20-24, were cancelled, the first two because of adverse weather conditions, the last due to lack of transportation to the island.

Because of the inaccessibility of the breeding sites, the seemingly aberrant and erratic behavior of the pelicans, and the lack of breeding success, detailed data concerning breeding ecology was not possible. I was able, however, to census the colony with some degree of accuracy, including number of nests and breeding pairs, and proportion of young to adult birds. Behavioral observations, in which the movements of birds from 15 nests were recorded, were made several times each day in sessions of approximately two hours. Each of these nests was given a number

FIGURE 1. Anacapa Island in relation to the southern California coastline and other northern Channel Islands.

FIGURE 2. West Anacapa Island showing major landmarks and colony sites.



and followed until deserted. When many of the original nests were deserted, it was necessary to assign numbers to replacement nests. By watching these nests closely it was possible to follow and recognize individual birds, to determine their sexes, and to describe and analyze each step of their behavioral sequences. Most of the observations were made through binoculars and a spotting scope at a distance of 200 to 300 feet. Observations were recorded on tape. To aid in census work and to analyze breeding postures and behavioral sequences, 35 mm slides and 16 mm films taken with a 400 mm lens were used.

One of the problems encountered in the course of this study was observing the nesting pelicans without disturbing them. It was discovered early that these birds were very prone to leave their nests and not return. Much care was taken to avoid disturbances that would cause the pelicans to leave their nests and thus expose the eggs to gull predation. Observations were originally planned from blinds, but the eventual location of the nesting site would have made this impossible; also, a blind would not have withstood the frequent gale winds.

Weather Conditions

During the first visit to Anacapa in February, the weather was pleasant and mild with temperatures in the 60's and 70's, clear skies, and slight breezes. During the months of March and April, high winds, reaching gale force of up to 40 to 45 knots, were not uncommon. Several trips were delayed or cancelled because of the wind and storm conditions. The temperatures were generally cool during these months.

The only rain that occurred in the course of the study was during the first part of February and the third week of March. The island was verdant during the winter months. Vegetation began drying up in mid-April, until by May the island was golden-brown.

Heavy fog enveloped the island during visits in June and July. Both trips in June were delayed because of poor visability.

NESTING ATTEMPTS, 1970

The following is a brief account of the sequence of events which took place in the pelican colony on Anacapa Island in 1970.

Pelicans were in breeding plumage and roosting with double-crested cormorants on offshore rocks when the field work began in mid-February. Their numbers gradually increased from 50 or 60 to about 300 by the second week of March.

The first nesting site had apparently been established in mid-March. I observed this colony on March 29 and counted 127 nests. At least one-fourth of these nests had already been deserted. The colony site was located on steep slopes at a cove entrance on the northwest end of the island (Figure 2). I was impressed by its nearly complete inaccessibility (at least to human intruders). Fifteen intact eggs, including three two-egg clutches, were seen in nests. Many broken eggshells littered the colony. Individual birds were observed flying from their nests showing no obvious signs of fright in their departure. It appeared that the pelicans were in the process of abandoning the colony. The number of nesting birds gradually dwindled as nests were deserted, until by April 1 the colony was virtually abandoned.

A new colony was established in mid-April on another inaccessible slope, this time on Bluff #2 on the north side of the island between Anacapa Peak and East Peak (Figure 2). There was no concurrent nesting elsewhere on the island. When the new colony was first observed on April 20, 65 nests were counted; approximately 120 pelicans were in the nesting area. These birds exhibited the same lack of nest-site tenacity that was evident in the first colony. On my first visit to this new colony (April 20-23) the nesting attempt seemed to be irresolute: nests were individually vacated; many of the deserted nests were incompletely built; few eggs were present; and active nest building was virtually nonexistent. On April 22 the colony was suddenly deserted.

On April 27 this colony was again active. New nests had been built and nearly all nests were occupied and active. Behavior associated with pair formation and nest building was at a high intensity. It appeared that after an unstable beginning the colony was becoming more firmly established. The lack of nest-site tenacity, however, was still evident. No eggs to date were seen in this colony.

Nesting activity reached its peak during the first two weeks of May. On May 10 I found that the colony had greatly expanded and was spread out across the cliff face of Bluff #2, with approximately 300 nests within view from the island. Nearly all nests were active, although only about 10 percent of them contained intact eggs. Collapsed eggshells and shell fragments were seen in nests and scattered about the colony.

By the first week of June it was evident that the process of abandonment had begun. Only half of the nests were still active and many birds were roosting on bluffs to the west of the colony. From a boat I counted 457 nests in the colony and about 700 birds on the island, including approximately 40 immatures.

By June 20 the colony was nearly abandoned. Only four incubating birds remained, each with one egg in its nest. All other nesting attempts had been abandoned, although about 100 pelicans were roosting in the nesting area. A total of 425 nests were counted in the colony. This represents a more accurate figure than the June 1 boat count. There was no other nesting on the island. Approximately 1,000 pelicans, including about 60 immatures roosting on the west island, were counted from a boat on June 24.

On July 29 I returned to Anacapa to determine the fate of the four remaining active nests. Of these, only one nest contained a nestling. The young pelican appeared to be about two weeks old. This was the only pelican to hatch in either colony on Anacapa Island in 1970.

In surveys of other historical breeding sites in California (Santa Barbara Island, San Miguel Island, Santa Cruz Island and Point Lobos) no attempted nesting was seen or reported in 1970.

To summarize brown pelican breeding on Anacapa Island for the 1970 breeding season, out of 127 nesting attempts in the first colony and 425 in the second colony (total = 552), only one chick hatched. Thus, a repeat of the 1969 disaster with the same reproductive failures caused by the collapse of thin-shelled eggs has occurred in 1970. The evidence is conclusive -- the brown pelican is presently incapable of reproducing in California.

The pelican was not alone in its plight. Approximately 50 pairs of double-crested cormorants attempted to nest on Anacapa in 1970. They nest side-by-side with the pelicans, and like the pelicans, they too suffered nearly total reproductive failure. The shells of the cormorant eggs were also thin, fragile, and easily crushed. As a result, only one cormorant nest containing three young was successful on Anacapa in 1970.

BREEDING BIOLOGY

Nests

The nests observed on Anacapa were bulky structures constructed primarily of sticks. They were 18 to 24 inches wide with a bowl diameter of 8-10 inches and a depth of 3-4 inches. Most were situated on steep, rocky and largely inaccessible slopes supporting sparse stands of Coreopsis maritima. Pelicans are able to push the Coreopsis over and break off protruding branches to form a foundation for the nest. Nearly all nests in both colonies, with the exception of those few built on bare rock, were built in this fashion. The Coreopsis anchors the nest firmly enough to support a large bulky nest which can be as high as two feet on the downhill side. These nests can easily support the weight of a man.

To the Coreopsis foundation is added the bulk of the nest, consisting primarily of twigs and branches of shrubby plants woven and intertwined together. The plant species most commonly used are: Artemisia californicus, Eriogonum latifolium, Eriogonum arborescens, Lupinus albifrons, Haplopappus detonsus, and Corethrogyne filaginifolia. Larger pieces of nesting material are used at the base of the nest, generally becoming smaller toward the crown. The bowl is lined with dried grasses (Hordeum, Avena, Bromus, and Festuca), Atriplex semibaccata, long vine-like strands of Marah fabacens, flower stems of the ice-plant Dudleya candelabrum, both fresh and dried herbaceous matter from Coreopsis, Artemisia, and Corethrogyne, plus feathers.

The nests of both colonies were newly constructed. I did not see any nests that were built by addition of new material to old nests from previous seasons. It was my impression that most nesting material was fresh as well. The many beaten-down shrubby plants on the island would bear witness to the annual harvest of nesting material by pelicans.

Why pelicans use the steep slopes for nest-building instead of the flatter bluffs where space would not be as limiting can only be speculated upon. The bluffs, while offering more space for possible nest sites than the cliffs, are also considerably more accessible to human or other intrusion. Inaccessibility of nests in colonial species would be an important factor in successful reproduction where nest desertion means almost certain egg loss. Inaccessibility of the colony has been cited as one of the primary conditions for the successful breeding of the great white pelican (Pelecanus onocrotalus roseus) in Africa, where nest desertion may be as important as predation in determining breeding success (Brown and Urban, 1969).

Egg Description, Egg Measurements, and Clutch Size

Eggs of the brown pelican are described by Bent (1922) as "...dull, lusterless, dirty white, usually more or less nest stained, and with a rough granular surface." Newly-laid eggs are quickly stained and soiled, and appear dirty-yellow in later stages. The shape of the egg has been described as either oval or sub-elliptical, each occurring in approximately equal numbers (Anderson and Hickey, 1970). The eggs of P. o. californicus are the largest of the three American subspecies (Wetmore, 1945).

Bent (1922) gives the mean length and breadth of 48 eggs of P. o. californicus as 78.5 x 50.6 mm. Anderson and Hickey (1970) give the mean eggshell weight of only those from Southern California as 10.59 gm. and the mean shell thickness as 0.579 mm in 85 eggs collected prior to 1943. They also give a mean weight of 7.89 gm. and a mean shell thickness of 0.424 mm for 9 eggs collected in 1962. The thinnest museum eggshells are seldom 20 percent thinner than normal (Hickey and Anderson, 1968; Ratcliffe, 1967). This may represent the critical level of thinning. Eggshells which are thinner may not hatch successfully. The pelican eggs collected in 1962 were 26 percent thinner than normal, suggesting that reproductive difficulties on Anacapa Island may have been present even then. The eggs and shell fragments collected in 1970 in conjunction with this study are presently being analyzed and measured. The results will be reported in a later paper.

It has generally been assumed that brown pelicans lay a replacement clutch in place of an original clutch which has in some way been destroyed or lost. I did not find evidence on Anacapa Island, nor have I found evidence in the literature, as to whether renesting does indeed occur. Schreiber (pers. comm.) in his study of Florida brown pelicans, has also not seen conclusive evidence of renesting. More work remains to be done before any definitive statements concerning renesting can be made.

The average clutch size of the brown pelican is considered to be three, although clutches up to five have been reported (Bent, 1922; Palmer, 1962). Hickey and Anderson (1970) give a mean clutch size of 2.95. It was not possible to determine an average clutch size of the Anacapa pelicans in 1970. The few intact eggs observed in nests were probably those which had not been crushed and did not, in all probability, represent the original number of eggs laid. No three-egg clutches and relatively few two-egg clutches were seen. Most of the intact eggs observed were single. It is a matter of conjecture as to whether clutch size is also affected in these reproductive failures.

Breeding Behavior

Van Tets (1965), in a comparative study of social communication patterns within the pelecaniforms, summarizes the function and need of behavioral signals in colonial nesting species. In many marine birds, such as the brown pelican, colonial nesting is probably a defense against predation and may be advantageous in making full use of limited nesting habitat. In such aggregations complex displays become necessary to communicate information between members of the crowded colony in order to enhance reproductive success.

There is little published data concerning brown pelican behavior (Palmer, 1962). The possibility that other manisfestations of reproductive abnormality in pelicans might be apparent in behavior prompted a study of behavioral patterns associated with breeding. These patterns were then compared with those of the still normally reproducing Florida pelicans, currently under study by R. W. Schreiber of the University of South Florida. Schreiber accompanied me for several days on Anacapa to make behavioral comparisons between the two populations. We found that the postures and behavioral sequences were very similar and that pair formation in the Anacapa colony seemed to be occurring normally. Nest-building and associated behavior also appeared normal, although many nests were abandoned before nest-construction had been completed.

The most striking difference in behavior was the inability of the Anacapa birds to hold to their nests. They were prone to leave their nests whether an egg was present or not. This was not necessarily provoked by alarm since the pelicans often left singly and not en masse, as would be expected in a panic flight. The Anacapa pelicans exhibited unusual behavior in leaving their nests unattended, regardless of the presence of eggs, to toy with nesting material, to wander about the colony, or to simply fly away. This was more commonly seen in the initial stages of colony establishment. Once the colony was firmly established, with nests completed, eggs laid, and incubation begun, nest-site tenacity seemed to be strengthened. But as eggs were crushed during incubation, nests were abandoned one-by-one until the colonies eventually were deserted.

Incubation in the Anacapa colony for most pelicans lasted until the egg was crushed or broken (incubation is normally a 30-35 day process). I observed several instances of incubating birds crushing and discarding their eggs. In one case there had been an egg in the nest for at least a week. The incubating bird was in the process of repositioning itself on the nest and had settled back down again. Suddenly the bird rose up, reached under its breast with its bill, and picked up part of a shell dripping with the egg contents. The bird dropped the shell, ate the contents, then heaved the shell about six feet from the nest. The bird then began violently jabbing with its bill at the nest bowl, its wings outspread and its body jerking while it tugged at pieces of egg-soaked nest material and tossed them out of the nest. The bird worked furiously for nearly 30 minutes, then suddenly stopped, clapped its bill, and stood on the edge of the nest preening and working at the nest for several hours. Later in the day the bird flew off and did not return. Another nest had been abandoned.

The pelicans on Anacapa are considerably more wary than the Florida populations, according to Schreiber. The Anacapa birds were easily disturbed, even by flocks of alarmed gulls, and were frightened away if approached closer than 200 feet or so. They made no attempt to stay and defend their nests as they do in Florida. According to Schreiber, the Florida birds will not leave in a panic flight until approached to within 20 to 30 yards. Before they are forced to fly away, they attempt to defend the site with threats, wing flapping, etc. When they are disturbed, they will usually fly a short distance to the water and wait for the intruder to leave. They will then come back to their nests. In contrast, the Anacapa pelicans rarely returned to their nests once they had been frightened off. If eggs happened to be in the nest, gulls invariably preyed upon them.

The above observations seem to indicate a degree of aberrant behavior in the Anacapa population. Behavior associated with pair-formation and nest-building appears to be normal, but the full cycle of behavior necessary for successful breeding seems to be inhibited.

DISCUSSION AND SUMMARY

The pelicans on Anacapa Island in 1970 have shown the same reproduction failures which characterized the 1969 population. The brown pelican cannot continue to endure year-after-year nesting failures and maintain a viable population. The number of wintering pelicans along the Pacific Coast has not yet shown a noticeable decline, but as the percentage of immatures decline, a population decrease is inevitable.

The cause of these reproductive failures can be directly attributed to eggshell thinning. The same symptoms seen in 1969 were equally evident in 1970. Discarded eggshells, broken and crumbled because they were too thin to withstand incubation, characterized pelican breeding on Anacapa Island.

Aberrant behavior in association with reproduction was also apparent. Presence of large amounts of chlorinated hydrocarbon residues found in pelican tissue must be considered as a potential cause of this erratic behavior. Induction of nonspecific hepatic enzymes by DDT compounds have been shown to cause a degradation of steroid hormones, including estrogen (Risebrough, et al., 1968), testosterone, and progesterone (Peakall, 1967). Depressed levels of these hormones could result in a number of physiological abnormalities which in turn could lead to a suppression of certain behavioral traits associated with reproduction.

Thinning of the eggshells, however, appears to be the primary cause of reproductive failure. Massive residues of the DDT compounds found in tissue and eggs of vulnerable species, controlled experiments showing DDE as highly effective in producing thin eggshells in several species, and the significant correlations between p,p'-DDE and eggshell thickness found in several species certainly implicates that compound as the prime factor. The physiological mechanism is not yet entirely understood and is currently under investigation.

There are, therefore, two possible causes of reproductive failures, one, an effect on behavior, and the other, an effect on eggshells. Studies in progress are linking these to pollutents in the marine ecosystem, particularly in the Southern California coastal waters.

RECOMMENDATIONS

It is difficult to make recommendations for an endangered species which is experiencing problems of which we know so little and which are hopelessly beyond our control. The following recommendations, however, can be made:

(1) Access to the upper part of West Anacapa Island be prohibited during the breeding season. Even in their precarious state, the pelicans and cormorants could not help but benefit if they were left alone. Since this is now the only pelican breeding site in California, it should be given special protection and consideration.

(2) Research be continued, but in such a manner as to avoid disturbing the breeding birds. Further egg collections seem merely repetitious. In any event, the number of researchers should be limited and under the sole direction of one individual or group, as it was in this study.

(3) A project be initiated to study the trophic pathways leading up to the contamination of pelicans and cormorants. The establishment of a monitoring system able to predict rates of entry of various pollutents into the environment and the rate of accumulation in both abiotic and biotic components of the marine ecosystem would be essential. Present monitoring programs cannot provide this information.

(4) An intensive investigation be conducted to determine major sources of contamination of the Southern California marine environment.

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Addendum

Currently the U. S. Fish and Wildlife Service, Denver Wildlife Research Center, is conducting pelican nesting studies in the Gulf of California, Mexico. Evidence gathered to date indicates reduction in clutch size in colonies varying from 500 to 17,000 nests. This is attributed to eggshell thinning and the collapse and disappearance of eggs.

Unknown is the extent to which Mexican pelicans, estimated to number 30,000-32,000, contribute to the population of 10,000-12,000 birds along the California coast August through November. Eight hundred young pelicans were banded and color-marked in the Gulf of California this spring. Notice of color marking of these birds has been publicized. It is hoped that sightings reported to the Denver Wildlife Research Center, Building 16, Federal Center, Colorado 80225 will provide much needed knowledge regarding brown pelican movement and migration.

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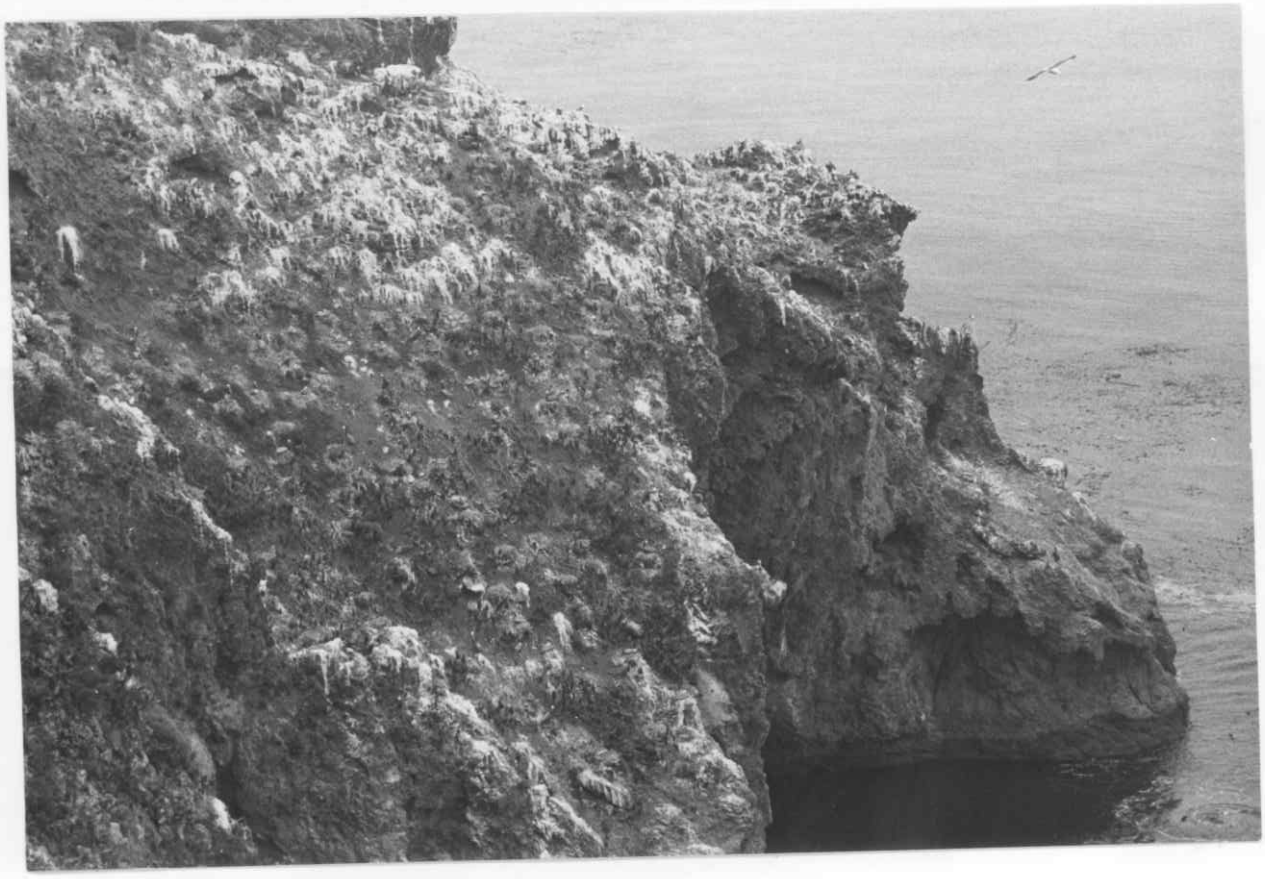
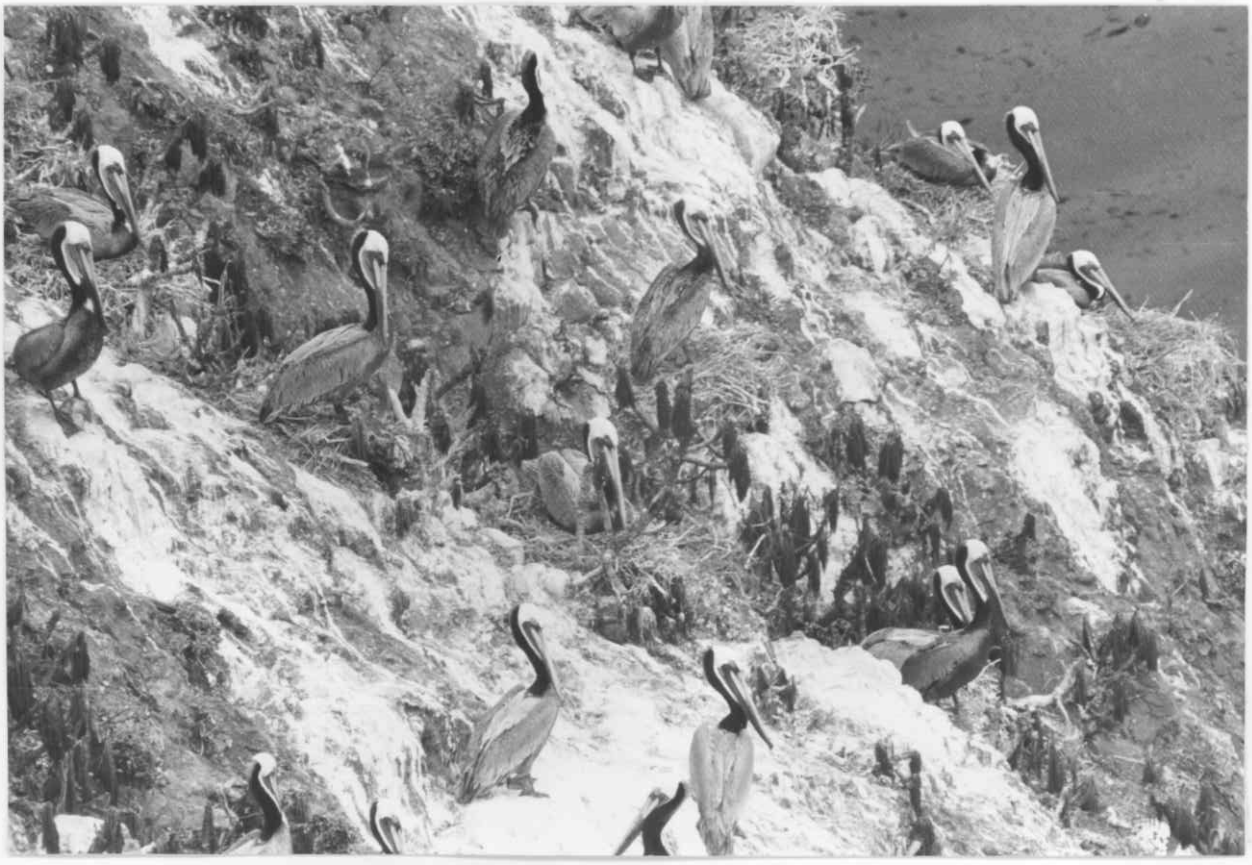
Brown Pelican - An Endangered Species

Site of the Second Nesting Colony, Anacapa Island, 1970



Close-up of Nesting Colony Which Produced One Young



Collapsed Thin-shelled Eggs, Typical of Those Found Throughout the Colonies