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POPULATION RECOVERY OF THE EASTERN BROWN PELICAN FOLLOWING ITS EXTIRPATION IN LOUISIANA

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ABSTRACT.—We report on the exponential growth of the Eastern Brown Pelican (*Pelecanus occidentalis carolinensis*) in Louisiana, following its extirpation in 1963, and its subsequent reintroduction (1968–1980). This population growth pattern is remarkable since the Brown Pelican exhibits low fecundity, a long life span, and is considered largely nonmigratory in the Gulf of Mexico. To understand the regional changes in breeding numbers of Brown Pelicans in the northern Gulf of Mexico, we investigated the long term trends of the other subpopulations in Florida and Texas. The Florida subpopulation of Brown Pelicans has exhibited a stable-limit cycle, but within the last decade the number of nesting birds has declined while the number of nesting colonies has steadily increased. The number of Brown Pelicans in Texas now exceeds estimates prior to the time pesticides caused reproductive failure of the subpopulation. The Louisiana subpopulation now equals or exceeds its historical (pre-pesticide) numbers. Although local recruitment can account for the exponential growth of Brown Pelicans in Louisiana, we believe that dispersal from colonies outside of Louisiana may have augmented the growth of its nesting population. *Received 11 February 2003, accepted 15 October 2003.*

Prior to the 1930s, estimates of the Louisiana subpopulation of the Eastern Brown Pelican (*Pelecanus occidentalis carolinensis*) ranged from 12,000–85,000 (Lowery 1955, 1974; King et al. 1977; Wilkinson et al. 1994), with a conservative estimate of 50,000 individuals for Texas and Louisiana combined (Schreiber 1980). Extirpation of the Brown Pelican in Louisiana had occurred by 1963 (Williams and Martin 1968), and the last recorded nesting effort of the native population was observed in 1961 (Van Tets 1965). During this same period, a severe decline in the Texas subpopulation occurred, and King et al. (1977) estimated that by 1961 <50 adults remained in Texas. Despite the extreme losses in Texas and Louisiana, the number of Brown Pelicans nesting in Florida remained generally stable (Williams and Martin 1968, Kushlan and Frohring 1985, Wilkinson et al. 1994).

While reproductive failure from organochloride pesticide contamination caused the decline of pelicans in Texas (King et al. 1977, 1985), the extirpation of Louisiana's subpopulation was attributed to direct bird mortality (Blus and Joanen 1975) and more recently to a reduction in prey abundance resulting from endrin contamination (Biglane and LaFleur 1967; Colten 2000, 2001). The rapid disappearance of the Brown Pelican (Norman and Purrington 1970) coincided with endrin use and production discharges (1958–1964) and massive fish kills (1963–1964) caused by endrin contamination (Mount and Putnicki 1966). However, it was not until 1975, when a severe die-off of pelicans (after reintroduction) in Louisiana occurred, that the extreme sensitivity of pelicans to endrin contamination was documented (Blus et al. 1979).

In 1968, the Louisiana Dept. of Wildlife and Fisheries and the Florida Fish and Wildlife Conservation Commission began reintroduction of the Brown Pelican into coastal Louisiana. A total of 1,276 Florida nestlings were transplanted from six colonies in Florida to three sites in Louisiana between 1968 and 1980 (for detailed transplanting information see Nesbitt et al. 1978, McNease et al. 1984). The first nesting attempts of transplanted birds occurred during the spring of 1971, and at that time, the birds were almost 3 years old (Williams and Joanen 1974). During the spring of 1975, endrin pollution caused a die-off of about 40% of a standing population of 400–450 Brown Pelicans (Winn 1975, Nesbitt et al. 1978, Blus et al. 1979). Since then, the Louisiana population has continued to grow.

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The objective of our study was to investigate the long term growth trend of the Eastern Brown Pelican in the Gulf of Mexico, with an emphasis on the nesting birds in Louisiana, and compare these numbers to those of Florida and Texas. Given that the Louisiana subpopulation has exhibited an exponential increase of nesting birds, we investigated the potential for local recruitment versus long distance emigration and dispersal from surrounding subpopulations in augmenting Louisiana's population growth.

METHODS

We used breeding Brown Pelican census data from Louisiana, Texas, and Florida, the states comprising the largest subpopulations of breeding pelicans along the U.S. Gulf of Mexico. These data were based on nest counts (Florida and Louisiana) or breeding pairs (Texas); hereafter, nest numbers are used as a common unit of measure. In Louisiana, pelican nests and nestlings were counted yearly (except 1991) with a mean of four flights (rotor or fixed-wing) per year (1993–2001). The nesting data were collected by the Louisiana Dept. of Wildlife and Fisheries (Hess and Linscombe 2001). Surveys prior to 1993 usually involved a combination of aerial and ground census techniques, as summarized by McNease et al. 1992. In Texas, breeding pairs were estimated as described in the Texas Colonial Bird Survey (Lange 1993). Nesting pair data from Texas were provided by the U.S. Fish and Wildlife Service (Houston, Texas). The Florida Fish and Wildlife Conservation Commission collected Florida nesting data. Nest counts in Florida were conducted during peak nesting periods and summarized between two zones: Atlantic and Gulf of Mexico coasts.

We used an exponential growth equation ($N_t = N_o e^{rt}$) to calculate the intrinsic growth rates of nesting subpopulations in Louisiana and Texas (Manugistics, Inc. 1995). In the equation above, N_t is the estimated number of nests for a given year, N_o is the initial number of nests at time zero, r is the intrinsic growth rate, and t is the time in years. Number of nests and time served as dependent and independent variables, respectively.

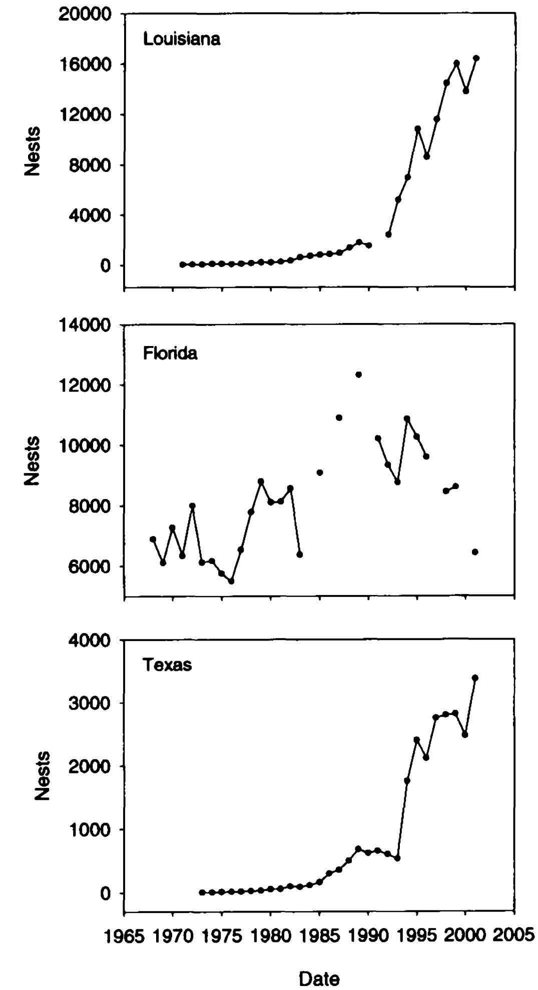

FIG. 1. The Brown Pelican breeding populations in Louisiana and Texas have grown exponentially while declines occurred in Florida.

RESULTS

Louisiana.—The population of nesting pelicans in Louisiana has grown exponentially from 1971–1999, with slower rates of growth occurring during 1999–2001 (Fig. 1). During 2001, the population peaked at 16,405 nests (Fig. 1). A best-fit exponential model describing population growth from 1971–2001 suggested an intrinsic growth rate (r) = 0.25 (R^2 = 0.97).

The overall (1971–2001) mean nestling production per active nest was 1.66. Peak nestling production occurred in 2001 with 34,641 young produced; at this time the high-

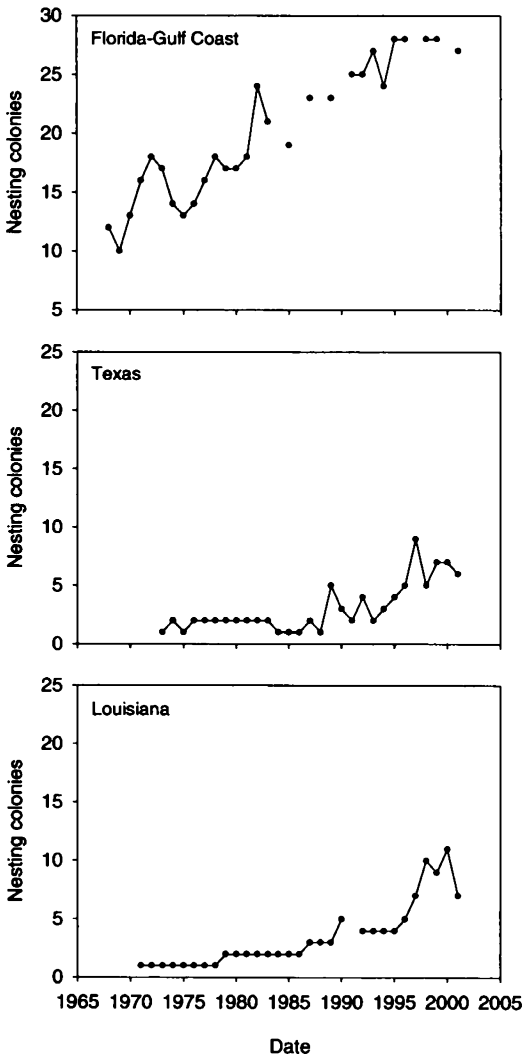

FIG. 2. While the number of Brown Pelican colonies increased along Florida's Gulf coast (a mean of one colony every two years since 1968), the number of nesting birds decreased (see Fig. 1). The number of nesting colonies in Texas and Louisiana has remained low despite the immense increase in the number of nesting birds.

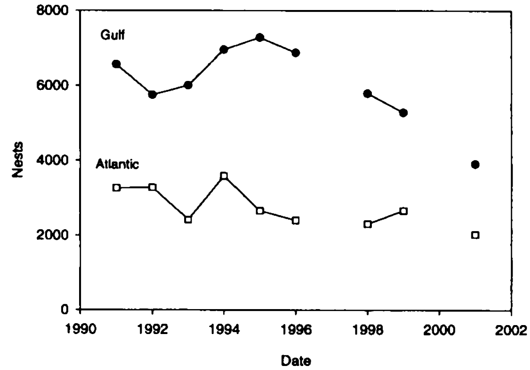

FIG. 3. In Florida, the Atlantic Brown Pelican subpopulation remained relatively stable from 1990–2001, but there was a decrease in the Gulf coast subpopulation.

est yearly mean number of nestlings per active nest (2.11) was recorded for Louisiana. The peak number of nesting colonies (11) in Louisiana occurred during the 2000 breeding season (Fig. 2). An interannual increase in nest production (2,639) occurred from 2000–2001; concomitantly, four nesting colonies were abandoned (Fig. 1, Fig. 2). In 2000, a new colony of approximately 10,000 nests was initiated on a 12-ha dredge spoil island (Baptiste Collette or Plover Island, near the mouth of the Mississippi River). This immense, concentrated shift comprised more than one-half of the total nesting population in Louisiana.

Interannual fluctuations in the Louisiana subpopulation occurred during the following three time intervals: 1989–1990, 1995–1996, and 1999–2000 (Fig. 1). Decreases in nest numbers during the spring of 1990 and 1996 correspond to years that had protracted freezing temperatures during the preceding winters. During 1999 and 2000, a 50–100 year local drought coinciding with low Mississippi River stages resulted in high estuarine salinity across the Louisiana coast.

Florida.—Florida nesting birds have exhibited cyclic changes in nest numbers from 1968 onward (Fig. 1). Following a general pattern of increasing growth from 1968–1990, statewide pelican nest numbers have declined over the past decade, and the number of nests (6,432) in 2001 fell below the 1968–1990 mean of approximately 8,000 nests.

The decline in the number of nests in Florida has occurred most noticeably among the Gulf coast colonies, while colonies located along the Atlantic coast have remained relatively stable (Fig. 3). Concomitant with the decline in nest numbers on Florida's Gulf coast, there was a linear increase in the number of colonies, and a mean (1968–2001) increase of one colony every two years (Fig. 2).

Texas.—A peak nesting population of 3,373 breeding pairs among a total of seven colonies was recorded for Texas in 2001 (Fig. 1). The mean number of nesting pairs from 1997–2000 was 2,839. The Texas population has grown exponentially with an intrinsic growth rate (r) = 0.22 (R^2 = 0.94, Fig. 1). Fluctuations in the number of nesting pairs in Texas are similar to those observed in Louisiana with noticeable interannual peaks and declines occurring during 1989–1990, 1995–1996, and 1999–2000 (Fig. 1).

DISCUSSION

Since its extirpation and reintroduction, the Eastern Brown Pelican in Louisiana has provided a remarkable example of exponential growth of a nonmigratory population (Palmer 1962) of long-lived (>20 years) birds. Newly introduced species, with rapid maturation and high annual fecundity, commonly exhibit exponential population growth. For example, Bock and Lepthien (1976a, 1976b) found that populations of Cattle Egrets (*Bubulcus ibis*; r = 0.21, 1956–1971) and House Finches (*Carpodacus mexicanus*, r = 0.23, 1962–1971) grew exponentially after their introductions into regions of the United States. Interestingly, the Louisiana pelican subpopulation has grown at intrinsic rates similar to that of "r-selected" bird species. This raises the question of whether local recruitment can account for the rapid increase in the Brown Pelican nesting population in Louisiana.

Based on a simple exponential model, local recruitment could explain the observed growth of the Brown Pelican population in Louisiana, provided that the estimated growth rate is 0.25/year. However, since this rate is as high as those observed in r-selected species, we suggest an alternative explanation, i.e., that immigration into Louisiana has augmented this growth. This immigration may have involved subadult pelicans, produced elsewhere, joining the Louisiana nesting population. This hypothesis also would explain the protracted decline in the Florida Gulf coast population concurrent with the rapid increase in the Louisiana breeding population.

The ability to detect emigration into Louisiana from banded birds has been constrained by the remoteness of pelican breeding and feeding areas in Louisiana. However, the steady increase of nesting colonies on Florida's Gulf coast, while nest numbers decreased, does indicate that pelicans in Florida are seeking either new nesting habitat or improved forage conditions, or they are avoiding disturbance. Schreiber (1976) believed that food availability was the main reason for movement of nonbreeding Brown Pelicans. Adjacent to Florida, Alabama's Gaillard Island nesting colony has grown rapidly; there were four nests in 1983 (the first account of nesting pelicans recorded in the state), and the population peaked in 1999 with approximately 5,200 nests (R. B. Clay pers. comm.). From early band returns, Wood et al. (1995) concluded that the Alabama colony (Gaillard Island) was initiated by birds from the panhandle of Florida.

Dispersal from natal colonies.—In a long term analysis of Brown Pelican band returns, Schreiber and Mock (1988) concluded that Florida's west coast (Gulf of Mexico) birds comprised a distinct subpopulation from that of Louisiana's. In their study, 82% of band returns were from Florida's Gulf coast, indicating a largely resident population. Other band returns were from the Keys (8%), Cuba (5%), and Alabama (1%), but none were reported from Louisiana. In a later study on pelican dispersal, Wood et al. (1995) found, conversely, that banded birds from a natal colony on the Florida panhandle moved both eastward and westward along the Gulf coast, and movement into Louisiana was documented (though only one band was recovered in Louisiana).

Long range dispersal of pelicans throughout the Gulf of Mexico has been reported historically (Mason 1945, Schreiber and Mock 1988, Sykes and Langridge 1991, Johnsgard 1993, Wood et al. 1995). As of 2001, banded pelicans from Louisiana have been reported from every Gulf coast state, and also from Cuba, the Yucatan Peninsula, Belize, and Guatemala (J. Harris pers. comm.). These recent Louisiana band returns confirm earlier findings (Mason 1945, Schreiber 1976) that Brown Pelicans, especially juveniles, move randomly and for long distances. A distinct pattern of dispersal from Louisiana's colonies, however, is not discernable at this time.

Whether breeding birds are shifting toward the northernmost portions of the Gulf of Mexico remains debatable. Nonetheless, this pattern is conceivable given the northward expansion of breeding colonies along the Atlantic coast of the U.S. Since 1980, first breeding records for Brown Pelicans have been reported for Georgia, Virginia, Maryland, Delaware, and New Jersey (see Wilkinson et al. 1994). Warm temperatures may facilitate a northward dispersal pattern, and the warmest decade since instrumentation began (1861) occurred 1990–2000 (Houghton et al. 2001). An interdecadal comparison between the 1980s and mid-1990s showed a notable reduction in pelican numbers (>70% or 1,300 individuals) in Puerto Rico and the U.S. Virgin Islands (Collazo et al. 1998). The authors did not find evidence of reproductive failure or nesting and roosting habitat changes.

Limitations on population growth.—Nelson (1979) proposed that populations of pelicaniform species are controlled mostly by environmental factors (climate and food availability). Fledging success of the California subspecies (*P. o. californicus*) was dependent on the local abundance of northern anchovy (*Engraulis* sp.; Anderson et al. 1982). Along the Pacific coastlines of North and South America the importance of food abundance on seabird mortality is well understood, especially as it is related to El Nino-Southern Oscillation events (Duffy et al. 1988). In the Gulf of Mexico, relationships between food supply and breeding success have not been widely studied. Poor food availability, however, has been implicated in reproductive failures in southern Florida near the Keys (Kushlan and Frohring 1985). Moreover, there was a strong, positive association between statewide mullet (*Mugil* spp.) landings and Brown Pelican nesting effort in Florida during the period 1968–1992 (Nesbitt et al. 1996). Whether food supply has influenced decreasing nest numbers along Florida's Gulf coast is unknown.

Other density independent forces such as human disturbance (Jehl 1973, Anderson and Keith 1980, Anderson 1988) inhibit successful breeding at local levels and may influence colony site selection or abandonment. There are significant differences, for example, in human population growth in the coastal areas among Louisiana, Florida, and Texas (Barrett 2001). From 1990 to 2000, the human population on Florida's Gulf coast has increased 20.8%, and Texas' population has grown 18.7%. In contrast, the population of coastal parishes in Louisiana has grown only 4.8%. Thus, habitat fragmentation by coastal land development and the probability of nesting colony disturbance is of greater concern in Florida and Texas than in Louisiana.

Habitat stability.—The greatest future problem for Brown Pelicans in Louisiana is the stability of natural nesting habitat. Barrier islands in Louisiana are the aging relics of Mississippi River deltas, and the rapid erosion of these islands has been largely irreversible, as there is little "new" sand or coarse-grained material entering the system. This has resulted in the need to replenish, with dredge material, historically successful natural nesting islands in Louisiana. The use of created islands (dredge material) by nesting pelicans has been encouraging in Louisiana and elsewhere (Wood et al. 1995). High rates of island fragmentation in Louisiana conceivably could facilitate the establishment of new colonies that have reduced predator activity (Kushlan and Frohring 1985). The fact that within one year more than 60% of the nesting population initiated a colony on a relatively small dredge spoil island reflects this species plasticity to changes in habitat.

The mean number of nests per colony in Louisiana in 2001 (2,344 nests per colony) is an order of magnitude higher than that of Florida's statewide density (161 nests per colony). The exponential increase in nests we observed in Louisiana contrasted with the disproportionate number of new nesting colonies suggests that a sustained amount of nesting habitat, rather than food availability, will be a future concern in Louisiana. In Florida, the decrease in the number of nesting pairs along the Gulf coast, with no decline in the number of colonies, is the reverse of what is being seen in Louisiana. In Florida, the food base, rather than the availability of suitable nesting sites, may limit the population.

In general, the growth of the subpopulations of Brown Pelicans in Louisiana, Texas, and Alabama, during periods when declines were observed along the Gulf coast of Florida and Puerto Rico and in the Virgin Islands, indirectly suggests that Brown Pelicans may have the ability to shift to habitats where suitable nesting and forage conditions exist outside of intense human disturbance.

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