THE DYNAMICS OF SUBADULT FLOCKS OF WHOOPING CRANES WINTERING IN TEXAS, 1978-79 THROUGH 1982-83

A Thesis

by

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THE DYNAMICS OF SUBADULT FLOCKS OF WHOOPING CRANES

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ABSTRACT

The Dynamics of Subadult Flocks of Whooping Cranes
Wintering in Texas, 1978-79 through 1982-83
(August 1984)
Mary Anne Bishop, B.B.A., University of Wisconsin
Chairman of Advisory Committee: Dr. R. Douglas Slack

Subadult flocks of color-banded whooping cranes were studied on the wintering grounds at Aransas National Wildlife Refuge, Texas for 1978-79 to 1982-83. Data were collected from aerial survey maps for 1978-79 through 1982-83 and from field observations during 1980-81 through 1982-83 winter seasons. Subadult flock composition, habitat selection, movements, daily activities, and intraflock and extraflock relationships were examined.

On the wintering grounds, color-banded subadults joined flocks composed primarily of nonbreeding cranes, including sexually immature subadults, and mature, unpaired adult cranes. Average seasonal flock size varied between 4.4-5.6 cranes over the 5 seasons. Fluctuations in flock size and composition appeared to be a result of seasonal availability of food on the marsh and pair bonding.

Subadult and adult whooping crane habitat selection was similar. Cranes fed in the seasonally flooded salt marsh during the fall and spring. During the colder winter months, cranes foraged in shallow bays. In early fall, unusual food concentrations in the marsh and uplands attracted large numbers of subadult and unpaired adult cranes. These aggregations were temporary and dispersal occurred with the apparent depletion of the food resource.

Subadults principally utilized areas not defended by paired cranes. From 1976-83 the subadult flocks preferred 3 traditional sites: Dunham Bay, middle and southern Sundown Bay, and Ayres and Roddy islands. Flock site selection was related to 1st year home range.

Pair formation occurred in subadult flocks. Six pair bonds formed between dayds that exhibited high frequencies of association over 1-3 seasons.

DEDICATION

This thesis is dedicated to my parents, Joyce and Joe Bishop who have always encouraged a curiousity, enthusiasm and respect for knowledge.

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Other crane enthusiasts from the U.S. and Canada have supported this study since its inception. Whooping Crane Conservation Association members James Mallott, Jim Chism and Jerome Pratt, the Secretary-Treasurer, all gave encouragement and important support. Drs. George Archibald, Scott Melvin, Georgette Maroldo, and Scott Derrickson provided advice during various stages of the project.

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INTRODUCTION

North America's tallest bird, the whooping crane (Grus americana) has long been the symbol of endangered wildlife in our country. From a low of 21 birds in 1941, its numbers have grown to approximately 144 in the wild and captivity in December 1983. The present population includes 75 birds in the Wood Buffalo National Park, Northwest Territories Canada-Aransas National Wildlife Refuge, Texas USA population (Pratt 1984). Since the 1940's, research by the U.S. Fish and Wildlife Service (USFWS), National Audubon Society (NAS), Canadian Wildlife Service (CWS), Texas Parks and Wildlife Department (TPWD), and the efforts of the Whooping Crane Recovery Team and the Whooping Crane Conservation Association have contributed to the conservation and management of whooping cranes that winter at Aransas National Wildlife Refuge (ANWR).

Since the summer of 1977, prefledged whooping cranes have been individually marked using colored leg bands on their breeding grounds in Wood Buffalo National Park (WBNP), Canada (Kuyt 1978). As of March 1984, there are an estimated 26 banded whooping cranes in the WBNP-ANWR population including 4 banded in 1977, 5 in 1978, 4 in 1979, 3 in 1980, 1 in 1981, 3 in 1982, and 6 in 1983 (T.V. Stehn and E.F. Johnson, unpubl. rep., U.S. Dep. Inter., Fish and Wildl. Serv., ANWR, Austwell, Tex., 1984). This group of individually identifiable whooping cranes has afforded a unique opportunity to study the life cycle of this endangered bird.

The format and style of this thesis follow that of The Journal of Wildlife Management.

While the juvenile and the breeding adult stages of the WBNP-ANWR population have been studied and described (Stevenson and Griffith 1946; Allen 1952, 1956; Novakowski 1966; Walkinshaw 1973; Blankinship 1976; Kuyt 1981a,b), there have been very few studies of subadult whooping cranes (Kuyt 1979a,b; Bishop and Blankinship 1982), because of difficulties in identifying and following individual cranes over a period of years. The subadult stage usually begins at about 10 months of age when the young bird either willfully separates from its parents, or is driven off by its parents. From that time, until the crane becomes sexually mature it is considered a subadult.

The initiation of the subadult stage has been observed on the wintering grounds at ANWR by Blankinship (1976). He reported a chick driven from its parent's territory shortly after its widowed female parent remated. There are also historical records of parents migrating north from ANWR without their young of the year (ANWR Files). Bard (1956) reported on 2 chicks of the year deserted in Saskatchewan during spring migration. In spring 1983, a combined USFWS, CWS, and NAS team radio-tracked 2 families during their spring migration. Both pairs arrived at WBNP with their chick (T.V. Stehn, unpubl. rep., U.S. Dep. Inter., Fish and Wildl. Serv., ANWR, Austwell, Tex., 1983). Thus, while the initiation of the subadult stage in the ANWR population has occurred as early as 8 months of age, initiation usually occurs at 10-11 months of age, after the families have migrated from ANWR.

The only other information available on the transition from chick to subadult comes from an experimental flock of whooping cranes at Grays Lake National Wildlife Refuge, Idaho-Bosque del Apache National Wildlife

Refuge, New Mexico. Since 1975, greater sandhill cranes (*G. canadensis tabida*) have been used as foster parents to this flock of whooping cranes. The breakup of the foster-parent families is similar to those observed among sandhill crane families. Prior to the family breakup, the whooping crane chick begins to spend time away from its parents during daily activities. Some of the chicks voluntarily separate from their parents while still on the wintering grounds. Most families breakup during spring migration, especially at staging areas in Colorado. Only a few pairs return with their young to their nesting territories and then chase the chicks off (Drewien and Bizeau 1978; R.C. Drewien, unpubl. rep., U.S. Dep. Inter., Idaho Coop. Wildl. Res. Unit, Moscow, Idaho, 1982).

Prior to color banding, it was often postulated that subadult cranes became "wanderers" during the breeding season (Walkinshaw 1973). Kuyt (1979a,b) documented the first evidence of sexually immature whooping cranes on the WBNP breeding grounds. He located 7 of the 9 birds banded in 1977 summering near the nesting area during 1978. All but 1 of the 7 were in a 14 km x 5 km area.

In the experimental population both sandhill cranes and whooping cranes do not always spend the summer near their original hatching grounds. Nor do they always spend consecutive summers in the same area. Sandhill cranes join large flocks of subadults, up to 100 in number and spend their summers in a flock. While some of the younger subadult whooping cranes in the experimental flock associated with sandhills in these flocks, others have become increasingly more solitary (Drewien 1973, Drewien and Bizeau 1978).

On the Texas wintering grounds, paired adult whooping cranes will defend territories. Prior to the initiation of color banding in 1977, flocks of apparently nonterritorial whooping cranes had been observed at ANWR (Stevenson and Griffith 1946, Allen 1952, Walkinshaw 1973, Blankinship 1976). Bishop and Blankinship (1982) reported flocks with color-marked whooping cranes at ANWR from 1978-81. They found that flocks consisted of unpaired adult and subadult cranes. Flock size and age-class composition fluctuated throughout the season.

Except for studies in captivity (Kepler 1976, 1978) there is little information on pair formation in whooping cranes. In 1980, 2 birds banded in 1977 nested with unmarked birds (>4 years of age) providing the first evidence of wild whooping cranes nesting at 3 years of age (Kuyt 1981b). Blankinship (1976) reported a widowed female with a chick remating a few weeks after her mate disappeared at ANWR. Most recently, Bishop and Blankinship (1982) observed both 2- and 3-year-olds leave subadult flocks with unmarked birds (>4 years of age) and establish territories while on the ANWR wintering grounds. To date, no pair bonds have formed among the whooping cranes in the experimental flock. However, 3-, 4-, and 5-year-old males have established and defended territories on the summer breeding grounds (R.C. Drewien, unpubl. reps., U.S. Dep. Inter., Idaho Coop. Wildl. Res. Unit, Moscow, Idaho, 1981, 1982).

The objectives of this study were to: (1) monitor the habitat selection and local movements of subadult flocks on the ANWR wintering grounds; (2) evaluate subadult flock composition by age class and identifiable individuals throughout the winter season; (3) analyze the activity cycle of subadult cranes; (4) examine subadult intraflock and extraflock relationships; and (5) investigate pair formation within subadult flocks. This study was part of an ongoing NAS research project begun in November 1970 whose goal is to study the behavior and habitat use of whooping cranes wintering on the Texas coast (Blankinship 1976).

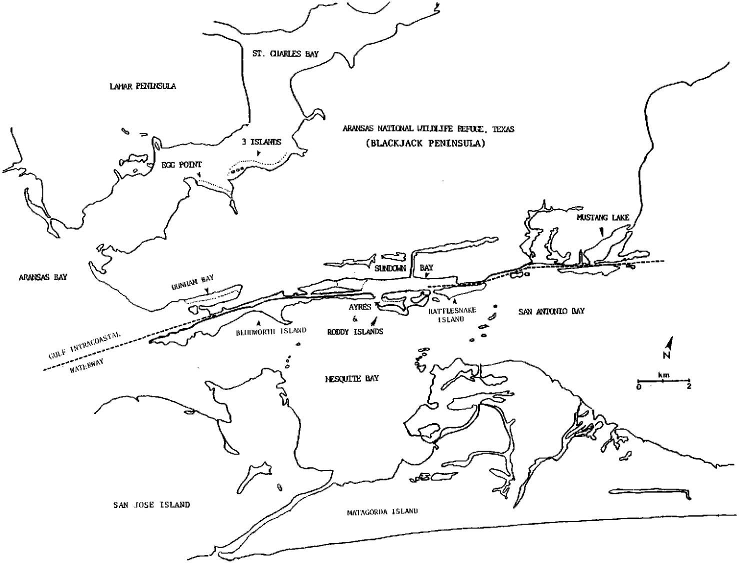
STUDY AREA

Aransas National Wildlife Refuge, located on Blackjack Peninsula 60 km northeast of Corpus Christi, Texas, consists of approximately 21,862 ha of bay shorelines, salt marshes and flats, grasslands, and live oak (*Quercus virginiana*) and redbay (*Persea borbonia*) thickets. Approximately 7,692 ha of nearby Matagorda Island were administered as part of ANWR during this study. The refuge lies principally within Aransas County with a small portion in Refugio County. It is bounded by St. Charles Bay on the west, and by Aransas, Mesquite, and San Antonio bays on the east (Fig. 1). San Jose and Matagorda islands serve as barriers to the Gulf of Mexico.

Field work was concentrated in 4 areas (Fig. 1): western shore of Dunham Bay; middle and southern Sundown Bay; eastern shore of Ayres Island; and eastern shore of St. Charles Bay from Egg Point to Little Devil Bayou. These shorelines were accessible via a small boat and allowed unobstructed, close-up observation of the cranes. All of the study areas except St. Charles Bay border the Gulf Intracoastal Waterway (GIWW). Whooping cranes were exposed throughout the season to barges, tugs, oilfield crew and service boats, commercial fishing boats, and recreational craft.

Dunham and Sundown bays are both shallow (0.15-0.6 m), thus effectively preventing most larger boats from entering these bays. Sports fishermen regularly enter the bays in the fall but are rarely seen during winter, while commercial fishermen set crabtraps in both bays during fall and early spring. The western shore of Ayres Island borders the GIWW. The southern ends of Ayres and Roddy islands border

Fig. 1. Study area at Aransas National Wildlife Refuge (ANWR), Texas, with principal observation sites outlined with dotted lines. Gulf Intracoastal Waterway (GIWW) located with dashed line.


ST. CHARLES BAY
LAMAR PENINSULA
ARANSAS NATIONAL WILDLIFE REFUGE, TEXAS
(BLACKJACK PENINSULA)
3 ISLANDS
EGG POINT
MUSTANG LAKE
SUNDOWN BAY
ARANSAS BAY
DUNHAM BAY
AYRES & RODDY ISLANDS
RATTLESNAKE ISLAND
SAN ANTONIO BAY
BLUDWORTH ISLAND
GULF INTRACOASTAL WATERWAY
N
km
0 2
MESQUITE BAY
SAN JOSE ISLAND
MATAGORDA ISLAND

Wynne's Cut, a narrow channel used by crew boats and recreational craft for access to Mesquite Bay. The inlet between the 2 islands is too shallow (0.1-0.5 m) for all but recreational airboats.

St. Charles Bay is deeper than the other 3 sites (0.3-1.5 m) and is a popular fishing and hunting area. Seasonal waterfowl hunting is allowed along the nonrefuge portion of the western shore of St. Charles Bay. Sports and commercial fishermen operated crabtraps and trotlines along the eastern shore throughout the season.

The salt marshes and flats associated with each study area are dotted with shallow brackish and salt water ponds. The size and depth of these semi-permanent and permanent ponds vary considerably with seasonal high tides, precipitation and associated drainage towards the bays, and prevailing winds. Dominant vegetation in the salt marshes are: saltmarsh cordgrass (Spartina alterniflora), glasswort (Salicornia spp.), saltgrass (Distichlis spicata), saltwort (Batis maritima), sea-oxeye (Borrichia frutescens), and saltflat-glass (Monanthochloe littoralis).

In the bays, the stout razor clam (Tagelus plebeius) is the most common bivalve (Harper 1973, Bishop and Blankinship 1982) and is an important food item of the cranes while at ANWR, especially during the lower water levels of December and January (U.S. Dep. Inter. 1980). Blue crabs (Callinectes sapidus) are also an important crane food item. High tides in the fall and spring and heavy rains facilitate movement of blue crabs into the tidal flats and make them readily available to the cranes (Hedgpeth 1950, Blankinship 1976). Other invertebrates consumed by whooping cranes in the marsh include fiddler crabs (Uca spp.) and the pulmonate snail (Melampus bidentatus) (Allen 1952, Bishop and Blankinship 1982).

Cattle grazing has been a traditional land use of the Blackjack Peninsula since the 1880's. After the refuge was created in 1937, livestock grazing by permittees continued until 1973. After a 9 year absence cattle grazing was initiated in July 1982. During the 36-year period of continuous grazing, burning and rotary mowing were used irregularly as additional means to control brush invasion. Over the years, the lack of fire and overgrazing by cattle changed the Peninsula's upland habitat from oak savannah-tall grass prairie to primarily brushland dominated by live oak mottes interspersed with running live oak brush (Scifres and Kelley 1979).

Since 1973-74, ANWR personnel have practiced prescribed burning of upland habitat as a means of reducing heavy grass cover, controlling shrubby vegetation, and stimulating the new growth of grasses and forbs. Burned areas on Blackjack Peninsula have been attractive to whooping cranes as feeding sites. Cranes have been observed feeding on parched acorns and on snails in small ponds on the burns (ANWR Files, Bishop and Blankinship 1982). Cranes may feed on insects, other invertebrates, and snakes on the burns (Labuda and Butts 1979).

The climate at ANWR is humid, subtropical characterized by mild winters and warm summers. Precipitation averages 93.5 cm annually with peak rainfall occurring in September. The high September rainfall is a result of heavy downpours accompanying tropical storms. Warm southeasterly winds prevail year round on the refuge. The winds have a moderating effect so that temperatures along the coast are often warmer during the winter, and cooler during the summer than nearby inland areas. Prolonged southeasterly and easterly winds also push water from the Gulf of Mexico into the bays and salt flat ponds that are frequented by the whooping cranes. Polar Canadian air masses, "northers," are characteristic of late fall and winter months and often bring 2-3 days of cooler weather. Strong winds often associated with the "northers" push water out of the shallow salt flat ponds and can cause the mean water level in the bays to drop as much as 0.5-1.0 m (U.S. Dep. Com. 1972).

There is a slight diurnal Gulf tide with a maximum range <0.6 m (Hedgpeth 1950). Seasonal high tides in the bays occur during the fall and spring. These higher levels may be maintained for days or a week or 2 at a time, flooding the salt marsh and its semi-permanent and permanent ponds (Gunter 1950). Storms and winds can also modify water levels.

METHODS

Marking Technique

Study birds had been color banded as prefledged chicks, 60-65 days old, in WBNP by the CWS (Table 1). Two sizes of color bands were used: 75 or 80 mm high lymply plastic and 38 mm plexiglass color bands. The bands were the same diameter as standard No. 9 aluminum bands and were placed above the tibio-tarsal joint. An additional standard USFWS aluminum band was placed above the tibio-tarsal joint or above the foot (Kuyt 1978, 1979b, unpubl. rep. Can. Wildl. Serv., Edmonton, Alberta, 1980). Combinations of distinctive color bands allowed for identification of individuals and age class. For this study, all banded birds were also assigned an identification number. (Table 2). Three subadult birds, 1 from 1977, 1 from 1979, and 1 from 1980 were not banded as chicks and were therefore unidentifiable.

Field Observations

Dates of Study

Field observations were for 3 winter seasons, 1980-81 through 1982-83. In 1980-81 daily observations began the 1st week in November 1980 and, except for 19-31 December 1980 or severe weather conditions, continued until 28 April 1981. For 1981-82 daily field observations began with the arrival of the 1st cranes on 20 October 1981 and, except for severe weather conditions, continued until the last cranes departed on 3 May 1982. During 1982-83 winter season, field observations were limited to 14 field days and included observations in November 1982

Table 1. Number of banded whooping cranes by hatch year wintering at ANWR and environs for 1978-79 through 1982-83 seasons.

		Age class					
Year hatched	Banded at WBNP	Chicks banded/ unbanded	1 Yr	2 Yr	3 Yr	4 Yr	5 Yr
1977	9	8[a]/1	9	8	7	6[b]	6[b]
1978	8	7[c]/0	5	5	5	5	
1979	6	5 /1	5	5	5		
1980	6	4 /2[d]	3	3			
1981	3	2 /0	1				
1982	7	5[e]/1					

[a]One bird did not winter on Texas Coast. Observed migrating with sandhills spring 1978.
[b]One bird not confirmed on its Matagorda Island wintering area but believed to have nested 1982, 1983 and sighted during fall migration 1983.
[c]One chick disappeared November 1978, presumed dead.
[d]One chick disappeared December 1980, presumed dead.
[e]Two of 5 banded chicks found dead at ANWR.

Table 2. Banded subadult whooping cranes wintering at ANWR, and environs, 1980-81 through 1982-83 winter seasons.

Cohort	Band colors[a]	Bird number	Sex[b]
1977	R-G	01	F
	R-R	02	
	R-W	03	M
	R-Nil	04	M
	G-R	05	F
	W-R[c]	06	M
	B-R	07	M
1978	RWR-B	10	M
	RWR-O	11	
	Nil-W	12	M
	S[d]	13	M
	Nil-RWR	14	
1979	BWB-R	20	
	BWB-B/R	21	M
	BWB-R/W	22	
	R-BWB	23	
	R/W-BWB	24	M
1980	R-R/W	30	M
	R/W-R[e]	31	M
	R-R/B	32	M
	R/B-R	33	F
1981	G-R/W	40	

[a]Color codes for left-right leg bands, R = red, B = blue, G = green, W = white, O = orange, Nil = no band, RWR = red band with white stripe in center, BWB = blue band with white stripe in center, G/R = green band over a red band on same leg. Double bands have since interlocked on Birds 21, 30, 32, 33, and 40.

[b]Presumed sex determined from behavioral observations at ANWR and WBNP except 1980 cohorts determined from blood samples.

[c]Not seen since summer 1981, presumed dead.

[d]This bird lost its 1 color band and only retains a USFWS aluminum band.

[e]Not seen since spring 1981, presumed dead.

and January-March 1983.

Locating Birds

Birds were primarily located and identified from boats operating in the GIWW and in various bays at ANWR. GIWW platform markers were also used as elevated observations posts to locate birds in the marsh. Between 12 April and 3 May 1982, and on a few occasions in 1983, subadults were located in the marsh from a car parked on a road parallel to Sundown Bay marsh and on a road that penetrated a short ways into the marsh. There were no observations of cranes on burn areas during this study. Aerial surveys by ANWR and TPWD also provided additional information on locations of banded subadults.

Data Collection

Data were collected from 2 primary sources: aerial survey maps for 1978-79 through 1982-83 and my field observations for 1980-81 through 1982-83. Additional behavioral observations were provided from boat observations by the NAS (D.R. Blankinship, unpubl. data, Biologist, NAS, Rockport, Tex.) and ANWR personnel (T.V. Stehn, pers. commun., Biologist, U.S. Dep. Inter., Fish and Wildl. Serv., ANWR, Austwell, Tex.).

Aerial surveys were conducted by ANWR and TPWD 1-3 times weekly, or biweekly. Areas surveyed included ANWR and Matagorda and San Jose islands, Lamar Peninsula, and Welder Point. For 1978-79 through 1980-81, both ANWR and TPWD aerial survey maps were used, accounting for 50, 62, and 53 survey flights per season, respectively. For 1981-82 and

1982-83 only ANWR aerial survey maps were examined, accounting for 18 and 27 census flights per respective season. Aerial survey maps were visually inspected for numbers and locations of subadult flocks. My field observations during the 1980-81 through 1982-83 provided information on numbers, composition, movements, and social behavior of the subadult flocks .

A subadult whooping crane was any banded bird that: (1) was no longer accompanied by its parents; (2) had not nested in Canada; and (3) was not paired and defending a winter territory. For field observations a subadult flock was defined as a group of 2 or more birds, at least 1 of which was a banded subadult, in close proximity to each other and interacting. All adult-plumaged, unbanded birds in subadult flocks were defined as at least 4 years old in 1980-81, 5 years old in 1981-82, and 6 years old in 1982-83. Therefore, the 3 subadult birds not color-banded as chicks would have been counted in this unbanded bird age category.

Because banded subadults were rarely noted during aerial surveys, it was not possible to identify subadult flocks <u>per se</u>. Therefore, for aerial survey data a subadult flock was any non-family group of 3 or more. Flocks of 2 were counted as a subadult flock only if at least 1 of the members was positively identified as a color-banded subadult.

For my field work, all observations of marked subadults were noted including the date, time, location, any association with other birds, and any movements. Observations of flocks in the marsh were limited due to high vegetation and the wariness of the birds. Therefore, field observations depended almost exclusively on locating and identifying the subadults in the bays.

Whenever possible, flocks were observed for extended time periods from a chair placed in the water behind a 4.1 m outboard boat. Observations were made using a 15-60x telescope and 7 X 35 binoculars.

During 1980-81 the method used in observations was focal-animal sampling. This sampling method records spontaneous and intensive social interactions of any individual, or in this case, a specified group of individuals, as well as group members' nonsocial behaviors (Altmann 1974). A record was made of the length of each sample period and for each focal individual, the amount of time during the sample that the individual was actually in view. Behavioral data during 1981-82 and 1982-83 included ad libitum notes, activity schedules, and nearest neighbor determinations (Altmann 1974, Lehner 1979).

Throughout the 1981-82 season, subadult flock members were sampled for activity schedules using instantaneous (point) sampling (Altmann 1974). Flock members were sampled individually in a random order without replacement. The sampled bird's behavior was recorded at 12 or 15 sec intervals using a wristwatch or an automatic timer. Sampling periods were for 12 or 15 min whenever possible. Time budgets for subadults located in the bays were collected from 16 November 1981-31 March 1982. From 1 April-3 May 1982 activities of subadult flock members in the marsh were also sampled.

Nearest neighbor data were collected during flock observations from December 1981-April 1982. Nearest neighbor scan samples, a type of instantaeous sample whereby several individuals are "scanned" at a point in time and each crane's closest companion is noted (Altmann 1974), were taken at random intervals for all visible flock members during observation periods.

Descriptions of behavioral units were adapted from the ethogram for the Japanese crane (G. japonensis) devised by Masatomi and Kitagawa (1975), from whooping crane postures observed at Patuxent Wildlife Research Laboratory and the International Crane Foundation (C.B. Kepler and G. Archibald, unpubl. rep., U.S. Dep. Inter., Fish and Wildl. Serv., Laurel, Md., no date) and from ethological descriptions of sandhill cranes by Nesbitt and Archibald (1981) and Voss (1976). Behaviors were coded to a combination of letters and numbers and recorded on a data sheet or on cassette tapes and later transcribed.

Data Analysis

Initial flock counts from the ground and air, nearest neighbor determinations, and time budget data provided the data base for computer analysis. Most analyses were performed using the Statistical Analysis System (SAS) (SAS Inst. 1982) software package and the Amdahl 470 computer at Texas A&M University or computers at the Northeast Regional Data Center in Gainesville, Florida. For all other analyses, nonparametric tests were used (Siegel 1956). Statistical tests were considered significant at the 0.05 level of probability.

Average monthly and seasonal (October-April) flock size, and seasonal range of flock size for specific areas, for all ANWR locations and surrounding environs (including San Jose and Matagorda islands), and for habitat (marsh and uplands or bays) were calculated for the 5 seasons beginning 1978-79 and ending 1982-83. For 1978-79 and 1979-80, average flock sizes and ranges were calculated from ANWR and TPWD aerial survey data and from NAS boat observations (D.R. Blankinship, unpubl. data). For 1980-81 through 1982-83 average flock sizes and ranges were obtained by combining aerial survey data and initial bird counts for all subadult flock field observations, including all incidental sightings. Because aerial surveys rarely identified color-banded subadults, subadult flocks of 2 were not completely sampled for any of the 5 seasons.

In order to detect any bias in my interpretation of aerial survey maps, I compared flock sizes by data collection method. Using the 1980-81 data, average monthly flock size for all flocks ≥ 3 obtained for aerial survey data and for field observations were compared for significant differences using a Wilcoxon matched-pairs signed-ranks test.

Using aerial survey data for all 5 seasons, I analyzed relationships between total numbers of cranes in flocks ≥ 3 and habitat type per aerial survey, and between total numbers of flocks ≥ 3 and habitat type per aerial survey using a 3-way analysis of variance with the SAS general linear models procedures (SAS Inst. 1982) was performed. Total numbers of cranes in flocks ≥ 3 or total number of flocks with ≥ 3 cranes per aerial survey were used as the response (dependent) variables. Habitat type (either marsh and uplands or the bays) and time (winter season and month) were the predictors (independent) variables.

A 2-stage test was used to analyze the underlying frequency distribution of flock sizes. Using a FORTRAN program developed by Gates and Ethridge (1972) for fitting discrete frequency distributions, the theoretical distributions of seasonal flock sizes were generated for each season by data collection method. The observed frequencies were 1st compared to their respective theoretical zero-truncated Poisson distribution using Chi-square goodness-of-fit statistic. If significant differences were detected, the observed distribution was compared to a theoretical negative binomial distribution using the same test statistic.

Initial bird count and flock membership for all field observations were used to determine flock composition and associations among marked birds throughout each season. For 1980-81 through 1982-83 seasons, a frequency of association (FOA) (Hawkins and Klimstra 1970) between any 2 banded subadults was calculated based on the number of times that the 2 were observed in the same initial flock count, divided by the pair's pooled number of initial flock count observations for that season. This proportion was multiplied by 100 and expressed as a percentage. Thus a FOA could vary from zero (when 2 cranes were never observed in the same initial flock counts the whole season) to 100% (when 2 birds were never seen without each other). The FOA's were calculated only for those subadults sighted >5 times in a season. Frequencies of association were also used to determine any subgroups within the flocks.

Five classes were used to separate associations. A FOA >50% was high, 25-50% was moderate, 10-24% was low, and below 10% was considered very low. A score of zero constituted no association.

The distribution of frequencies of association were compared by season and by age classes. A Kolmogorov-Smirnov (K-S) statistic was used to test for significant differences.

Monthly age class composition for subadult flocks during the 1980-81 and 1981-82 seasons was used to describe a "typical group" (Underwood 1981). The total number of cranes sighted is the sum of all initial subadult flock counts:

$$\sum_{j=1}^{q} x_j$$

where q is the number of initial flock counts, the j^{th} flock having x_j members, and each member of the j^{th} flock has $x_j - 1$ companions.

The typical subadult flock member sighted has C companions, where:

$$C = \sum_{j=1}^{q} x_j (x_j - 1) \Big/ \sum_{j=1}^{q} x_j = \left(\sum_{j=1}^{q} x_j^2 \Big/ \sum_{j=1}^{q} x_j \right) - 1$$

The flock containing the typical subadult flock member has C_1 members of a given age class, y, where y_j is the number of cranes of that age class in the j^{th} flock and

$$C_1 = \sum_{j=1}^{q} (x_j \, y_j) \Big/ \sum_{j=1}^{q} x_j$$

For all these calculations, initial flock counts were used. Any unidentified flock members were subtracted from these counts.

Nearest neighbor scan samples were analyzed to obtain a similarity index: $D = x + z / 3n + y$; based on (x) the number of times bird x was closest to z, (z) the number of times bird z was closest to x, (n) the total number of nearest neighbor samples for the month, or season, and (y) the number of times bird x and bird z were both members of the sampled flock (D.B. Holiday, pers. commun., Dep. Statistics, Texas A&M Univ., College Station, Tex.). A similarity measure of zero indicated that the 2 birds were never nearest neighbor or were never in the same flock. A similarity measure of 1 indicated that the birds were always together and were always mutually nearest neighbors.

Similarities were then determined monthly and seasonally for all pairs of banded subadults and 1 unbanded bird. These similarities were analyzed using SAS statistical software package, procedure ALSCAL (SAS Inst. 1983) for multidimensional scaling. Multidimensional scaling provided a 2-dimensional configuration in which similar birds tend to be close to each other, while not so similar birds tend to be further apart. A measure of how well the configuration fits the data, referred to as stress, was expressed as a percentage. Stress categories were designated as follows: 0.0 - 2.5% perfect fit, 2.5 - 5.0% excellent fit, 5.0 - 10.0% good fit, 10.0 - 20.0% fair fit, and >20.0% a poor fit.

Time budget samples were collected to determine how banded and unbanded flock members spent their time. Frequencies of behaviors for flock members observed in the bays were tabulated separately from behaviors observed in the marsh. This separation of data was necessary as time budgets on birds located in the marsh were limited to April and May 1982 and were collected after most cranes had migrated.

Frequencies of behaviors in the bays were analyzed by location, group size, and time of day. A 2-sample _t_-test for proportions was used to detect significant differences in the occurrence of behaviors by location and by group size.

RESULTS AND DISCUSSION

Habitat Selection

Seasonal Trends

Aerial survey data for 1978-79 through 1982-83 was analyzed for habitat preferences. The number of subadult flocks observed in the marsh and uplands were compared with the number of subadult flocks observed in the bays. The number of flocks per aerial survey was found to differ significantly (App. 1) (ANOVA; $F = 4.92$, $df = 69, 331$, $P < 0.01$) by the month, year, and habitat. Similarly the total number of cranes in flocks per aerial survey varied significantly (App. 2), (ANOVA; $F = 6.14$, $df = 69, 331$, $P < 0.01$) by the month, year, and habitat. This significant 3-way interaction precluded any multiple comparison of means.

Generally subadults followed the same seasonal trends in habitat selection as the paired adults and families. When they 1st arrived in mid- to late October they fed principally on blue crabs in the salt marsh (Blankinship 1976, U.S. Dep. Inter. 1980). Peak flock use of the salt marsh and upland habitats was in November and December (Fig. 2) and was related to unusual food concentrations.

Flocks were never observed in the bays during October for all 5 seasons (Fig. 2). During November flocks were recorded in the bays; however, the majority of the flocks were still observed in the marsh. Usually by early December as water levels dropped and colder weather set in, subadult flocks moved out to the bays to feed. While in the bays, the cranes were observed probing the bottom and feeding on clams, most

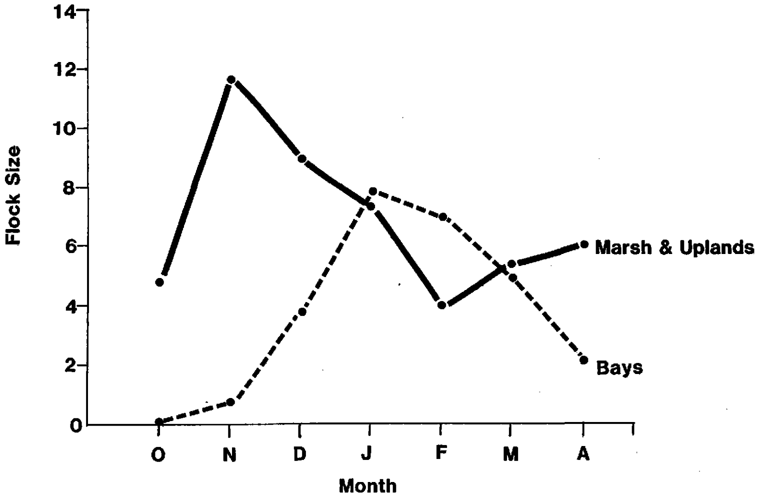


Fig. 2. Average number of whooping cranes in subadult flocks per aerial survey by habitat, 1978-79 through 1982-83 winter seasons.

notably stout razor clams. Occasionally blue crabs, and less often eels (species unknown) were caught and eaten (Blankinship 1976, this study).

From December until March the cranes were observed feeding in the bays in larger flocks ranging up to 19 birds. Aerial data for the 5 winter seasons indicated that the highest average flock size in the bays occurred in January (Fig. 2, p. 24). During the winter months subadult flocks and subgroups within the flocks regularly frequented the salt marshes adjacent to the bays they fed in. From mid-March until April migration the subadults spent the majority of their time feeding in the salt marsh and in flooded salt flat ponds.

Flock preference for the marsh during fall and early spring coincides with the availability of blue crabs. In his study of the ANWR salt marsh, Hedgpeth (1950) noted that there was a steady supply of small crabs entering the salt flats from early summer to near midwinter. The greater part of the population of larger blue crabs moved into the salt marsh with the high tides typical of fall and spring or during irregular flooding associated with hurricanes during summer and early fall. He noted that during the colder months, crab movements were limited.

This fall and spring preference for the marsh is influenced by 2 other factors. First may be the increased availability of insects in the marsh during the warmer fall and early spring months. Second is the high water in the bays during the fall and spring. Whooping cranes were rarely seen foraging in water higher than approximately 40 cm.

Flocks on upland areas have been associated with both acorns and prescribed burns, principally during the fall and early winter. The acorn mast matures from late August to early December, with most nuts falling to the ground before December (U.S. Dep. Agric. 1965). Throughout the 1940's, small groups of whooping cranes were observed feeding on fall acorn crops in the thicketized oak habitat that adjoins the salt marsh (Stevenson and Griffith 1946, Allen 1952). When scrub oak areas were mowed to control brush during 1968, groups of 24-33 whooping cranes moved in to feed on acorns for the following 2 weeks (ANWR Files).

The presence of acorns on prescribed burn areas may also explain the tendency for flocks to respond to fall burns. Following fall burns in 1976, 1977, and 1980 temporary flocks of 24-33 whooping cranes were observed feeding on parched acorns (Bishop and Blankinship 1982). Spring burns of upland areas have failed to attract aggregations, whereas fall burns of the same area have. For example, a March 1975 burn of the upland area adjacent to Egg Point (Fig. 1, p. 8) failed to attract aggregations, whereas the October 1976 burn of the same area attracted as many as 29 birds (ANWR Files).

Unusual Food Concentrations

Both in the past and throughout this study, unusual concentrations of natural and artificial food sources stimulated large temporary aggregations. Some of these aggregations may have stimulated subadult flock formation in areas close to the temporary food resource.

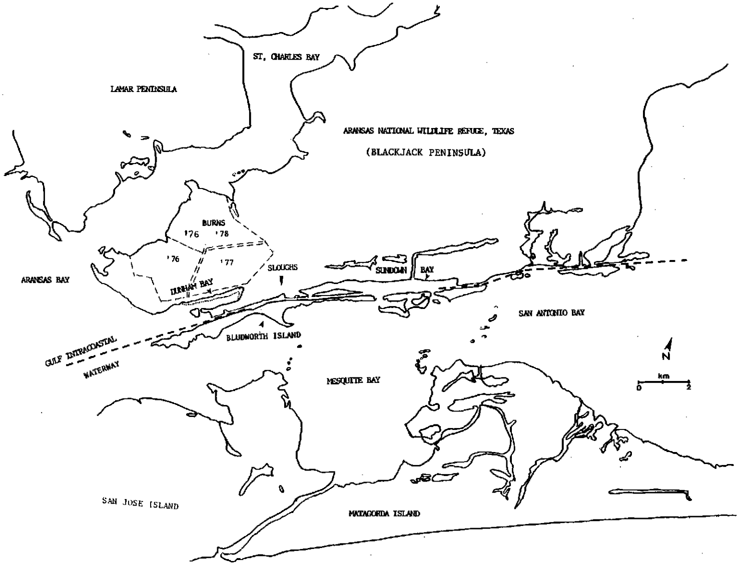
Historical Food Concentrations. As mentioned above, acorns attracted large temporary aggregations on mowed areas in 1968, and on burn areas in 1976 and 1977 (Fig. 3) (ANWR Files). Immediately after the 1976 and 1977 aggregations, a subadult flock of 5-10 cranes formed nearby at Dunham Bay and continued to use the bay throughout the remaining season (Bishop and Blankinship 1982).

Artificial food concentrations during 1964-65 through 1969-70 also attracted temporary aggregations. From 1964-65 through 1967-68 winter seasons, 2 (39 ha) experimental fenced fields were cultivated with food crops such as hegari, corn, and wheat. These plots were intended to create supplemental food sources for the whooping cranes during periods when natural foods were low, as well as to attract the cranes inland and away from the GIWW. During some seasons grain was spread in fields for the cranes after cultivated food crops were exhausted. Whooping crane response varied with virtually no use of the plots during 1 season, and response during the other 3 seasons. As many as 18 cranes were observed feeding on cultivated crops at 1 time. Supplemental feed spread during the 1966-67 and 1967-68 seasons attracted on 1 occasion of 34 birds of the 47 birds on the refuge. Fear of a possible disease outbreak brought the end of grain spreading at these fields in early 1968 (Shields and Benham 1969).

A partially drained marine impoundment and supplemental grain scattered adjacent to the impoundment attracted as many as 48 out of a population of 56 whooping cranes in 1970. For 6 weeks a small subadult flock remained in the area (D.R. Blankinship and D. Dolton, pers. commun.).

Aggregations 1978-79 Through 1982-83 Winter Seasons. During 4 of the 5 seasons, temporary aggregations associated with prescribed burn

Fig. 3. Specific bay location (dotted lines) for principal subadult flock during 1978-79 and prescribed fall burn areas (dashed lines) for 1976-78 at Aransas National Wildlife Refuge (ANWR), Texas. Gulf Intracoastal Waterway (GIWW) located with dashed line.


ST. CHARLES BAY
LAMAR PENINSULA
ARANSAS NATIONAL WILDLIFE REFUGE, TEXAS
(BLACKJACK PENINSULA)
BURNS
'76
'78
'76
'77
SLOUGHS
SUNDOWN
BAY
ARANSAS BAY
DUNHAM BAY
SAN ANTONIO BAY
BLUDWORTH ISLAND
GULF INTRACOASTAL
WATERWAY
N
km
0
2
MESQUITE BAY
SAN JOSE ISLAND
MATAGORDA ISLAND

areas and blue crabs formed during November and December. Limited observations during 3 of the seasons indicate that these aggregations attracted large numbers of subadults and unpaired cranes.

In early November 1978, a loose aggregation with as many as 20 birds, including pairs and family groups, formed in the marsh and sloughs northeast of Dunham Bay. This aggregation broke up by the beginning of December (Bishop and Blankinship 1982). While this was the 1st year with color-banded subadults, at least 3 of the 9 marked 1-year-olds were observed in this aggregation (D.R. Blankinship, unpubl. data).

The following November 1979, a large aggregation congregated in a pond at Cedar Point on Bludworth Island (Fig. 4) which contained a concentration of blue crabs. This large group was 1st noted on 9 November and peaked around 18 November 1979 when 19 birds were observed at Cedar Point. At least 11 of the 13 existing marked birds were observed in this aggregation. This concentration of whooping cranes slowly began to disperse and by 1 December flocks were no longer observed there (Bishop and Blankinship 1982).

Large flocks associated with prescribed burn areas were recorded during the 1979-80, 1980-81 and 1982-83 seasons. Following the break up of the aggregation at Cedar Point in November 1979, aerial surveys noted groups of 6-15 on burn areas adjacent to Sundown Bay (Fig. 4). The following 1980-81 season, as many as 30 whooping cranes and a hundred sandhills were observed feeding on a burn adjoining Charles Bay (Fig. 5) during November and December aerial censuses (ANWR Files, TPWD Files). Many of the cranes on the burn regularly frequented the shoreline at nearby Egg Point. Field observations of flocks feeding at Egg Point and

Fig. 4. Specific bay locations (dotted lines) of principal subadult flocks, and prescribed fall burn areas (dashed lines) at Aransas National Wildlife Refuge (ANWR), Texas, in 1979-80. Gulf Intracoastal Waterway (GIWW) located with dashed line.

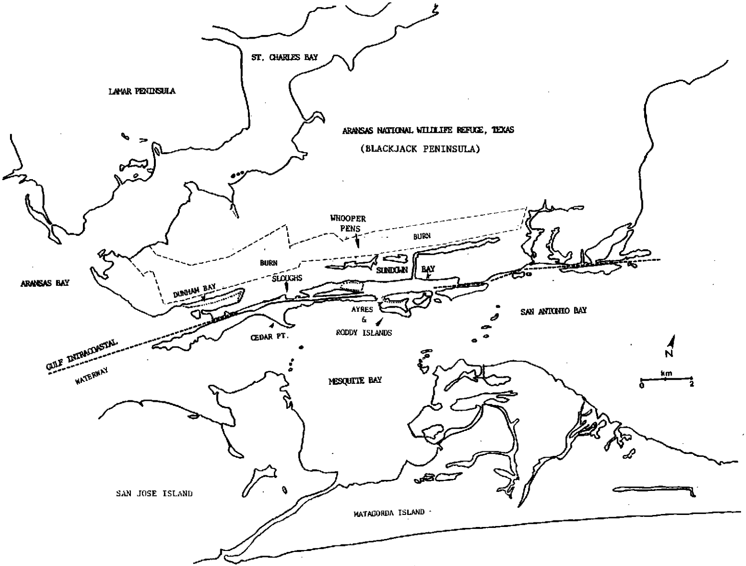
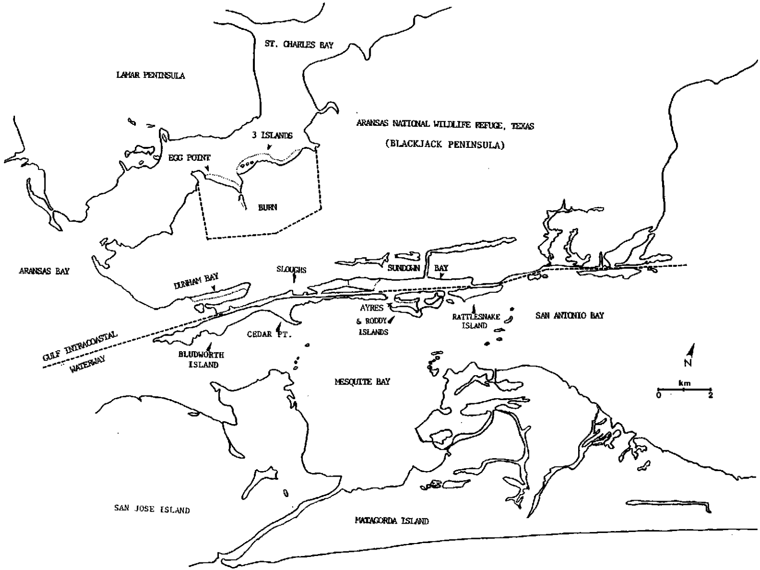

ST. CHARLES BAY
LAMAR PENINSULA
ARANSAS NATIONAL WILDLIFE REFUGE, TEXAS
(BLACKJACK PENINSULA)
WHOOPER PENS
BURN
BURN
SLOUGHS
SUNDOWN BAY
ARANSAS BAY
DUNHAM BAY
AYRES & RODDY ISLANDS
CEDAR PT.
SAN ANTONIO BAY
GULF INTRACOASTAL WATERWAY
MESQUITE BAY
N
km
0 2
SAN JOSE ISLAND
MATAGORDA ISLAND

Fig. 5. Specific bay locations (dotted lines) of principal subadult flocks, and prescribed fall burn areas (dashed lines) at Aransas National Wildlife Refuge (ANWR), Texas, in 1980-81. Gulf Intracoastal Waterway (GIWW) located with dashed line.


ST. CHARLES BAY
LAMAR PENINSULA
ARANSAS NATIONAL WILDLIFE REFUGE, TEXAS
(BLACKJACK PENINSULA)
3 ISLANDS
EGG POINT
BURN
ARANSAS BAY
SLOUGHS
SUNDOWN
BAY
DUNHAM BAY
AYRES
& RODDY
ISLANDS
RATTLESNAKE
ISLAND
SAN ANTONIO BAY
CEDAR PT.
GULF INTRACOASTAL
WATERWAY
BLUDWORTH
ISLAND
N
km
0
2
MESQUITE BAY
SAN JOSE ISLAND
MATAGORDA ISLAND

nearby Three Islands located 14 of the 17 banded subadults (Bishop and Blankinship 1982).

In November 1982, aerial surveys recorded as many as 25 cranes on the northern half of middle pasture (Fig. 6). It is believed that acorns attracted the high crane use of the area. At the beginning of December, the prescribed burn of the adjacent north pasture caused a shift in crane use to that pasture. Groups ranging in size from 2-30 were recorded on the burn until the beginning of February (ANWR Files, R.D. Slack and H. Hunt, unpubl. rep., U.S. Dep. Inter., Fish and Wildl. Serv., ANWR, Austwell, Tex., 1983).

While observations on the age-class and social composition of temporary aggregations are limited, at least in 1979 and 1980 aggregations, more than one-half of the cranes in the flocks were subadults and unpaired cranes. During the November 1979 aggregation at Bludworth Island, no families were identified. At Egg Point in St. Charles Bay during December 1980, only 1 family was observed in the aggregations. The high response by subadults and unpaired cranes to food concentrations as compared to the more limited response by families and pairs may be because the nonbreeders are not tied to defending and maintaining a winter territory.

First Year Home Range Fidelity

Subadults showed a definite tendency to stay in the area where they were raised their 1st year (Table 3). During the 1980-81 through 1982-83 field seasons, of 14 banded birds that spent their 1st year on Blackjack Peninsula, all but 2 wintered there. Similarly the 3 banded

Fig. 6. Specific bay locations (dotted lines) of principal subadult flocks, and upland use areas and fall burn areas (dashed lines) at Aransas National Wildlife Refuge (ANWR), Texas, in 1982-83. Gulf Intracoastal Waterway (GIWW) located with dashed line.

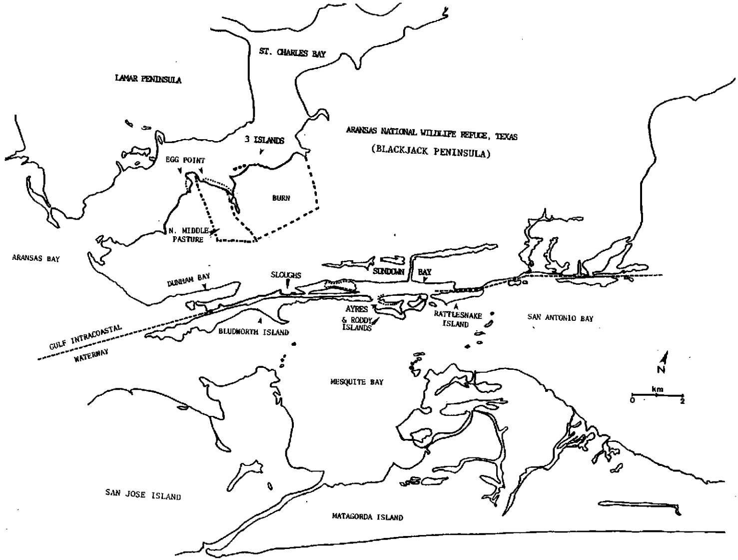

ST. CHARLES BAY
LAMAR PENINSULA
ARANSAS NATIONAL WILDLIFE REFUGE, TEXAS
(BLACKJACK PENINSULA)
3 ISLANDS
EGG POINT
BURN
N. MIDDLE PASTURE
ARANSAS BAY
DUNHAM BAY
SLOUGHS
SUNDOWN BAY
AYRES
& RODDY ISLANDS
RATTLESNAKE ISLAND
SAN ANTONIO BAY
BLUDWORTH ISLAND
GULF INTRACOASTAL
WATERWAY
MESQUITE BAY
N
km
0
2
SAN JOSE ISLAND
MATAGORDA ISLAND

Table 3. Location of banded whooping crane chicks at ANWR and environs for 1978-79 through 1982-83 seasons.

	Blackjack Peninsula					
Hatch year	Sundown Bay	Dunham Bay	Mustang Lake	San Jose Island	Matagorda Island	Welder Point
1977	4[a]	1	1	1	1	
1978	4[b]	1	1	1[c]		
1979	2	1			1	1
1980	2				1	1[d]
1981			1[e]	1		
1982	3[f]	1			1[g]	
Total Chicks	15	4	3	3	4	2
Alive Jul 83	11	4	2	2	3	1

[a]One crane missing since 1980-81, and 1 since 1981-82; both presumed dead.
[b]One crane missing since 1979-80, presumed dead.
[c]Chick disappeared Dec 1978, presumed dead.
[d]Crane missing since 1981-82, presumed dead.
[e]Crane died during migration Oct 1982.
[f]One chick died at ANWR, Feb 1983.
[g]Chick died at ANWR, Dec 1982.

birds raised on Matagorda Island have continued to spend their winters on the island. None of the Matagorda subadults were observed in any of the subadult flocks on Blackjack Peninsula during the 1980-83 seasons. The 3 banded birds raised on San Jose Island and Welder Point (northeast of Blackjack Peninsula, on San Antonio Bay) were observed in flocks on both Blackjack Peninsula and near their respective 1st year home territories. Thus, the subadults usually stayed in the same areas year after year, and this most likely fostered recognition and relationships with other birds in that area.

Traditional Use Areas

In their analysis of ANWR aerial survey data for 1950-78, Labuda and Butts (1979) noted that habitat use by whooping cranes was uneven. The Dunham Bay area (including the southern end of Bludworth Island), the Sundown Bay area (including Ayres, Roddy, and Rattlesnake islands), the Mustang Lake area (southeast corner of Blackjack Peninsula), and southern Matagorda Island (Fig. 1 p. 8) were defined as the 4 major use areas. Compared to all other areas, the Sundown Bay area was used most often and most consistently over the 28-year period, accounting for 30% of all crane-use days. They postulated that the site preference for these areas might be traditional.

Since 1976, subadult flocks on Blackjack Peninsula have shown a preference for 2 of these major use areas: the Sundown Bay area and the Dunham Bay areas. Dunham Bay was a traditional site for 5 winter seasons: 1976-77 through 1980-81. From 1979-80 through 1982-83, the middle and southern section of Sundown Bay as well as nearby Ayres and

Roddy islands were occupied by a large subadult flock. Beginning in 1980-81 season St. Charles Bay was the site of subadult flocks. Historically, this bay has not had high crane use (Labuda and Butts 1978).

1976-77 through 1978-79 Winter Seasons. Following 1976 and 1977 fall burns (Fig. 3 p. 29), a flock of 5-10 whooping cranes formed along the nearby western shore of nearby Dunham Bay. Both seasons the flock stayed in the bay from late November until the birds' spring departure the 1st week of April (Bishop and Blankinship 1982).

The next 1978-79 season, a subadult flock formed in Dunham Bay in early December 1978 following the break up of a temporary aggregation in the marsh and sloughs northeast of Dunham Bay. A group of 6-12 presumed subadults moved to the western shore of Dunham Bay (Fig. 3 p. 29) and used the area until their migration in mid-April (ANWR Files, Bishop and Blankinship 1982). Intermittently throughout the winter, groups of 4-10 frequented the Bludworth Island marsh across from Grass Island.

During the 1978-79 winter season, the Dunham Bay flock was the principal subadult flock on the refuge. Aerial sightings of flocks in Dunham Bay and adjacent marsh accounted for 67% of all groups observed. Five other areas accounted for all other flocks (Table 4).

1979-80 Winter Season. The breakup of the aggregation at Cedar Point on Bludworth Island in late November 1979 coincided with the appearance of subadult flocks at 4 other locations: the sloughs immediately south of Sundown Bay, San Jose Island, Dunham Bay, and Sundown Bay. From December through April, subadult flocks were observed

Table 4. Average subadult whooping crane flock size by month from ANWR and TPWD aerial surveys and NAS boat observations for 1978-79 season.

Location [a]		1978			1979				Seasonal	
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	Mean	Range
Dunham Bay	$\bar{x}$	5.0	6.2	5.6	4.9	6.4	9.1	4.6	6.1	2-12
	SE	2.0	0.8	0.8	0.5	0.8	0.7	1.1	0.4	
	N	2	12	10	8	7	7	5	51	
S Bludworth Is	$\bar{x}$		4.5	6.0	4.0		6.5		5.4	3-10
	SE		0.5	2.0			3.5		1.0	
	N		2	2	1		2		7	
S Sundown Bay	$\bar{x}$		2.0		4.5	7.0			4.5	2- 7
	SE				1.5				1.2	
	N		1		2	1			4	
Sloughs S of Sundown Bay	$\bar{x}$	3.0	4.0					4.0	3.7	3- 4
	SE								0.3	
	N	1	1					1	3	
San Jose Is	$\bar{x}$	2.0	2.7		2.0				2.4	2- 3
	SE		0.3						0.2	
	N	1	3		1				5	
Matagorda Is	$\bar{x}$	2.7	2.0				2.0		2.3	2- 4
	SE	0.7	0						0.3	
	N	3	2				1		6	

[a] All locations with at least 3 flock sightings during season.

in the southern and middle sections of Sundown Bay and along the western shore of Dunham Bay (Fig. 4 p. 32), accounting for 60% of all sightings (Table 5).

At Dunham Bay, 3 cranes began using the western shore and adjoining marsh in mid-December. Numbers grew to 6-7 birds by early February and remained at that level until migration in April. This flock tended to stay across from Grass Island at the entrance to Dunham Bay.

Throughout 1979-80, flocks ranging in size from 2-15 used the sloughs and marshes west of southern Sundown Bay throughout the 1979-80 winter season. Increased flock size at the end of November was probably a result of the break up of the aggregation at Cedar Point on nearby Bludworth Island and responses to prescribed burns on the uplands adjacent to Sundown Bay (Fig. 4 p. 32). While most flocks were located in estuarine ponds, aerial surveys noted groups on burn areas during December 1979 and January 1980. In mid-February the cranes began to feed in Sundown Bay. About that same time a flock was noted nearby at the southern end of Ayres and Roddy islands. For the remainder of the season, 1-2 flocks were observed regularly at Sundown Bay or Ayres and Roddy islands.

<u>1980-81 Winter Season</u>. During 1980-81, there were 4 large subadult flocks at ANWR: 2 at St. Charles Bay, 1 at Dunham Bay, and 1 at Sundown Bay (Fig. 5 p. 34). While flocks were recorded at Dunham Bay and Sundown Bay throughout the season, no flocks were observed at St. Charles Bay after mid-February (Table 6).

Flock formation in St. Charles Bay coincided with aggregations on

Table 5. Average subadult whooping crane flock size by month from ANWR and TPWD aerial surveys and NAS boat observations for 1979-80 season.

Location [a]		1979			1980				Seasonal	
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	Mean	Range
Dunham Bay	x̄	2.7	4.1	4.0	5.7	6.7	4.7	5.0	4.6	2-10
	SE	0.4	1.1	0	0.8	1.2	0.8	2.0	0.4	
	N	6	7	2	7	3	7	2	34	
S Bludworth Is	x̄		6.0			5.0	3.0		4.7	3- 6
	SE								0.9	
	N		1			1	1		3	
Cedar Pt Bludworth Is	x̄	3.0	13.1						11.9	3-19
	SE		1.6						1.9	
	N	1	7						8	
S Sundown Bay	x̄	2.2	5.0	7.9	5.7	4.8	5.7	4.0	5.5	2-15
	SE	0.2	1.2	1.1	1.1	0.5	1.4		0.5	
	N	5	4	8	7	4	9	1	38	
N Sundown Bay	x̄	4.0	3.5	9.7				3.0	6.1	3-14
	SE		0.5	2.2					1.5	
	N	1	2	3				1	7	
Whooper Pens	x̄			6.0	10.3				9.3	3-15
	SE				3.7				2.8	
	N			1	3				4	

Table 5, continued.

Location [a]		1979 Oct	1979 Nov	1979 Dec	1980 Jan	1980 Feb	1980 Mar	1980 Apr	Seasonal Mean	Seasonal Range
Sloughs S of Sundown Bay	$\bar{x}$		3.0	3.8	3.0	5.0			3.8	2- 7
	SE		1.0	0.3		2.0			0.5	
	N		2	4	1	2			9	
San Jose Is	$\bar{x}$		5.0	5.0		4.0	2.0		4.6	2- 8
	SE		1.5	1.5					0.8	
	N		4	3		1	1		9	
Ayres and Roddy is	$\bar{x}$				8.0	6.5	7.3	4.3	6.2	3- 9
	SE					0.5	0.9	0.7	0.6	
	N				1	2	3	3	9	
Matagorda Is	$\bar{x}$			3.0			2.0	4.0	3.0	2- 4
	SE								0.6	
	N			1			1	1	3	

[a]All locations with at least 3 flock sightings during season.

Table 6. Average subadult whooping crane flock size by month from ANWR and TPWD aerial surveys and field observations for 1980-81 season.

Location [a]		1980			1981				Seasonal	
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	Mean	Range
Dunham Bay	$\bar{x}$		3.8	4.1	4.8	3.2	3.0	3.1	3.8	2-10
	SE		0.4	0.4	0.3	0.2	0	0	0.2	
	N		13	8	32	9	21	11	94	
Egg Pt	$\bar{x}$	4.0	7.1	9.0	3.0	4.4			7.2	2-23
	SE	0	1.0	1.5	0.6	0.6			0.8	
	N	2	8	18	3	5			36	
Three Is	$\bar{x}$		6.7	4.1	5.1	3.0			4.6	2-11
	SE		2.2	0.4	0.5				0.3	
	N		3	20	17	1			41	
S Sundown Bay	$\bar{x}$	5.0	4.3	5.5	6.8	6.8	4.8	4.6	5.8	2-19
	SE	0	1.3	0.6	0.7	0.9	0.3	0.4	0.3	
	N	2	3	15	29	14	28	7	98	
N Sundown Bay	$\bar{x}$				5.0	2.0	5.0	2.0	3.0	2- 5
	SE								0.6	
	N				1	1	1	3	6	
Ayres and Roddy is	$\bar{x}$		2.0		5.0	5.0	4.0	3.1	3.6	2- 7
	SE				1.0		0.8	0.4	0.3	
	N		1		2	1	5	9	18	
S Bludworth Is	$\bar{x}$	3.0					3.0	3.0	3.0	3
	SE						0		0	
	N	1					4	1	6	

Table 6, continued.

Location[a]		1980 Oct	1980 Nov	1980 Dec	1981 Jan	1981 Feb	1981 Mar	1981 Apr	Seasonal Mean	Seasonal Range
Cedar Pt Bludworth Is	$\bar{x}$	4.0			3.0			3.0	3.3	3- 4
	SE							0	0.3	
	N	1			1			2	4	
Rattlesnake Is	$\bar{x}$						2.0		2.0	2
	SE						0		0	
	N						4		4	
Sloughs S of Sundown	$\bar{x}$	3.0	3.0	3.0	3.0	2.8	2.2		2.6	2- 5
	SE			0		0.6	0.1		0.2	
	N	1	1	3	1	5	9		20	
Dunham Bay to Sloughs	$\bar{x}$						2.0	2.6	2.6	2- 3
	SE							0.2	0.2	
	N						1	8	9	
Matagora Is	$\bar{x}$	3.0				3.0	3.0	3.0	3.0	3
	SE						0	0	0	
	N	1				1	3	4	9	
Upland Burns	$\bar{x}$	4.0	7.9	4.9	5.4	5.5			6.1	3-21
	SE	0	1.8	0.7	0.6	0.5			0.8	
	N	2	13	10	7	2			34	

[a]All locations with at least 3 flock sightings during season.

nearby burns. From 30 November to 11 December 1980, flocks ranging in size from 3-25 were located in the St. Charles Bay area known as Egg Point-Bill Mott Bayou (Fig. 7). Throughout the 2 weeks, small groups, apparently independent of each other, flew or walked to Egg Point from the direction of the burn. On 12 December 1980 the use of Egg Point-Bill Mott Bayou shoreline declined drastically. Similarly, few birds were seen arriving at the burn.

From November 1980 to mid-February 1981, a subadult flock frequented the area known as Three Islands in St. Charles Bay (Fig. 5, p.34). This flock exploited the prescribed burn area on a daily basis. While flock size ranged size from 2-13, typically there were 5-7 birds, with 2-3 banded subadults. After the Three Islands flock dispersed in February, 2 of the banded flock members were not seen again on the refuge throughout the remaining season.

At Dunham Bay, small flocks of 3-6 were repeatedly observed during November and December 1980. By January there were 1-2 flocks of subadults in Dunham Bay, that included as many as 5 banded subadults. One flock of 2-10 birds was observed only during January. This temporary flock utilized the far northern end of the bay. The other flock, a trio consisting of two 1-year-olds and an unbanded bird, utilized the western shore and marsh across from Grass Island until their mid-April migration.

During October and November 1980, aerial surveys recorded 5 groups of 3-7 birds in the marsh areas adjacent to the middle of Sundown Bay. Immediately following the mid-December dispersal of the Egg Point flock at St. Charles Bay, aerial surveys recorded groups of 3-9 primarily in

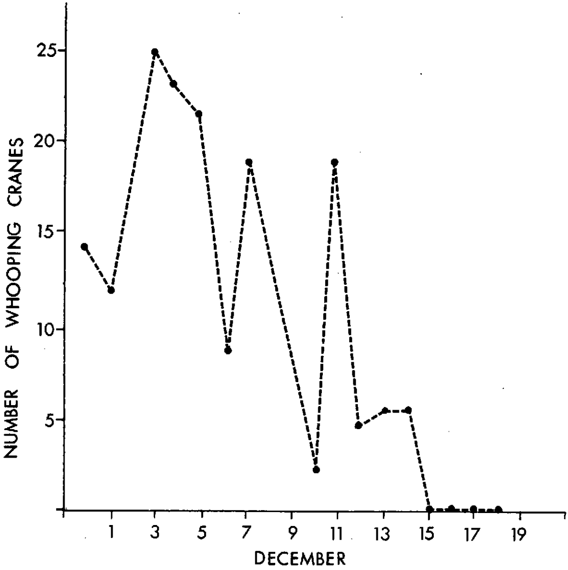


Fig. 7. Peak whooping crane flock size per day at Egg Point-Bill Mott Bayou, St. Charles Bay, 30 November-18 December 1980.

the marsh adjacent to middle and southern Sundown Bay (ANWR Files, TPWD Files).

From January through the 1st week in April 1981, Sundown Bay had the largest subadult flock (Table 6 p. 45), and all 3 banded subadult age classes (3-, 2-, and 1-year-olds) were present. During January and February flocks ranging from 3-19 birds were observed feeding in the bay. As many as 8 banded subadults were observed in a flock.

In March flock size at Sundown Bay decreased to 5-6 cranes as the birds began to spend more time in the salt marsh. At the same time, small flocks were observed in the Ayres and Roddy islands marsh during aerial surveys. From 6 April to 28 April, subadults flocks were observed only at Ayres and Roddy islands.

While flocks were observed at the southern end of the bay 4 times in January, the rest of the season the flock always utilized an area in the central part of Sundown Bay. This central area was unique from all other flock areas studied because it was limited on both sides by aggressive territorial pairs.

<u>1981-82 Winter Season.</u> A loose subadult flock with as many as 6 cranes formed along the western shore in Dunham Bay following a "norther" on 9 November 1981 that exposed mudflats along shorelines. This flock was temporary and disbanded within 2 weeks.

At the end of November a subadult flock formed in the Ayres and Roddy islands' inlet (Fig. 8) that stayed together the remainder of the 1981-82 season. During December 1981 and January 1982, the flock used both the Ayres and Roddy islands and Sundown Bay areas (Table 7). However, from February to mid-March the flock was observed all but 2

Fig. 8. Specific bay locations (dotted lines) of principal subadult flock, and prescribed fall burn areas (dashed lines) at Aransas National Wildlife Refuge (ANWR), Texas, in 1981-82. Gulf Intracoastal Waterway (GIWW) located with dashed line.

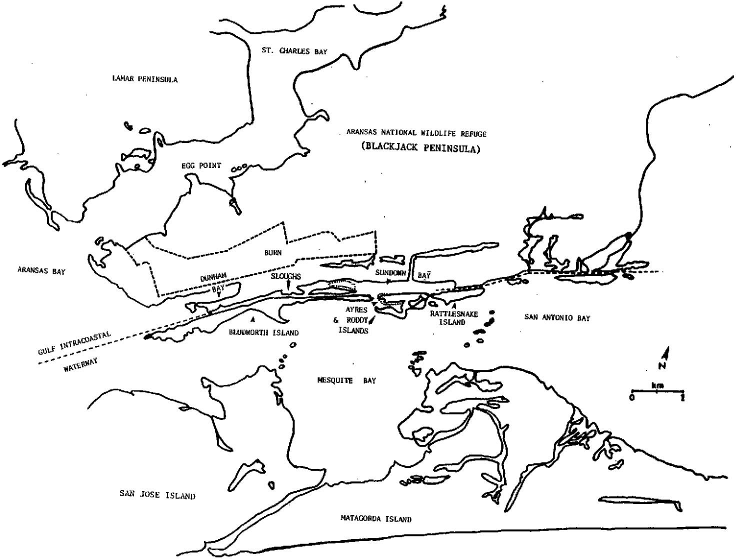

ST. CHARLES BAY
LAMAR PENINSULA
ARANSAS NATIONAL WILDLIFE REFUGE
(BLACKJACK PENINSULA)
EGG POINT
ARANSAS BAY
BURN
DUNHAM BAY
SLOUGHS
SUNDOWN BAY
AYRES & RODDY ISLANDS
RATTLESNAKE ISLAND
SAN ANTONIO BAY
BLUDWORTH ISLAND
GULF INTRACOASTAL WATERWAY
MESQUITE BAY
N
km
0 1
SAN JOSE ISLAND
MATAGORDA ISLAND

Table 7. Average subadult whooping crane flock size by month from ANWR aerial surveys and field observations for 1981-82 season.

Location [a]		1981			1982					Seasonal	
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Mean	Range
Ayres and Roddy is	$\bar{x}$	3.5	3.7	6.4	6.8	4.5	5.9	3.7		5.1	2-11
	SE	0.5	0.4	0.5	0.7	0.5	0.8	0.3		0.3	
	N	2	11	19	9	2	9	18		71	
S Sundown Bay	$\bar{x}$	2.3	4.0	5.0	5.3	7.9	8.2	3.9	2.0	6.2	2-12
	SE	0.3	1.0	0.8	0.8	0.7	0.6	0.6		0.4	
	N	3	2	4	17	17	17	10	1	71	
N Sundown Bay	$\bar{x}$	2.8		2.0	4.0	7.0	4.0	4.6	2.0	3.9	2-10
	SE	0.3		0	0	1.0		0.8	0	0.4	
	N	4		2	2	2	1	9	2	22	
Dunham Bay	$\bar{x}$	5.0	3.2	2.0				2.0		3.2	2- 5
	SE		0.3							0.3	
	N	1	16	1				1		19	
Rattlesnake Is	$\bar{x}$			3.0			2.5	2.0		2.3	2- 3
	SE						0.5	0		0.2	
	N			1			2	5		8	
Sloughs S of Sundown Bay	$\bar{x}$	4.5	5.0	3.0						4.3	3- 5
	SE	0.5								0.5	
	N	2	1	1						4	

Table 7, continued.

Location [a]		1981 Oct	1981 Nov	1981 Dec	1982 Jan	1982 Feb	1982 Mar	1982 Apr	1982 May	Seasonal Mean	Seasonal Range
S Bludworth Is	$\bar{x}$	2.0		3.3		5.0	3.3	4.0		3.4	2- 5
	SE			0.5			0.3	0.7		0.3	
	N	1		4		1	3	4		12	
Matagorda Is	$\bar{x}$	3.0	3.8			3.5	3.0	3.0		3.4	3- 5
	SE		0.5			0.5	0			0.2	
	N	1	4			2	2	1		10	

[a]All locations with at least 3 flock sightings during season.

times at Sundown Bay. By March, the cranes spent more time feeding in the marsh adjacent to Sundown Bay. Around 21 March the subadult flock shifted back to Ayres Island.

On 12 April, a substantial number of whooping cranes on the Refuge migrated north, including 4 subadult flock members. With territories left undefended, the remaining subadult flock members moved over to the middle and northern Sundown Bay marsh until their migration 3 weeks later.

The Sundown Bay-Ayres and Roddy islands flock was the principal flock on the Refuge during the 1981-82 winter season. Nine of the 13 color-banded subadults joined this flock some time during the season. Sightings of the flock at Ayres and Roddy islands, and the southern and northern sections of Sundown Bay accounted for 76% of all subadult flock sightings during this season.

1982-83 Winter Season. From November 1982 to early February 1983, aggregations associated with acorns and prescribed burns frequented the marsh and uplands near St. Charles Bay. Two principal subadult flocks formed on the refuge by the end of November 1982: 1 in the southern Sundown Bay area, and the other at the Egg Point-Bill Mott Bayou area of St. Charles Bay (Fig. 6 p. 37). The subadult flock at Egg Point fluctuated between 2-6 cranes. This flock disbanded at the end of February (Table 8).

The subadult flock at Sundown Bay stayed intact from the end of November until April migration. While the flock was 1st observed at Ayres Island, from the 1st week in December to the end of January the

Table 8. Average subadult whooping crane flock size by month from ANWR aerial surveys and field observations for 1982-83 season.

Location [a]		1982 Oct	1982 Nov	1982 Dec	1983 Jan	1983 Feb	1983 Mar	1983 Apr	Seasonal Mean	Seasonal Range
S Sundown Bay	$\bar{x}$		3.6	4.8	6.2	5.2	5.7	3.5	5.2	2-10
	SE		0.4	1.1	0.9	0.7	0.4	0.5	0.4	
	N		5	4	10	10	9	2	40	
Ayres and Roddy is	$\bar{x}$		4.0		2.0	3.5	4.0	5.0	3.3	2- 5
	SE				0	0.5			0.4	
	N		1		3	4	1	1	10	
Rattlesnake Is	$\bar{x}$					3.5	4.3		4.0	3- 5
	SE					0.5	0.3		0.3	
	N					2	4		6	
Egg Point	$\bar{x}$		6.0	3.0	4.4	3.0			3.8	2- 6
	SE			0	0.7	0.6			0.4	
	N		1	2	5	4			12	
Upland Burns	$\bar{x}$		13.0	6.5	5.0				7.2	4-13
	SE			1.5	1.0				1.6	
	N		1	2	2				5	
S Bludworth Is	$\bar{x}$						3.0	3.0	3.0	3
	SE						0		0	
	N						3	1	4	

Table 8, continued.

Location [a]		1982			1983				Seasonal	
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	Mean	Range
Sloughs S of Sundown Bay	$\bar{x}$		3.0	2.0		6.0			3.7	2- 6
	SE								1.2	
	N		1	1		1			3	
Dunham Bay	$\bar{x}$		2.0	4.0		3.0	4.0		3.4	2- 4
	SE			0					0.4	
	N		1	2		1	1		5	
Matagorda Is	$\bar{x}$	3.0				4.0	3.0	3.0	3.1	3- 4
	SE						0	0	0.1	
	N	1				1	4	5	11	

[a] All locations with at least 3 flock sightings during season.

flock was observed only in Sundown Bay. The flock used the same middle and southern section of the bay as the previous three seasons, including Sundown Island, the island in the bay that borders the GIWW. Flock size ranged from 2-10 birds, with all age classes represented except the 1-year-olds (there was only one 1-year-old in the population during this winter season).

Beginning in February, in addition to a Sundown Bay flock, other flocks were observed in the vicinity. Some 3-5 Sundown Bay flock members began to frequent Ayres and Rattlesnake islands (Fig. 6, p. 37). While on only a few occasions during the 5 previous seasons was a subadult flock >2 birds observed on Rattlesnake Island, during the February and March 1983, some 6 flocks were observed.

Changes in Traditional Use Areas. Dunham Bay was a traditional site for 5 years: 1976-77 through 1980-81. Although a flock formed in Dunham Bay during November 1981, it broke up after 2 weeks. From December 1981 until April 1983, flocks have been observed in this bay on only 7 occasions (Table 7 p. 52, Table 8 p. 56). Two factors may have influenced this change. First, in November 1981 a banded bird (Bird 10) established a territory at the site that the subadults used most often. Second, during the 1981-82 and 1982-83 seasons, there was only 1 subadult (Bird 20) that spent its 1st year in the Dunham Bay area (ANWR Files).

Since 1979-80 the middle and southern section of Sundown Bay as well as nearby Ayres and Roddy islands have been occupied by a large subadult flock. The initial stimuli for this flock's formation included the dispersal of a large aggregation on Bludworth Island, the presence of a late fall burn adjacent to the Sundown Bay marsh (Fig. 4, p. 32), and an apparent abundance of food in the tidal flats.

The use of Sundown Bay and Ayres and Roddy islands from 1979-80 through 1982-83 may be related to several factors. Many of the Sundown Bay flock members were raised in Sundown Bay. Since field observations began in 1980-81, 2-3 of the regular flock members in this bay (Birds 11, 21, 32) have been offspring from 2 pairs in the immediate area. Another 2-3 flock members (Birds 01, 14, 24, 33) are offspring of a pair at the northern end of Sundown Bay (ANWR Files; D.R. Blankinship, pers. commun.).

While none of the Sundown Bay flock members were raised at Ayres and Roddy islands, this area is very close to Sundown Bay and appears to be ideal habitat for subadults. There is a large salt marsh, as well as a shallow, protected inlet in which to feed on clams and crabs. Ayres and Roddy islands are also visually isolated from the territorial pairs at Sundown Bay. And, from 1979-80 to 1982-83 winter seasons, no pair consistently defended this area.

At St. Charles Bay, the formation of 3 subadult flocks during 2 seasons (1980-81 and 1982-83) was most likely due to the proximity of this bay to a burn. The 3 subadult flocks in St. Charles Bay exploited the nearby burn areas on a regular basis; however, these flocks were temporary and their dispersion apparently coincided with the depletion of the food resources on the upland areas. One of the flocks stayed in the area <1 month, and the other 2 flocks stayed <3 months, dispersing by mid- to late February.

In the past, the upland and salt marsh areas adjacent to St.

Charles Bay have attracted cranes in the fall, both before and after prescribed burns. Acorns in the scrub oak thickets and oak mottes in this area may have been the initial attraction. However, traditionally there had been no flocks in the St. Charles Bay. The formation of 3 flocks in 2 seasons in this bay may be an indication of a developing site preference. The reintroduction of livestock grazing in this area in July 1982, as well as the continued prescribed burning of the grazing pastures may make food resources in these upland and marsh areas more available to the cranes. This habitat manipulation may stimulate subadult flocks to continue using this bay on a seasonal basis.

Flock Size and Composition

Flock Size Distributions

Aerial survey data and ground observation data were tested for significant differences using the 1980-81 season average monthly flock size for all flocks ≥ 3. While aerial survey monthly averages were usually smaller than the ground observation averages, there was no significant difference in flock sizes (Wilcoxon matched-pairs signed-ranks test, $P > 0.05$) for the 2 methods.

Average seasonal subadult flock size varied between 4.4 - 5.6 cranes over the 5 seasons. The 1979-80 season had the largest average subadult flock, 5.6 birds (N = 124, SE = 0.31). Although this season's data included an incomplete sample of subadult flocks of 2, the high average flock size during 1979-80 was probably due to large 2- and 1-year-old age classes (8 and 5 cranes, respectively), (Table 2 p. 14). The 1982-83 season had the lowest average subadult flock size, 4.4 birds

(N = 103, SE = 0.20). Throughout this season there were only 4 cranes in the 2- and 1-year-old classes combined, the lowest for all 5 seasons. When the average monthly flock size for October-April was compared between the 5 seasons, there was no significant difference (Friedman 2-way ANOVA, Chi-r-squared = 5.143, df=6, $P > 0.05$) between seasons.

Flock size frequency for all 5 seasons was tabulated by month (Table 9). At the start of the winter season in mid- to late October, subadult flocks of 2-4 accounted for 88% of all flocks. By November, the percentage of flocks with 2-4 cranes dropped to 60% as larger flocks of 5-6 were commonly observed in the marsh and less often in the bays. While flocks of >6 birds accounted for 21% of all subadult flocks during November, these flocks were nearly always associated with unusual food concentrations in the marsh or upland burn areas.

The dispersal of temporary aggregations in the marsh and on prescribed burns, and the increased use of the bays for feeding during late November and early December, coincided with the appearance of subadult flocks at traditional bay sites (Fig. 2, p.24). At the same time, subadult flocks >6 birds were more commonly observed. From December through February, flocks >6 accounted for 28-31% of all groups observed. By March this dropped to 22% as the birds spent more time feeding in the flooded salt marsh. At the same time, flocks of 2-4 were more common, accounting for 56% of all subadult flocks.

With the onset of migration, flocks of 2-4 cranes increased to 81% of all groups observed during April. As early as the 1st week in April, subadults left ANWR for Canada. During at least 4 of the 5 seasons, the last cranes to leave ANWR were subadults (ANWR Files, this study).

Table 9. Frequency of subadult flock sizes by month at ANWR and environs from field observations, and ANWR and TPWD aerial surveys, 1978-79 through 1982-83 seasons.

Month		Number per flock				
		2[a]	3-4	5-6	7-8	≥ 9
Oct	%	33	55	10	2	
	N	16	27	5	1	
Nov	%	15	45	19	8	13
	N	20	60	25	11	18
Dec	%	7	46	18	17	11
	N	11	69	27	26	17
Jan	%	9	34	29	13	15
	N	16	59	50	23	26
Feb	%	13	31	26	16	15
	N	14	34	28	17	16
Mar	%	12	44	22	11	11
	N	20	73	36	18	19
Apr	%	23	58	13	5	1
	N	27	69	15	6	1
May	%	100				
	N	3				

[a]Subadult flocks of size 2 not completely sampled.

Typically 2-4 subadults remained on the refuge until late April or early May.

Flock size frequencies for each season and observation method (air or ground) were compared to their theoretical truncated Poisson distribution (Table 10). The frequency distributions around the means were significantly non-random for 3 of the 5 seasons of aerial surveys, and for all 3 seasons of ground observations. Distribution patterns for those season/method combinations with significant deviations indicated higher than expected preferences for smaller flocks of 2 and 3 cranes, and for larger flocks ≥ 9 cranes.

Those seasons and methods with significant differences from their theoretical Poisson distribution were also compared to their theoretical negative binomial distribution in order to see if there was a tendency for aggregation. No significant differences were detected in 4 of the 6 distributions. While the group size frequency distributions for 1980-81 and 1981-82 ground observations were significantly different from the Poisson and the negative binomial distributions, both seasons had a closer fit to the negative binomial distribution (1980-81, Chi-square = 17.70; 1981-82, Chi-square = 11.40), than the Poisson distribution (1980-81, Chi-square = 163.45; 1981-82, Chi-square = 211.10).

The tendency for group size frequencies to be non-random and clumped is possibly the result of 3 factors. These include the heterogeneity of the ANWR habitat, the strong associations between individual cranes, and fidelity to the 1st year home range. The availability of estuarine bays, salt and freshwater marsh, and live oak savannah uplands for feeding habitat, as well as both temporary and

Table 10. Comparison of observed seasonal group size frequencies with the theoretical Poisson and negative binomial distributions.

			Poisson		Negative binomial	
Observational method	Season	N	$\bar{X}$	Chi-square	K	Chi-square
Aerial surveys	1978-79	66	5.91	31.54*	3.10	7.66
	1979-80	106	6.22	81.81*	2.13	7.77
	1980-81	166	5.10	230.57*	0.86	9.39
	1981-82	30	4.57	3.09	--	--
	1982-83	56	4.41	1.86	--	--
Ground	1980-81	213	4.47	163.45*	2.46	17.70*
	1981-82	190	4.93	211.10*	1.75	11.40*
	1982-83	44	4.43	18.24*	3.00	5.62

*$P < 0.05$.

seasonal preferences for these habitats could result in a non-random distribution of flocks. If the habitat at ANWR was homogenous, group sizes would more likely take on random distribution. A 2nd factor that favors a non-random distribution of flocks sizes is the tendency for subadults to associate with each other non-randomly. As discussed later, subadult cranes exhibit strong social bonds with each other. These associations, coupled with the subadult fidelity to traditional use areas near their 1st year home range, would also favor a non-random distribution of subadult flock sizes.

Composition of Subadult Flocks

Throughout this study, subadult flocks were composed primarily of nonbreeding cranes. Nonbreeders included sexually immature subadults, as well as nonbreeding banded and unbanded adult cranes. Cranes from all color-banded age classes $\geq$1-years-old joined subadult flocks every season. Thus, by 1982-83 subadult flocks included banded cranes ranging from 1-5 years of age.

Flock composition on Blackjack Peninsula was related to 1st year home range. Subadults who spent their 1st year on Matagorda Island were never observed in subadult flocks on Blackjack Peninsula. However, at least 2 subadults raised on Blackjack Peninsula were known to have wintered for 1-3 seasons on Matagorda Island.

Subadult flocks that included families were noted only during the 1980-81 season. During December 1980 and January 1981, a family with an unbanded chick that was wintering on Matagorda Island frequented the prescribed burn near St. Charles Bay. The family joined flocks at Egg

Point 4 times in December and at Dunham Bay 3 times in January. In contrast to most pairs with chicks, this pair was not aggressive. During December, the family tolerated the constant presence of an unbanded bird, and in January often allowed a banded 2-year-old to accompany them.

Territorial pairs adjoining subadult flocks use areas sometimes joined flocks for a few hours. Known territorial pairs from other areas on Blackjack Peninsula and San Jose Island joined subadult flocks on <6 occasions during the 3 field seasons. This past 1983-84 season, however, ANWR personnel noted that a pair of banded birds (Birds 01 and 21) were unsuccessful in establishing a winter territory following their 1st 1983 nesting attempt in WBNP. The pair was observed with subadult flocks on 8 occasions from November 1983 to March 1984, and as a separate pair on 5 occasions (T.V. Stehn and E. F. Johnson, unpubl. rep., U.S. Dep. Inter., Fish and Wildl. Serv., ANWR, Austwell, Tex., 1984).

Age class composition and the number of companions in flocks containing the typical subadult whooping crane were determined monthly for the 1980-81 and 1981-82 seasons (Figs. 9 and 10, as per Underwood 1981). During the 1980-81 season the proportion of unbanded birds ($\geq$4-years-old) and 3-year-old banded birds in the typical flock decreased following the apparent depletion of food resources on the burn near St. Charles Bay. Decreases in a proportion of a given age class sighted with the typical subadult crane can suggest that the age class is moving more independently and in smaller groups than most of the population (Underwood 1981). If the aggregation at Egg Point in December included unbanded pairs that were not detected, the subsequent return of the

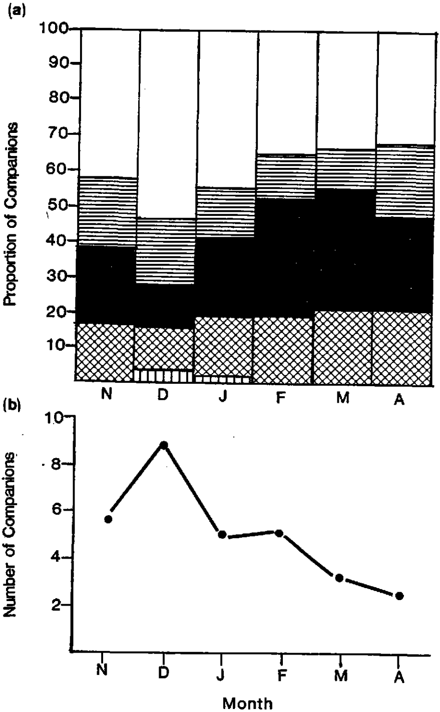


Fig. 9. Composition of flocks containing the typical subadult whooping crane by month at ANWR, 1980-81 season. (a) Proportion of companions belonging to specific age classes: vertical lines = chick; cross-hatching = 1-year-old; black = 2-years-old; horizontal lines = 3-years-old; white = $\geq$4-years-old (unbanded crane). (b) Number of companions found with the typical subadult whooping crane.

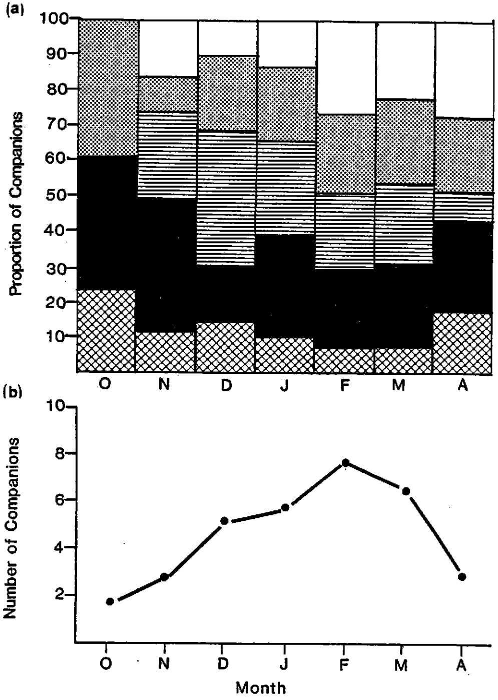


Fig. 10. Composition of flocks containing the typical subadult whooping crane by month at ANWR, 1981-82 season. (a) Proportion of companions belonging to specific age classes: cross-hatching = 1-year-old; black = 2-years-old; horizontal lines = 3-years-old; stipple = 4-years-old; white = ≥5-years-old (unbanded crane). (b) Number of companions found with the typical subadult whooping crane.

pairs to their territories could explain some of the decrease in the proportion of that age-class.

However, pair bonding of unbanded birds with both 3- and 2-year-old birds also accounted for the decrease proportion of unbanded cranes. During February and March 1981, 6 of the 10 cranes in the 3- and 2-year old age classes dropped out of subadult flocks on Blackjack Peninsula. Four of the 6 had formed pair bonds with unbanded birds.

In fall 1981, 2 more banded cranes established winter territories with unbanded birds. As a result, throughout the 1981-82 season, the proportion of unbanded cranes (≥5-years-old) comprising the typical flock never exceeded 28% in 1 month, as compared to a range of 31-53% per month during the previous season.

Trends in the number of companions found with the typical subadult whooping crane were different for the 2 seasons (Figs. 9b, 10b, pp. 66-67). For the 1980-81 season, the number of companions peaked during December when large numbers of cranes were feeding on the burn and at Egg Point. From January on, the number of companions declined as 1-3 subadult flocks were regularly observed on different areas of the Refuge. Throughout the 1981-82 season, there was only 1 principal subadult flock on the Refuge. During this season, the number of companions found with the typical subadult whooping crane peaked in February and did not experience a large decline until April migration.

Daily Activities of Subadult Flocks

Time budget samples were recorded for subadult flock members throughout the 1981-82 season. Subadult flocks located in the bays were sampled for 60.6 hours from mid- November 1981 to mid-April 1982. Sampling of subadults in the marsh was limited to approximately 5.7 hours, principally during April 1981. Activities were assigned to 9 categories: foraging and drinking, alert behavior, resting, comfort (body maintenance) movements, flying, walking, agonistic behavior, vocalizations, and dancing.

When activities in the bays were tabulated by 2-hour time periods, except for late afternoon hours (1600-1759), the time spent foraging, and in resting and comfort behaviors across all hours was in similar proportions (varying by <5%), (Table 11). Although the 1600-1759 hours were sampled least of all and therefore may be biased, the high proportion of time spent in foraging activites during this time period (76.5%) could reflect higher energy requirements prior to roosting for the evening.

Proportions of time spent in activities were also determined for the subadults sampled in the bay and the marsh, regardless of the time of day (Table 12). When in the bays, subadults spent over 50% of their time foraging, and approximately 16% of their time in resting, and 18% in comfort activities. Subadults observed in the marsh foraged 73%, rested 2%, and engaged in comfort activities 14% of the time sampled. The low proportion of time spent resting in the marsh is most likely due to the fact that the cranes tend to move to water to rest during the day and roost for the night.

In both the bays and the marsh, alert behavior accounted for only 6% of all activities. In contrast to these low numbers, subadults and

Table 11. Proportion of time spent in major diurnal activities by time of day for subadult flocks from point samples at ANWR bays, 1981-82 season. Data from 60.6 hours of observations.

Activity		Time of day 0800-0959	1000-1159	1200-1359	1400-1559	1600-1759
Foraging and drinking	%	51.1	53.5	53.5	51.5	76.5
	N	501	1751	3039	2208	709
Comfort and resting	%	38.6	34.0	36.7	36.0	12.7
	N	378	1111	2089	1547	118
Other	%	10.3	12.5	9.8	12.5	10.8
	N	101	407	557	535	100

Table 12. Proportion of time spent in diurnal activities by habitat for subadult flocks from point samples at ANWR, 1981-82 season. Data from 23.3 hours and 37.3 hours of observations for flocks >5 and ≤5 cranes, respectively; and from 5.7 hours of marsh observations.

Activity		Bay: All flocks	Bay: >5 birds	Bay: ≤5 birds	Marsh: All flocks
Foraging and drinking	%	54.2	50.6	56.4	72.9
	N	8,208	2,958	5,250	1,240
Alert	%	6.2	5.1	6.9	6.3
	N	945	299	646	108
Resting	%	16.2	21.9	12.5	2.2
	N	2,450	1,284	1,166	37
Comfort	%	18.4	17.2	19.2	14.1
	N	2,793	1,003	1,790	239
Locomotion					
Walking, running	%	3.6	3.2	3.9	3.2
	N	550	190	360	55
Flying	%	0.3	0.4	0.3	1.1
	N	53	24	29	18
Agonistic	%	0.9	1.4	0.6	0.1
	N	134	83	51	2
Vocalization	%	0.1	0.1	0.1	0.1
	N	9	3	6	2
Dancing	%	0.1	0.1	0.1	0.0
	N	8	2	6	0

unpaired adult whooping cranes in the Grays Lake-Bosque del Apache flock spent 23-35% of their time in alert behavior on the New Mexico wintering grounds (R.C. Drewien, unpubl. rep., U.S. Dep. Inter., Idaho Coop. Wildl. Res. Unit, Moscow, Idaho, 1982). Tacha (1981) has suggested that alert signals serve to reduce mortality from potential sources such as hunters and predators. The subadult flocks I observed at ANWR during 1981-82 were in the areas along the GIWW: Dunham and Sundown bays, and the inlet between Ayres and Roddy islands. No hunting is allowed in these areas during the whooping cranes' winter stay. However, in New Mexico the whooping cranes are exposed to snow goose (*Anser caerulescens*) hunters from late November through early January. The bays at ANWR also offer a virtually predator-free environment. In New Mexico, however, the cranes feed primarily in corn and alfafa fields where potential predators such as coyotes (*Canis latrans*) and eagles (*Aquila chrysaetos*) are common.

During the 1981-82 season there was 1 principal subadult flock that frequented both the Ayres and Roddy islands area and Sundown Bay (Fig. 8, p. 51). At Ayres and Roddy islands the proportion of time spent foraging (57%) and in alert behavior (7%) was significantly higher (2-sample proportion t-test; foraging, $t = 7.20$, $P < 0.001$); alert, $t = 7.42$, $P < 0.001$) than at Sundown Bay (foraging = 50%, alert = 4%). At Ayres and Roddy islands the flock spent 30% of their time resting and in maintenance behavior as compared to an approximate 41% while at Sundown Bay.

Without further studies, it is not possible to conclude that the higher proportion of time spent feeding at Ayres and Roddy islands is related to a quantitative or qualitative difference in food resources between the 2 areas. Gibson (1978) points out that energy needs depend on body weight, ambient temperature, and the activity. And energy needs cannot be directly related to the amount of time spent foraging. This is because food abundance, availability and quality may vary throughout a season. During the 1981-82 season, subadult flocks frequented Ayres and Roddy islands primarily from November until mid-January, and frequented Sundown Bay from January until mid-March when they moved back over to Ayres Island. Thus, the differences in foraging behavior between the areas could reflect both seasonal differences in energy needs, as well as differences between the 2 habitats.

The higher proportion of alert behavior at Ayres and Roddy islands as compared to Sundown Bay (7% versus 4%) may be due to the terrain. For the most part, the inlet between Ayres and Roddy islands was visually isolated from other areas on 3 sides. At Sundown Bay, however, the cranes fed in the middle section of the bay, which offered an unobstructed view of the 3.6 km long bay.

Group awareness allows birds to spend less time in surveillance (Goldman 1980, Morse 1980), while at the same time the presence of "more eyes" offers an increased ability to locate food (Thompson et. al. 1974, Caraco 1981). In order to test if large flocks fed a greater proportion of the time and were alert a smaller proportion of the time than small flocks as a result of having "more eyes", flocks in the bays were categorized in 2 groups: >5 birds and $\leq$5 birds. In contrast to what I predicted, cranes in flocks $\leq$5 foraged more, and were alert more often than cranes in flocks >5 birds (Table 12 p.71). However, while flocks >5 spent less time feeding and being alert, they spent more time resting (21.9%) than flocks ≤5 (12.5%).

The activity proportions for the 2 flock size categories, however, are influenced by site selection differences. Approximately 80% of the samples for flocks ≤5 were at Ayres Island. For flocks >5 birds, approximately 50% of the samples were from Ayres Island and 50% from Sundown Bay. The lack of predator pressure in the bays, the temporal differences in habitat selection by the subadult flocks for these 2 areas, and the potential differences in energy needs across the winter season make it impossible to conclude that the activity data either supports or does not support the hypothesis that "more eyes" allow for more feeding time.

Flock Relationships With Territorial Pairs

Cranes are gregarious and all 15 species flock year round. For most species of cranes, flocks during migration and on the wintering grounds include families, pairs, and nonbreeders. In sandhill cranes, these flocks appear to be loosely organized assemblages of smaller groups with 1-7 cranes (Miller and Stephen 1966). Sandhill cranes leave the roosts in small groups and join large foraging flocks in open cultivated fields (Lovvorn and Kirkpatrick 1982). These subgroups continue to behave as units as the large flocks feed across the fields. Activities such as feeding, standing alert, and dancing are synchronized among the small group members, but not among the flock as a whole. While it is unusual to see single cranes apart from the feeding flock, adults with young and pairs are frequently observed at a distance from other groups (Miller and Stephen 1966).

Territorial behavior has been recorded on the wintering grounds for 5 species of cranes: hooded crane (G. monachus), white-naped crane (G. vipio), Japanese crane (G. japonensis), Siberian crane (G. leucogeranus), and whooping crane. Depending on the food resource, families and pairs may defend feeding territories during the day. However, with the exception of the whooping cranes and a few Japanese cranes, all families, pairs, and subadults will roost together at night (Archibald 1973, 1975, 1981; Masatomi and Kitagawa 1974; Sauey 1976).

The distribution of food in the bays and marsh and the low numbers of whooping cranes apparently make it energetically feasible for pairs to defend territories at ANWR. Although new pairs may change territories from 1 season to the next, information on successful nesting pairs at WBNP (E. Kuyt, unpubl. data, Biologist, CWS, Edmonton, Alberta) and the location of their chicks at ANWR indicate that the same winter territories are occupied by pairs year after year (D.R. Blankinship, unpubl. data) Territories at ANWR vary in size and some pairs and families may peacefully share portions of their territory with neighbors (Blankinship 1976).

In contrast to the other 4 winter-territorial species, whooping cranes at Aransas maintain subadult flocks and territorial pairs as separate social units during the day and night. Limited observations indicate that territorial pairs do not flock with other cranes at evening roost sites but instead roost in their territories (D.R. Blankinship, pers. commun.; this study). While aggregations associated with unusual food concentrations have included both families, pairs, and subadults, these were always temporary and broke up with the depletion of the food source.

During this study Dunham Bay, Sundown Bay, Ayres and Roddy islands, and St. Charles Bay were the principal areas used by subadult flocks. Territorial boundaries of pairs adjacent to the subadult flocks' home ranges were not distinct and there was a zone of overlap. Often, if the territorial pair was not in the bay or was at the other end of the territory, the subadults would feed in the territorial pair's territory.

Response by territorial pairs to subadult flocks in these principal use areas varied with the individual pair. Neighboring pairs sometimes joined flocks for short time periods. For example in January and February 1981, 2 unbanded pairs with territories on the east shore of Dunham Bay fed with subadult flocks on the west shore of the bay for 0.5-3 hour periods during 6 of 10 observation periods. Neighboring pairs at Ayres Island and at Sundown Bay joined subadult flocks in these 2 areas on 6 occasions during the 1981-82 season.

On a few occasions, known pairs not from the immediate area joined the subadult flocks for a short time. For example, in 1981-82, Bird 10 and Bird 07 each defended territories in the Dunham Bay area. Both pairs joined subadult flocks in Sundown Bay on 1 occasion and stayed for and 1-3 hours. Generally, when territorial pairs, including unbanded pairs, did join flocks, dominance displays were sometimes exhibited, but usually there was no physical aggression.

Territorial aggression towards flock members from neighboring pairs was observed at all principal flock sites. The regularity of the aggressive bouts varied with the season and the location. For example, at Sundown Bay where subadult flocks were bordered on both sides by territorial pairs, 1-3 aggression bouts were observed during most field observations over all 3 seasons. In contrast, subadult flocks at Ayres and Roddy islands were chased by the neighboring territorial pair from northern Ayres Island only 6 times during the 1981-82 season.

Agression bouts typically began with a unison or guard call by the territorial pair, followed by the territorial male flying in and continually chasing flock members. High bows, wing shake bows, adornment walking, head shaking, and displacement preening displays were also observed. Aerial pursuits of flock members were noted only for particular territorial males.

On some occasions chasing bouts caused flock members to depart from the bay. Usually the flock members either walked quickly exhibiting submissive postures or flew a short ways into the salt marsh. Except for a few occasions when a stationary adornment display was observed, flock members always responded to territorial males with avoidance and other submissive behaviors.

In 1981-82, a aggressive 3-year-old male (Bird 12) established a territory adjacent to the northern home range of the Sundown Bay flock. In contrast to other territorial males, flock members always responded to this bird's behavior with flight behavior. Several times this male was observed aerially pursuing flocks with as many as 7 birds from Sundown Bay. On such occasions he would typically unison call and fly directly at the flock, not pausing to land. The flock would immediately take to the wing and depart from the bay, the male still in pursuit. Often this bird did not return to his territory for 10-70 min. On at least 3 occasions he pursued the subadults over to Ayres Island where he landed and continued to chase flock members. By the end of the 1981-82 season, and throughout the 1982-83 season, the subadult flock used Sundown Island more often and expanded the southern end of their home range, allowing a greater distance from this bird. At the same time, Bird 12 expanded his territory northward, away from the flock's home range.

Several related factors may contribute to paired cranes' tolerance of subadult flocks in their immediate vicinity. First, subadult birds are always submissive to adult pairs. Second, subadult flocks principally utilize areas not defended by paired cranes, and the subadult flocks tend to use the same traditional areas season after season. This fosters a familiarization and tolerance of the subadults by neighboring cranes similar to the tolerance noted in breeding pairs sharing territories. And 3rd, many of the subadult cranes are offspring of the nearby territorial pairs, particularly in Sundown Bay and Dunham Bay. For example, in the 1981-82 Sundown Bay-Ayres and Roddy islands flock, 3 of the regular flock members were offspring of 2 pairs in the immediate area.

Intraflock Relationships

Factors Promoting Flocking Behavior

Gregariousness, the tendency of birds to respond positively to the presence of others of their own kind, promotes and maintains flocking behavior (Emlen 1952, Crook 1961). From 1980-81 through 1982-83 winter seasons, nearly all banded subadults that spent their 1st year on

Blackjack Peninsula or San Jose Island (Table 3, p. 38) joined subadult flocks on Blackjack Peninsula during each winter season. And, all the flocks observed during this study contained the nonbreeding cranes: that is, the unpaired adult cranes and subadults. Thus it would seem that in addition to gregariousness, the attraction between individuals whose situation is the same or very similar, may also be important in promoting flocking behavior (Walther 1972). Bonds between individual cranes is a 3rd factor that contributes to the flocking behavior. Environmental factors can also promote flocking. These factors include low temperatures, drought, light intensity, structure of the environment and seasonality (Emlen 1952).

Advantages To Flocking. The tendency in birds to flock is the outcome of evolutionary selection pressures. For flocks to form and persist, all individuals must enhance their fitness. That gain may be relative to living alone, living in another flock, or the risk of changing flocks (Alexander 1974).

Suggested adaptive advantages to flocking in birds include: learning, minimization of aggression, mate selection, feeding efficiency, and predator avoidance and detection (Moriarty 1976). Of these advantages, increased feeding efficiency and predator detection and avoidance are the 2 most cited reasons for flocking. While there is a controversy as to which was the primary selection pressure for flocking (Murton 1971, Lazarus 1972), many suggest it is a combination of the 2 factors (Goss-Custard 1970; Morse 1970, 1980; Balda and Bateman 1971; Thompson et al. 1974; Krebs and Barnard 1980). The reasoning is that if a bird can rely on others to detect a predator, it can feed longer.

Predator detection, avoidance, and deterrence has been a suggested advantage of flocking in cranes (Tacha 1981, Lovvorn and Kirkpatrick 1982). Cranes are preyed on by crows (Corvus spp.), owls , eagles, peregrine falcons (Falco peregrinus), coyotes, and wolves (Canis lupus) (Walkinshaw 1949; Allen 1952; Cramp 1980; Drewien, unpubl. rep., 1982). Outside of the breeding season all social classes of sandhill cranes tend to roost in large clusters on shallow water areas, leaving larger spaces unoccupied (Guthery 1972, Lovvorn and Kirkpatrick 1982).

Similar behavior was observed among subadult whooping cranes. Limited observations at subadult roost sites during April and May 1982, and January 1983 indicated that while some subadults did not flock together during the day, they roosted for the night with other subadults in tight flocks on shallow salt marsh ponds. Throughout all 3 winter seasons subadults resting or sleeping in the bays during the day, would often bunch up, standing <0.5 m apart. Thus, clustering behavior while resting or roosting apparently serves to discourage predators and increase the possibility of their detection.

Flocks of cranes will exhibit group behavior that will deter predators. Common cranes (G. grus) attacked by a white-tailed eagle (Haliaetus albicilla) were observed to bunch together and face the stoop. Demoiselle cranes (Anthropoides virgo) flocks have been known to cooperatively drive off predators such as crows (Cramp 1980). Subgroups of sandhill cranes have been observed walking towards a coyote after its presence was detected (Lewis 1971; W.M. Brown, pers. commun., Idaho Coop. Wildl. Res. Unit, Moscow, Idaho).

While no studies have been undertaken, it would appear that flocking behavior in subadult whooping cranes could enhance feeding efficiency. By feeding in a group, the need for individual vigilance is lowered, potentially allowing more time for feeding. And, by feeding at traditional, undefended areas where they are tolerated by neighboring cranes, subadults minimize the need for food searching as well as the risk of not finding any food.

Seasonality Of Flocking Behavior. In the ANWR-WBNP population, subadults apparently flock in groups ≥3 birds seasonally. In the fall, subadult flocks of up to 6 birds have been observed staging for 10-14 days in Saskatchewan, Canada. During spring migration, subadult flocks of up to 7 birds have been sighted. Migratory flocks that included subadults, paired adults, and families together have also been observed (U.S. Dep. Inter., unpub. reps., Fish and Wildl. Serv., Pierre, S.D., 1978-1983). On the wintering grounds, subadult flocks ranging from 3-23 accounted for at least 65% of all flocks per month (Table 9, p. 61).

On the WBNP summering grounds, however, large flocks have not been sighted during aerial surveys. In July 1978, several subadults were sighted in an area where there were few breeding pairs. The subadults were spread out as singles or in duos (Kuyt 1979a). Most subadult sightings since then have been of flocks of 2, and occasionally of 3. Only 1 flock of 5, and 1 flock of 4 have ever been observed in WBNP (E. Kuyt, pers. commun.). The preference for larger flocks on the wintering grounds may be the result of decreased territorial aggression outside of the breeding season.

Social Behavior

Social intolerance is an important factor in regulating the size of flocks (Emlen 1952). Among the subadult flocks aggression was infrequent. In only 1 flock were threat displays in the form of chasing and aerial pursuit regularly observed, and this was only for a 3-week period. This particular flock's membership had included 1 new pair that established a territory shortly after the flock broke up, as well as a possible other pair of unbanded cranes.

In all other flocks high intensity threat displays such as bill sparring, charging, pecking, and aerial pursuit among flock members were minimal. Of these behaviors, pecking and chasing were the most frequently observed. Pecking was associated with response to an unusual outside stimulus such as a nearby boat, or it occurred when 2 birds were feeding close together, or for no apparent reason. Chasing was also observed in connection with food, but more often with the arrival of other cranes.

Aside from the flock already mentioned, aerial pursuit among flock members was observed only 5 times during the 1980-81 and 1981-82 seasons. In 3 instances, subadults that were aerially pursued by another flock member continued to stay with their flocks. The other 2 observations involved cranes that attempted to feed with a subadult flock and were subsequently aerially pursued by a dominant flock member. In both cases the pursued crane left the area did not try to rejoin the flock.

Archibald (1975) reported that for cranes in the genus Grus, the adult form of the unison call begins at 18 months and coincides with an increase in aggressive behavior. The unison call serves as a sexual display between members of mated pairs, and between pairs in vocal contact, and as a threat in territorial threat displays.

Throughout this study, subadults of all age classes (1-5 years of age) unison called while in flocks. Unison calling occurred when flock members arrived or departed, when territorial males chased flock members, and during intraflock chasing bouts. While flock members observed did not defend territories, it appeared that their unison calling was a threat display. In newly forming pairs, a unison call as a threat display by 1 of the birds often stimulated its partner to join in.

Tacha's (1981) studies on alert behavior in sandhill cranes found that adult cranes with mates spent more time exhibiting social signals than cranes without social bonds. Similarly, Nesbitt and Archibald (1981) noted that the frequency and intensity of aggressive displays in subadult sandhills was less than that of paired males.

The low frequencies of aggression observed among ANWR subadult flock members may be related to the gregarious nature of the birds during a time in their life cycle when permanent social bonds have not yet fully developed. Additionally, individual recognition of flock members as well as the relative stability of flock membership also serve to establish and maintain relationships. All of these factors coupled with the apparent abundance of food resources may keep aggression among subadult whooping cranes at low levels.

Reproductive behavior in subadults was rarely observed. Dancing bouts were observed <15 times during the 3 winter seasons of field observations. Birds landing or wing flapping after bathing sometimes stimulated a dancing bout. The low frequencies of dancing may be because field observations were concentrated in the bays. Most bays did not have an exposed shoreline or a firm substrate. When cranes were observed at evening and early morning roost sites in the marsh from mid-April to early May 1982, 5 dancing bouts were noted. Thus it appears that cranes are more likely to dance on a firm substrate such as that in the salt marsh, and under certain social situation such as at roost sites.

Flock Stability

Frequencies of association (FOA) were used to identify flocks and subgroups as well as to measure flock stability. For example, if all FOA's between subadults were very low (<10%), it would indicate that there was little flock stability and that membership changed at random.

Among banded subadult whooping cranes, there were 14 out of 163 dyads with high (>50%) seasonal FOA's for the 3 seasons of field observations. These dyads were usually the core or permanent members of a larger flock that fluctuated in size and frequented a particular area on the refuge throughout the flock's duration.

<u>1980-81 Winter Season</u>. Three principal subadult flocks were observed for 2.5 to 3.5 months. Two flocks, 1 at the southern end of Dunham Bay, and 1 at Sundown Bay each contained a dyad with a seasonal FOA >90%, (Birds 20 and 24, 10 and 21) (Table 13). The Dunham Bay dyad, Birds 20 and 24, were part of a trio with an unbanded bird (>4-years-old). While these 2 subadults joined the temporary Egg Point flock

Table 13. Intraflock frequencies of associations (%) between banded subadult whooping cranes based on initial flock counts at ANWR, 1980-81 season.

	Three Islands			Sundown Bay							Dunham Bay	
Bird ID	06	01	02	12	10	21	14	05	11	22	20	24
06(21)[a]		16(5)[b]	14(5)	4(2)								
01(16)			38(10)	5(2)								
02(20)				25(10)								
12(30)					10(7)	12(8)	7(5)	14(8)	24(12)	20(11)		
10(43)						98(42)	38(24)	35(20)	21(13)	18(21)		
21(44)							37(24)	34(20)	22(14)	19(13)		
14(45)								27(17)	22(14)	17(12)		
05 (34)									34(17)	35(18)		
11 (33)										82(31)		
22 (36)												
20 (20)												100(20)
24 (20)												

[a] Total number of times each bird present in initial flock count.
[b] Number of times dyad present in initial flock count.

during December, the remainder of the season was spent in Dunham Bay. All seasonal associations for both banded birds with all other subadult birds were very low (<10%) indicating that this trio was a very cohesive flock.

The 1980-81 Sundown Bay flock had a trio as its core flock that included a 2- and a 1-year-old male bird (Birds 10 and 21, seasonal FOA = 98%) and an unbanded crane. During January, 4 subadults (Birds 05, 11, 12, and 22) joined the Sundown Bay core flock. All 4 birds maintained moderate (25-50%) associations with the trio throughout the month.

In February, a 7th banded subadult (Bird 14), joined the flock and maintained a high FOA (86 and 88%) with the core pair for February and March. During February, Birds 05, 11, 12 and 22 subadults had FOA's with the core pair ranging from 17-71%.

By mid-March, 3 of the subadults (Birds 11, 12, and 22) had dropped out of the Sundown Bay flock. On 1 occasion in late March, Bird 11 tried to rejoin the flock and was aerially pursued by Bird 10. The remainder of the season Bird 11 was observed over on Ayres and Roddy islands with Bird 22. These 2 cranes maintained a high seasonal FOA of 82%. The 3rd crane, Bird 12, left the Sundown Bay flock at the end of February. The remainder of the season Bird 12 was sighted with an unbanded crane around Rattlesnake Island.

The 3rd principal flock was at Three Islands in St. Charles Bay from December 1980 to mid-February 1981. This flock had no high associations and only 2 moderate associations (Table 13, p. 85). The most consistent flock member was Bird 02. During December a 2-year-old

(Bird 12) joined the flock and had a FOA with Bird 02 of 82% for the month. By January, Bird 12 dropped out and joined the Sundown Bay flock. Bird 01 joined the Three Island flock in January. Her FOA with Bird 02 in January was 89%. By mid- February, the flock broke up and Birds 02 and 01 were no longer observed in any flocks on the Refuge.

Throughout the Three Islands flock's duration, the group was joined off and on by Bird 06 and an unbanded bird. While the FOA's between Bird 06 and other flock members are low (Table 13, p. 85) there was a consistent association.

From late November until mid-December a large temporary flock formed at Egg Point in St. Charles Bay in response to a nearby burn (Fig. 7, p.48). With the exception of 2 subadults that wintered on Matagorda Island, all banded subadults were observed at Egg Point between 30 November and 16 December 1980. The large numbers of subadults at Egg Point contributed to the high proportion (52/91) of very low (<10%) seasonal FOA's that otherwise might have been zeroes, indicating no association (Fig. 11, App. 3).

<u>1981-82 Winter Season</u>. This season was very different from the previous 1980-81 season. There were 7 high (>50%) associations, accounting for 19% of all dyads (Fig. 12a., Table 14). All high FOA's were associations observed in 1 principal flock that formed in late November and stayed intact until the end of March. Initially this flock frequented Ayres and Roddy islands, but from February until mid-March it was observed only in Sundown Bay.

The Ayres and Roddy islands-Sundown Bay flock had a core pair consisting of a 4-year-old female and 2-year-old male (Birds 01 and 21,

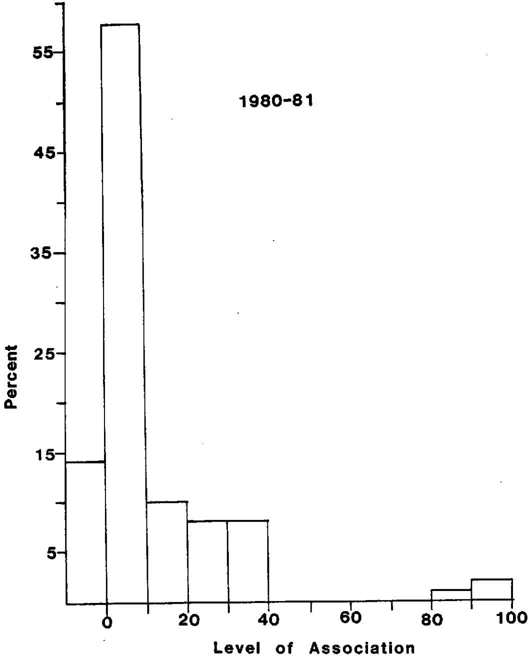


Fig. 11. Distribution of FOA's for all subadult whooping crane dyads at ANWR, 1980-81; N = 14 individuals, 91 dyads.

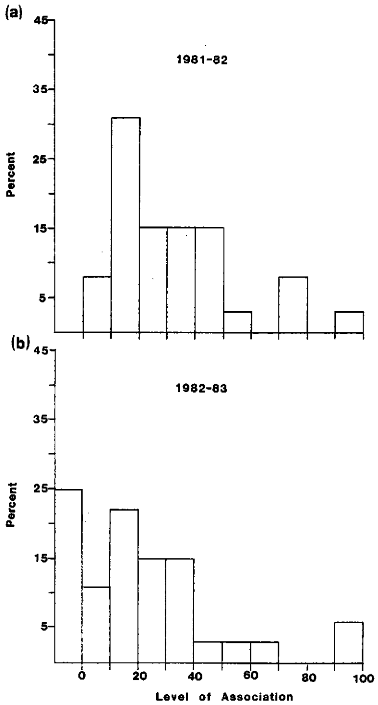


Fig. 12. Distribution of FOA's for all subadult whooping crane dyads at ANWR. (a) 1981-82 season, N = 9 individuals, 36 dyads. (b) 1982-83 season, N = 9 individuals, 36 dyads.

Table 14. Frequencies of associations (%) for banded subadult whooping cranes based on initial flock counts at ANWR, 1981-82 season.

	Sundown Bay-Ayres Island core flock								
Bird ID	01	05	11	14	21	20	24	32	33
01(69)[a]		47(41)[b]	75(59)	75(60)	96(68)	41(40)	14(13)	25(25)	12(12)
05(59)			51(43)	46(41)	47(41)	32(31)	15(13)	35(30)	11(10)
11(69)				75(60)	76(60)	38(38)	14(13)	26(26)	11(11)
14(71)					76(61)	39(39)	15(14)	28(28)	13(13)
21(70)						39(30)	14(13)	25(25)	12(12)
20(68)							22(19)	44(38)	4(4)
24(39)								17(14)	4(3)
32(56)									6(6)
33(45)									

[a]Total number of times each bird present in initial flock count.
[b]Number of times the dyad present in initial flock count.

seasonal FOA = 96%). Two other subadults, Birds 11 and 14, were permanent flock members and had high (75%) seasonal FOA's with this pair, and with each other (Table 14, p. 90). While Bird 05 had moderate seasonal FOA's with 3 of the 4 permanent flock members, and a high seasonal FOA with the 4th flock member, she maintained a high monthly FOA with all 4 permanent flock members during December, February, and March.

Birds 20 and 32 were a subgroup of this Ayres and Roddy islands-Sundown Bay flock and their highest seasonal FOA was with each other (44%). Both birds maintained moderate (25-41%) seasonal associations with all 5 permanent flock members.

Two other subadults, Birds 24 and 33 had low seasonal associations with flock members. For the 2nd season in a row, Bird 24 was accompanied by an unbanded bird (>5-years-old). This pair had a moderate level of association with the flock during January and March, and a low (<25%) association during December and February. Bird 33, a 1-year-old, had a moderate association with the flock during December, a low association in January, but by February dropped out of the flock. For the remainder of the season she was usually observed alone, on or near her parent's territory. Thus, with the exception of Birds 24 and 33, the 7 other subadults on Blackjack Peninsula (Birds 01, 05, 11, 14, 20, 21, 32) all associated with each other at moderate-high levels during the 1981-82 season, and were usually observed as 1 flock either at Ayres and Roddy islands or in Sundown Bay.

1982-83 Winter Season. Two principal subadult flocks were observed during 1982-83: 1 large subadult flock at Sundown Bay and Ayres and

Roddy islands, and 1 smaller flock at St. Charles Bay. The Sundown Bay flock included 4 high FOA's (Fig. 12b p. 89 ; Table 15). Birds 20, 24, and 14 were the core of the flock, along with an unbanded companion of Bird 24. Bird 32 maintained a high association with the flock during December 1982-February 1983.

While Birds 01 and 21 were the permanent flock members in 1981-82, and continued to maintain a high (92% FOA) with each other during 1982-83, they participated in the large subadult flocks only from November 1982-January 1983. By February, this pair was observed only in the vicinity of Ayres Island, sometimes with 1-3 other subadults.

A 2nd principal subadult flock formed at Egg Point at the end of November 1982 and dispersed by the end of February 1983. Two subadults, Birds 33 and 40 were members along with 3-4 unbanded cranes. Bird 40, a radio-banded 1-year-old was observed in this flock throughout the flock's duration. However, when the Egg Point flock broke up, Bird 40 returned to its parent's home range on San Jose Island for the remainder of the season. Bird 32 was observed with the Egg Point flock on 3 occasions in January, but as in the previous season, appears to have spent the remainder of the seasons near her parent's territory.

Seasonal and Age Class Distribution of FOA's

The distribution of FOA's during the 1980-81 season included a high proportion very low FOA's (Fig. 11, p. 88) and was significantly different from both the 1981-82 season (K-S, D = 0.63, $\underline{P} < 0.001$) and the 1982-83 winter season (K-S, D = 0.35, $\underline{P} < 0.005$). In addition to the temporary aggregation at Egg Point in December 1980, 2 other factors

Table 15. Frequencies of associations (%) for banded subadult whooping cranes based on initial flock counts at ANWR, 1982-83 season.

Bird ID	01	05	11	14	20	21	24	32	40
01(14)[a]		19(4)[b]	17(3)	38(8)	27(6)	93(13)	23(5)	33(7)	0
05(11)			6(1)	4(1)	0	20(4)	0	4(1)	3(1)
11(6)				17(3)	18(3)	19(3)	19(3)	11(2)	0
14(15)					52(10)	33(7)	47(9)	61(11)	0
20(14)						23(5)	93(13)	33(7)	0
21(13)							17(4)	29(6)	0
24(13)								35(7)	0
32(14)									0
40(18)									

[a]Total number of times each bird present in initial flock count.
[b]Number of times dyad present in initial flock count.

contributed to the high proportion very low FOA's during the 1980-81 season. First, there were 3 subadults (Birds 06, 07, and 12) that were in constant companionship with unbanded birds (> 4-year-old). By February all 3 birds were observed only with the unbanded birds, and no longer associated with other subadult flocks. The mean level of associations ($\overline{FOA}$) for these 3 birds with all other birds was 9.5%. This same 1980-81 season, there were 3 other subadults (Birds 01, 02, and 13, $\overline{FOA}$'s = 12%), that were no longer sighted in any subadult flocks after February. Thus there were 6 out of 14 subadults with low to very low mean seasonal $\overline{FOA}$'s.

No significant differences were detected in the distribution of FOA's for the 1981-82 and 1982-83 seasons, (Fig. 12, p. 89) (K-S, $D = 0.28$, $\underline{P} > 0.10$). With the exception of 2 birds, these 2 seasons included the same 7 subadults.

The distributions of FOA's for each subadult age class (1-5 years of age) were tabulated (Apps. 4, 5, 6) and then compared with each other using the K-S 2-sample test. The distribution of FOA's was significantly different in the 4-year-old age class from both the 1- 2- and 3-year-old age classes (K-S, $\underline{P} < 0.01$).

In order to determine if particular relationships persisted between seasons, I correlated seasonal FOA's for subadult dyads. There was no correlation in the FOA's from 1 winter season to the next. Correlating FOA values for dyads in 1980-81 with the same dyads in 1981-82 produced $\underline{r} = -0.002$ ($N = 21$, $\underline{P} > 0.05$). And correlating subadult FOA's in 1981-82 with 1982-83 values resulted in $\underline{r} = 0.15$ ($N = 28$, $\underline{P} > 0.05$).

Spatial Proximity Within Flocks

Individual distance between subadult flock members was variable. When resting, preening, or sleeping both during the days and at evening roost sites, cranes were often <0.5 m apart. When feeding in the bays, the cranes usually maintained a minimum distance of 1-2 m.

Nearest neighbor samples were used to determine if the subadult cranes spaced themselves closest to certain individuals while in the principal flocks. Using seasonal and monthly nearest neighbor similarities for the subadult flock at Ayres and Roddy islands-Sundown Bay during the 1981-82 season were calculated and are represented on multidimensional graphs (Figs. 13; Apps. 4, 5, 6). All configurations except January 1981 had good to excellent stress ratings, indicating that the distances in the graphs preserved the corresponding nearest neighbor similarities.

The multidimensional scaling representations for this subadult flock indicate that birds with high seasonal FOA's demonstrated a tendency for physical proximity to each other. Among the permanent flock members that season (Birds 01, 05, 11, 14, 21), there was a preference for physical proximity between Birds 01, 14, and 21. Although 1981-82 was their 1st winter season together, Birds 01 (female) and 21 (male) have since remained together, and nested at WBNP (E. Kuyt, pers. commun.). While Bird 14 (sex unknown), was in close proximity to Birds 01 and 21, it did not prefer either members of this pair over the other and vice versa.

Of the other 2 permanent flock members, Bird 11 was usually close

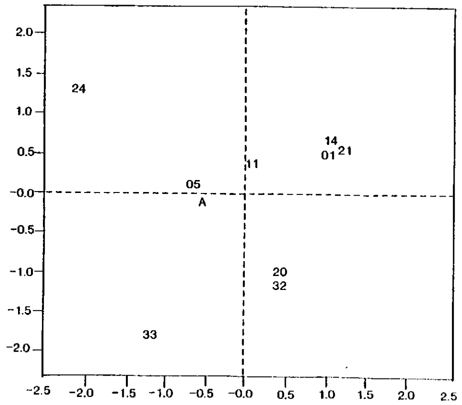


Fig. 13. Multidimensional scaling representation in 2 dimensions using nearest neighbor similarities for Ayres and Roddy islands-Sundown Bay subadult flock members, 1981-82 season; stress = 7%. Numbers indicate Bird Numbers, and A denotes an unbanded bird.

to 3 of the permanent flock members: Birds 01, 14, 21 although none of them showed a strong preference to be near Bird 11. Although Bird 05 was a permanent flock member in 1981-82, she was usually nearest neighbor to cranes that were not permanent flock members.

Birds 20 (sex unknown) and 32 (male) constituted a subgroup within the 1981-82 flock, and their movements were usually independent of the principal flock. While in the flock, this pair showed a tendency for physical proximity to each other (Fig. 13 p. 106; Apps. 7-9).

During 1981-82, Birds 33 and 24 both had low associations with other flock members. Bird 33, a 1-year-old female, joined the flock only during December and January. For both months she had a tendency to be near Bird 05, although Bird 05 was usually closer to other birds. Bird 24 and his unbanded companion joined the Ayres and Roddy islands-Sundown Bay flock most often during January and March. When in the flock, Bird 24 showed no preference for any particular subadult. This was surprising as the previous season Bird 24 had a FOA of 100% with Bird 20, another flock member.

The results for the 1981-82 season confirm that the birds with a high FOA also demonstrate a tendency for physical proximity to each other. Subadults that joined the flock off and on usually showed no preference for proximity to permanent flock members. Presently, sexes are known for only some of the subadults. Until the sexes of all birds are known, it is not possible to conclude if tendencies for physical proximity among certain cranes is due to individual or sexual preferences.

Pair Formation in Subadult Flocks

Age of Pairing

Until recently there has been no information on pair formation in wild cranes. Walkinshaw (1972) postulated that cranes paired in the nonbreeding flocks which formed in the spring after the young of the year were chased off by their parents. Since then, Drewien (pers. commun.) found that greater sandhill cranes began to pair at 18-24 months of age, and by 24 months over 50% were paired. At 36 months, almost all were paired with no difference between in the sexes. He observed that pair formation begins on the wintering grounds and in Colorado during spring migration.

Before the banding of subadults whooping cranes began in 1977, there was only 1 observation of pair formation at ANWR. Blankinship (1976) reported a female with offspring re-pairing approximately 3 weeks after her mate disappeared at ANWR.

Pair bonding has been observed among subadult flock members. Until May 1983, however, all pairs were banded birds pairing with unbanded birds that could not be positively identified. The 1st evidence of pair bonding in banded birds was in 1980 when 2 nests were built by pairs that included 3-year-olds (Kuyt 1981b), (Table 16).

During the 1980-81 winters season, 3 marked subadults left the large subadult flocks with unmarked birds during January and February. Prior to their departure all 3 banded birds were observed to be in constant companionship with an unmarked bird. Once the pairs left the flocks, they rarely rejoined the flocks. However, only 1 pair

Table 16. Number of birds by age of 1st pairing for banded whooping cranes in the WBNP-ANWR population, May 1980 - July 1983.

	Age (Years)						
	3	3.5	4	4.5	5	5.5	6
Nesting at WBNP	2		1				1
Winter Territory		3		1			

established and defended a territory during the remainder of that winter season.

While some 2.5-year-olds have dropped out of flocks with unbanded birds, the youngest birds to establish and defend winter territories have been 3.5-years-old (Table 16). The establishment of a winter territory has not always been proceeded by breeding at WBNP the following summer. In some pairs, winter territories were defended 2 years before any nesting attempt in Canada.

Of 3 known 1st time breeding pairs who did not defend a territory at ANWR prior to nesting, 2 of the pairs established a territory the following winter season. The 3rd breeding pair, was unsuccessful in establishing their 1st winter territory and were observed with a subadult flock on 7 occasions (T.V. Stehn and E.F. Johnson, unpub. rep., U.S. Dep. Inter., Fish and Wildl. Serv., ANWR, Austwell, Tex., 1984).

Typically new pairs established a territory immediately after their arrival at ANWR. Three of the banded birds (Birds 07, 10, and 12; all males) that paired with unmarked birds during this study established their winter territories adjacent to their parent's territory. Since then, Stehn and Johnson (unpubl. rep., U.S. Dep. Inter., Fish and Wildl. Serv., ANWR, Austwell, Tex., 1984) have documented another 2-4 pairs that have also located their territories adjacent to 1 of the crane's parents. They postulate that territories are established as close as possible to the area where the male spent his 1st winter. The tendency to locate near parents was also observed on the breeding grounds for greater sandhill cranes (R.C. Drewien, pers. commun.). Thus, similar to the banded subadults, some paired cranes have exhibited a fidelity to the 1st year home range when they establish their winter territories.

Factors in Pair Formation

Tacha (1981) concluded that pairing for the 3 subspecies of midcontinental sandhill cranes takes place during the northward migration, primarily when the cranes are in huge flocks on the Platte River Valley of Nebraska in March and April.

In his observations of captive cranes, Archibald (1975) found that some cranes were apparently compatible from the start and required little display to form their pair bond, whereas other cranes required extended periods of mutual display. He outlined 5 important factors in the pairing process of cranes: mutual proximity, unison calling, guard calling, dancing, and visual threats.

Although there are only a few cases where there are detailed observation on relationships for more than 1 season, pair bonding in subadult whooping cranes appears to be a lengthy process of familiarization. During this study, 2 pairs were observed in the principal subadult flocks over 1-2 seasons that have since successfully bred in Canada. One other pair that was observed in subadult flocks during the 3 seasons of field observations, established their 1st winter territory this past 1983-84 winter season (T.V. Stehn and E.F. Johnson, unpubl. rep., U.S. Dep. Inter., Fish and Wildl. Serv., ANWR, Austwell, Tex., 1984). During pair formation in the flocks, dancing, guard calling and visual threats within these individual pairs were rare. Unison calling was not observed at all in 1 pair and in the other 2 pairs only on a few occasions. However, all 3 pairs were in constant mutual proximity to each other.

One pair (Bird 10 and an unbanded crane), was part of a trio within a larger flock. While the unbanded bird could not be individually identified, it appeared that the trio members had a 98% frequency with each other during the entire 1980-81 field season. Within the trio, Bird 10 and the unbanded bird were usually in close physical proximity with each other. Similarly, the 2nd pair's (Birds 01 and 21) FOA prior to their 1st breeding attempt was 96% their 1st season together, and 94% their 2nd season. This pair had high FOA's with 2 other birds (76% and 76%) their 1st season together, but were nearest neighbors with each other >50% of the time.

The 3rd pair, Bird 24 and an unbanded crane, had a 100% FOA for 3 seasons of field observations. Their 1st season in 1980-81 was spent as part of a trio with Bird 20. The following 1981-82 season, Bird 24 and its unbanded companion joined the large subadult flock at Ayres Island-Sundown Bay off and on throughout the season. During this 2nd season together they were also observed as a pair at Dunham Bay, middle and northern Sundown Bay, and southern Bludworth Island. Throughout the 1982-83 season, the pair was observed with a large subadult flock in the Sundown Bay area throughout the season.

In contrast to Tacha's findings, none of the subadults observed paired during the spring migration. The 5 pairs that formed during this study, as well as the 1 pair that formed during the 1983-84 season, were all in mutual proximity to each other at least 1 winter season. And, all of these pairs were observed together the following summer on the breeding grounds (E. Kuyt, pers. commun.).

Migration may, in fact, play an important role in the initial contact or continued contact between members of a potential pair. Subadult birds that associated continually throughout a winter season have been observed migrating north together (U.S. Dep. Inter., unpubl. reps., Fish and Wildl. Serv., Pierre, S.D., 1981-1983). Similarly, subadults that the CWS has observed together on the breeding grounds (E. Kuyt, pers. commun.), were later observed together during fall migration. Fall staging areas may also offer an initial contact between nonbreeding birds. Subadult flocks with as many as 6 cranes have been observed staging for 1-2 weeks in Saskatchewan (U.S. Dep. Inter., unpubl. reps., Fish and Wildl. Serv., Pierre, S.D., 1980-83). Therefore, while migration may be important in pair formation, it does not appear to be limited to that time.

Mate Availability As A Limiting Factor

Cranes are long-lived and lifetime monogamous birds. Emlen and Oring (1977) point out that it is advantageous for long-lived monogamous birds to breed with former mates because there is lower aggression and higher synchrony. This in turn allows a pair to breed more rapidly and efficiently, and increase their reproductive success.

In cranes there is a long period of parental investment by both sexes that may last 8-11 months a year. Burley (1981) suggests that species with large, biparental investment will exhibit mate selection based on mate quality. High quality individuals will be most desired, and those same individuals can afford to be more selective. Mate availability may often become the limiting factor.

The nonbreeding flocks and subgroups in large flocks offer the conditions under which available mates can meet and select a suitable partner. With no paired adults and families in the flocks, there is less competition, dominance, and aggression. Pair bonds can form over an extended period of time thus assuring compatibility while reinforcing synchrony.

Among the older banded birds in the WBNP-ANWR population there appears to be two 6-year-olds, and two 5-year-olds that were not paired as of July 1983. Considering that banded birds have bred as early as 3-years-old, this indicates that the age of 1st pairing is highly variable. If there is a shortage of potentially compatible mates, pairing may be delayed.

Available mates within the subadult flocks may be a limiting factor in pair formation in the WBNP-ANWR population. Although as many as 29 pairs have nested at WBNP during 1 breeding season (E. Kuyt, pers. commun.) in many years chick survival is low (see Table 1, p. 13). For example, only 1 bird presently survives from the 1981 hatch, and only 3 birds still survive from the 1982 hatch.

The tendency of subadults to stay near the 1st year home range on the wintering grounds may also prevent an ongoing, continual contact among nonbreeding birds. This may be particularly true of the birds raised on Matagorda Island. None of the 1st-year Matagorda Island birds joined flocks on Blackjack Peninsula during this study, although small subadult flocks ranging from 2-5 cranes have been observed during aerial surveys (ANWR Files, TPWD Files).

The apparent lifetime monagamous pair bond also prevents any new pair combinations among breeding cranes unless 1 of the partners dies. Another additional factor that could limit mate availability is an uneven sex ratio. While it has not been determined if this is the case in the WBNP-ANWR population, it has been a problem in the experimental Grays Lake-Bosque del Apache whooping crane flock. In that experimental population 4-,5-, and 6-year-old males have established breeding territories but have not yet paired due to low numbers of subadult females (R.C. Drewien, unpubl. reps., Idaho Coop. Wildl. Res. Unit, Moscow, Idaho, 1981, 1982).

CONCLUSIONS

The subadult stage in the life cycle of a whooping crane is characterized by gregarious behavior. On the ANWR wintering grounds, color-banded subadults joined flocks composed primarily of nonbreeding cranes. The nonbreeders included the sexually immature subadults, and the mature, unpaired adult cranes.

On the wintering grounds, subadult and adult whooping crane habitat selection was similar. Upon arrival in the fall, the cranes fed in the seasonally flooded salt marsh. During the colder winter months, the cranes foraged in shallow bays and inlets and regularly frequented the adjacent salt marshes. With the seasonal spring tides the cranes again fed primarily in the salt marsh.

In the fall, unusual food concentrations attracted aggregations that included large numbers of subadult and unpaired adult cranes. These large flocks were typically associated with concentrations of blue crabs in the salt marsh, acorns in upland scrub oak thickets and oak mottes, and prescribed burns in the marsh and uplands. The appearance of flocks of subadults in St. Charles Bay during 2 of the 5 field seasons was most likely due to the bay's proximity to controlled burns. A site preference for this bay may be developing.

Average seasonal subadult flock size varied between 4.4 - 5.6 cranes over the 5 seasons. Fluctuations in flock size and composition appeared to be a result of seasonal availability of food on the marsh and pair bonding. The distribution of flock size frequencies for 4 winter seasons were non-random and indicated higher than expected preferences for small flocks of 2 and 3 cranes, and for larger flocks ≥ 9

cranes.

Subadults principally utilized areas not defended by paired cranes, and at least from 1976-1983 the subadult flocks on ANWR preferred 3 traditional sites. These sites include Dunham Bay, middle and southern Sundown Bay, and Ayres and Roddy islands.

Subadults have shown a definite tendency to stay in the area where they were raised their 1st year. Banded subadults observed in flocks on Blackjack Peninsula had spent their 1st year on Blackjack Peninsula, Welder Point, or San Jose Island. Cranes raised on Matagorda Island were never observed in flocks on Blackjack Peninsula.

Subadult birds were always submissive to adult pairs. Territorial pairs tolerated subadult flocks in their immediate vicinity, although aggression was frequent. The tolerance by territorial pairs of subadult flocks was most likely enhanced by a familiarization resulting from traditional use in certain areas as well as individual recognition of former or neighboring offspring.

While subadult flocks were open in membership, relationships were based on individual recognition. Some strong associations existed between individual subadults although these bonds were often temporary, or seasonal in duration. Subadults that maintained high associations showed a preference for physical proximity with each other while in the flocks.

Pair formation occurred in subadult flocks. The 6 pair bonds that were observed developed from high associations over 1-3 winter seasons. Some subadults left the large subadult flocks during the winter season and paired with unbanded birds. Once these pairs left the flocks, they rarely rejoined the flocks, although most of these pairs did not establish their 1st winter territory until the following fall. Some pairs participated in subadult flocks during the winter, and made their 1st breeding attempt the following summer.

The subadult flocks appeared to offer the conditions under which available mates could meet and select a suitable partner. However, in the ANWR-WBNP population, mate availability could be a limiting factor in pair formation.

RESEARCH NEEDS AND MANAGEMENT RECOMMENDATIONS

In the interest of preserving optimum conditions for the subadult flocks and the adult cranes, there are several suggestions I would like to make.

There is a need for further information on habitat use by the whooping cranes while they are wintering on ANWR. Currently our information on habitat use for birds on Blackjack Peninsula has come primarily from boat observations and the weekly and bi-weekly ANWR and TPWD aerial surveys. For birds on San Jose and Matagorda islands, our information is based almost exclusively on aerial surveys.

Since the summer of 1981, some prefledged chicks have been color-banded and radio-tagged in WBNP. Some radios are still in operation after 2.5 years. The radio-tagged birds offer a tremendous opportunity to obtain much needed information on wetland and upland use by cranes on the wintering grounds.

Such research is also timely in light of the changes in management of public lands on Matagorda Island. While some 4,654 ha (including 1,618 ha of wetlands leased to National Audubon Society) of the southern portion is privately owned and used as 1 operating ranch, the remaining 17,763 ha is public lands.

From 1971-1983, some 7,692 ha of Matagorda Island uplands were administered as part of the National Wildlife Refuge System. The other 8,725 ha of coastal wetlands, and 1,345 ha of Gulf lands were under the jurisdiction of the Texas General Land Office. Through a series of legal actions, the Texas Parks and Wildlife Department (TPWD) entered into a 100 year agreement with the National Wildlife System to manage portions of public lands on Matagorda as a wildlife refuge, and portions as a park and wildlife management area. The primary purpose of TPWD management is the protection of wildlife, especially endangered and threatened species and migratory birds. All recreational developments are secondary and of much lower priority. (State of Tex., unpubl. rep., TPWD, Austin, Tex., 1982).

Portions of Matagorda Island have been designated as critical habitat for the whooping crane. As many as 19 whooping cranes have been observed wintering on the island. The marshes of Matagorda Island represent the largest suitable habitat available for the whooping crane population (U.S. Dep. Inter., unpubl. rep., San Antonio, Tex., 1982). With the increased use of Matagorda Island for recreational purposes, the biological/physical carrying capacity of the island for the whooping cranes must be determined. This requires a knowledge of what kinds of recreational user behavior the cranes will tolerate, and how much disturbance cranes will tolerate per unit of time.

For example, the whooping cranes will not tolerate human activity on the uplands, whether it be foot or vehicular traffic (U.S. Dep. Inter., unpubl. rep., San Antonio, Tex., 1982). Due to the lack of visual barriers on the uplands, any human activity can be seen from long distances. Thus any increased activity on the Matagorda Island uplands should be monitored for its effects on crane behavior.

Whooping cranes in the bays are subject to disturbance from recreationalists, in particular airboat operators. While it varies with the individual bird, and possibly with the size of the motor, airboats more often than not will flush whooping cranes. Airboats will displace cranes from their location for anywhere from 15 min to a few hours (this study).

TPWD has conducted aerial surveys since 1976, immediately before and after, as well as during the waterfowl hunting season. The surveys have found that hunters, and in particular hunters operating from airboats, may occassionally cause or limit the movement of cranes. Much of this is due to the practice of driving waterfowl with airboats (J. Smith, unpubl. rep., TPWD, Rockport, Tex. 1980). The surveys have found that the cranes roamed more in the duck hunting area, after the season.

There is a need to research the possibility that hunting, is in fact, limiting the expansion of the whooping crane range into new areas on Matagorda Island. And this research should determine if the use of airboats and other shallow water vessels, especially for hunting in the bayside marshes, not only on Matagorda Island but also at San Jose Island and St. Charles Bay, are disturbing the whooping cranes by displacing them. Within this context, TPWD should consider the possibility of closing certain areas to hunting so that the resulting effects on crane behavior could be monitored.

There is a need to investigate the long-term effects of burning on the habitat both at ANWR and on Matagorda Island. Burns offer a natural additional food source for cranes. Burn intensity and frequency should be monitored so that the long-term habitat conditions and food availability are not sacrificed.

Both subadults, chicks, and adult whooping cranes exhibit a site fidelity on the wintering grounds that is demonstrated by traditional use areas. Because of this behavioral tendency, the likelihood of expansion into new available habitat is very slim, and will most likely be a very slow process. The management implications of this site fidelity is that ANWR and the other surrounding wintering areas should be managed intensively for the cranes, in order to guarantee their maximum welfare. What is most important then is the preservation of the land immediately surrounding ANWR and other wintering areas. One means to accomplish this is to obtain conservation easements on, or purchase outright the surrounding habitat.

Steps also need to be taken to prevent ongoing and potential habitat destruction of whooping crane habitat. In particular there is a need to determine whether or not the Gulf Intracoastal Waterway poses a potential threat to the welfare of the whooping crane. Presently the majority of the cranes on Blackjack Peninsula feed in the bays adjacent to the GIWW (see Fig. 1, p. 8). Over the years, erosion due to boat traffic has decreased the availability of salt marsh habitat on both sides of the GIWW. This is especially evident in Sundown Bay where the southern opening has gone from a few meters wide, to several hundred (D.R. Blankinship, unpubl. data). Aside from the habitat loss through erosion, there is always the potential of an oil or chemical spill from barges in the heavily-used GIWW. Such an accident could be devasting to the whooping crane population.

The possibility of relocating the GIWW has been under discussion for many years. A preliminary recommendation of The Whooping Crane Recovery Plan (1980) is that part of the GIWW be moved eastward so it would pass between Aransas and the barrier islands of Matagorda and San Jose. If we are to preserve whooping crane habitat, relocating the GIWW should be one of management's top priorities.

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APPENDICES

Appendix 1. ANOVA for effect of year, month, and habitat on the number of whooping crane flocks ≥ 3 for 1978-79 through 1982-83 at ANWR and environs, ($\bar{N} = 401$).

Source	SS	df	F	PR > F
Model	222.92	69	4.92	0.01
Year	48.32	4	18.39	0.01
Month	12.21	6	3.10	0.01
Habitat	58.12	1	88.51	0.01
Year x Month	11.43	24	0.73	0.83
Year x Habitat	1.70	4	0.65	0.63
Month x Habitat	43.52	6	11.05	0.01
Year x Month x Habitat	47.62	24	3.02	0.01
Error	217.37	331		
Total	440.29	400		

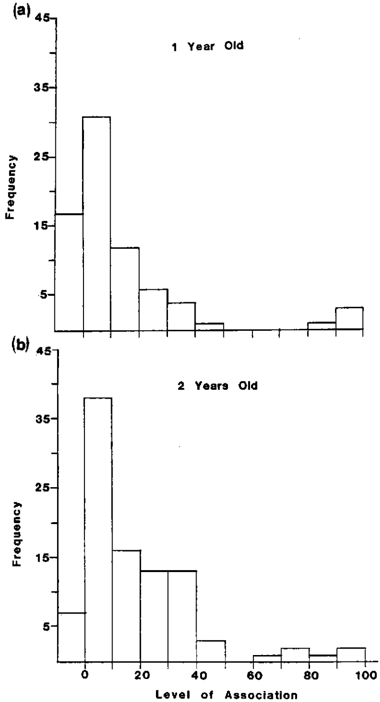
Appendix 2. ANOVA for effect of year, month, and habitat on the total number of whooping cranes in flocks >3 for 1978-79 through 1982-83 at ANWR and environs, (N = 2304).

Source	SS	df	F	PR > F
Model	8,183.81	69	6.14	0.01
Year	1,245.16	4	16.12	0.01
Month	661.88	6	5.71	0.01
Habitat	1,366.57	1	70.76	0.01
Year x Month	503.24	24	1.09	0.36
Year x Habitat	174.51	4	2.26	0.06
Month x Habitat	2,019.47	6	17.43	0.01
Year x Month x Habitat	2,212.98	24	4.77	0.01
Error	6,392.24	331		
Total	14,576.05	400		

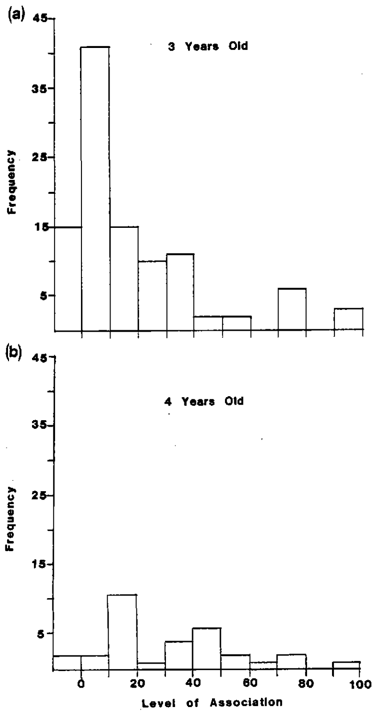
Appendix 3. Frequencies of associations (%) for banded subadult whooping cranes based on initial flock counts at ANWR, 1980-81 season.

Bird ID	01	02	05	06	07	10	11	12	14	13	20	21	22	24
01(16)[a]		38(10)[b]	9(4)	16(5)	2(1)	2(1)	4(2)	5(2)	7(4)	0	9(3)	2(1)	4(2)	9(3)
02(20)			2(1)	14(5)	0	0	6(3)	25(10)	3(2)	0	0	0	4(2)	3(1)
05(34)				8(4)	2(1)	35(20)	34(17)	14(8)	27(17)	3(1)	4(2)	34(20)	35(18)	4(2)
06(21)					4(2)	2(1)	11(5)	4(2)	6(4)	4(1)	8(3)	2(1)	7(4)	9(3)
07(32)						0	2(1)	2(1)	3(2)	5(2)	4(2)	0	1(1)	0
10(43)							21(13)	10(7)	38(24)	2(1)	0	98(42)	18(12)	0
11(33)								24(12)	22(14)	3(1)	4(2)	22(14)	82(31)	4(2)
12(30)									7(5)	3(1)	2(1)	12(8)	20(11)	2(1)
14(45)										6(3)	8(5)	37(24)	17(12)	8(5)
13(7)											8(2)	2(1)	2(1)	8(2)
20(20)												0	4(2)	100(20)
21(44)													19(13)	0
22(36)														4(2)
24(29)														

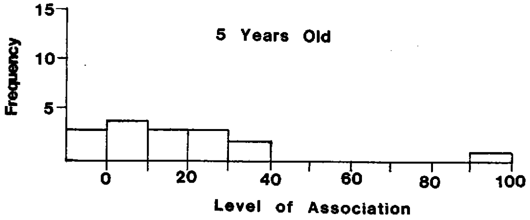
[a]Total number of times each bird present in initial flock count.
[b]Number of times dyad present at initial flock count.



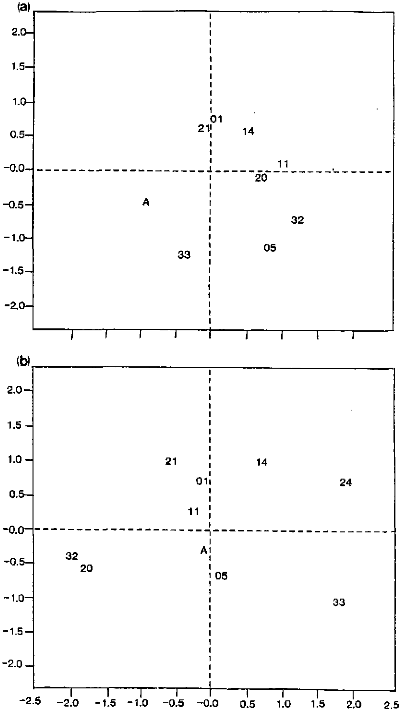
Appendix 4. Distribution of seasonal FOA's for nonterritorial whooping cranes in specific age classes. (a) 1-year-olds, N = 7 individuals, 75 dyads. (b) 2-year-olds, N = 9 individuals, 96 dyads.



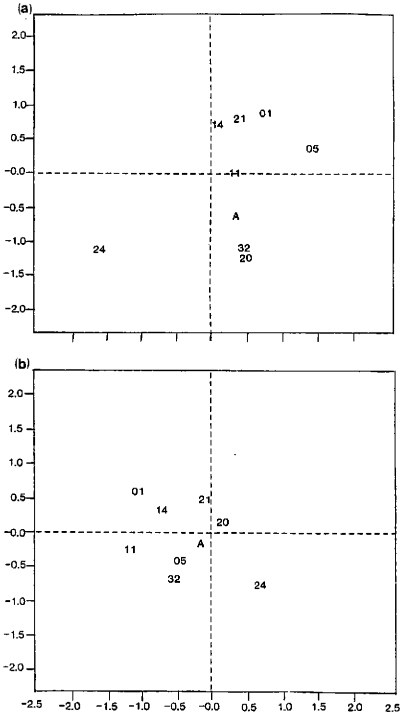
Appendix 5. Distribution of seasonal FOA's for nonterritorial whooping cranes in specific age classes. (a) 3-year-olds, N = 10 individuals, 105 dyads. (b) 4-year-olds, N = 4 individuals, 32 dyads.



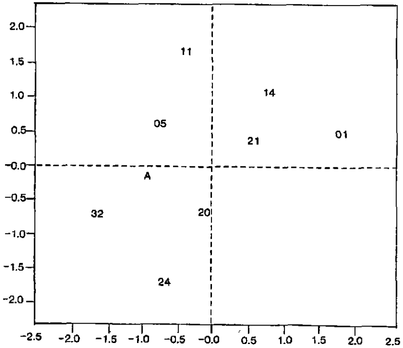
Appendix 6. Distribution of seasonal FOA's for nonterritorial whooping cranes 5-years-old, N = 2 individuals, 16 dyads.



Appendix 7. Multidimensional scaling representation in 2 dimensions using nearest neighbor similarities for Ayres and Roddy islands-Sundown Bay subadult flock members. Numbers indicate Bird Numbers, and A denotes an unbanded bird. (a) December 1981, stress = 5%. (b) January 1982, stress = 14.6%.



Appendix 8. Multidimensional scaling representation in 2 dimensions using nearest neighbor similarities for Ayres and Roddy islands-Sundown Bay subadult flock members. Numbers indicate Bird Numbers, and A denotes an unbanded bird. (a) February 1982, stress = 6.7%. (b) March 1982, stress = 3.5%.



Appendix 9. Multidimensional scaling representation in 2 dimensions using nearest neighbor similarities for Ayres and Roddy islands-Sundown Bay subadult flock members, April 1982; stress = 5.3%.

VITA

Mary Anne Bishop was born 6 September 1952 to Joseph and Dorothy Bishop in Berea, Ohio. She attended the University of Wisconsin and the Universidad Catolica in Santiago, Chile, as an undergraduate and graduated with a B.B.A. in Real Estate and Urban Land Economics from the University of Wisconsin in August 1974.

Ms. Bishop was an English language instructor in Valparaiso, Chile, in 1975, and a housing counselor in San Antonio, Texas, during 1976. From 1977-1980 she was employed by the San Antonio Zoological Gardens in San Antonio, Texas, as a zoo keeper in the Bird and Large Mammal Departments. During the 1979 summer, she was an avicultural intern at the International Crane Foundation in Baraboo, Wisconsin.

In November 1980, Ms. Bishop began a project to study the behavior of color-banded subadult whooping cranes at Aransas National Wildlife Refuge, Texas, under the sponsorship of the National Audubon Society. The following June 1981 she entered the M.S. program in the Department of Wildlife and Fisheries Sciences at Texas A&M University, College Station, Texas. Since August 1983, she has been enrolled in the Ph.D. program at the Department of Wildlife and Range Sciences, University of Florida, Gainesville. The permanent mailing address for Mary Anne Bishop is 118 Newins-Ziegler Hall, University of Florida, Gainesville, Florida 32611.

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