PASSIVE DISPERSAL OF CALIFORNIA BROWN PELICANS

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The Brown Pelican (*Pelecanus occidentalis*) is generally only found closely associated with shoreline habitat (Murphy, 1936). In western North America, it is unusual to find Brown Pelicans inland. Although inland occurrences of seabirds have been reported in the past in the American Southwest (Vorhies and Phillips, 1937; Clary, 1930), details are recently increasing as observer coverage improves (McCaskie, 1970a). Here, we will (1) report our data and review other observations on inland occurrences of California Brown Pelicans (*P. o. californicus*), and (2) demonstrate how these occurrences are related to meteorological events.

METHODS

Between 1970 and 1975, we banded 6,426 nestling California Brown Pelicans in the "Midriff Area" of the Gulf of California (Fig. 1a). In addition, we banded 554 fledglings on the Pacific Coast side of Baja California and California, and 441 on the Sinaloa Coast of Mexico during this same period. Young pelicans were also marked with either colored plastic leg streamers or plastic leg bands. The color codes represented years of banding and colony of origin. Sightings of live birds plus recoveries from dead or injured birds are included in our analysis, and both together are termed "encounters" (Bird Banding Offices, 1972). Sightings showed no patterns significantly different in distribution from recoveries of hatching year pelicans, so are combined for analysis here. Encounters of pelicans at the site of banding were not included in our analyses.

RESULTS AND DISCUSSION

Occurrence and Description of Inland Movements.

Encounters of banded and marked pelicans. It is apparent that young pelicans in the northern part of the Gulf of California (including the Midriff Area) experience a much greater chance of occurring inland than birds dispersing in other directions. All of our inland encounters are from pelicans banded in the Midriff Area; none are from those banded elsewhere (Fig. 1). Of 181 late summer or fall encounters in the Gulf of California 73 (40 percent) represent encounters in the Midriff Area or north (Table 1). Of these 73, 11 (15 percent) are from inland areas of the Sonoran Desert (Shreve and Wiggins, 1964) (Table 1, Fig. 1b), and two more are from inland farther south. The inland encounters represent 4.7 percent of the total Gulf of California encounters and 2.7 percent of our total encounters of first-year pelicans (n = 479, including the California coast).

Two additional "inland" recoveries in California were associated with river channels connected directly to the ocean and not more

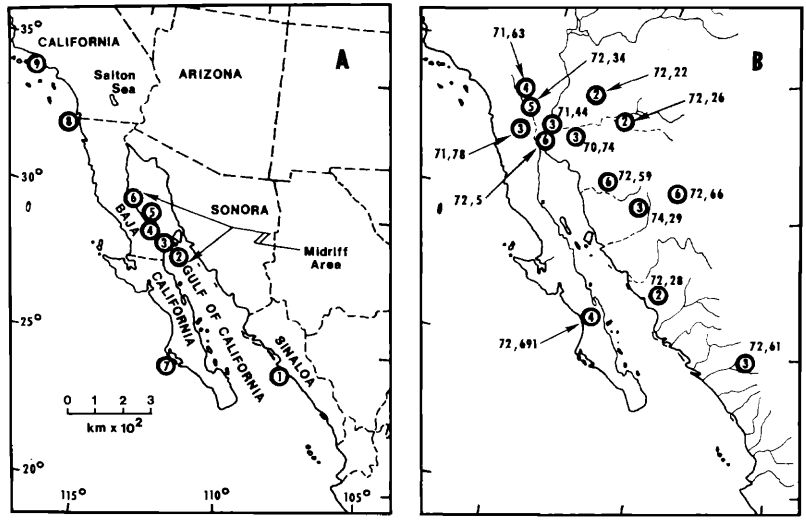

FIGURE 1. (A) The Gulf of California with the Midriff Area and locations of Brown Pelican banding shown. Areas of banding are coded as follows: 1 - Bahia del Pabellon, Sinaloa, 2 - Isla San Pedro Martir, 3 - Isla San Lorenzo Area, 4 - Isla Piojo, 5 - Puerto Refugio Area, 6 - Isla San Luis (Salvatierra), 7 - Bahia de Magdalena, 8 - Isla Coronado Norte, and 9 - Anacapa Island, California.
(B) Inland encounters of California Brown Pelicans. Circled numbers indicate location of inland encounter, and site of banding. The first number is the year of banding and encounter, and the last number is the number of days from banding to encounter.

than 10 km inland. Three of 38 Brown Pelican recoveries from birds banded at Anacapa Island, California by Bond (1942) were of this type.

An additional inland encounter occurred in Baja California (Fig. 1b), where a live pelican was shot 32 km from the nearest salt water (no rivers were near). This recovery is not included in Table 1 because the pelican was recovered almost 700 days after fledging. No other inland recoveries have been received by us for pelicans older than 78 days post-fledging.

Inland occurrences of unmarked pelicans and other marine birds. McCaskie (1970a) and Lawson (1973) reviewed past occurrences of Brown Pelicans in the southwestern desert. In 1968, 1969, and 1970 Brown Pelicans and Brown Boobies (*Sula leucogaster*) were reported on private swimming pools at Yuma, Arizona (C. Lard, pers. comm.). In 1972, record numbers of Brown Pelicans were reported during July in the Tucson-Phoenix vicinity of Arizona and at the Salton Sea, California in July and August (Monson, 1972; McCaskie, 1972). Unusually high numbers were again reported in 1976: 49 separate sightings near Yuma (R. W. Wright, pers. comm.), 8 in the Tucson area, 40 at Salton Sea National Wildlife Refuge (NWR) in California (Fig. 2), and some in southern Nevada. Brown Pelican occurrences even as far north as Utah and

TABLE 1.

Encounters of Brown Pelicans in or near the Gulf of California during their first year[1], including only those birds that moved away from the colony of banding.

Location	June–Oct. No.	June–Oct. %	Nov.–Feb. No.	Nov.–Feb. %	% of total first-year[1] encounters
Inland, Southwest	13	7.1	0	0.0	4.7
North of Midriff	12	6.6	6	6.3	6.5
Midriff Area	61	33.7	32	33.3	33.6
South of Midriff	68	37.6	40	41.7	39.0
E. Coast, Baja Calif.	27	14.9	18	18.8	16.2

[1]First-year pelicans are those encountered 350 days or less post-banding.

Idaho have been reported: at Salt Lake in Utah in April of 1934 (Woodbury, 1937) and at Priestlake, Idaho in mid-September 1974 (F. S. Todd, pers. comm.).

Historical reports of inland Brown Pelicans from Mexico are, as expected, rare due to lack of observer effort. We were made aware of one such occurrence at Ciudad Obregon, Sonora in September of 1971 (J. E. Mendoza, pers. comm.). The frequency of marked pelican encounters in Mexico already discussed suggest that inland occurrences there are not uncommon, and that lack of historical data from Mexico is due to lack of published reports rather than lack of birds.

McCaskie (1970a) logically assumed that four species of pelecaniforms (Brown Pelicans; Brown Boobies; Blue-footed Boobies, *S. nebouxii*; and Magnificient Frigatebirds, *Fregata magnificens*) sighted in the Sonoran Desert came from the Gulf of California. Additional marine birds reported inland, probably originating in the Gulf of California, include the Wandering Tattler (*Heteroscelus incanum*) (Witzeman, 1972), Heermann's Gull (*Larus heermanni*) (McCaskie, 1969, 1970b), Yellow-footed Western Gull (*L. occidentalis livens*) (McCaskie, 1970c; Devillers, et al., 1971), Black Skimmer (*Rynchops nigra*) (McCaskie, 1971), Sooty Shearwater (*Puffinus griseus*) (Quigley, 1973), and others (McCaskie, 1970d).

It is not within the scope of this paper to review all such occurrences, nor to review similar occurrences in the Eastern U.S. (see Smith, 1910 and Musselman, 1950). We do wish to emphasize that such inland dispersals are and have been more common than formerly believed for Brown Pelicans and other marine species that breed or winter in the Gulf of California. The majority of these are dispersals into the desert areas surrounding the Gulf of California, mainly noted to the north and northeast in the late summer and early fall. Dispersals into inland areas along water courses are probably active dispersals and are not related to the phenomena we discuss here. Since the flow of the Rio Colorado into the Gulf of California has been amost nil for the past few decades (Felger, 1976), movements into the Sonoran Desert are not of this type.

Age ratios of inland Brown Pelicans. As already implied, inland occurrences of Brown Pelicans involve mostly young, inexperienced birds. Phillips, et al. (1964) stated that there were no records of adult Brown Pelicans in Arizona. Lawson (1973) reported 39 of 39 confirmed pelicans in Nevada as immatures. All of 20 inland Brown Pelicans found near Tucson in 1972 were hatching-year birds. Similarly, no adults were seen on the Salton Sea NWR from 1952 (when records were begun) through 1971 (n = 93); from 1972 to 1975, when 103 more individual pelicans were recorded, only two were adult-plumaged birds. McCaskie (1970a) reported only three adults in about 100 of his records from the Salton Sea, and no adults were known anywhere else inland (another 71 records). Thus, of the 426 known-age, inland pelicans, only five (1.2 percent) were adults.

Factors for Inland Movements.

Active dispersals. Food shortage has been suggested as a factor responsible for inland movements of oceanic birds. McCaskie (1970a) believed that inland movements of Brown Pelicans, Blue-footed Boobies, awnnd Bro Boobies were due to normal post-breeding dispersal combined with the birds being "pressured" out of the Gulf in search of food. He also speculated (1970b) that this event was related to periodic, but only rumored, "dieoffs of marine life in the Gulf of California." It is tempting to relate events in the Gulf of California to those in other areas such as Peru, where starving seabirds have been reported inland (Murphy, 1936:304-5, 903; Leck, 1973). However, these movements usually involved all age classes and extensive areas. We doubt that such extremes occur in the Gulf of California, although periodic and potential food shortages do occur (Anderson and Anderson, 1976).

Since 1969, several instances of possible food shortages have occurred in the Gulf of California. One was in January 1971 when unknown numbers of surface fish died during a period of unseasonably cold water along the Sonora coast (H. J. Schafer, pers. comm.). The most severe food shortages were observed in 1973 when few inland records of Brown Pelicans were reported (see Fig. 2), and Brown Pelicans essentially failed to breed in the Midriff Area (Anderson, 1973).

Of 15 Brown Pelicans that were captured alive and carefully examined soon after their inland discovery in 1972 (C. L. Hanson, pers. comm.), none were emaciated or thin, and only one was in a slightly weakened condition. Other pelicans found dead had apparently died of injuries, accidents, and starvation after arrival inland. We therefore doubt that inland Brown Pelicans are actively dispersing into the desert in search of food.

Passive dispersals. "Passive bird dispersal" or "dispersal movements" are described by Hickey (1943:36) and Welty (1964:404-6) as related primarily to severe weather and prevailing winds in the majority of documented instances. Most inland "wanderings" of the Ancient Murrelet (*Synthliboramphus antiquum*) have been directly associated with weather disturbances (Munyer, 1965;

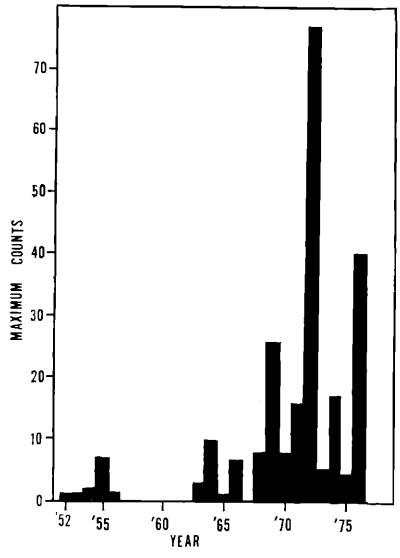

FIGURE 2. Brown Pelican censuses from the Salton Sea National Wildlife Refuge. G. McCaskie (pers. comm.) reported a maximum of 105 Brown Pelicans on the Salton Sea in 1972, and we use the refuge records here as an index of inland movements for the Southwest, since the Salton Sea tends to attract inland dispersing pelicans.

Verbeck, 1966). A single documented Brown Pelican occurrence far inland in Washington was attributed to a severe storm off the coast (Bowles, 1922). Tuck (1960:181-6) discusses certain weather phenomena associated with the "wrecks" of Common Murre (*Uria aalge*) and Thick-billed Murre (*U. lomvia*) in the interior of eastern North America. Most of these movements (called "migrational drift" in some cases) were explainable on the basis of a "single meteorological event," and Tuck believes that such instances are usually the result of a combination of events, i.e., concentrations of murres coupled with peculiar meterological conditions. Inland occurrences of unusual pelagic birds in Texas have also been attributed to tropical weather disturbances which originate far at sea (Pulich and Pulich, 1973). In 1976, two hurricanes penetrated unusually far inland into the Sonoran Desert. These resulted in the following inland seabird records: large numbers of Least Storm Petrels (*Halocyptena microsoma*) at Salton Sea; Brown Pelicans at Tucson, Arizona (two were reported just ahead of the front associated with Hurricane Kathleen), and a Blue-footed Booby at Fresno, California.

Weather patterns in the Southwest. Two patterns prevail in the northern Gulf of California from July through October (Fig. 3), both resulting in movements of moist air into the desert regions. Blake (1923) describes the "Sonora Storm" as resulting in a prevailing wind from the south during May through October, with moist air from the Gulf as a major factor in the genesis of thunder-

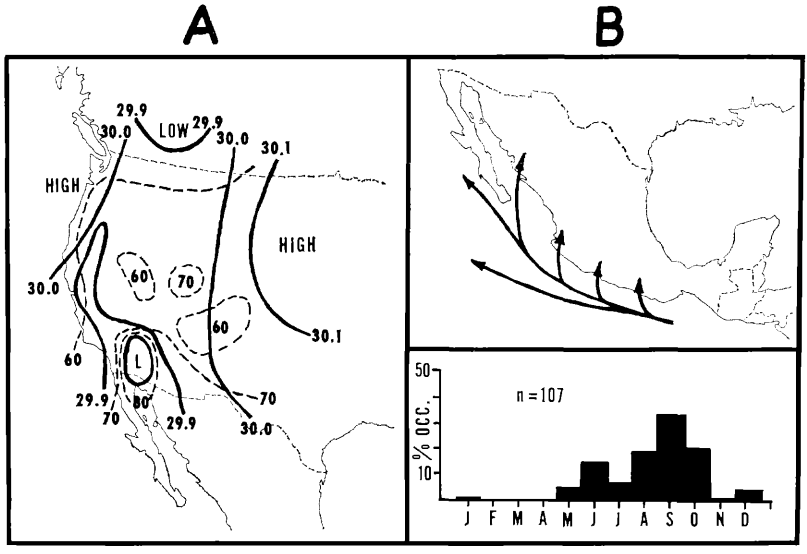

FIGURE 3. Late summer, early fall weather patterns influencing Brown Pelicans in the Southwest. (A) Type map for Sonora Storms (from Blake, 1923). The heavy black lines represent approximate barometric pressure and the dotted lines temperature. (B) Trajectories of tropical storms off the West Coast of Mexico from 1921 to 1969 and the seasonal occurrences of such storms that move inland (from Serra, 1971).

storms inland. For example at Yuma, Arizona maximum storm intensities are generally reached in July and August. Winds from the south or southwest usually last from one to four days between January and June; they intensify in duration and velocity in June (two to six days), grow in July and August (seven to 15 days), and then dwindle by October (one to six days) when prevailing systems out of the north again dominate the weather pattern (U.S. Dept. of Commerce, 1966-67, 1968-72).

Tropical disturbances (called "chubascos" in Mexico) frequently move northward enough to have an influence in extreme Southern California and Arizona (Blake, 1923). Serra (1971) demonstrated that such storms move inland and reach their maximum intensity in September, and on occasion extend northward well into the Gulf of California.

Figure 4 shows the periods of prevailing south winds and periods of thunderstorm activity in certain areas of the American Southwest. The data from Brawley, California show little or no rainfall in the Salton Sea area, but this is near the usual center of low pressure in the Sonora Storm (Fig. 3).

All of the 13 inland encounters shown in Figure 1b in the Southwest were preceded by 5- to 18-day periods of south winds, coupled with 1- to 6-day periods of intense winds, and periods of thunderstorm activity. A large influx of pelicans at Salton Sea in 1969 (McCaskie, 1970a) was preceded by a 7-day period of south winds. The record influxes of 1972 outside the Salton Sea were preceded by

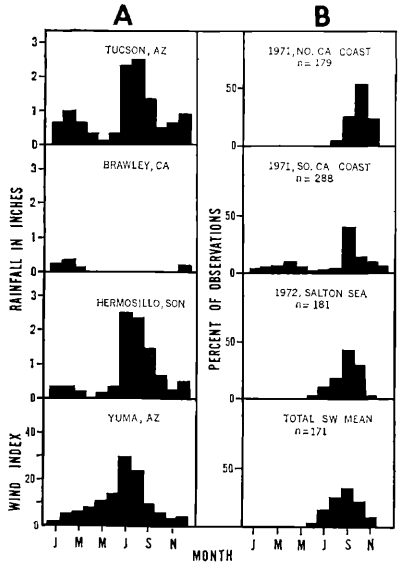

FIGURE 4. (A) Weather data in the Southwest. Tucson, Brawley, and Hermosillo rainfall data were adapted from Dunbier (1968). Yuma wind data were obtained from U. S. Department of Commerce (1966-1967, 1968-1972). Monthly wind indices were calculated by summing the relative intensities of prevailing south winds for each day on a scale of 0 to 3. These mean indices represent data from 1966 through 1972. (B) Brown Pelican occurrences during the postbreeding period. California coastal pelican censuses were obtained through R. M. Jurek (pers. comm.) and Southwest means from McCaskie (1970a).

a 10-day period of south winds, including three days of intense winds and thunderstorms. Monson (1972) also reported that the 1972 influxes in Arizona were preceded by unseasonably early rain in southern Arizona. The 1976 influxes were associated with unusually lengthy and steady flows of air from the Gulf of California into the Southwest and much cloudiness during the late summer "rainy season." The average pattern of Brown Pelican influx also closely follows the average patterns in the Southwest (Fig. 3, Fig. 4). Although Brown Pelican encounters are distributed about the same in the various Gulf of California zones from June through February, inland encounters occur only in the earlier period (Table 1). Our conclusion therefore is that inland dispersals are passive, weather-induced anomalies of the postbreeding dispersal of young birds. Disoriented marine birds tend to drift downwind (Matthews, 1968). As with Herring Gulls (*Larus argentatus*) (Gross, 1940) and other birds (Lack, 1954), young Brown Pelicans are probably also more nomadic than adults and thus more subject to weather influences.

One might ask: "Why so few inland encounters in northern and central California, when the dominant storm patterns in October-

November off the Pacific Northwest blow inland?" There are two reasons: (1) the majority of Brown Pelicans are gone from the northwest coast by then (Anderson and Anderson, 1976); and (2) Brown Pelicans seldom soar to great heights (where they are more subject to disorientation and prevailing winds) off the California Coast as they so commonly do in the thermal-rich environment of the coastline in the Sonoran Desert.

Use of Inland Habitat.

The Salton Sea in the Imperial Valley of southern California (Fig. 1) is an unusual area in many ways. The permanent body of water there today was formed from 1905 to 1907, but the Salton Basin has a history of intermittent flooding (Carpelan, 1961), dating back to the Pleistocene (Edmondson, 1966). The lake supports a small salt water fishery, but salinity is increasing each year and the lake could become a "brine lake" by the year 2000 (Walker et al., 1961).

Brown Pelican counts on the Salton Sea NWR (Fig. 2) suggest increased use in recent years (1963-75), but they may also reflect increased observer coverage. Phillips et al. (1964) implied that inland records of Brown Pelicans were increasing. Since mostly young pelicans are found inland, it is doubtful that Brown Pelicans are becoming established during postbreeding dispersals.

Since the Salton Sea area is seldom overcast, Brown Pelican movement into that area probably involves only visual orientation (see Emlen, 1975) by birds that happen to come within sight of it. Using the ratio of Salton Sea pelican encounters to unmarked pelicans in Salton Sea as a basis of predicting unmarked pelicans in the total recovery area, the mean number of inland pelicans from 1970 to 1974 is about 171 individuals per year (n = 4 years because of negligible reproduction and banding in 1973; Anderson, 1973).

Whether Brown Pelicans return to the Gulf of California is a matter open to question. Guy McCaskie (pers. comm.) believes that most boobies appearing on the Salton Sea eventually die because he has seen a number of dead birds. Dead Brown Pelicans have also been found on the Salton Sea NWR.

Some Brown Pelicans may return to the Gulf of California through their associations with migratory waterbirds. Woodbury (1937) reported a Brown Pelican among 20-30 White Pelicans (*P. erythrorhynchos*) in Utah. In one instance, a flock of migrating White Pelicans in November of 1974 was observed by one of us (D.V.T.) moving south out of the Salton Sea area with a juvenile Brown Pelican included. We have frequently seen mixed pelican flocks at Salton Sea. White Pelicans winter along the Sonora-Sinaloa Coast (Palmer, 1962), where both species are common in winter, often in the same coastal habitat.

Other species of Gulf of California waterbirds may be more successful colonizers than Brown Pelicans or boobies (see Howell, 1923), and the Sonora storm pattern may have enhanced their distribution into the Southwestern Desert—especially with the

advent of newly-created artificial reservoirs. How weather patterns can affect avian distribution is discussed by Gauthreaux (1972) and Williamson (1975). McCaskie and Suffel (1971) believed that Black Skimmers would become established as breeders at Salton Sea, and this indeed occurred in 1975 (Grant and Hogg, 1976). Adult Yellow-footed Western Gulls are also now regular on the Salton Sea (Devillers et al., 1971). The sporadic breeding of Laughing Gulls (*L. atricilla*) and Gull-billed Terns (*Gelochelidon nilotica*) at Salton Sea (McCaskie, 1970d) attests also that some colonization is possible.

The ecology of the Salton Sea is complex, but the recent situation is barely 75 years old. Passive dispersals like those discussed here are of interest in the study of bird dispersal and range expansion. Because of the recentness of the Salton Sea and inland reservoirs, these dispersals probably initially involve disorientation, then visual reorientation, and in some species, regular use of new areas. If conditions remain stable at the Salton Sea, future data from there and other inland bodies of water will be of much ornithological interest.

SUMMARY AND CONCLUSIONS

Movements of Brown Pelicans into the Sonoran Desert are most strongly related to weather patterns at the time of postbreeding dispersal. They involve almost entirely juveniles. These influxes probably result in losses of most of the individuals involved. Inland movements are not of great enough magnitude to cause concern about Brown Pelican losses, but the data are of interest in the study of bird dispersal. Other species of Gulf of California waterbirds are becoming established visitors on some areas of permanent water in the desert. However, to date, Brown Pelicans cannot be included among the successful species.

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