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EASTERN BROWN PELICANS: WHAT DOES 60 YEARS OF BANDING TELL US?

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Abstract.—Analysis of the 3106 recoveries of Brown Pelicans banded in North and South Carolina and Florida between 1925 and 1983 indicate an 8.8% recovery rate with most recoveries occurring outside the breeding season. Florida birds move shorter distances than do Carolina birds. Carolina birds disperse southward and winter mostly in Florida. Florida pelicans are primarily year-round residents. Some east coast Florida birds move north, but many are found dead in the Keys and in Cuba. Most west coast Florida birds remain there. Distinct migratory patterns exist and most mortality occurs during migration, especially of young birds. More than half the banded pelicans recovered die from human activity, with entanglement in fish line a major cause of mortality. A life table presently cannot be calculated for this species, but a reproductive life of only 4–7 yr seems indicated for this population. Food supply and cold weather are important considerations in the biology and distribution of Brown Pelicans. Banding of adults and nestlings should continue.

EL PELÍCANO PARDO OCCIDENTAL: QUE NOS HA ENSEÑADO 60 AÑOS DE ANILLAJE

Resumen.—Un análisis de 3106 anillos recuperados provenientes de pelícanos pardos (*Pelecanus occidentalis*) anillados en Carolina del Norte y Sur y Florida entre el 1925 y 1983 indican que hay una tasa de recuperación de anillos de 8.8%, siendo ésta recuperación mayor fuera de la época de reproducción. Pelícanos de la Florida recorren distancias más cortas que los de las Carolinas. Los de las Carolinas se dispersan más hacia el sur e invernan mayormente en la Florida. Los pelícanos de la Florida son primordialmente residentes el año entero. Algunos pelícanos de la costa este de la Florida se mueven hacia el norte, pero muchos son encontrados muertos en los Cayos y Cuba. La mayoría de los pelícanos de la costa oeste de la Florida permanecen allí. Existen patrones migratorios distintinguibles y la mayoría de la mortandad ocurre durante la migración, especialmente de juveniles. Más de la mitad de los pelícanos anillados recuperados murieron a causa de actividad humana, siendo la muerte por lineas de pesca una de las mayores causas. Al presente, no se puede preparar un cuadro de vida para ésta especie, pero ésta población aparentemente tiene una vida reproductiva de solo 4–7 años. Abastos de alimentos y clima frio son consideraciones importantes en la biología y distribución del pelícano pardo. El anillaje de adultos y juveniles debe continuar.

Brown Pelicans (*Pelecanus occidentalis*) are among the best studied large birds in North America, especially along the southeast coast, where large numbers of individuals have been banded since 1925. Mason (1945) reported on 563 recoveries made prior to 1945. Henny (1972) attempted to calculate mortality rates for samples of the Carolinas and Florida banding data. Schreiber (1976) showed that color-marked juveniles undertook a primarily southward post-fledging dispersal. We analyze here

the over 3100 recoveries of Brown Pelicans banded in Florida and North and South Carolina. We attempt to: (1) delineate populational and age-class differences in dispersal behavior; (2) examine mortality causes; and (3) determine longevity; to add these important elements of the species' biology to other available data (Schreiber 1980 and references therein; Lawrence and Schreiber 1974; Schreiber and Mock 1987; Schreiber and Schreiber 1982; Schreiber and Schreiber 1983; Schreiber et al. 1987, Wolf et al. 1985).

METHODS

We analyzed 3106 band recoveries of Brown Pelicans banded in Florida and North and South Carolina between 1925 and 1983 as provided by the Bird Banding Laboratory of the U.S. Fish and Wildlife Service. Unfortunately, information on the total number of pelicans banded prior to 1955 is not available. We used the SAS statistical package to manipulate these data, after checking all records for internal consistency. Distance between banding and recovery was calculated from latitude and longitude information. We divided bandings into three groups: nestlings; Hatching Year birds (HYs), less than one year old when banded, based on a 1 Apr. hatch date in Florida; and After Hatching Year (AHYs) or what we refer to as adults, realizing that Brown Pelicans do not begin to breed until 36+ mo of age. Few birds 6–36 mo old are captured for banding and we believe it's safe to assume that the vast majority of the AHY birds are adults. With the high percentage of banded birds recovered in this species, we believe the band recoveries accurately reflect movements and mortality of the populations studied. We thus discuss the recovery information as populational data.

RESULTS AND DISCUSSION

Banding and recoveries.—Between 1925 and 1983, 1311 pelicans banded in Florida and 1806 pelicans banded in South Carolina were recovered. Unfortunately, records of totals banded during that entire period are not available. Between 1955 and 1979, 6021 pelicans were banded in Florida and 570 (9.5%) were recovered. In that same time span, 16,018 were banded in South Carolina and 1473 (8.6% were recovered). The combined recovery rate was 8.8%.

Most banding occurred during the breeding season, May–Aug. in the Carolinas and usually May–Sep. in Florida (Fig. 1). In Florida some birds were banded in all months. Many of these were adults captured away from the nesting colonies.

Most recoveries (77%) occurred outside the breeding seasons, during Sep. through Mar. (Fig. 2). Most recorded mortality of birds banded as nestlings occurred in Dec.–Mar., with a consistent increase in Sep.–Nov., and a slight decrease in Apr.–Aug. The pattern of mortality is similar in Florida and the Carolinas. We believe this indicates that many nestlings are able to survive on their accumulated body fat for some period immediately post-fledging (Schreiber 1976), but the strain of cold weather

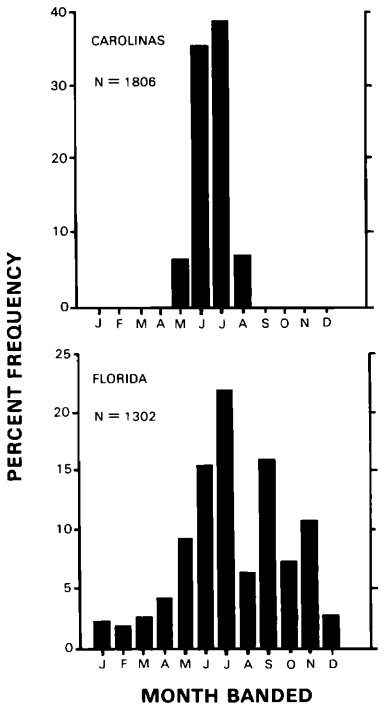

FIGURE 1. Distribution by month of banding of recovered Brown Pelicans.

and migration (see below) then result in mortality. Note that mortality of Florida birds is spread out over a longer period of months and throughout the entire first year, whereas most Carolina birds have died by Apr.

We find it strange that no recovery of Carolina HY and AHY birds was recorded in Jul.–Oct. and Aug.–Sep., respectively. Most mortality of the Carolinas birds occurs during the migration period, Nov.–Dec. and Feb.–Mar., as they move south in the fall and north in the spring. A similar pattern occurs in the Florida adults, but Jan. is the peak time for mortality and some deaths occur throughout the year. Hatching Year birds in Florida present a similar pattern to that of adults, as do the Carolinas birds, but our sample size for the Carolinas is quite small.

Dispersal pattern.—The dispersal patterns of the Carolinas and Florida east and west coast populations are distinctly different (Table 1). Carolina pelicans disperse southward and winter mostly in eastern Florida. No recoveries were found to the north; 72% of the Carolina birds were found dead south of the Carolinas, predominately in east Florida (40%), Florida west coast (18%) and the Florida Keys (8%). Approximately 2% were recovered in Cuba.

Pelicans banded in Florida are primarily year-round residents and tend to stay on their respective coasts. Pelicans of Florida's east coast moved

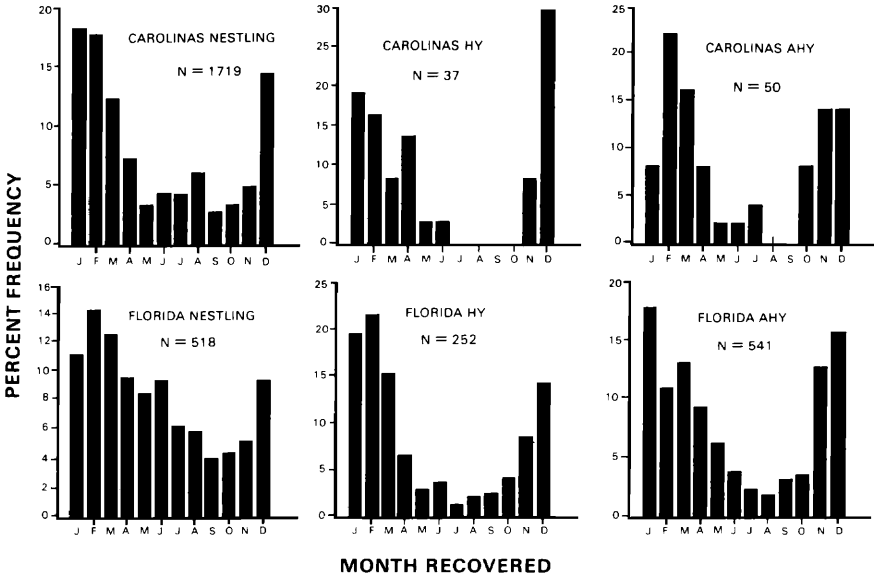

FIGURE 2. Percent frequency by month for recoveries of Brown Pelicans in the Carolinas and Florida, by age of banding: nestlings, Hatching Year birds (HY), and After Hatching Year (AHY) or adults.

north only in small numbers (2.4% in Georgia and 1.6% in the Carolinas), most died in east Florida (55%), but a significant portion were found dead in Cuba (22%), the Keys (10%), and west Florida (8%), where the majority were found north of 26°N (Marco Island).

On the other hand, the vast majority (82%) of the Florida west coast birds were found dead in west Florida where they obviously are year-round residents. Some movement occurred to the south into the Keys and Cuba, and also to the north into Alabama, but none were recovered in Louisiana. Few of these west coast birds move around the peninsula to Florida's east coast. Birds banded in the Florida Keys tend to remain in the Keys with some movement up both coasts of Florida, primarily onto the west coast. Surprisingly, no pelicans banded in the Keys have been found dead in Cuba. However, the small sample of pelicans banded in the Keys is a problem in intepreting the movements of this subpopulation (Kushlan and Frohring 1985).

Carolina and east coast Florida pelicans are found along the Gulf coast, indicating that the populations on the two coasts are not totally separated, but band recoveries suggest that little movement occurs from west to east Florida. We are surprised that pelicans from Florida's west coast are not found in Louisiana. This may indicate that the pelicans of Florida are a distinct subpopulation, with little exchange between subpopulations along the Gulf of Mexico.

TABLE 1. Percent frequency of Brown Pelicans recovery sites in relation to banding site.

Recovery site	Banding site			
	Keys	West Florida	East Florida	Carolinas
Keys	77.3	8.0	9.9	7.5
West Florida	15.1	81.7	8.4	17.7
East Florida	7.5	2.1	54.6	40.1
Carolinas	—	—	1.6	28.4
Cuba	—	4.8	21.9	1.8
Georgia	—	+[a]	2.4	4.1
Bahamas	—	+	+	+
Alabama	—	1.2	—	+
Louisiana	—	+	—	+
Mississippi	—	+	—	+
Other[b]	—	+	+	—
Totals	53	421	822	1924

[a] + = less than 1%.

[b] All single recoveries: Rhode Island, Virginia, Jamaica, Honduras, Guatemala, Mexico, Nicaragua.

Distance between banding and recovery site.—Florida birds moved shorter distances between banding and recovery than did Carolina birds, with significant differences between all age classes (Tables 2 and 3). The pattern of movement is similar between locations, with birds banded as nestlings moving the least distance, Hatching Year birds the farthest, and adults an intermediate distance. Mean recovery intervals (length of time, in years between banding and recovery) reveal a more complicated pattern, but again with significant differences between age classes and locations (Tables 3 and 4). Florida nestlings have the longest mean recovery interval (2.5 yr), and both Hatching Year and adults are similar (1.6 yr). The longest mean recovery interval for the Carolina birds is found in adults (1.8 yr), shortest in HY birds (0.8 yr), and intermediate in nestlings (1.5 yr). All these are significantly different between age classes and location except between nestlings and adults in distance in Florida, and nestlings

TABLE 2. Mean ± Standard Error (number of recoveries) distance from banding site and recovery interval for Brown Pelicans banded in Florida and the Carolinas.

Age class	Florida	Carolinas	$P <$
	Distance (km)		
Nestling	150.1 ± 8.6 (511)	410.4 ± 6.9 (1699)	0.0001
HY	328.1 ± 35.5 (251)	689.0 ± 57.1 (37)	0.0001
AHY	264.1 ± 13.2 (535)	597.9 ± 55.2 (50)	0.0001
	Recovery interval (yr)		
Nestling	2.52 ± 0.15 (518)	1.49 ± 0.05 (1719)	0.0001
HY	1.57 ± 0.26 (252)	0.82 ± 0.17 (37)	0.529
AHY	1.51 ± 0.11 (541)	1.85 ± 0.47 (50)	0.060

TABLE 3. Log transformed *t*-test *P*-values for distance and recovery interval, by age class. *P*-values less than 0.05 are significant.

Age class	Distance		Interval	
	Florida	Carolinas	Florida	Carolinas
Nestling–HY	0.0001	0.0001	0.0001	0.027
Nestling–AHY	0.852	0.0001	0.0001	0.394
HY–AHY	0.0004	0.191	0.0219	0.024

and adults in interval in the Carolinas (Table 4), and HY and adults in distance in the Carolinas.

Plotting the recovery interval and distance from banding site shows that birds banded as nestlings in Carolina disperse farthest during their first year, with movement back toward the nesting colony at about one year of age, followed by dispersal away again during their second year, with movement back toward the nesting colony at about 24 mo (Fig. 3). A similar pattern also occurs during their third year, but the recovery rate is much smaller then, so the pattern becomes less clear. In Florida, of birds banded as nestlings, the initial dispersal away from the colony is much less rapid than that by the Carolina birds (Fig. 3). However, in the second and third year we cannot detect a distinct pattern and it appears that these Florida birds may remain within a couple hundred km of their natal colony after they are about 1 yr old. Carolina birds banded as nestlings move more than 500 km from their colony site at least twice and probably on an annual basis. Florida birds banded as nestlings do not disperse more than 250 km from their natal colonies.

Plotting only Florida birds as nestlings or adults shows a similar sine-wave movement during the 2 yr of available data for adults, with a farther dispersal away from the colonies than is seen in nestlings (Fig. 4) who tend to wander locally until about their first breeding season (3 yr of

TABLE 4. Causes of mortality for banded Brown Pelicans recovered dead.

Cause	Florida			Carolinas			
	Nestling	HY	Adult	Nestling	HY	Adult	Total
Cause unknown (found dead)	299	151	314	1156	25	35	1980
"Natural" causes (predation, disease, starvation, etc.)	60	12	39	154	7	5	277
Hit by vehicle	3	1	4	11	0	1	20
Shot	12	20	45	39	0	5	121
Fishing gear	49	27	46	70	3	2	197
Oil/tar	1	0	0	2	0	0	3
Traps	0	1	0	1	0	0	2
Total	424	212	448	1433	36	48	2601

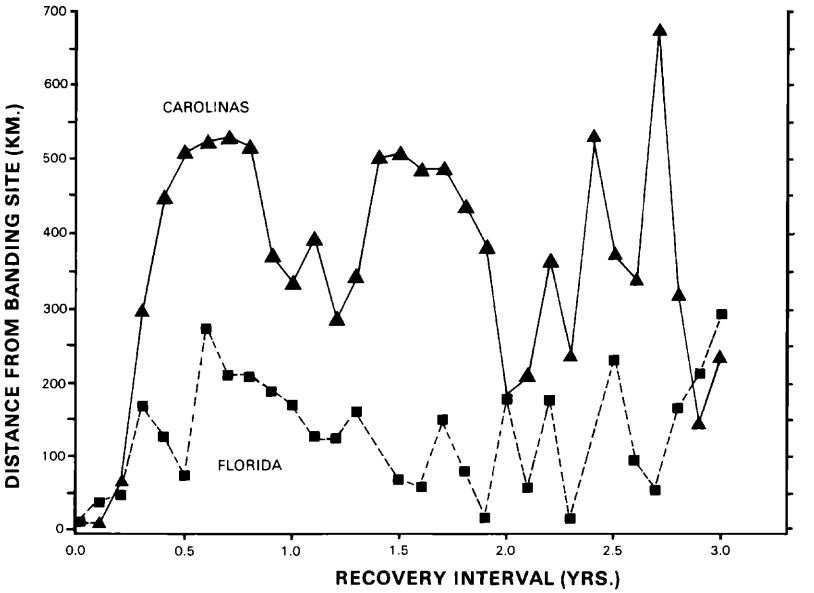

FIGURE 3. Recovery interval in years and distance (km) from banding site for nestling Brown Pelicans banded in Florida and the Carolinas. Each monthly point represents a minimum of three recoveries.

age). Adults move up to 450–575 km from the colony during the non-breeding season.

These data indicate that eastern Brown Pelicans, and especially the more northern populations, should be considered a truly migratory species, undergoing movement south away from the breeding colonies at the end of the breeding season in the last months of the year and back north toward colony sites in the late winter and spring. This pattern was suggested by Palmer (1962) based on data in Mason (1945). Our data clearly indicate that young birds do not travel farther than do adults.

Causes of mortality.—Of the pelicans recovered, the vast majority are reported as "found dead" (Table 4). Of those with a known cause of death, 55% were related to human activity, a level of human-induced mortality that we believe is significant. Pelicans appear to become oiled only rarely, which can be explained because pelicans rarely sit on the water when roosting or loafing and they must visually sight their prey fish prior to entering the water (Schreiber and Schreiber 1982, Schreiber et al.1975). Unusual mortality also occurs (one hit by train), but shooting and becoming entangled in fishing gear are the major human-induced causes of death. Further analysis of these mortality causes by decade shows that shooting has become less important in recent years, but entanglement in fishing gear has increased since the 1940s and now is an important cause of death (Fig. 5).

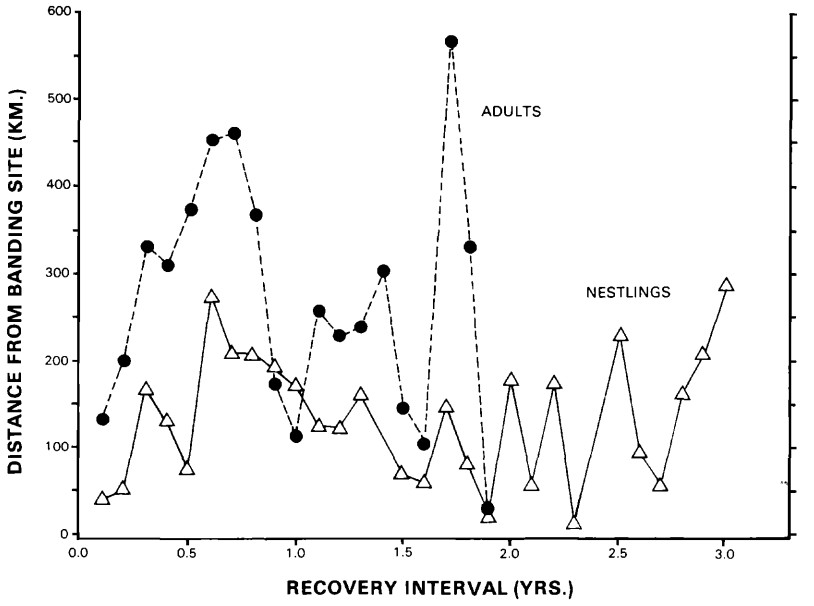

FIGURE 4. Recovery interval in years and distance (km) from banding site for nestling and adult Brown Pelicans banded in Florida.

Longevity and life-table.—The life table method of estimating age-specific survival rates is now considered invalid if only young birds have been banded (Anderson et al. 1985, Henny 1972). Primarily only nestling or fledgling Brown Pelicans have been banded, thus we are unable to calculate a life table for this species at present. Future workers must concentrate on banding nestlings AND adults in order to calculate a life table. Such data are needed for proper management of the species. In as much as the recovery rate of Brown Pelicans is high, this species would seem amenable to such studies. However, our experience indicates that capture of adults in the numbers needed for life table calculations is exceedingly time consuming and must be done outside the nesting season to minimize disturbance of breeding activities (Anderson and Keith 1980). Perhaps an effective method of capture will be devised.

In the meantime, we have plotted the numbers of birds recovered with their age at recovery (Fig. 6). Only 30% of birds banded as nestlings and Hatching Year birds survive their first 12 mo of life after banding (probably 14–15 mo of age as most banding is done when nestlings are 2–3 mo old). Less than 2% live beyond 10 yr of age, and only 3 individuals have survived beyond 20 yr to 31, 37, and 43 yr.

Henny (1972) calculated a similar first year mortality rate of 70% in his smaller sample, but he also showed that Brown Pelicans apparently lose bands from band wear beginning at about 12–15 yr of age. Thus,

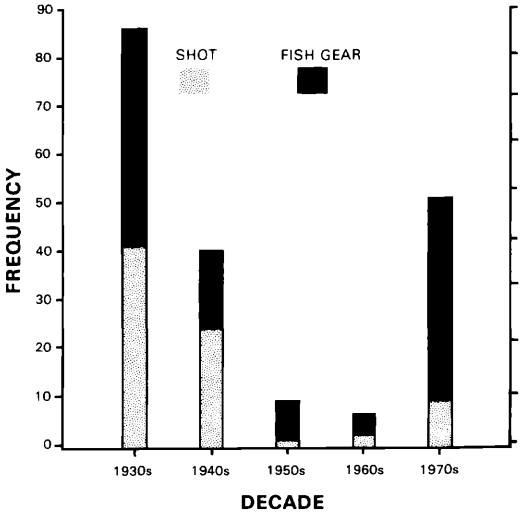

FIGURE 5. Frequency of recoveries by decade of Brown Pelicans reported as either "shot" or "entangled in fish gear."

severe band wear may be related to the lack of recoveries after 20 yr of life in this species. Clearly, a band that is not corroded by salt water must be devised for birds inhabiting the marine environment in order to provide proper data on longevity and mortality rates. Brown Pelicans begin to breed at 3 yr of age (Schreiber et al., in press) and our banding analysis suggests that the effective reproductive life span of this population is only 4–7 yr for most adults.

Reproductive success of Brown Pelicans fluctuates widely between years, being primarily dependent upon fish availability (Anderson et al. 1982), but with "the mean centering around or slightly below one young fledged per nesting pair per year" (Schreiber 1979 and data summarized therein). DDE greatly inhibited reproductive rates in the population of Brown Pelicans nesting in South Carolina at least from the late 1960s to the mid 1970s, and probably earlier (Blus et al. 1979). Thus, at present it is difficult to determine whether the South Carolina population has a higher reproductive success rate than does the Florida population. The available data seem to indicate that about 1 young/pair/year as a long term mean is produced in all populations. We would predict that productivity of a given colony might be independent of post-breeding mortality in the short term. South Carolina Brown Pelicans undergo a distinct migration and that behavior appears to cause higher mortality rates than is found in the Florida birds who move less. The relations between the costs of migration and reproduction should be studied in this species. As the Carolina population recovers from the DDE problems, detailed long term studies of reproductive success and mortality rates will allow us to elucidate the true population dynamics of this species.

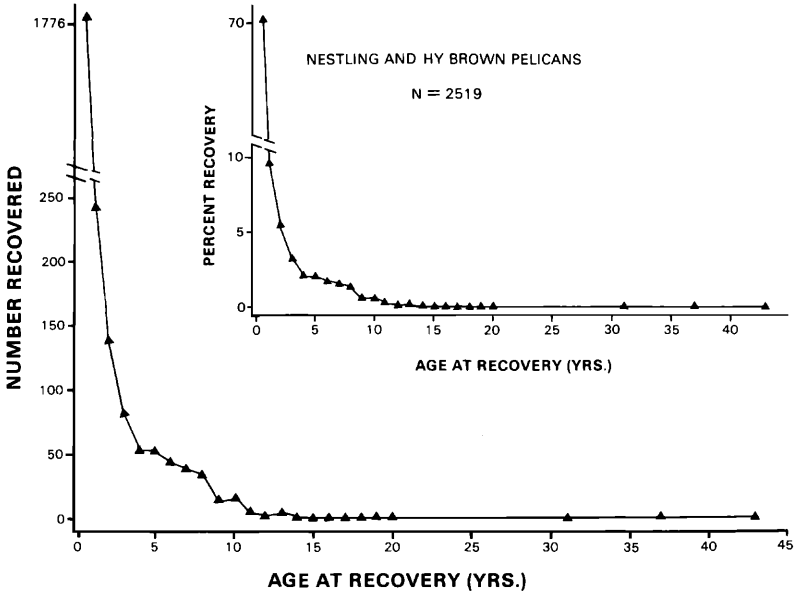

FIGURE 6. Absolute and percent frequency by age at recovery by month for 2519 nestling and Hatching Year Brown Pelicans banded in Florida and South Carolina.

Distribution.—The eight species comprising the family Pelecanidae have an essentially tropical-subtropical distribution or inhabit regions where freezing temperatures rarely occur (Cramp et al. 1977, Crivelli and Schreiber 1984, Palmer 1962). In the eastern United States, Brown Pelicans appear to breed as far north as possible, limited by their physiological tolerance to cold temperatures (Schreiber 1980). The exposed pouch and webbed toes are affected especially (Kale, pers. comm.). We suggest that cold, including cold weather as it affects the surface availability of fish, is a cause of the origin of the southern movement of Brown Pelicans at the end of the breeding season in the eastern portion of their range. Our data show significant differences in the recovery interval between Carolina and Florida populations during post-fledging periods, and Carolina birds have a higher initial mortality rate. We suggest these northern birds migrate because they cannot tolerate the cold weather and in so doing they incur an added mortality cost. In spring they migrate north to breed at the periphery of their range. White-bellied or juvenile birds are not or only rarely found nesting in Florida colonies (Schreiber et al., in press) but they breed (although rather unsuccessfully) in South Carolina and Louisiana (Blus and Keahey 1978). Perhaps these younger birds are unable to breed in Florida because of competition with adults for nest sites. The relations between availability of food, availability of nesting habitat, behavioral interactions between age classes, and atmospheric conditions should be investigated in this species.

CONCLUSIONS

Brown Pelicans are extremely popular birds and recoveries of banded birds are frequent. Banding is the only way to obtain certain information about this species. Continued studies of reproductive success in individual colonies throughout the range of Brown Pelicans, along with banding of large numbers of adults and nestlings should be carried out. Such data will allow further understanding of their mortality, migration, and life span characteristics. This information is necessary for a complete understanding of Brown Pelican natural history.

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