THE BREEDING ECOLOGY AND MANAGEMENT OF WHITE PELICANS AT STUM LAKE, BRITISH COLUMBIA

by

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ABSTRACT

This study was conducted to identify aspects of the breeding ecology of white pelicans (Pelecanus erythrorhynchos) in British Columbia and to develop a management plan to preserve and enhance white pelicans and their habitat in British Columbia. Field studies were conducted during the breeding seasons from 1977 to 1980.

The major migratory route of white pelicans in British Columbia occurs in the Okanagan Valley. Pelicans arrive at Stum Lake, the only known breeding location in British Columbia, in mid April and remain on the Fraser Plateau until late September. Eighty-three percent of all pelicans observed in British Columbia during the summer were located within 80 km of the breeding lake. Chilcotin Lake, approximately 70 km west of Stum Lake, was the primary foraging site during the study. Identification of bone samples collected on the breeding island indicate that pelicans in British Columbia prey chiefly on non-game fish species, such as sucker (Catostomus spp.).

Pelicans at Stum Lake selected flat unvegetated areas to nest. The presence of herring gulls (Larus argentatus) did not appear to affect their nesting distribution. Inter-nest distances were calculated in 1977 and 1978 and found to be similar to distances recorded for other white pelican colonies in North America.

Mean clutch size of white pelicans at Stum Lake during years without disturbance was 1.95 ± 0.21. Mean egg mortality was 10% of all eggs laid. Nest abandonment was the major mortality factor. Nestling and fledgling mortality claimed a further 26% and 20% respectively, of all eggs laid. Total mortality of young during 1977 and 1978 was 56% of all eggs produced. In years when coyote predation or human disturbance occurred, survivorship of young and overall productivity of the colony was reduced. The potential impact of coyote predation and human disturbance were examined over longer periods by using a simple simulation model.

The results of this study were discussed in terms of potential management practices that would enhance white pelicans in British Columbia.

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CHAPTER 1.

INTRODUCTION

Two species of pelicans occur in North America. The brown pelican (*Pelecanus occidentalis*) is strictly marine while the white pelican (*Pelecanus erythrorhynchos*) occupies both marine and fresh water habitats. Presently both species of pelican are suffering population declines throughout all or part of their breeding range. The decline of the brown pelican appears to be associated primarily with reproductive failures resulting from the accumulation of chemical residues (Blus *et al*. 1974, Anderson and Anderson 1976, and Anderson *et al*. 1977). The decline of the white pelicans appears due to several factors that differ between colonies.

Factors limiting the productivity of white pelican colonies in North America include mammalian predation (Scott 1960, Blokpoel 1971), fluctuating water levels (Hosford 1965, Evans 1972), human-induced disturbance (Hall 1925, Mansell 1965, Carson 1966, Vermeer 1970a), parasites and disease (Greichus and Greichus 1973, Wobeser *et al*. 1974), sibling rivalry and/or starvation (Knopf 1975, Johnson 1976), and adverse weather conditions (Bartholomew *et al*. 1953, Lies and Behle 1966, Adolphson and Adolphson 1968, Bremer 1977).

In Canada, at least 20 white pelican colonies have been abandoned over the past 80 years. This loss represents almost one half of the 46 colonies present at the turn of the century (Vermeer 1970a). Since Vermeer's study an additional 6 colonies have been abandoned in Alberta. The remaining 7 colonies in Alberta occur only in the more northern, unsettled regions of the province (Markham and Bretchel 1978). There is some evidence that white pelican colonies abandoned during one year can be re-occupied in following years (Vermeer 1970a, Roney 1978, Roney 1979). In general, however, there appears to be a growing number of abandoned colonies in Canada that are not being re-colonized or relocated. White pelicans are now classified as 'threatened' in Canada. A 'threatened species' is defined as 'any indigenous species of fauna or flora that is likely to become endangered in Canada if the factors affecting its vulnerablity do not become reversed' (Committee on the Status of Endangered Wildlife in Canada).

In British Columbia, the only known breeding colony occurs at Stum Lake approximately 70 km west of Williams Lake. Pelicans were thought to have bred at several other localities in British Columbia (Thompson 1933); however, these possible breeding records remain unconfirmed. At present, fewer than 300 pelicans nest at the Stum Lake colony. Prior to my study, the status of the population was uncertain and information on their breeding ecology was fragmentary. Previous data indicate that the breeding population at Stum Lake may have been larger than present population levels. During the last 10 years, however, the population appears to have stabilized slightly and may even be increasing. In recognition that historical population levels may have been larger, and that the population has such a restricted breeding distribution within the province, the white pelican was officially designated as an 'endangered species' in British Columbia as of March 1980. An 'endangered species' is defined as 'a population immediately facing extinction in British Columbia and requiring special enhancement measures or both to ensure their survival' (B.C. Fish and Wildlife Branch).

My study had two broad objectives: 1) To determine the present status and to document the natural history of white pelicans in British Columbia, and 2) To develop a plan to manage and enhance white pelicans and their habitat in British Columbia (Chapter 8). Specific objectives were:

1) To determine the present status, distribution, and trends in the population (Chapter 3);

2) To determine the location of foraging sites and the characteristics of these feeding areas (Chapter 4);

3) To determine the characteristics of the breeding habitat and to locate alternative breeding sites suitable for modification (Chapter 5);

4) To document the breeding colony's reproductive success (Chapter 6);

5) To assess the role of intraspecific behaviour and interspecific relations on their breeding success (Chapter 7); and,

6) To relate the preceding natural history information to potential management practices that would enhance white pelicans in British Columbia (Chapter 8).

CHAPTER 2.

DESCRIPTION OF STUDY AREA

2.1 Location and Habitat

White Pelican Provincial Park is located on the Fraser Plateau in central British Columbia (52° 16'N by 123° 3'W), approximately 70 km west of Williams Lake (Fig. 1). The land surrounding the lake is forested and gently sloping. The dominant tree species are lodgepole pine (Pinus contorta), trembling aspen (Populus tremuloides), and white spruce (Picea glauca).

The lake lies at an elevation of 1218 meters. It covers approximately 900 ha and has a mean depth of approximately 2.5 m (Burns and Klein 1973). The water is slightly alkaline (pH = 8.6) and supports a large number of lake chub (Couesius plumbens). Five small islands lie within the lake, three of which have been used for nesting by pelicans. The nesting islands are Island One, Island Two, and Scaup Island (Fig. 1). Both Scaup Island and Island One are low, exposed, rocky outcroppings, and are 300 and 600 meters respectively from the nearest mainland. These islands have very little vegetation, except for small patches of stinging nettle (Urtica dioica), water hemlock (Cicuta douglasii), and various sedges (Carex spp.) growing along the shoreline. Scaup Island is the smallest of the three nesting islands and has an area of only about 90 m^2, whereas Island One has an area of approximately 400 m^2. The largest and most commonly used island for nesting is Island Two.

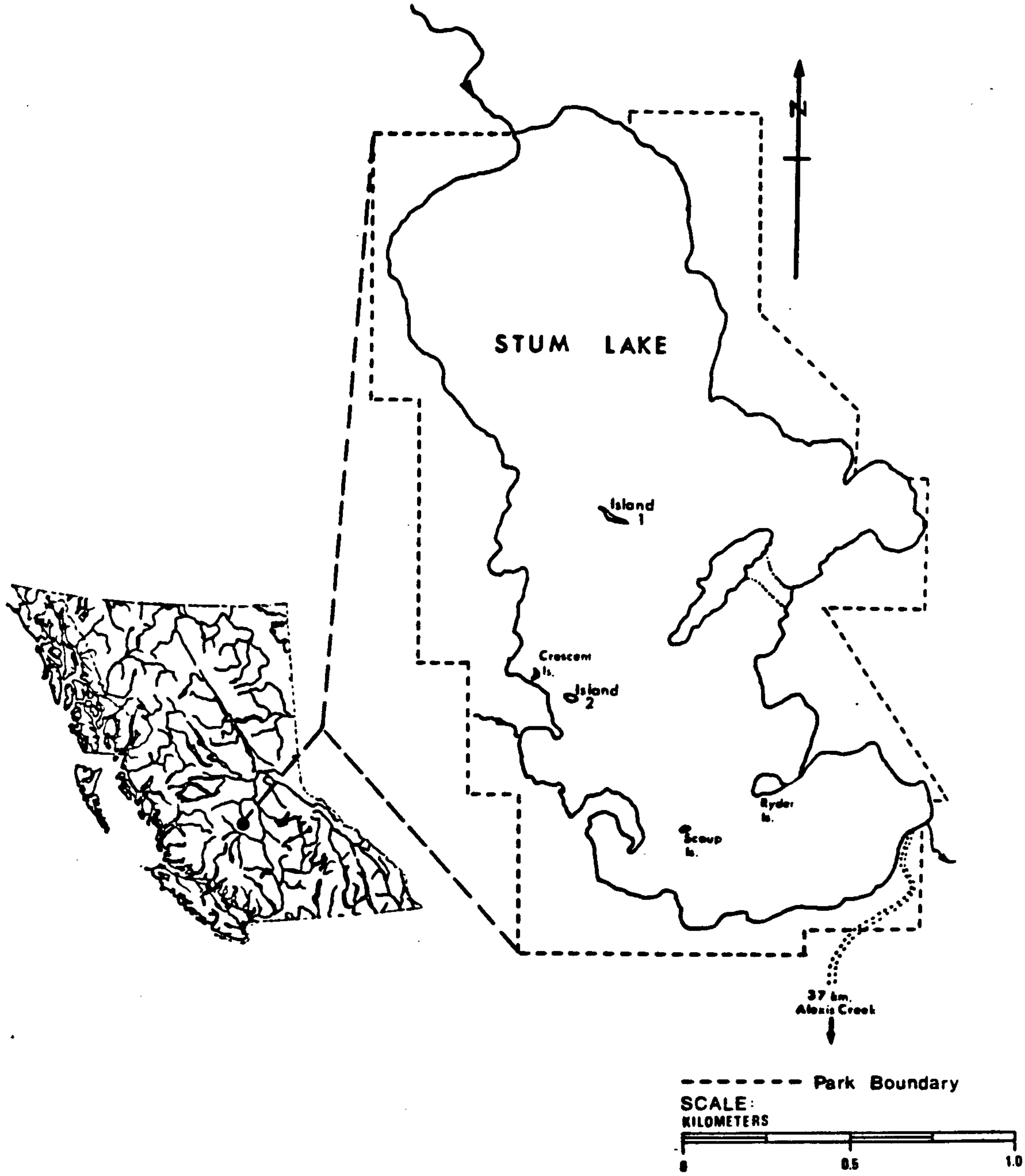

Figure 1. Location and configuration of Stum Lake, British Columbia.

It has an area of approximately 1000 m^2 and rises gradually from its shore to its highest point (6.7 m above lake level). It is situated only 84 m from the mainland. The remaining two islands (Crescent and Ryder) on the lake are heavily vegetated and are not used by the pelicans for nesting or roosting.

Herring gulls (Larus argentatus) also nest on Island One and, to a lesser extent, on Scaup Island. Other birds that occasionally nest on Island Two include common loons (Gavia immer), Canada geese (Branta canadensis), mallards (Anas platyrhynchos), lesser scaup (Aythya affinis), ring-necked ducks (Aythya collaris), tree swallows (Iridoprocne bicolor), and white-crowned sparrows (Zonotrichia leucophrys). For a more detailed description of the birds and plant communities of White Pelican Provincial Park, refer to Koza (1981).

2.2 Climate

The climate at Stum Lake is characteristic of the slightly cooler sub-zone of the Cariboo-Aspen-Lodgepole Pine Biogeoclimatic Zone sensu Krajina (1959). Weather data were collected at the Alexis Creek-Tautri Creek Weather Station (52° 33'N by 123° 11'W) located 30 km northwest of Stum Lake. The weather station lies at an elevation of 1219 meters. Data cover the period from 1971 to 1980. Daily minimum and maximum temperatures recorded during spring, 1979, differed only slightly between Stum Lake and the weather station (Fig. 2). Daily maximum temperatures recorded at Stum Lake averaged about 2°C cooler than those at the weather station.

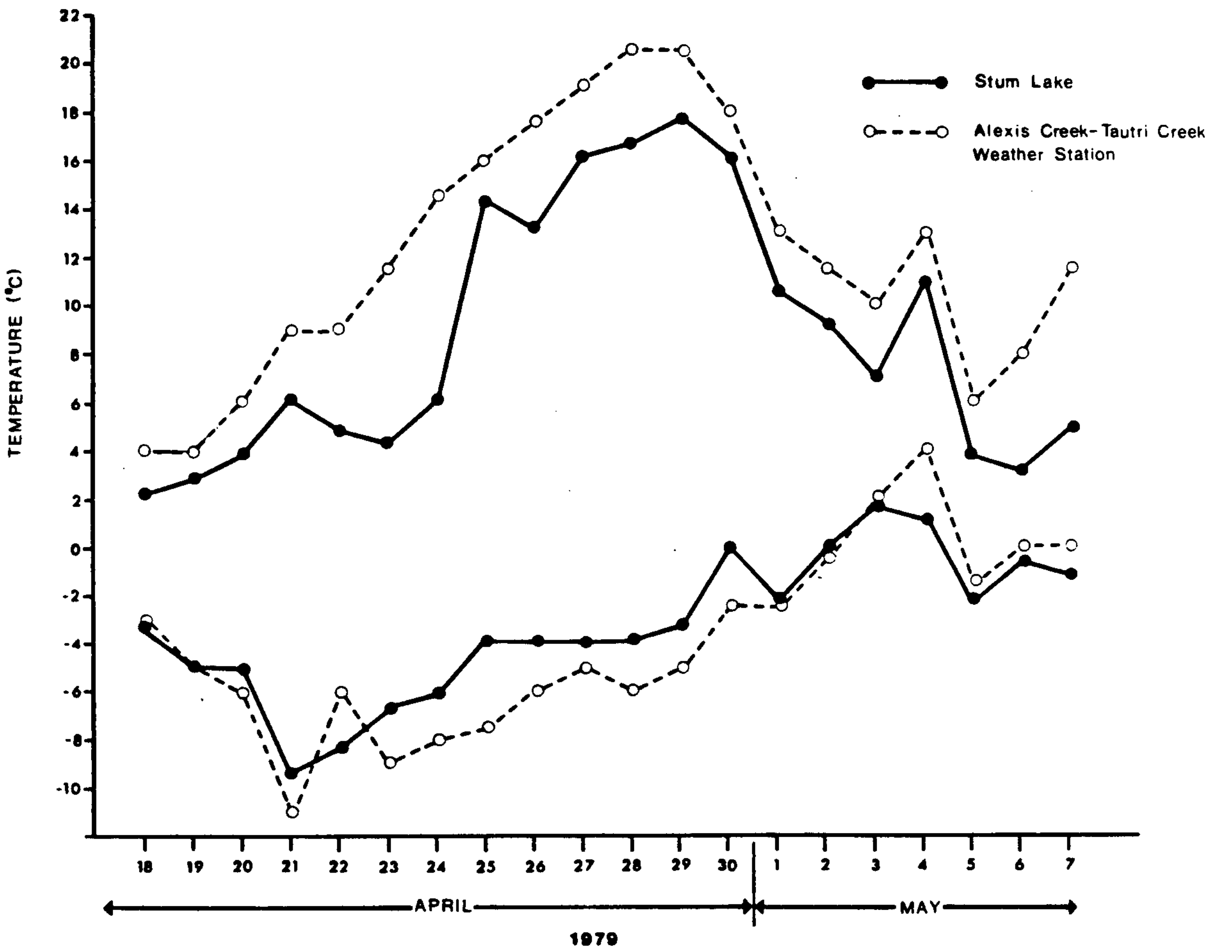

Figure 2. Daily minimum and maximum temperatures for Stum Lake and the Alexis Creek-Tautri Creek Weather Station.

Mean daily minimum and maximum temperatures ranged from -6°C to 8°C respectively in April, increasing steadily until July when mean daily minimum and maximum temperatures ranged between 3°C and 20°C (Fig. 3). Mean minimum and maximum temperatures decreased to -1°C and 15°C respectively by September. During the period when pelicans were at Stum Lake (April to September) the mean daily temperature was 7.8°C. The average number of frost-free days per year was 79; however, frost has been recorded in every month of the year. The study area receives an average total precipitation of 448 mm ± 41 mm (sd) per year, with approximately 251 mm ± 68 mm (sd) of precipitation during the breeding season from April to September.

Break-up of ice at Stum Lake occurred between 2 May and 3 May in 1978, later than 8 May (estimated between 10 May and 12 May) in 1979, and between 30 April and 1 May in 1980. The mean date of break-up at Stum Lake for those 3 breeding seasons, assuming my estimate during 1979 is accurate, was 4 May.

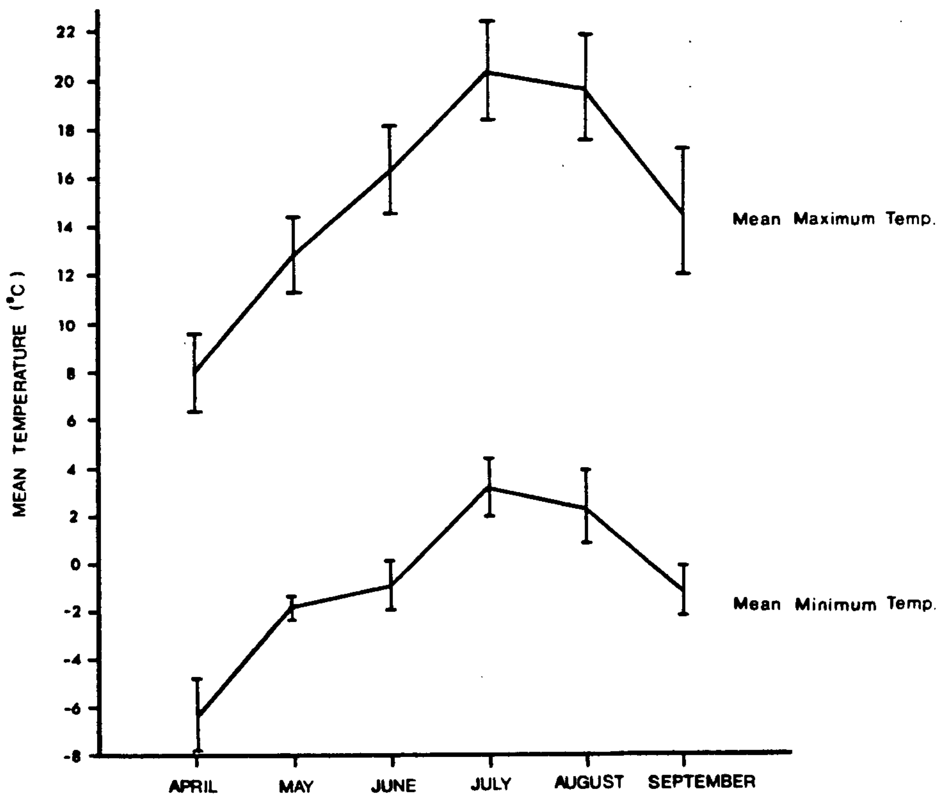

Figure 3. Mean monthly minimum and maximum temperatures for Alexis Creek-Tautri Creek Weather Station from 1971 to 1979.

CHAPTER 3.

DISTRIBUTION AND ABUNDANCE OF WHITE PELICANS IN BRITISH COLUMBIA

3.1 Introduction

Prior to my study, the status of the white pelican population in British Columbia was uncertain. The colony had been surveyed during 11 breeding seasons; however, more than seven different groups had participated in the counts. Consequently, the timing of the surveys, the methods of data collection, and the resulting data varied considerably. During the 11 breeding seasons, adults were estimated only two times; nests, only two times; accurate nest counts, three times; and accurate nest counts as well as an estimate of adults, four times. During at least two surveys, pelicans were forced to abandon the breeding lake while counts of nests and eggs were conducted.

Earlier data suggest that the present white pelican population at Stum Lake is smaller than historical levels. Heavy losses of young, resulting from coyote predation and human-induced disturbances, were recorded from 1971 to 1974. The number of visitors at the lake also appeared to be growing during the same period. In view of these points, there was increasing concern regarding the ability of the colony to survive.

In addition, relatively little was known concerning the migratory routes and summer distribution of pelicans nesting in British Columbia. Information regarding the migratory routes through the United States and wintering areas of white pelicans breeding west of the Rocky Mountains was also insufficient. At present, the only published account of white pelican migrations west of the Rocky mountains is that presented by Vermeer (1977). The suggested migratory route, however, is limited to only seven banding returns from pelicans that fledged at Stum Lake.

The major objective addressed in this chapter was to determine the present status, distribution, and trends in the pelican population in British Columbia. Specific objectives were to:

1. Determine the wintering areas and migratory routes of pelicans breeding west of the Rocky Mountains,
2. Determine the migratory route and the summer distribution of white pelicans breeding at Stum Lake and,
3. Determine the history, present status, and population trend of white pelicans at Stum Lake.

During the study, several earlier population records (nests and/or adults) were located, the earliest from 1953. These earlier counts were used to determine long-term trends in the population.

3.2 Methods

3.2.1 Distribution of White Pelicans in Western North America

White pelican sightings recorded during the spring and fall in British Columbia were obtained from the B.C. Provincial Museum. Records ranging from 1922 to 1978 were examined and mapped to determine the major migration route of white pelicans through British Columbia. The migratory route of pelicans south of the Canada-U.S. border were determined by mapping spring and fall sightings listed in the Journal of American Birds (1965 to 1978). Total numbers of birds observed were divided by the number of years of data to provide a yearly average. Wintering areas were determined by mapping pelicans censused during the Mexico Winter Waterfowl Survey (U.S. Fish and Wildlife Service 1979), and by locations listed in the Journal of American Birds.

3.2.2 Population Status

Historical records of white pelicans in British Columbia were located at the British Columbia Provincial Museum in Victoria. Information gathered there included early records of foraging sightings, numbers of adults at Stum Lake, clutch sizes, and numbers of young fledged. I studied the colony from 1977 to 1980 and recorded colony occupation, minimum numbers of adults, clutch sizes, numbers of nests, the productivity of nests (young fledged/nest), and survivorship of the young (young fledged/egg laid).

3.3 Results

3.3.1 Wintering Areas and Migration Routes of White Pelicans in Western North America

The majority of white pelican breeding colonies occur in central Canada and north central United States (about 30), while only 6-7 colonies occur west of the Continental Divide. Banding recoveries indicate that there is little mixing between the two populations on their summer and winter ranges (Vermeer 1977). The winter range for the eastern populations lies along the coastal regions of the Gulf of Mexico and the east coast of Mexico (Strait and Sloan 1975). The principal wintering grounds for white pelicans that breed west of the Rocky Mountains lie along the coasts of southern California and western Mexico (Fig. 4). Seven recoveries of pelicans banded at Stum Lake in 1968 also indicate an autumn migration towards the southern California coastline (Vermeer 1977). Other colonies west of the Continental Divide that are known to migrate south and winter along the west coasts of California and Mexico include pelicans from Great Salt Lake, Utah (Behle 1958), Pyramid Lake, Nevada (Kridler 1960) and those from the Warner Valley, Oregon (S. Elefant pers. comm.). Pelicans of the Yellowstone Lake colony, Wyoming, situated in the Rocky Mountains, fly mainly to southern California and the west coast of Mexico during their fall migration; however some fly to Texas and eastern Mexico (Diem 1967).

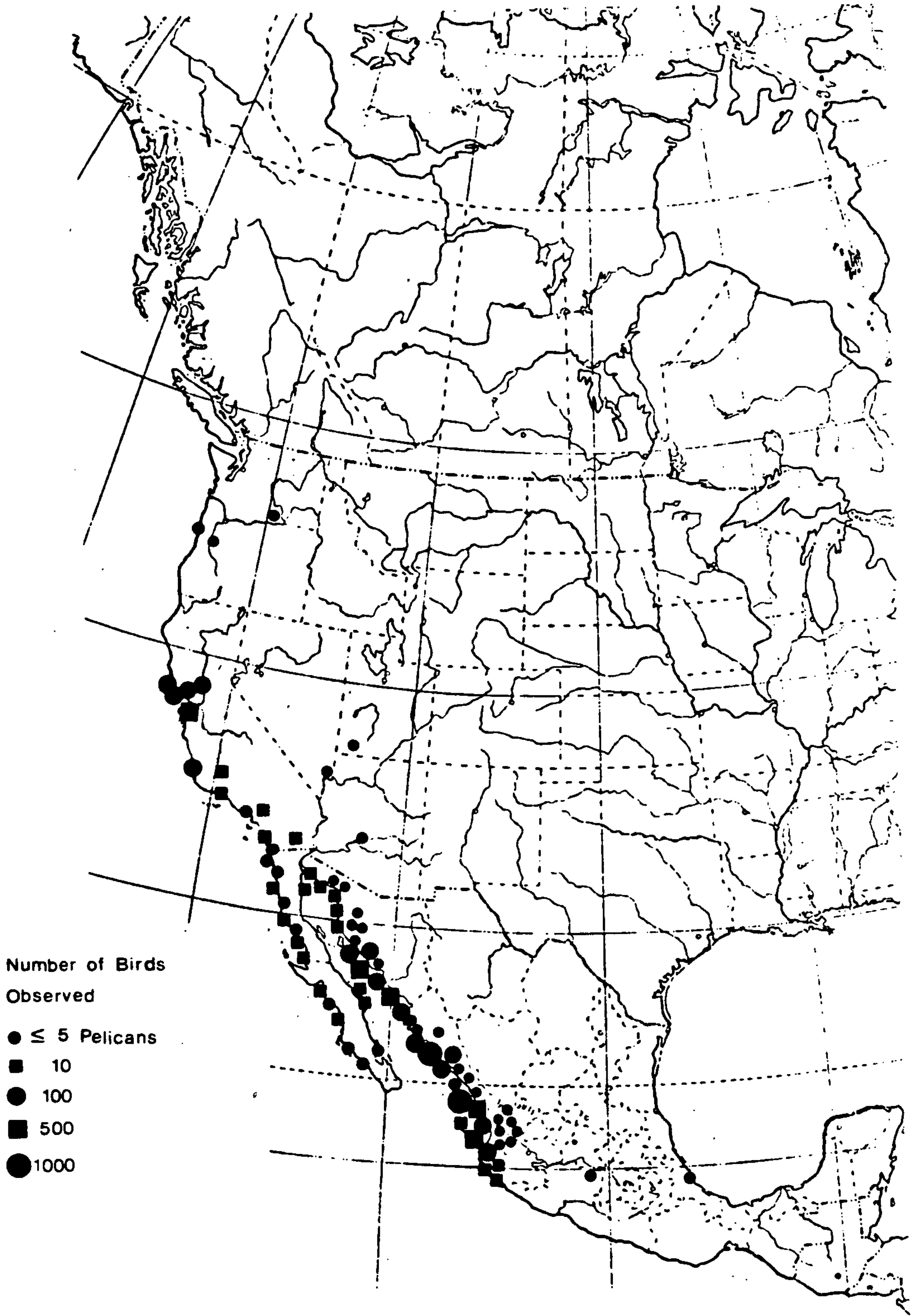

Figure 4. Principal wintering areas for white pelicans west of the Rocky Mountains.

The northwest migration during the spring begins in March and continues until April or May (Palmer 1962). The migratory route through the western United States is not clearly defined, probably due to the dispersal of birds to their particular breeding colonies (Fig. 5). Since pelicans no longer breed in Washington, consistent spring and fall migration records from McNary Wildlife Refuge in southern Washington indicate that the birds from Stum Lake pass through this area. Flocks of 20 or more white pelicans have been recorded during the summer in eastern Washington; however, these birds are probably non-breeders (Brittel 1976). Non-breeding pelicans have also been observed during the summer at the McNary Refuge. The last nesting records of white pelicans in Washington occurred during the early 1930's. Prior to that period, they bred regularly in eastern Washington, primarily in the Moses Lake area (Brittel 1976).

The major migratory route of white pelicans in British Columbia occurs in the Okanagan Valley. The birds continue to travel northwest through the Nicola Valley towards the Fraser Plateau (Fig. 6). Pelicans have frequently been observed resting overnight at Stump Lake (R. Howie Pers. Comm.), approximately 35 km south of Kamloops, in the Nicola Valley. The coast does not appear to be a major migratory route for pelicans during the spring or fall migration. The several coastal sightings are generally older records and usually represent single birds or very small groups. In the lower mainland, pelicans are considered as 'casual' during the summer, only occurring one or two times per decade (Checklist of

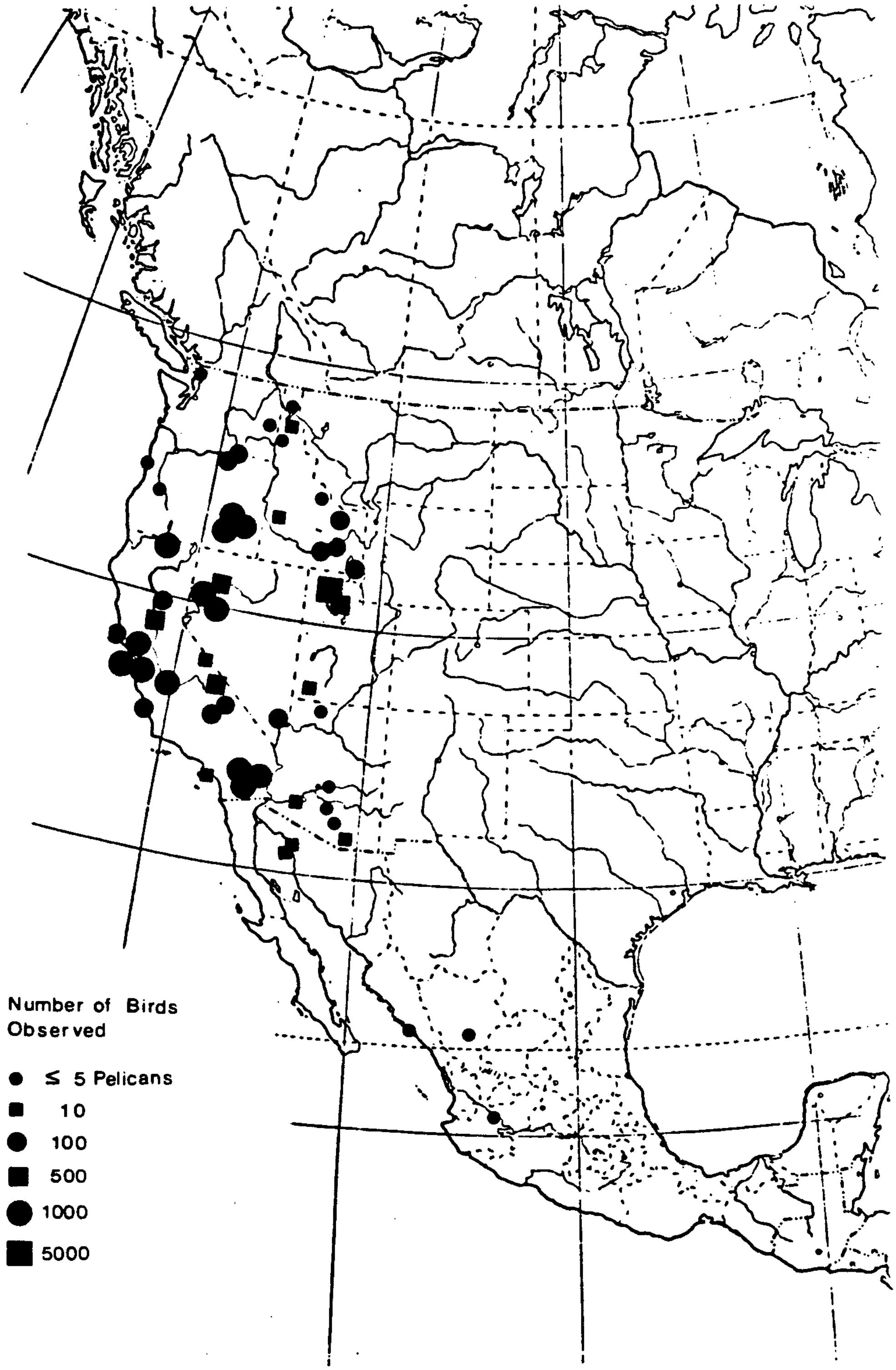

Figure 5. Migratory route of white pelicans breeding west of the Rocky Mountains.

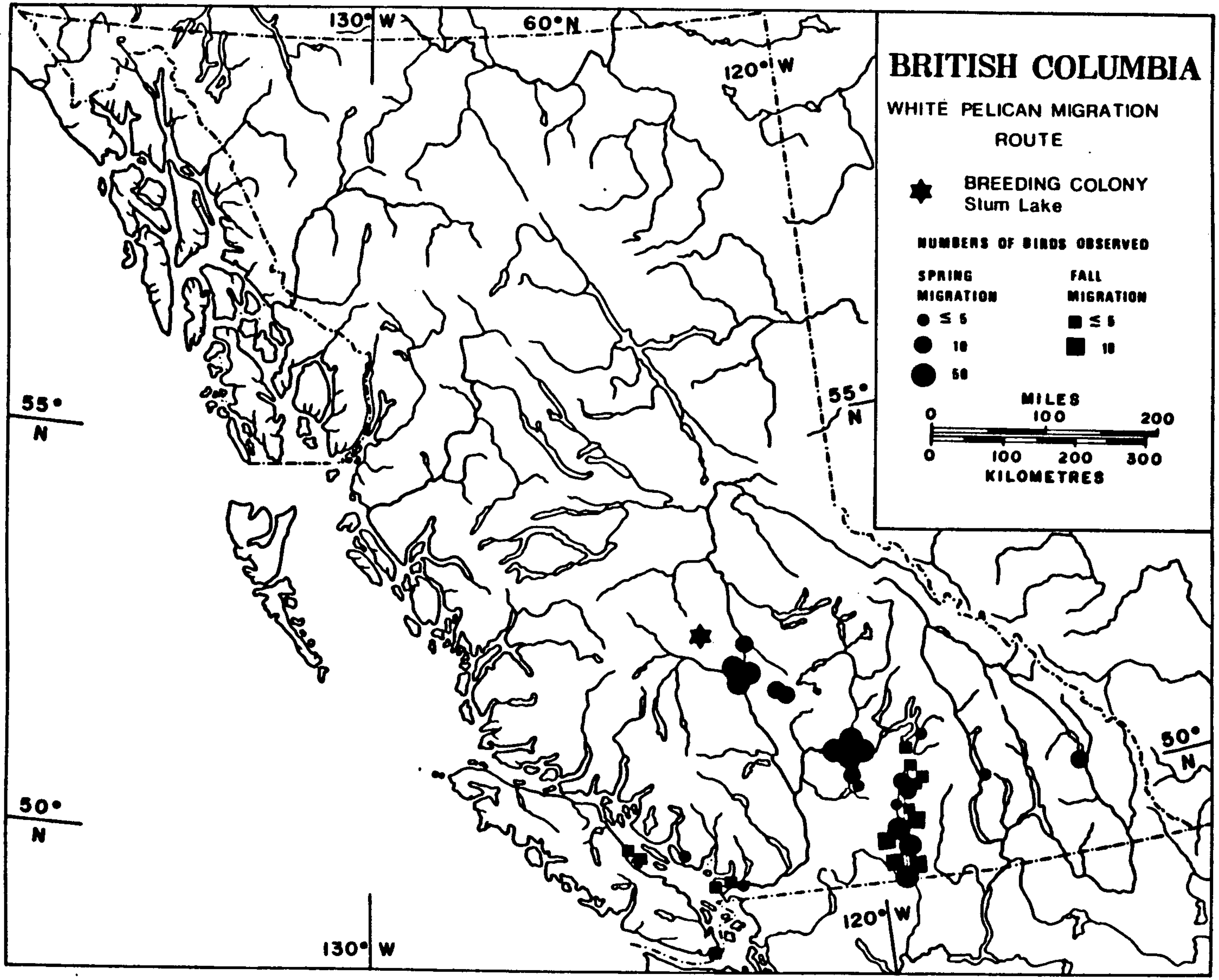

Figure 6. Migratory route of white pelicans in British Columbia.

Vancouver Birds 1975).

The approximate time of arrival of the birds generally coincides with the spring melt. The pelicans first arrive in the Chilcotin region in mid-April, one to two weeks before the ice leaves Stum Lake. Regular sightings have been recorded at Alkali Lake (about 80 km southeast of Stum Lake) during this period. The mean date of arrival for pelicans at Stum Lake (two breeding seasons) is 17 April, while the mean date of ice break-up at the breeding lake (three seasons) is 4 May (refer to Section 6.3.1 for details).

During the summer, the pelicans used several lakes on the Fraser Plateau as foraging sites. Eighty-three percent of white pelicans observed during the summer (260 of the 315 pelicans sighted) were within 80 km of the breeding lake (refer to Section 4.3.1 for details). The latest date that pelicans have been recorded in the area was 14 September during 1973. Fall migration sightings indicate that the birds generally follow their spring migratory route. One pelican banded at Stum Lake was shot near Vancouver in October 1968, while two others were recovered in December in southern Washington and central Utah (Vermeer 1970b).

3.3.2 History, Present Status, and Population Trends

The white pelican has been a regular breeder in British Columbia for many years. The first recorded information for the species in B.C. occurred in 1892 from the Cariboo-Chilcotin region of the province. Pelicans were reported by Rhoads (1893) as common during migration on Lac La Hache (110 km from Stum Lake). Several spring and fall sightings were recorded along the Okanagan Valley in the early 1900's (B.C. Provincial Museum Records). Munro (1930) reported the species as occurring regularly during migrations in the Nicola Valley in the late 1920's. In a survey of white pelican breeding colonies in North America from 1931 to 1932, Thompson (1933) listed several localities in B.C. where pelicans were thought to have bred. These included Swan (Pantage), Sucker, Anahim, Puntzi, Tzenzaicut, and Pelican Lakes. These lakes are all remote and there has been no confirmation that pelicans actually nested at any of them.

The first confirmed breeding observation for white pelicans in B.C. occurred on 1 July, 1939 at Stum Lake. Eggs and young were photographed at that time, although numbers of nests and young were not recorded. Since that time, Stum Lake has remained the only known breeding colony of white pelicans in B.C. No further records of nesting exist until the breeding season of 1950. Pelican eggs were collected twice during 1950, but population counts were not made.

In 1953, I.McT. Cowan made the first population census at the Stum Lake colony and counted 140 nests. Six years later, L.G. Sugden observed the colony and counted 59 eggs, 70 live young, and 9 dead young on two islands. He estimated 100 to 150 adults on the lake but did not record the number of nests. In late May of 1960, G. Van Tets visited the nesting island and found it deserted with many broken pelican eggs. He estimated the total number of abandoned nests at 239. Numbers of nests were not counted in 1963, although two colonies were reported to have 130 and 150 adults (Lies and Behle 1966). In 1964, a minimum count of 146 nests was obtained by three surveying parties. Nest counts in 1964 are not clear since several conflicting records exist. It appears, however, that there were at least 146 nests during that year. R.T. Wright visited the colony in 1967 and 1969, and found 153 and 87 nests respectively on one island. In both years, pelicans were forced to leave their nests during the nest survey. K. Vermeer banded 45 of the 83 nestlings in 1968 and counted 85 nests. From 1971 to 1974, G.R. Ryder was a park warden at the colony and found 104, 116, 118, and 108 nests respectively. He was the first to record the survival of young in the colony. The total adult population was also estimated during those years. My study extended from 1977 to 1980. Total numbers of nests for these four years were 86, 105, 96, and 120. The historical abundance of the colony at Stum Lake is illustrated in Figure 7 which summarizes the number of adults and nests recorded from 1953 to 1980.

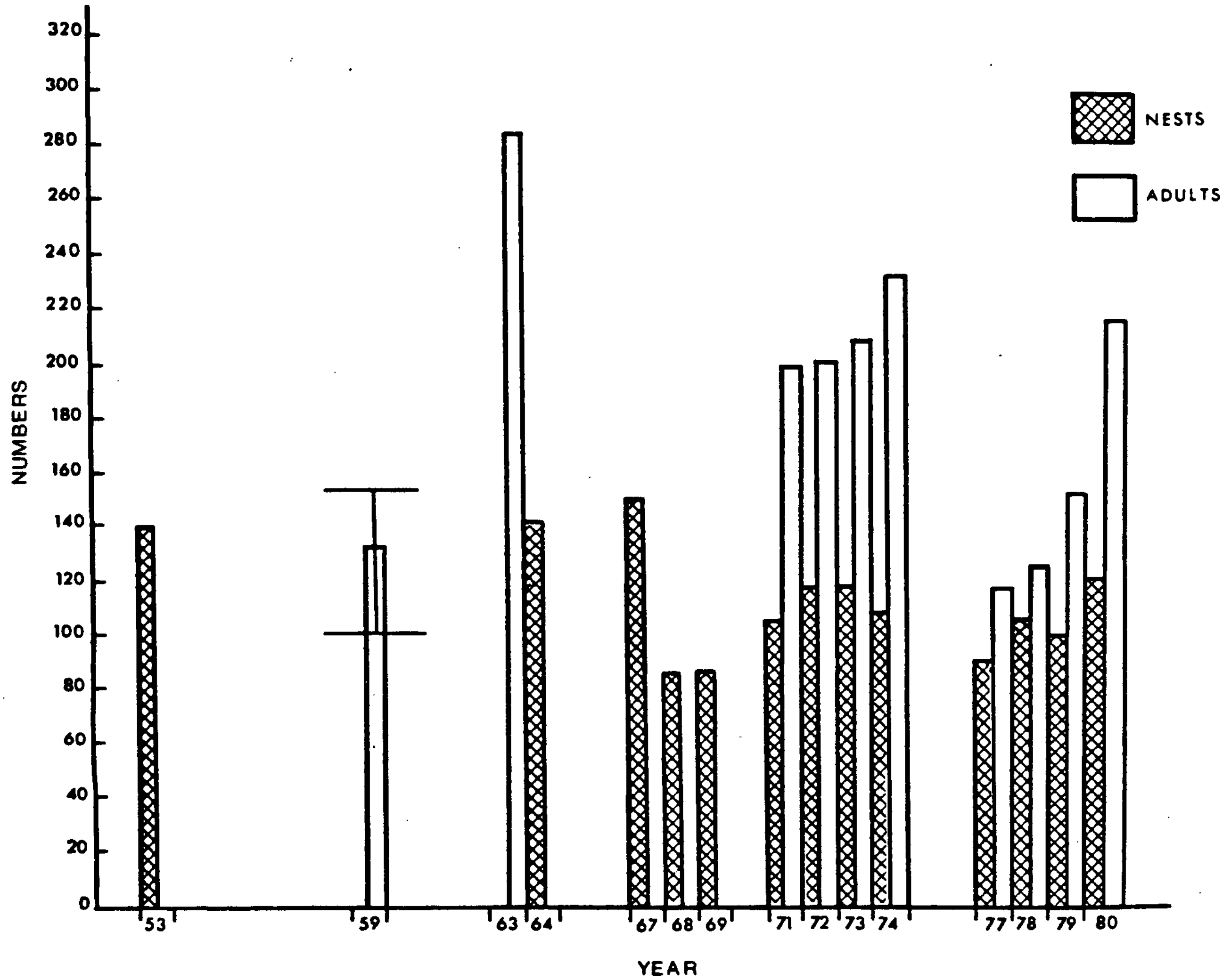

Figure 7. Number of nests and pelicans observed at Stum Lake, British Columbia (in 1959 exact numbers are not available and a range is given).

The trend in the population is more accurate using numbers of nests rather than adults. The number of adults present at the colony fluctuates daily and changes dramatically within a single breeding season. Numbers of nests however change only slightly during the incubation and brooding periods, and therefore provide a better index of the reproductively-active adult population. Although the colony is generally lower in numbers of nests in recent years compared with the 3 earliest breeding records (1953, 1964, and 1967), a long-term declining trend is not evident in the population. From 1967 to 1968, there was a substantial drop in the number of nests at Stum Lake. During the years from 1968 to 1974, the colony fluctuated mildly, but generally remained relatively stable at about 103 ± 14 nests/year. During my study period from 1977 to 1980, the population appears to have increased slightly.

3.4 Discussion

The wintering areas of white pelicans breeding at Stum Lake appear to lie along the coasts of southern California and western Mexico. The majority of white pelican sightings along the coast occurred in brackish estuaries and protected bays, marshes, and lagoons. The San Francisco Bay area appeared to be the most important wintering area along the California coast. However, the major wintering areas for white pelicans breeding west of the Rocky Mountains are in the Gulf of California and extend south to Guadalajara, Mexico. The few inland sightings of wintering white pelicans usually were in marshes and lagoons within National Wildlife Refuges.

Migratory routes of white pelicans through the United States are not clear, and pelicans may follow two general fly-ways. One route seems to extend northward from wintering areas in the San Francisco Bay area to inland and northern states. The other fly-way appears to be more inland from the Gulf of California, northward through Arizona, Nevada, Utah, and Idaho. This latter fly-way closely resembles the route taken by pelicans from Stum Lake as indicated from Vermeer's (1977) seven banding returns.

The migratory route through British Columbia is well defined. The majority of the birds travel through the Okanagan and Nicola Valleys, then northwest towards the Fraser Plateau. This route through British Columbia is also a major fly-way for Canada geese and other waterfowl species (Myres and Cannings 1971).

White pelicans undoubtedly have been regular breeders in British Columbia for many years. Rhoads (1892) listed white pelicans as 'common' during migration on Lac La Hache almost a century ago. During the last decade the colony appears to have been stable, and may be increasing. However, numbers of breeding adults have not yet reached the levels recorded prior to 1968. Factors that warrant its endangered status in British Columbia under present legislation include: the very restricted breeding range of the population, (only one location in British Columbia); the small size of the population, (less than 300 individuals); the low reproductive potential of the population, (age at first breeding is three years); and the taxonomic importance of the population, (only representative of the Family Pelecanidae in British Columbia).

CHAPTER 4.

FORAGING DISTRIBUTION, HABITAT CHARACTERISTICS, AND FOOD HABITS OF WHITE PELICANS IN BRITISH COLUMBIA

4.1 Introduction

The feeding habits of white pelicans in North America have been poorly understood for many years. This lack of knowledge probably has been an indirect but important factor contributing to their decline in North America. Since the mid-1800's pelicans have been persecuted repeatedly on their nesting grounds by people who believed the birds consumed large numbers of important game fish. Henshaw (1879) reported that white pelican colonies in the southwestern United States were continually harassed for this reason. At Yellowstone Lake, Wyoming, the white pelican population was controlled from 1923 to 1932 in an effort to reduce the birds' impact on the number of trout in the lake (Anon. 1932). Acting under the orders from the Park Superintendent, two rangers destroyed eggs and clubbed young to death. During 1931, the Montana Government removed state protection for white pelicans and made an appeal to hunters to exterminate the birds (Anon. 1932). A Montana newspaper, describing the birds, stated:

> "Measuring some seven feet of wingspan on an average, the birds not only eat fish for food and store others for short times in their beaks, but kill fish for the pure love of killing."

In Canada, the situation remained much the same as in the United States. In 1964, fishermen caused white pelicans nesting at Suggi Lake, Saskatchewan, to completely abandon their colony for the season (Carson 1966). This colony was disturbed again by fishermen in 1970, causing the pelicans to desert it permanently (Vermeer 1971).

Although white pelicans are "threatened" in Canada (Committee on the Status of Endangered Wildlife in Canada 1979) and migrate between United States and Canada, they still are not protected by the federal Migratory Bird Convention Act of 1916. The belief that the birds consumed large quantities of economically valuable fish was the primary reason for their exclusion from the act (Vermeer 1971). Protection of the white pelican has been considered unnecessary because the species has no monetary value.

Recent studies have begun to refine our concepts of the food habits and foraging requirements of white pelicans. Investigations have been carried out at Chase Lake, North Dakota (Johnson 1976, Lingle and Sloan 1980), Great Salt Lake, Utah (Low *et al*. 1950), Lake of the Woods, Ontario (Mansell 1965), Prince Albert National Park, Saskatchewan (Trottier *et al*. 1980), and Birch Lake, Alberta (Ealey 1979). The majority of these studies have shown that white pelicans do not consume economically valuable game fish, but coarse fish instead. In British Columbia, relatively little is known concerning the foraging habits and activities of white pelicans.

Specific objectives of the foraging activities study were:

1. To provide information on the foraging distribution and movements of white pelicans in British Columbia;
2. To document the characteristics of foraging areas, to determine specific habitat requirements; and,
3. To analyse food habits of pelicans nesting at Stum Lake.

These objectives were secondary to my efforts to document pelican numbers and productivity.

4.2 Methods

4.2.1 Foraging Distribution of White Pelicans in British Columbia

I conducted 3 aerial surveys of selected lakes on the Fraser Plateau during the 1977 breeding season (27 June, 5 August, 25 August). The surveys were conducted to determine the foraging and breeding distribution of white pelicans in B.C. and to find potential nesting habitat suitable for manipulation (refer to Section 5.3.3). I selected lakes on the basis of their distance from Stum Lake, the abundance of fish, and the presence of islands. Initially, B.C. Fish and Wildlife Branch Lake Surveys were used to determine fish abundance, and aerial photographs were used to locate lakes with islands. The majority of the lakes surveyed were north of Highway 20 between Riske Creek and Anahim Lake. Surveys were flown between 11:00 and 15:00 hours using fixed-wing aircraft (Cessna 185) at an altitude of approximately 350 m. Two observers recorded time, location, number of birds, and habitat characteristics of the lakes and islands. Habitat features noted included the water depth between the island and the mainland, estimated visually from the aircraft or obtained from previous Fish and Wildlife Lake Surveys, and presence or absence of loafing sites (sand bars, islands, etc.). The foraging distribution was mapped using the data collected from 3 aerial surveys and from older records of summer sightings (1 June to 30 August) obtained from the B.C. Provincial Museum.

4.2.2 Movements of Pelicans

During the spring (1979 and 1980) and summer (1977 and 1978) surveys, I recorded movements of pelicans departing from the nesting lake. The measurements were recorded to provide additional insight into the location of foraging areas for white pelicans on the Fraser Plateau. I assumed that these pelican movements were primarily associated with foraging excursions because pelicans did not forage at Stum Lake. I recorded the time, number of birds, and the direction of flight.

4.2.3 Food Habit Analyses

In late August 1978, after the pelicans had left the nesting island, I examined the island for remains of food that had been partially consumed by the breeding birds. Six right-opercular bones, one right cleithrum bone, two caudal fin bones, and 133 vertebrae were collected. The bones were identified at the Department of Zoology's Oesteology Museum, U.B.C.

4.3 Results

4.3.1 Foraging Distribution of White Pelicans in British Columbia

In British Columbia the foraging range of white pelicans during the summer was chiefly confined to the lakes of the Fraser Plateau (Fig. 8). The pelicans did not forage at Stum Lake. Appendices I and II contain summer sightings recorded during 3 aerial surveys in 1977 and foraging records from the period 1920 to 1978 obtained from the B.C. Provincial Museum, respectively. Eighty-three percent (260 pelicans) of all white pelicans sighted during the summer on the Fraser Plateau (not including pelicans sighted at Stum Lake or during migrations) were within 80 km of Stum Lake (Fig. 9). The other sightings in British Columbia recorded during the breeding season, excluding those on the Fraser Plateau, occurred along the Okanagan Valley (4) and southern coastline (5). These 9 sightings are all greater than 300 km from Stum Lake and probably represent the less constrained movements of non-breeding sub-adults (one and

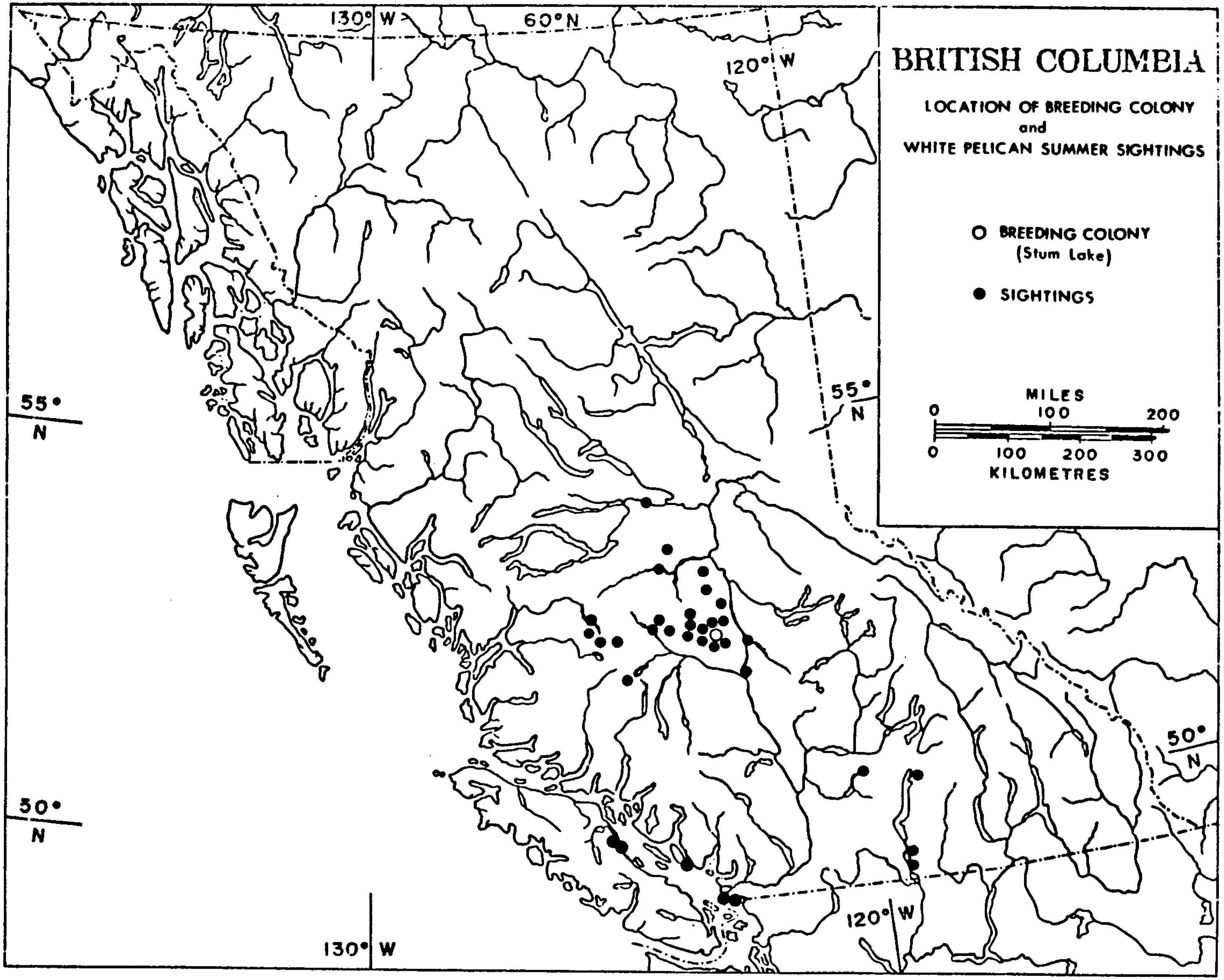

Figure 8. Foraging sightings of white pelicans in British Columbia.

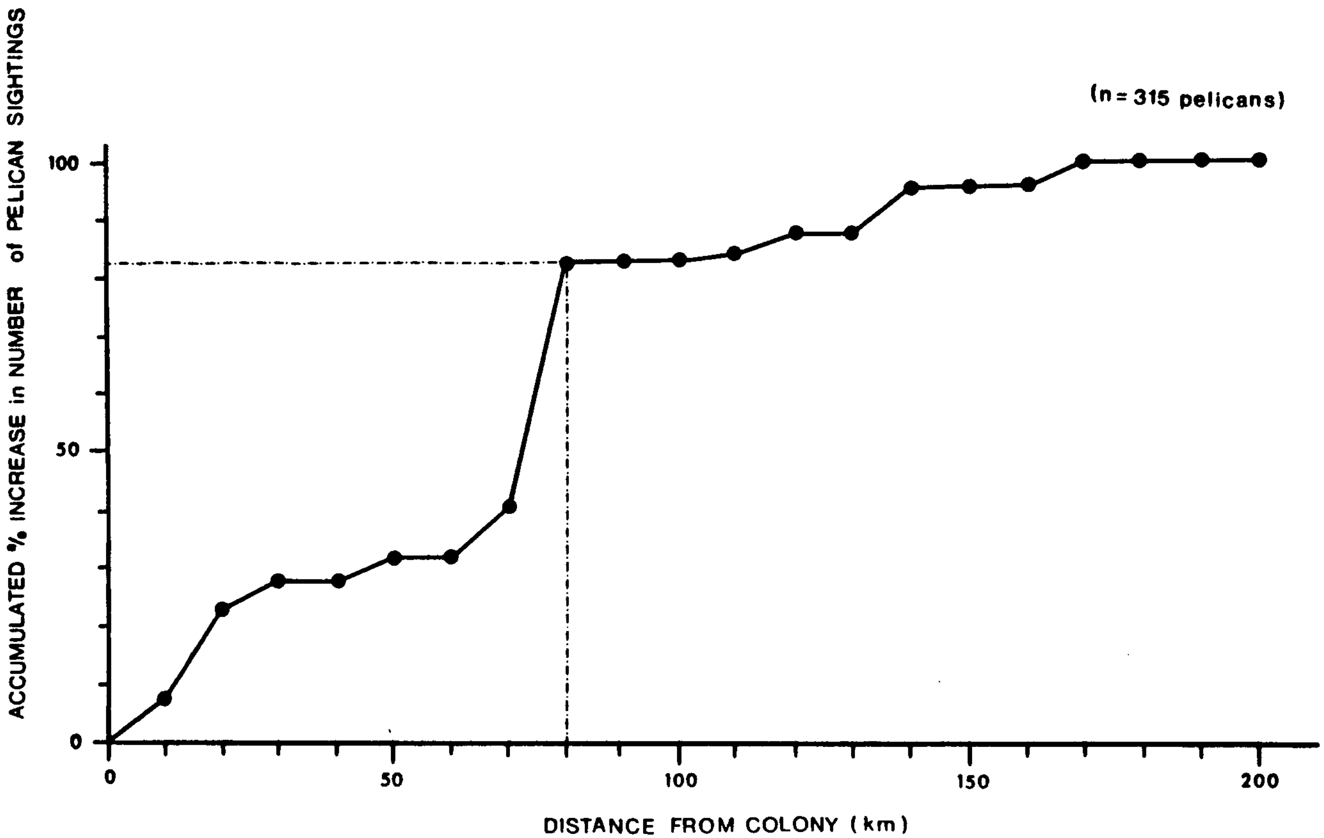

Figure 9. Cumulative frequency of pelican sightings in relation to distance from the colony.

two year olds) from Stum Lake or other colonies south of British Columbia. For example, a non-breeding 2-year old pelican, banded and wing-marked in the Warner Valley, Oregon, was observed at Stum Lake on 22 June 1977. This sub-adult was approximately 1000 km from its natal colony.

During the 1977 and 1978 breeding seasons, foraging pelicans travelled distances ranging from 3 km, one way, (Beaver Lake) to 142 km, one way (Towdystan Lake). The lake used most consistently for feeding during the breeding season was Chilcotin Lake, 71 km west of the colony. This heavy use by pelicans of Chilcotin Lake, indicated by my aerial surveys, was later confirmed by E. Hennan (Pers. Comm.) who observed the birds there daily throughout the summer of 1978.

The 'foraging home range' for pelicans breeding at Stum Lake was defined as the area encompassing the lakes that had moderate to heavy use by pelicans (Fig. 10). Lake importance was defined by the number and frequency of use by pelicans. Lakes were classified as having light, moderate, or heavy use: light use, only one or two pelicans sighted on the lake; moderate use, between three and 14 pelicans reported on the lake, not necessarily during every survey; and heavy use, a total of 15 or more pelicans observed and/or birds always present. The lakes of primary importance for foraging pelicans during the summer were Beaver and Alex Graham lakes to the south, Rosita and Tautri lakes to the north, and the Alexis Lake chain, Palmer, and Chilcotin lakes to the west.

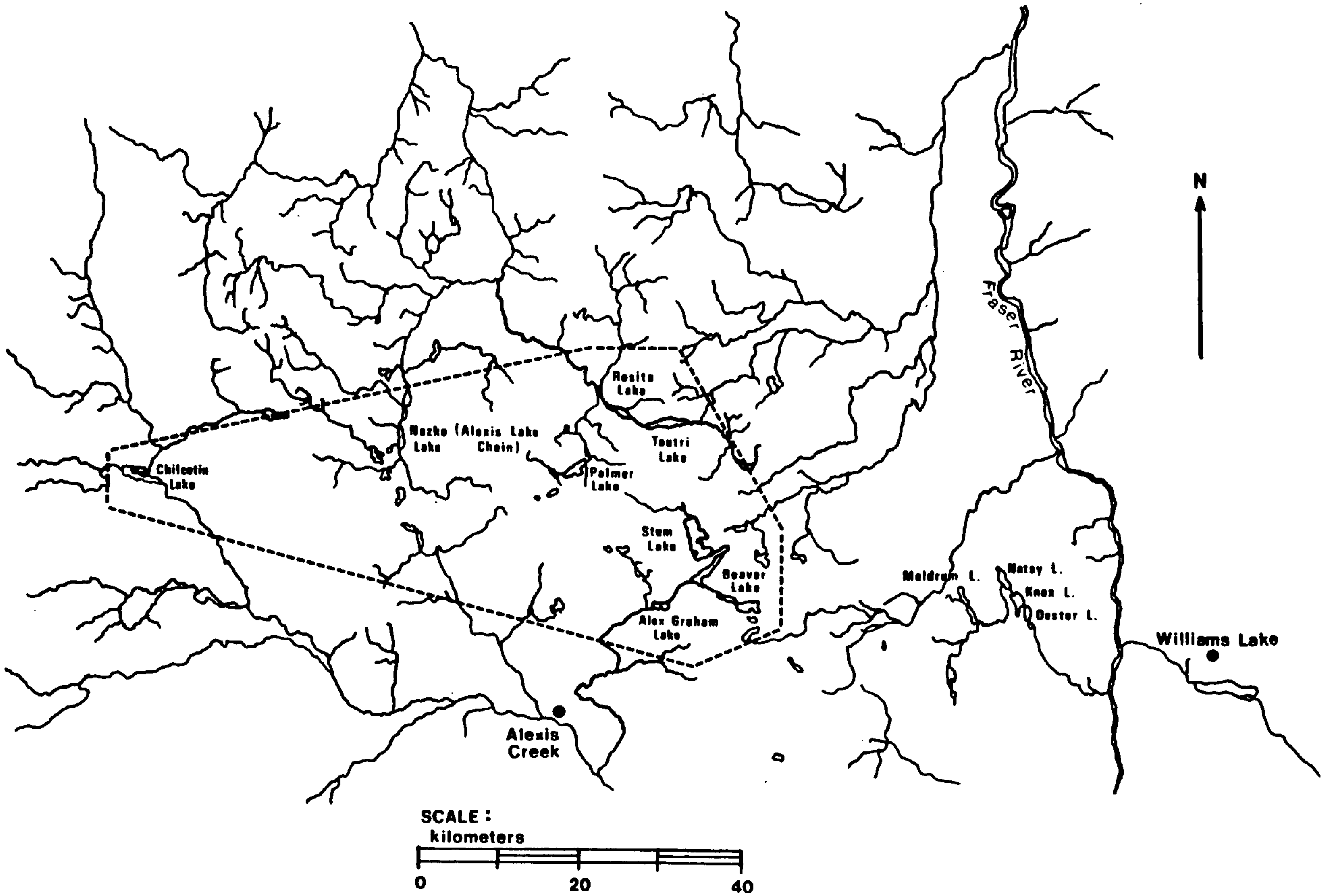

Figure 10. Summer foraging range of white pelicans breeding at Stum Lake, British Columbia.

4.3.2 Movements of Pelicans

The movements of pelican flocks departing from Stum Lake were studied to provide additional information concerning important foraging areas during the breeding season. To determine if seasonal differences existed, movements were classified as occurring prior to or after break-up at Stum Lake. During the spring, while ice covered Stum Lake, I recorded the vanishing bearings of 283 pelicans in 26 flocks as they left Stum Lake. Flock sizes ranged from solitary individuals to one very large flock of 48 birds (average flock size was 10.9 birds). The mean direction of movement during the spring for the 26 flocks observed leaving Stum Lake was 108° (Fig. 11-A). Travel during the spring (prior to ice breakup) was strongly directional, using Rayleigh's test ($P < 0.001$; Fig. 11-A). Movements based on the 283 individual pelicans were similar and also highly directional.

During the summer (after ice break-up), I observed 315 pelicans in 50 flocks departing from Stum Lake. Flocks ranged from 1 to 25 birds, with an average flock size of 6.3 birds. The mean direction of travel during the summer was 289° from Stum Lake and was also significantly directional ($P < 0.001$; Fig. 11-B). Analyses of the 315 individuals provided similar results.

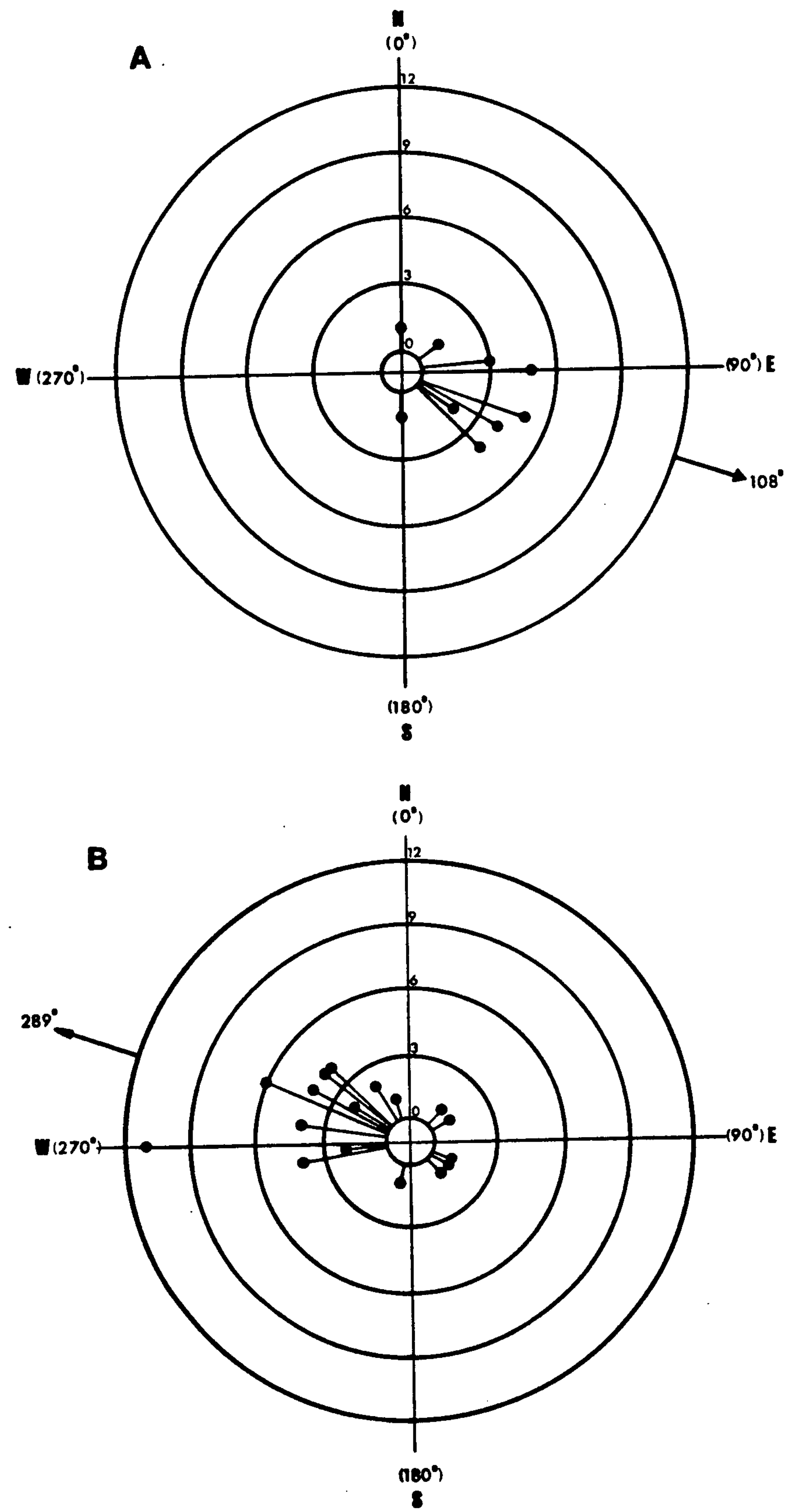

Figure 11. Vanishing bearings of white pelicans departing from Stum Lake. A) Mean direction of white pelican spring movements, 1979 and 1980; B) Mean direction of white pelican summer movements, 1977 and 1978.

4.3.3 Habitat Characteristics of Foraging Lakes

White pelicans have been observed feeding on relatively few lakes, compared with the hundreds of lakes that lie on the Fraser Plateau. Seventy-eight percent (60 of 77 birds) of the pelicans sighted during the 3 aerial surveys were observed on only two lakes. It seems apparent that pelicans are selective in their choice of foraging lakes, as 15 or more lakes of comparable size occur within their range.

One important factor in the selection of foraging sites was the distance between the foraging site and the colony. In general, lakes further from the colony were not as frequently used as lakes closer to the colony. Only 17% (53 of 315 birds) of all pelicans sighted during the summer in British Columbia, were recorded at distances greater than 80 km from Stum Lake (Fig. 9).

The abundance of food also appears to have a major influence on the selection of foraging sites. Data from the British Columbia Fish and Wildlife Branch Lake Surveys suggest that foraging pelicans from the Stum Lake colony select lakes with a greater abundance of food (Table 1). Although Chilcotin Lake was not surveyed by the British Columbia Fish and Wildlife Branch , the lake is well known for its abundant supply of trout and coarse fish (J. Leggat Pers. Comm.).

TABLE 1. Food abundance of several lakes and frequency of foraging by white pelicans from Stum Lake, B.C.

Lake	Food Abundance[1] (Kg)	Pelican Utilization[2]
Chilcotin	very high (unsurveyed)	high
Palmer	81.5	moderate
Alex Graham	56.0	moderate
Taharti	32.0	low
Beaver	28.0	low
Stum	2.4	nil

1 Calculated from B.C. Fish and Wildlife Lake Surveys (Nets set for a 12 hour period)

2 Lake use by white pelicans determined from aerial surveys conducted during 1977. (See Appendix I)

Not only did pelicans select lakes with an overall high abundance of fish, but they also selected lakes offering a greater availability of fish, that is, shallow lakes. For example, Chilcotin Lake, at which 40 of the 77 feeding observations were recorded, is very shallow. Mean depth of the lake is about 1 to 2 m and fish are highly accessible to a surface-feeding bird. The majority of pelicans observed foraging during 1977 and 1978 were in shallow water close to shore. At Chilcotin Lake, pelicans usually foraged in the shallows along the shoreline, at creek mouths, and occasionally swam up those creeks.

Another important component of the foraging habitat was the presence of 'loafing' sites. Groups of 3 to 20 birds frequently utilized such areas for resting and preening at Chilcotin and Rosita Lakes. It was not determined whether these were used as night roosts (pelicans from Stum Lake did stay away from the breeding colony for periods greater than 24 hr). The most commonly used loafing sites were the deltas and sand bars at river mouths. In all cases, these loafing sites were low and flat and had little or no vegetation, thereby giving the birds an unobstructed view of the surroundings.

4.3.4 Food Habits

White pelicans breeding at Stum Lake appear to be utilizing primarily non-game or 'coarse fish' as their major food source. The six right-opercles, one cleithrum, and two caudal fins discovered on the breeding island were all identified as bones from sucker (Catostomus spp.), probably large scale sucker (C. macrocheilus). Several vertebrae of northern squawfish (Ptychocheilus oregonensis) were also present among the bone samples. A minimum number of 7 fish were recorded (6 sucker and 1 northern squawfish). They were estimated to be between 30 and 40 cm long (J.D. McPhail pers. comm.). Bones from game species (trout, char, etc.) were not found in the sample.

4.4 Discussion

The majority of white pelican summer foraging sightings in British Columbia occurred on the Fraser Plateau. Pelicans nesting at Stum Lake foraged on lakes ranging from 3 km to 142 km distant (one way). The one-way travelling distances to foraging areas for the Stum Lake colony are similar to those recorded for other white pelican colonies in North America. One-way foraging distances at Great Salt Lake, Utah, ranged from 48 to 160 km (Behle 1958) and those at Birch Lake, Alberta, ranged from 30 to 69 km (Ealey 1979). On the basis of fish tag recoveries, Johnson (1976) found that one-way foraging distances for the Chase Lake, North Dakota, colony ranged from 50 to 307 km. However, 28 of the 31 fish tags recovered (90%) had their origin within 127 km of the colony.

During the spring and summer, dramatic differences were recorded in the movements of pelican flocks departing from Stum Lake. During the spring (prior to ice break-up) the mean direction of movement from Stum Lake was 108°, while the mean direction of movement during the summer (after ice break-up) was 289° from Stum Lake. The difference in the preferred flight directions suggest at least two explanations. During the spring, the lower elevation lakes to the southeast may become free of ice sooner than other lakes in the surrounding area. The closest lower elevation lakes (approximately 945 m elevation) are in the direction of the observed spring movements and are only 35 km from Stum Lake. These lower lakes, such as Meldrum, Knox, Dester, and Natsy Lakes, may provide an important food source prior to the energy demanding periods of courtship and egg laying. In other waterbirds clutch sizes are known to vary in relation to food supply (Klomp 1970, Bengston 1971, Raveling 1979). Therefore, it is possible that these lakes to the southeast of Stum Lake could have a direct influence on the overall productivity of the colony.

A second explanation for the southeasterly foraging direction during the spring is that in that region less time may be required for pelicans to locate lakes free of ice. At this time, the birds have just passed through these areas on their migration to Stum Lake.

The complete reversal of preferred foraging direction during the summer probably results from pelicans locating more productive foraging lakes no longer covered with ice. Observed flight directions of pelicans departing from Stum Lake during the summer (generally northwest of the colony) correlate very well with actual foraging sightings recorded during the aerial surveys. The lake with by far the greatest use (Chilcotin Lake), lies approximately 280° (northwest) from Stum Lake.

White pelicans breeding at Stum Lake appeared to be highly selective in their choice of foraging lakes. Of the 26 lakes surveyed from the air, 78% (60 of 77 birds) of the total number of pelicans sighted were observed on only two lakes. Pelicans selected lakes with an overall high abundance of fish as well as those lakes offering a greater availability of food, that is, lakes with extensive littoral areas for feeding. Pelicans observed foraging often used shallow areas close to shoreline and creek mouths. Din and Eltringham (1974) observed African white pelicans (P. onocrotalus) foraging in this manner and concluded that the birds were driving fish into shallower areas where they could be caught more easily.

Loafing sites appeared to be an important component of the foraging habitat. Ealey (1979) found that pelicans in northern Alberta spent a great deal of their time loafing when away from the breeding colony. The majority of the time spent loafing included preening and resting. A key characteristic of the loafing sites at Chilcotin Lake was the absence of vegetation on the islands. Din and Eltringham (1974) felt that the major factor in the choice of an area for loafing African white and pink-backed pelicans (*P. rufescens*) was a flat area which lacked cover that might conceal the approach of predators. They also noted that the birds would avoid steep or heavily vegetated areas.

Bone samples collected on the breeding island at Stum Lake were identified as bones from sucker and northern squawfish. Remains from game fish were not recorded. These sparse results support other food habit studies of white pelicans in North America. Hall (1925) and Bond (1940) found that white pelicans at Pyramid Lake, Nevada, consumed 97% and 89% non-game species respectively. Low *et al*. (1950) did not provide data but stated that pelicans at Great Salt Lake, Utah, fed almost exclusively on non-game fish. Pelicans at Lake of the Woods, Ontario, consumed 87% non-game species (Mansell 1965). Species taken by pelicans in these studies included minnow, chub, stickleback, bullhead, carp, perch, ling, catfish, sucker, and crustaceans.

Both fish species found on the breeding island at Stum Lake, like other coarse fish, have high upper lethal temperatures (approximately 29°C) and are often found at depths of only a few feet from the surface (Scott and Crossman 1973). Conversely, game fish such as trout, have lower upper lethal temperatures (approximately 24°C) and consequently are found in deeper colder water in lakes and streams. Because of the differences in temperature requirements between game and non-game fish, and the fact that white pelicans feed only by catching prey from the surface, it seems logical that they will catch more coarse fish (squawfish, suckers, etc.) than they will game species (trout, char).

CHAPTER 5.

CHARACTERISTICS OF THE NESTING HABITAT

5.1 Introduction

The primary nesting habitat requirements of white pelicans in North America are relatively well understood. Isolated lakes which contain at least one island are probably the major requirement. The nesting lakes must be near a local food source; however, close proximity of fish is often less important than the isolation of the nesting site (Vermeer 1970a). Water barriers around the island(s) of sufficient depth and distance from the mainland also are necessary to reduce mammalian predation. These water levels must remain relatively stable for successful reproduction (Evans 1972). In years of low water, nesting islands can become continuous with the mainland, exposing nesting birds and their nest contents to the threat of mammalian predation (Scott 1962, Houston 1966, Lapp 1976). When water levels become too high, flooding can occur, causing nests and eggs to be washed away (Houston 1962, Evans 1972). Nesting islands vary a great deal in size and form; however, the majority of white pelican islands are low, relatively flat, sparsely vegetated, and treeless (Vermeer 1970a).

The breeding range of white pelicans in British Columbia is very restricted. At present the entire population breeds only at Stum Lake. Although white pelicans have nested at Stum Lake for at least 40 years, information regarding their breeding habitat is limited. To better understand the nesting habitat requirements of pelicans at Stum Lake, the current nesting habitat must first be described and evaluated. Once evaluated, it might be desirable either to make habitat improvements or to create additional nesting habitat. The presence of alternative breeding habitat could reduce the risk of "having all the pelican eggs in British Columbia in one basket".

Objectives addressed in this chapter were:

1. To determine the characteristics of white pelican nesting habitat at Stum Lake; and,
2. To recommend alternative nesting sites suitable for manipulation.

5.2 Methods

5.2.1 Measurements of the Breeding Habitat

I recorded characteristics of nesting habitat at Stum Lake in August 1977 and 1978 after the adults and fledglings had left the nesting island. The height of land above the lake level and the island area were determined for the three islands used for nesting by pelicans. The water depth and distance between the major breeding island (Island Two) and the mainland were also measured. I estimated distances between the mainland and the secondary nesting islands (Island One and Scaup Island) from aerial photographs. Topography and vegetative cover of the three islands were recorded. For each nest site, I recorded aspect, slope, substrate, and vegetative and physical features (logs, rocks, stumps).

5.2.2 Spatial Distribution of Nests

During 1977 and 1978, I measured the inter-nest distances (the distance between centers of adjacent nest mounds) in late August after the pelicans had left the island. During the four breeding seasons, I recorded the spatial configuration of the different nesting groups and mapped these in relation to the physical attributes of the islands.

5.2.3 Aerial Surveys

I conducted three aerial surveys in 1977 to locate alternative breeding sites or potential nesting habitat suitable for modification (details of the flights are discussed in Section 4.2.1). Several lakes with islands were recorded. I rated the islands' potential as pelican nesting habitat as either good, moderate, or poor. The criteria used to rate the islands were, in order of importance: isolation, water depth between the island(s) and the mainland, distance from the mainland, island topography, and vegetative cover. Water depth, distance(s) between the island(s) and the mainland, and island topography were either obtained from British Columbia Fish and Wildlife Branch Lake Surveys or were estimated visually from the aircraft. I also recorded the presence or absence of vegetation on the islands.

5.3 Results

5.3.1 Physical Characteristics of the Breeding Habitat at Stum Lake

Five small islands lie within Stum Lake, three of which have been used as nesting sites by white pelicans (Fig. 1). Two of the islands were used as nesting sites for only 3 and 4 years (Scaup Island and Island One respectively) during the 13 years for which data are available. The island utilized consistently in all 13 years was the largest one, Island Two. The two remaining islands in the lake, Crescent and Ryder Islands, are heavily vegetated and are not used by pelicans. During my study, pelicans nested on Island Two every year.

The main breeding island (Island Two) is 84 m from the nearest mainland (Fig. 12). The island slopes gradually up from the south-facing shores to the highest point near its center, 6.7 meters above the lake level. About half of the island's total area ranges between zero and five percent slope. The island is approximately 86 m in length by 42 m in width, and has a total area of about 1,000 m^2. Water depths (when water level is 1.91 m below bench mark) between the breeding island and the mainland increase gradually for the first 5 to 10 m from their shorelines, then increase more rapidly to a maximum depth of 5.4 m (Fig. 12).

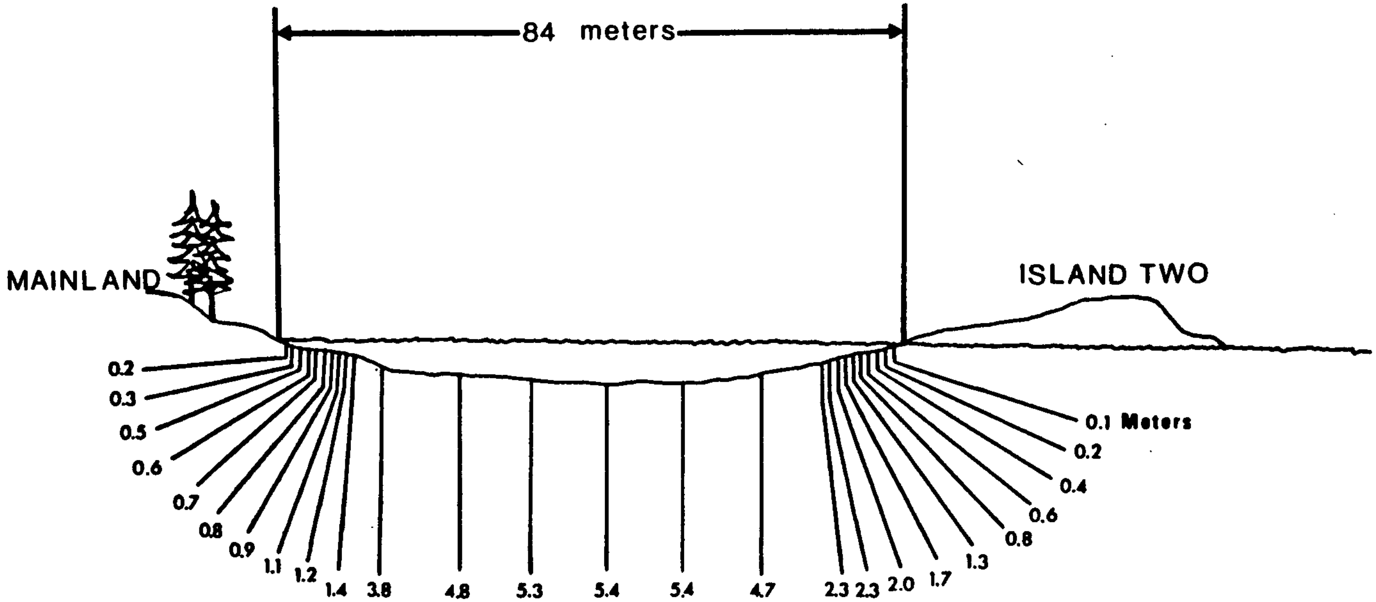

Figure 12. Water depths between the main breeding island (Island Two) and the mainland.

The dominant plant species on the lower southern shores of Island Two include stinging nettle (Urtica dioica), fireweed (Epilobium angustifolium), and wild raspberry (Rubus idaeus). Gooseberry (Ribes lacustre) and willow (Salix spp.) were most abundant on the steeper northern shore (Fig. 13). The higher regions of the island were either barren or supported a cover of several species of grass. Bare ground accounted for about 25% of the island's area. A number of fallen snags lay scattered in these bare areas. Several standing snags and a few living lodgepole pine (Pinus contorta) and white spruce (Picea glauca) occurred close to shore.

The two other islands that have been used by pelicans at Stum Lake (Island One and Scaup Island) are low, exposed, rocky outcroppings. Both islands are flat and have little vegetation, except for small patches of stinging nettle (Urtica dioica), water hemlock (Cicuta douglasii), and various sedges (Carex spp.) growing along the shoreline. Island One is about 600 m from the nearest mainland and has an area of approximately 400 m^2. The island is 63 m in length by 13 m in width and is 1.5 m above the lake level. During my study, pelicans nested on Island One only once (1979). However, pelicans used the island a great deal during the courtship period, especially while ice still covered the lake, and later in the breeding season after the young had fledged. Scaup Island, the smallest of the three islands is 300 m from the nearest mainland. The island is only 12 m in length by 6 m in width and has an area of about 90 m^2. It is approximately 1 m above lake level. Herring gulls bred on both Island One (about 100 nests) and Scaup Island (3 to 4

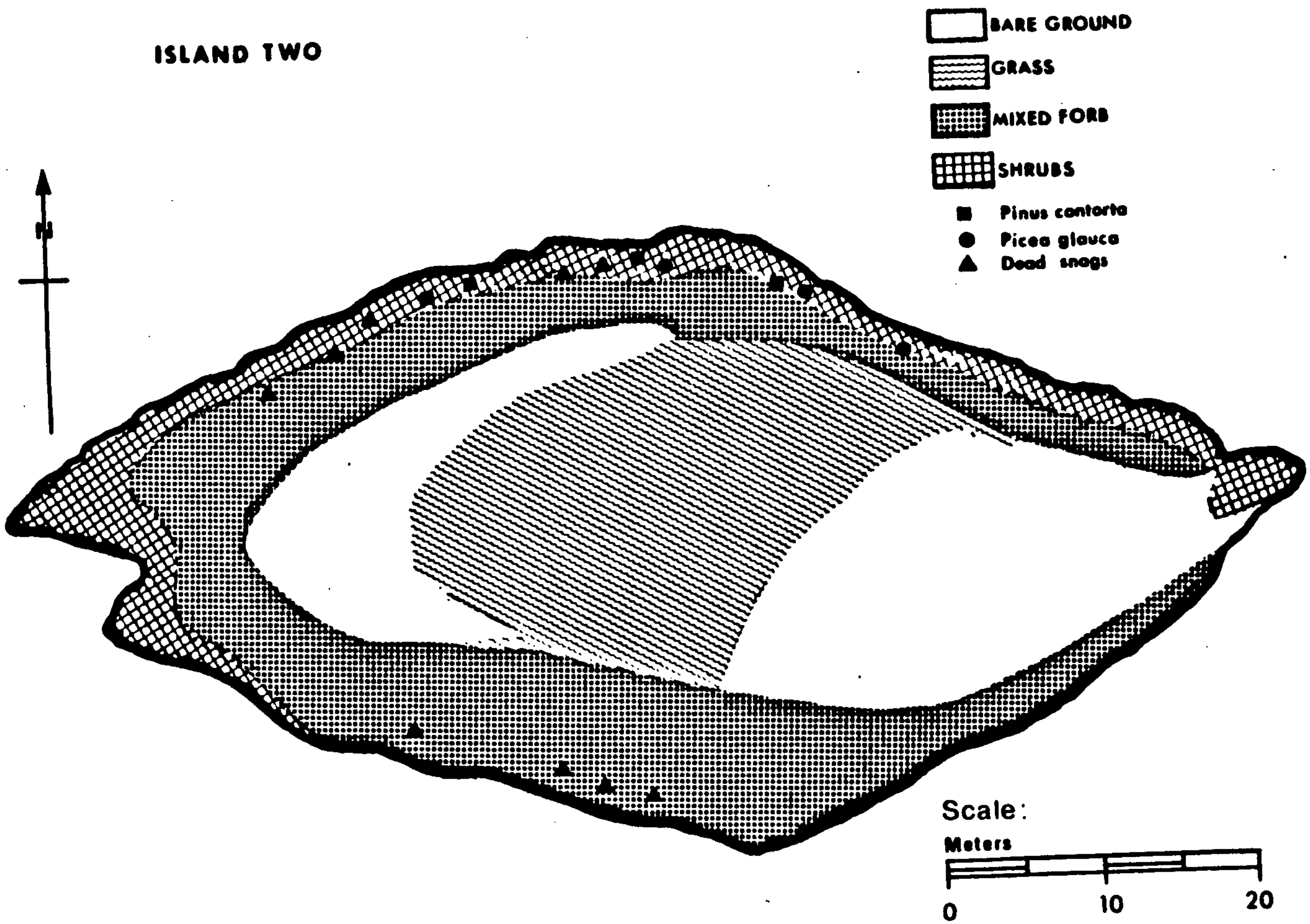

Figure 13. Habitat map of Island Two at Stum Lake, British Columbia during 1977 and 1978.

nests) during my study.

5.3.2 Nesting Distribution of White Pelicans at Stum Lake

White pelicans at Stum Lake generally selected nesting sites that were located in relatively flat areas on Island Two. Seventy-one percent (61 of 86 nests) of all nests in 1977 and 79% (83 of 105 nests) of all nests in 1978 were built in areas ranging from 0 to 5% slope (Fig. 14). Approximately 50% of the island ranged between 0 and 5% slope. Combining data for both years, pelicans utilized nesting areas with slopes ≤ 5% in greater proportion than their availability (Chi-Square One Sample Test $P < 0.001$). During 1978, only 1% (1 in 83) of the nest sites located on slopes ≤ 5% had an egg roll from a nest, while 14% (3 in 22) of the nest sites on slopes > 5% had eggs roll from those nests.

In addition to selecting nest sites in flat areas, pelicans also appeared to prefer areas with bare ground. During 1977 and 1978, 77% (147 of 191 nests) of all nests at Stum Lake were built on bare ground. These unvegetated areas accounted for only about 25% of the island's total area. Bare-ground areas were used significantly more often than would be expected in terms of their availability in relation to vegetated areas Chi-Square One Sample Test $P < 0.001$). The other 44 nests were built among fireweed patches. Nests built among fireweed were established in early spring and young fireweed plants were probably killed by a combination of trampling and guano deposition. The presence of roots indicated that grasses and herbaceous plants had previously occupied nearly all the nest

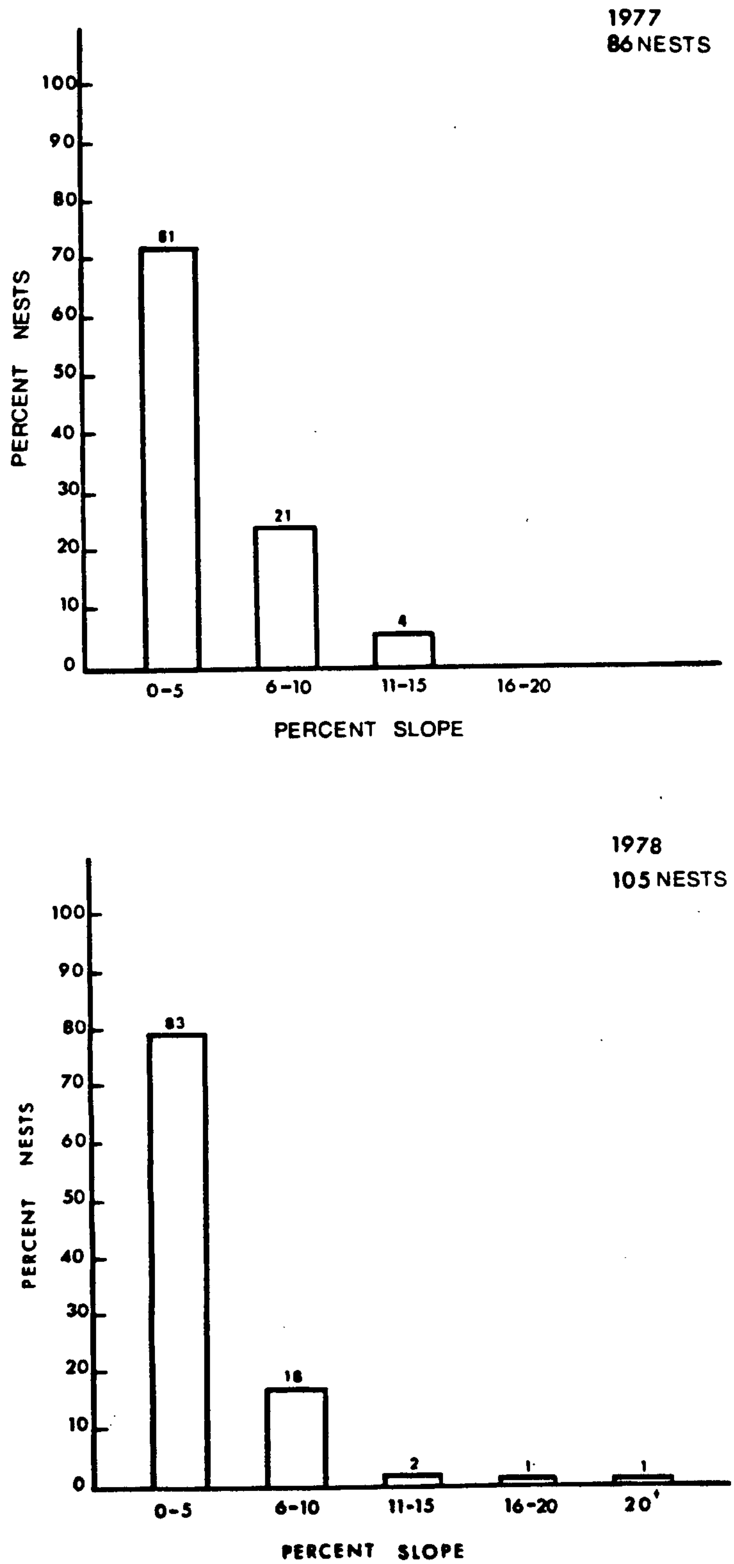

Figure 14. Nest site selection by white pelicans on Island Two at Stum Lake, British Columbia during 1977 and 1978.

sites.

Physical barriers (logs, rocks, stumps, and vegetation) between nesting birds and adjacent to nests also appeared to influence the nesting distribution. Logs were the most common form of barrier between nesting pelicans at Stum Lake. Sixty percent of the nests in 1977 and 45% of the nests in 1978 were built within 50 cm of barriers.

The spatial distribution of the nesting groups at Stum Lake changed dramatically from year to year. The pelicans nested in 7 distinct groups in 1977, 3 groups in 1978, 7 groups in 1979, and 3 groups in 1980 (Fig. 15). Nesting groups ranged in size from only 3 pairs (1979) to 83 pairs (1980). From the 1977 breeding season to the 1978 breeding season, 69% (72 of 105) of the nests were located in areas unused the previous year. From 1978 to 1979 and from 1979 to 1980, 78% (63 of 81) and 82% (99 of 120) of the nests, respectively, were constructed in areas unused the previous year. During the four breeding seasons, an average of 76% of the nests were constructed in areas unused in the previous year.

One factor that influenced the nesting group distribution at Stum Lake was disturbance by predators. Coyote harassment caused the pelicans to abandon their nest sites and initiate new sites on several occasions during 1979 and 1980. Early in the breeding season of 1979, the majority of the pelicans had established their nesting sites in one large group on Island Two. Colony disruption by coyotes, only one to two days prior to egg laying, forced pelicans to lay their eggs and nest on Island One.

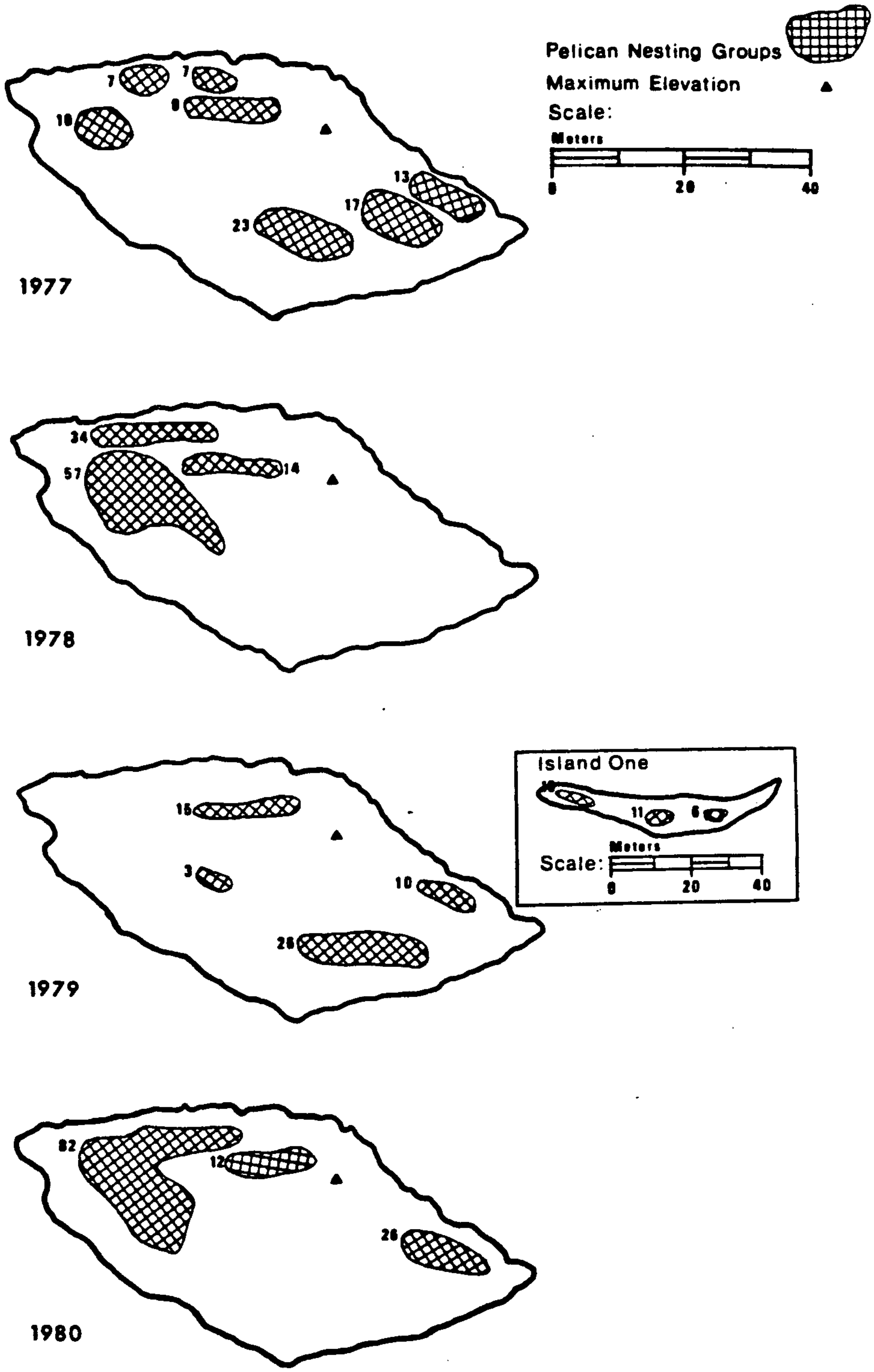

Figure 15. Spatial distribution of nesting groups at Stum Lake, British Columbia from 1977 to 1980.

Human disturbance also had a similar affect on the nesting distributions of the groups. During 1979, a low-flying aircraft caused the disruption of several nesting groups during the courtship and egg laying periods.

The social environment (where a few birds attract others to a site) may be extremely important in the formation of nesting groups. During the courtship period at Stum Lake, pelicans often flew from island to island to join other groups of courting birds. Birds with newly initiated nests would occasionally abandon their sites to join courting flocks. Birds with established nests or those with eggs generally would not join courting flocks.

At Stum Lake, herring gulls did not appear to influence pelican nesting activity. The pelicans utilized all three islands during their courtship at Stum Lake in 1979, and the presence or absence of gulls did not seem to cause any deviations from their normal behaviour. Although the gulls had arrived and begun nesting before the pelicans, courting pelicans often displaced gulls from their nests.

Although nesting group sizes varied a great deal, mean inter-nest distances (distance between centers of adjacent nests) differed only slightly between 1977 and 1978 at Stum Lake. No relationship was found between nesting group size and mean inter-nest distances (Fig. 16). The distance to nearest neighbour ranged from 52.0 cm to 732.0 cm (a solitary nest) in 1977 and from 68.0 cm to 186.0 cm in 1978. The mean inter-nest distances for all nests at Stum Lake was 92.3 ± 23.8 (SD) cm in 1977 and 99.1 ± 23.1 (SD) cm in 1978 (Fig. 17). Mean inter-nest

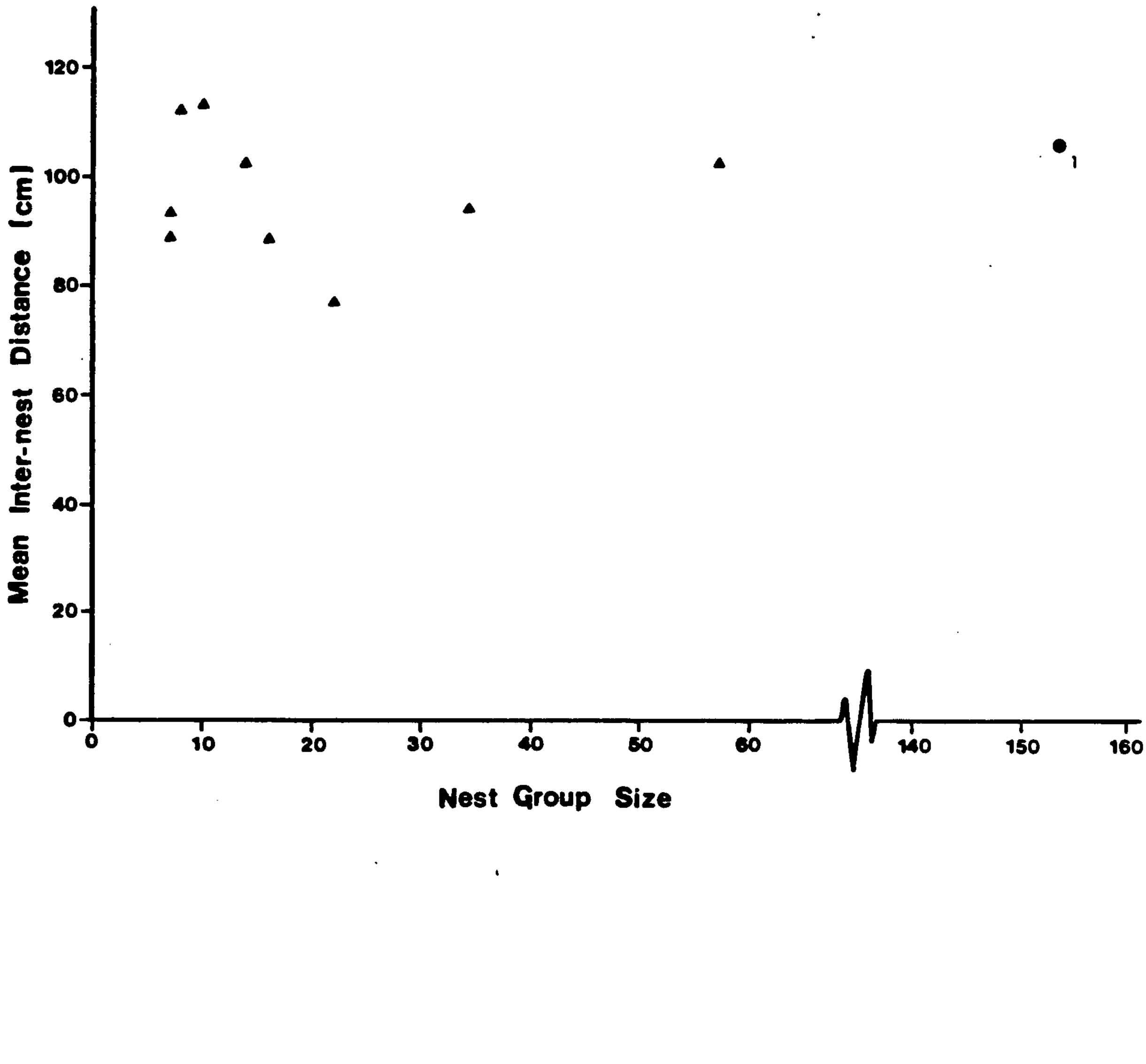

Figure 16. Group size and mean inter-nest distances at Stum Lake, B.C. during 1977 and 1978 (1 = data from Knopf 1975).

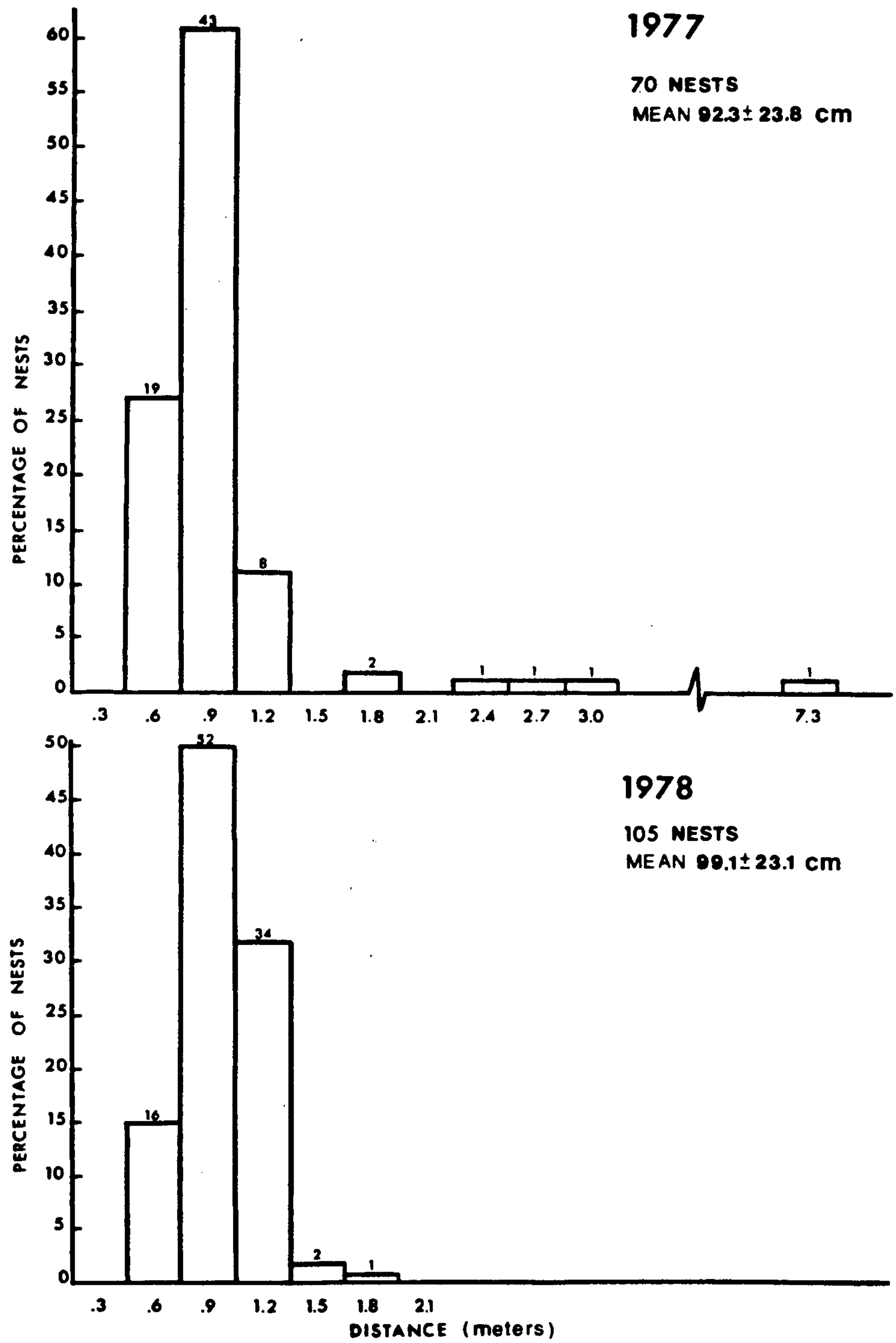

Figure 17. Distribution of distances between nest centers at Stum Lake, British Columbia during 1977 and 1978.

distances approximate three pelican bill lengths (mean bill length is 34.7 cm, Godfrey 1966).

5.3.3 Alternative Nesting Habitat

I conducted three aerial surveys during 1977 to locate potential nesting habitat. Several lakes which contained islands were observed; however, their suitablity as nesting habitat was extremely variable. Taharti Lake, approximately 20 km northeast of Stum Lake (52° 27'N by 122° 53'W) appeared to be the best suited as potential pelican habitat. The lake is about 2 km long by 0.5 km wide. The smaller of the two islands in the lake is relatively flat and located 213 m from the nearest mainland. The area of the island is about 1.3 ha. The maximum depth of the lake is 5.5 m with a minimum depth of 4.9 m occurring around the island. The island is heavily timbered, however removal of part of the tree cover would not be difficult. In addition, white pelicans occasionally use this lake as a foraging site (British Columbia Fish and Wildlife Branch Lake Surveys). Although the lake was relatively isolated from human activity at the time of the survey, a recent British Columbia Forest Service access road may limit the lake's potential as a secondary nesting site.

5.4 Discussion

The nesting habitat of white pelicans in North America varies considerably. Pelicans utilize both natural and man-made islands. Natural islands include low lying gravel bars (Hosford 1965, Evans 1972), rocky outcroppings (Schaller 1964, Vermeer 1970a, this study), floating tule beds (Finley 1907), and hilly islands with gentle slopes (Mansell 1965, Vermeer 1970a, Johnson 1976). Man-made nesting sites include islands of dredged material (Landin and Soots 1977) and those created by water impoundments (Lapp 1977, Domenick 1979). Infrequently pelicans will nest on narrow peninsulas (Hosford 1965, Tait _et al_. 1978) and lake shorelines (Schaller 1964); however, these sites are usually unproductive. The sizes of nesting islands can range from small gravel bars that are subject to flooding in years with high water, to large hilly islands such as Gunnison Island at Great Salt Lake, Utah (66 ha in area and 88 m above lake level, Knopf 1975).

In British Columbia, pelicans at Stum Lake have nested on three natural islands. The most consistently used island has an area of about 1000 m^2 and is located 84 m from the western mainland. It slopes gently and has two unvegetated areas near the center. Shrubs and several trees and snags occur on the island's periphery, while grasses occupy the center regions of the island. As in other colonies in North America, pelicans at Stum Lake nested on the unvegetated, gentle slopes of the island. Knopf (1975) observed that white pelicans at Great Salt Lake selected similar sites, but usually only those within a few vertical meters of the water level.

The preference shown by pelicans toward relatively flat nesting areas may be an adaptation to reduce the loss of eggs that roll from nests. During 1978, egg losses at Stum Lake were much higher in nests on slopes > 5% compared with nests on slopes ≤ 5% (refer to Section 5.3.2).

The spatial distribution of nesting groups at Stum Lake changed dramatically from year to year. Shifts such as these have been recorded for many white pelican colonies in North America (Hall 1925, Bond 1940, Lies and Behle 1966, Knopf 1975, Beaver and Ballantyne 1979, Diem 1979, Trottier et al. 1980). Such changes in nesting patterns are not well understood and may occur for more than one reason.

One factor that influenced the nesting group distribution of white pelicans at Stum Lake was coyote harassment. There is some evidence to suggest that coyote harassment during the spring may increase the spatial dispersion of the nesting groups. During 1979, one large nesting group on Island Two was split into several smaller groups on two islands after a coyote attack. Weather appears to indirectly influence the rate of disturbance by coyotes. During cooler springs at Stum Lake, ice remained on the lake longer and provided coyotes with access to the islands. Human disturbance also appears to have a similar 'scattering' affect on the nesting groups at Stum Lake.

Another factor that may influence the spatial distribution of the nesting groups is the water level of the lake. Water levels at Birch Lake, Alberta, fluctuate widely from year to year. During years of low water the island's area increased dramatically and, as a result, nesting groups were established farther apart (Beaver and Ballantyne 1979). Water levels at Stum Lake, however, have remained relatively stable during my study.

Trottier et al. (1980) suggested that the presence of herring gulls nests may affect the nesting distribution of white pelicans at Prince Albert National Park, Saskatchewan. At Stum Lake however, herring gulls did not appear to affect the nesting distribution. Activity and movements of courting pelicans did not change according to whether gulls were present or not. In 1979, pelicans occasionally courted on islands where herring gulls were already on nests. During these periods, the gulls immediately left their nests. Knopf (1975) also noted similar behaviour by California gulls (Larus californicus) in the presence of white pelicans.

At Stum Lake, mean inter-nest distances were 92.3 cm in 1977 (70 nests) and 99.1 cm in 1978 (105 nests). Knopf (1975), at Great Salt Lake, Utah, found that the distance between nest edges (153 nests) was 59.0 ± 16.2 cm. Recalculating Knopf's data to include the mean diameter of a nest (47.3 cm, Bent 1922) results in a similar measurement to those recorded at Stum Lake. Distances between nest centers at the Great Salt Lake colony were 106.3 cm. Inter-nest distances seem to be relatively constant for the species and do not appear to be a function of group size.

The breeding distribution of white pelicans in British Columbia is very restricted. By creating secondary breeding habitat, we might be able to buffer future impacts occurring at the Stum Lake colony. Additional breeding habitat could be created in two ways. Existing islands could be manipulated to produce nesting habitat for pelicans or artificial islands could be constructed. The most suitable islands are those that would require only the removal of some vegetation. Criteria to census exisiting islands suitable for alteration included:

(i) minimal habitat improvement necessary; that is, only the removal of some vegetation;

(ii) Relatively flat islands that have sufficient water barriers (depths and distances to the mainland); and,

(iii) Most importantly, islands that are isolated from human activity.

At present, the best potential alternative nesting site occurs at Taharti Lake, approximately 20 km northeast of Stum Lake. However the lake's potential may be limited because of human activity. It is recommended that further aerial surveys be conducted to locate additional sites that may be more suitable as secondary nesting habitat.

CHAPTER 6.

REPRODUCTIVE SUCCESS OF WHITE PELICANS AT STUM LAKE, BRITISH COLUMBIA

6.1 Introduction

Many factors affect the breeding success of colonial waterbirds such as pelicans. Limiting factors include mammalian predation (Scott 1962, Blokpoel 1971, Vestjens 1977), human disturbance (Hall 1925, Carson 1966, Vermeer 1970a, Johnson and Sloan 1976), food availability (Brown and Urban 1969, Whitfield 1978), fluctuating water levels (Hosford 1965, Evans 1972, Vestjens 1977), parasites and disease (Greichus and Greichus 1973, Wobeser _et al_. 1974), and adverse weather conditions (Bartholomew _et al_. 1953, Adolphson and Adolphson 1968, Bremer 1977).

Prior to my study, relatively little was known concerning the limiting factors affecting white pelicans breeding at Stum Lake. Nesting surveys had been recorded, but many of these appeared to be of a destructive nature. For example, Wright and Wright (1970), describing a survey to determine numbers of nests and eggs at Stum Lake during 1969, wrote:

> "In the gathering dusk we slowly and quietly sculled our canoe closer and closer to Pelican Island (Island Two). As we were about to beach, a slight movement gave us away and with a rush of air through feathers, 300 white pelicans laboured into the air. Once, twice, three times the big birds passed over our heads as they circled the island, gradually gaining altitude."

Coyote predation also has been recorded at Stum Lake. The dramatic differences, however, in the effect of timing that both coyote predation and human disturbance have on colony productivity and survivorship of young have not been established. In addition, the overall reproductive success and the survivorship of young previously had not been recorded during natural conditions (years with no coyote predation or human disturbance). Information regarding colony occupation and early nesting phenology at Stum Lake was non-existent prior to my study.

Objectives addressed in this chapter were:

1. To document the schedule of spring arrivals and to describe the early nesting phenology;
2. To obtain a disturbance-free estimate of the clutch size and overall reproductive success of pelicans breeding at Stum Lake; and,
3. To determine the effect of predation and human disturbance on colony productivity and survivorship of young.

6.2 Methods

6.2.1 Population Estimates

I conducted population surveys at Stum Lake during the summers of 1977 (29 May to 28 August), 1978 (3 May to 28 August), and 1980 (11 August to 16 August), as well as during the spring of 1979 (17 April to 7 May) and 1980 (15 April to 19 May). To minimize disturbance to courting and nesting birds, most observations of the colony were made from the mainland with the aid of a 20 to 45x spotting scope. Nine different observation sites were established, ranging from 100 to 800 m from the birds. A tenth observation site from a canoe at an anchored marker buoy (approximately 700 m) allowed me to see the portion of the island not visible from the mainland. The proportion of the colony visible from the mainland ranged from 71% to 100% and averaged about 90%.

Numbers of adult pelicans and nests were censused on a daily basis in 1977 and 1978 except when prohibited by adverse weather conditions or alternative activities. During the spring surveys in 1979 and 1980, I recorded numbers of adults and nests three times per day in order to document the schedule of spring arrivals and the establishment of nesting sites.

Clutch size and the number and fate of young were recorded in 1977, 1978, and 1980 to determine the survivorship of young (successfully fledged young per egg laid) and the mean productivity of the colony (young fledged per nest). Clutch sizes and survival of young were estimated by obtaining more detailed observations of selected nests. I sampled 23 nests (total numbers of nests was 86) during 1977 and 30 nests (total number of nests was 105) during 1978. Nests selected included only those that were completely visible. To facilitate viewing in 1978 and 1980, I observed nests and their contents from a harness suspended in a tree 11 m above ground level.

6.3 Results

6.3.1 Colony Occupation

Pelicans first arrive in the Chilcotin region of British Columbia from their wintering grounds from early to mid-April. The time of arrival usually coincides approximately with the spring melt. During 1979 and 1980, pelicans first arrived at Stum Lake on 19 April and 15 April, respectively, while ice still covered the lake. In both years, flocks ranging in size from three to 30 individuals arrived during the next two to three weeks (Fig. 18-A and 19-A). Estimates of new individuals arriving at the lake were confounded because some pelicans left the lake during the evening and returned in the morning. The number of birds present increased gradually until the end of April, then began to level off. In both years, the peak numbers of birds observed at Stum Lake occurred on 4 May. The interval from time of first arrival to break-up of the ice was about two weeks. The mean date of ice break-up at Stum Lake for three breeding seasons was 4 May.

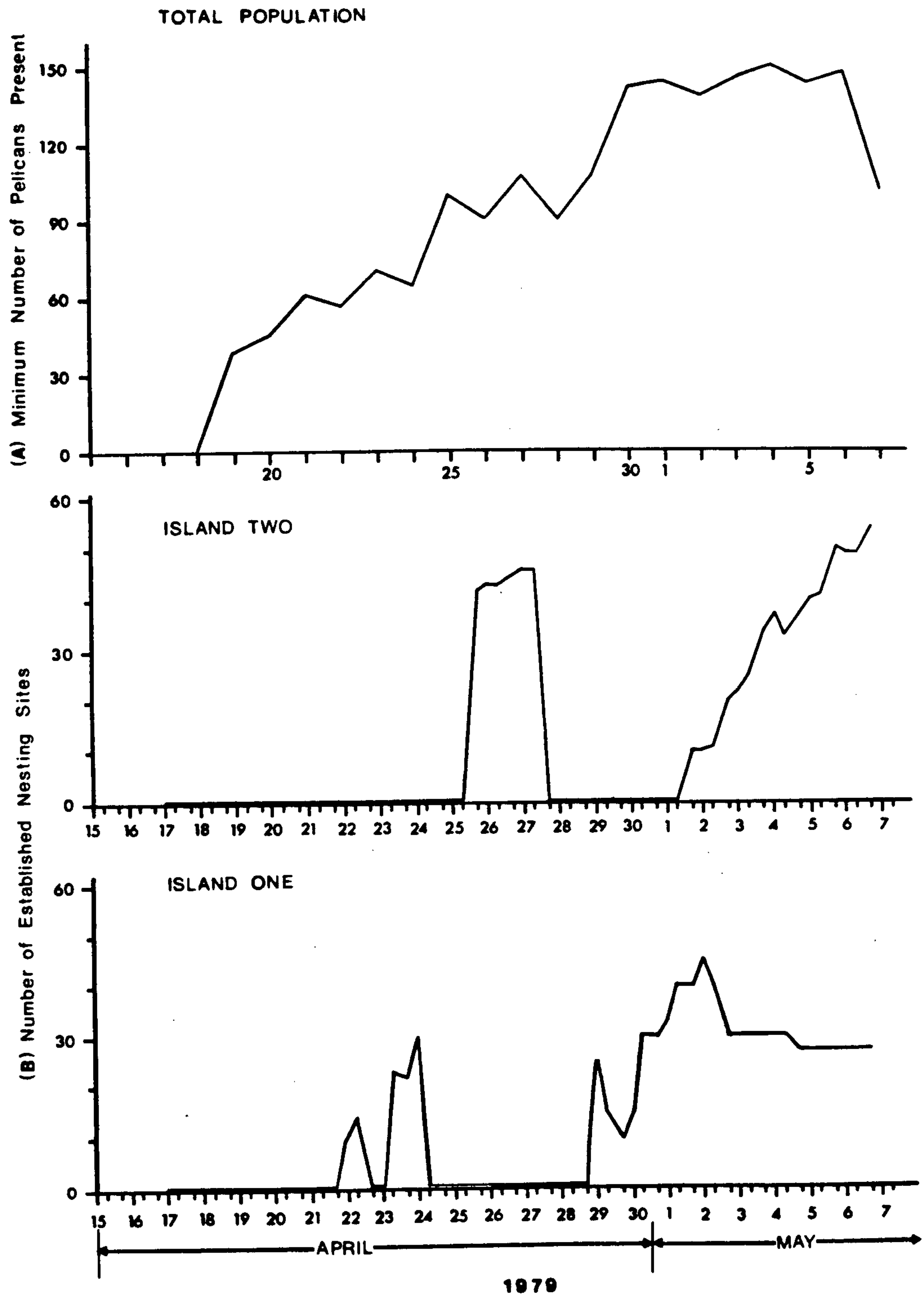

Figure 18. Colony occupation and nest site establishment during spring 1979 at Stum Lake, British Columbia.

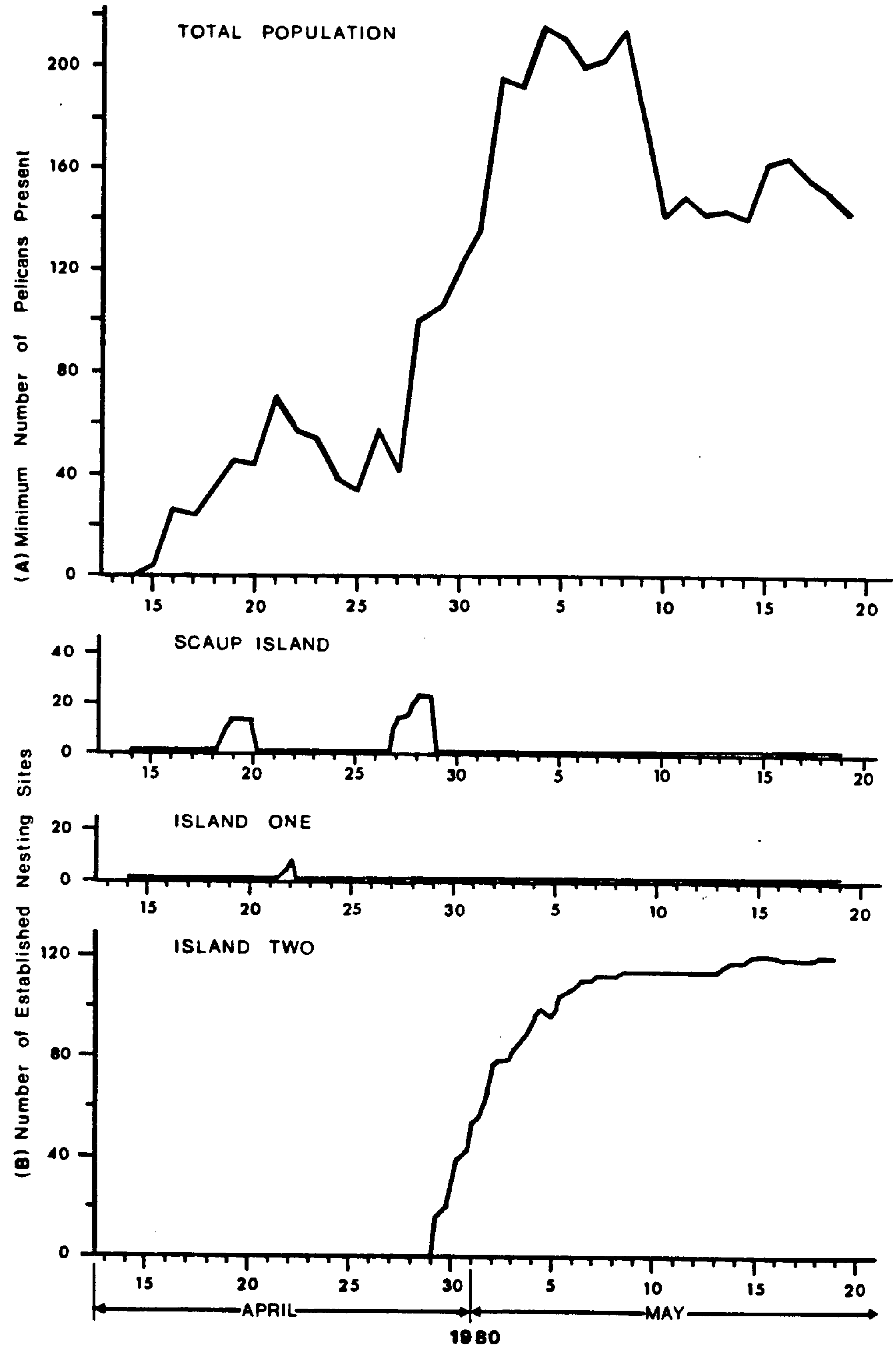

Figure 19. Colony occupation and nest site establishment during spring 1980 at Stum Lake, British Columbia.

The estimated date of first arrival at Stum Lake during 1977 and 1978 was 27 April and 22 April, respectively. These dates were estimated by subtracting the average period of courtship (3 days), copulation and egg-laying (5 days), and incubation (30 days) from the first observed hatching date. However, this approach does not take into account any delays in the courtship period that might result from external influences such as coyote attacks or human disturbances.

Coyote harassment during the courtship period appeared to delay colony occupation. In 1980, coyotes harassed courting pelicans for five consecutive days (20 to 24 April). A noticeable reduction in the numbers of pelicans present on the lake occurred during this period (Fig. 19-A). Courting birds probably abandoned Stum Lake temporarily for safer feeding lakes, in response to the continuous coyote harassment. In 1979, however, coyote harassment was less intense (3 incidents from 22 April to 27 April). Colony occupation appeared to have been delayed only slightly during this period (Fig. 18-A).

6.3.2 Early Nesting Phenology

Pelicans began courting immediately upon their arrival at Stum Lake. Herring gulls, which were already present on Island One, called briefly, but did not appear disturbed by the courting pelicans. Courtship activity consisted of groups of males chasing one to several females around the breeding island. Chases were often interspersed with courtship flights, in which flocks of pelicans would circle the island several times. Immediately after landing, the males continued to pursue the females and would occasionally bite or jab at the back of their necks. Courtship activity continued for two or three days. A pair bond was established when a male could successfully defend a female from other males.

During the early phases of courtship, the birds were extremely erratic in their behaviour. Courting flocks would burst into the air unpredictably and would fly together to a different island where they would begin courting again.

Mutual pouch displaying (expansion of gular pouch) and bowing became much more common once the pair bond had been established. The paired birds then joined other courting birds, or attempted to obtain a nesting site on a nesting group's periphery. In all cases, the nesting site was selected by the female while the male stood beside and defended her. If the pair could successfully defend the nest site, a series of copulations took place over the following four or five days. The first eggs were observed on the fifth day.

In 1979 and 1980, nesting sites were first initiated three and four days, respectively, after pelicans first arrived at Stum Lake (Fig. 18-B and Fig. 19-B). In both years, courtship activity and nest site establishment first took place on the low, open islands (Scaup Island and Island One). These open sites probably allow pelicans to observe approaching predators more easily. Coyotes were commonly observed on the ice during these early nesting periods, but only one adult pelican (male) was killed by coyotes. The adult was mortally wounded during the evening of 27 April 1979, only 1 day after it had established a nesting site on Island Two. Vegetation on the island evidently obscured the approaching coyotes. Coyote harassment was the major cause of nest abandonment during the early nesting period. The shifts in nesting sites caused by coyote harassment (Figs. 18-B and 19-B) must increase energy costs to the birds and caused significant delays in the breeding season.

Although the more open island habitats were used to a greater degree during the early stages of courtship, possibly to allow greater visibility while ice remained on the lake, there was a strong tendency for pelicans eventually to nest on Island Two. During 13 seasons for which there are data, pelicans have nested on Island Two during all 13 breeding seasons; Island One, 4 breeding seasons; and Scaup Island, 3 breeding seasons. During 1979, 18 established nest sites were abandoned on Island One and re-established on Island Two from 2-7 May (Fig. 18-B). These birds had been nest-relieving and copulating at their sites for several days, but had not yet laid eggs. The only nests not abandoned on Island One were those nests which contained eggs (27 nests). Again in 1980, all 23 established nests sites on Scaup Island were deserted on 29 April and re-established on Island Two within one day. It seems probable that most of the present breeding adults were fledged on Island Two and now nest on the same island traditionally.

6.3.3 Commencement of Egg Laying and Hatching

Egg laying in 1979 began on 4 and 6 May on Islands One and Two respectively. During 1980 egg laying was first recorded on 5 May. On these dates, only one adult of a nesting pair was left on most of the nest sites. In the above three subcolonies at Stum Lake, egg laying began an average of 5 ± 1 ($\bar{x}$ ± SD) days after undisturbed nests were first established.

During 1977 and 1978 at Stum Lake, the first eggs hatched on 4 June and 30 May, respectively. The dates when 50% of all nests had one or more hatchlings were 7 June during 1977 and 1 June during 1978 (Fig. 20). Estimated dates of first hatching during the 1979 and 1980 breeding seasons, based on an incubation period of 30 days, are 3 June and 4 June, respectively. The mean date of first hatching, using all 4 breeding seasons, was 3 June ± 7 days (SD).

6.3.4 Clutch Sizes

The mean clutch size at Stum Lake during years without disturbance (1977, 1978) or when disturbance occurred after the completion of courtship and egg laying (1971, 1972) was 1.95 ± 0.21 (n = 411). Clutch sizes during years when disturbances occurred prior to or during laying (1973, 1974, and 1980) were significantly smaller (1.69 eggs/nest) than during years without such disturbance ($\underline{t}$ = 2.05, $\underline{df}$ = 755, $\underline{P}$ < 0.04). Clutch sizes and other population data are summarized in Table 2.

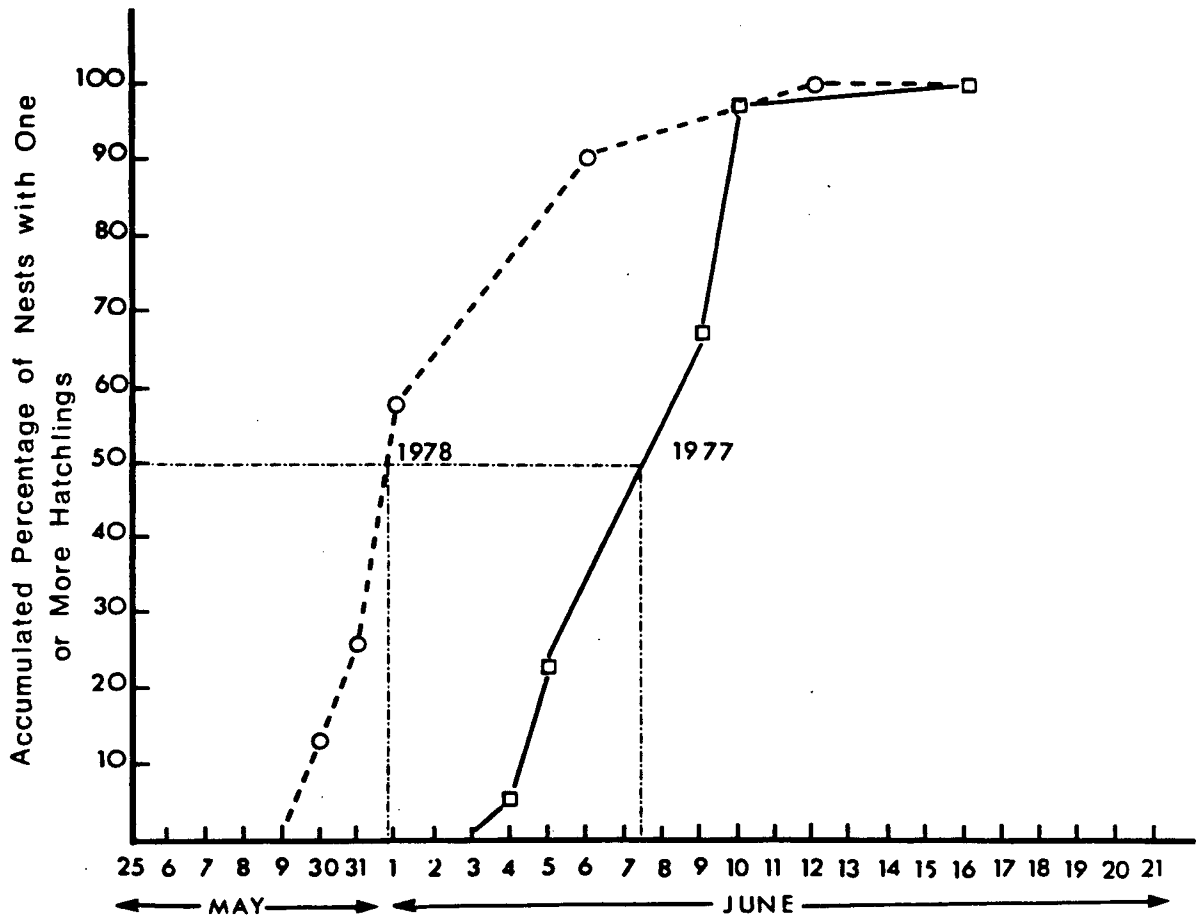

Figure 20. Hatching dates of white pelican eggs at Stum Lake, B.C.

TABLE 2. Number of adults, nests, clutch sizes, productivity, and survivorship of white pelicans at Stum Lake, B.C.

Year	Minimum Number of Adults	Total Number of Nests	Mean Clutch Size	Fledged Young	Productivity (young/nest)	Survivorship (young/egg laid)
1953	-	140	-	-	-	-
1959	(100-150)[1]	-	-	-	-	-
1960	-	(239)[2]	-	-	-	-
1963	280	-	-	-	-	-
1964	-	146	-	-	-	-
1967	-	153	1.79	-	-	-
1968	-	85	-	-	-	-
1969	-	87	1.65	-	-	-
1971	198	104	1.89	77	0.74	0.39
1972	202	116	2.21	10	0.09	0.04
1973	212	118	1.46	75	0.64	0.44
1974	234	108	1.84	24	0.22	0.12
1977	121	86	1.70	64	0.74	0.44
1978	130	105	1.93	89	0.85	0.44
1979	150	96	-	-	-	-
1980	215	120	1.78	62	0.52	0.29
Grand Mean ± S.D.	187±53	113±23	1.81±0.21	57±29	0.54±0.29	0.31±0.17
n	10	13	9	7	7	7

[1] Average number of adults used to calculate Grand Mean

[2] Abandoned nests (not used in Grand Mean)

When all 9 years for which clutch sizes are available for Stum Lake are considered (including those years experiencing disturbance), the overall mean clutch size was 1.81 ± 0.01 (n = 997). The clutch size frequency of white pelicans at Stum Lake during 1977 and 1978 is summarized in Figure 21. In both years the most frequently occurring clutch size was two eggs per nest.

6.3.5 Reproductive Success

During two years without disturbance of any kind at Stum Lake (1977 and 1978), average egg mortality was 10% of the eggs laid in the sample nests. Infertile eggs, (or eggs with arrested embryonic development) accounted for 5.1% (2 of 39 eggs) and 1.7% (1 of 58 eggs) of eggs laid in 1977 and 1978, respectively. Nest abandonment accounted for a further egg loss of 2.6% (1 of 39 eggs) in 1977 and 6.9% egg loss (4 of 58 eggs) in 1978. One of the above eggs was eaten by a common crow (*Corvus brachyrhynchos*) within 30 minutes after the nest had been abandoned. The remaining egg mortality resulted from egg displacement (eggs rolling out of nests). Egg displacement accounted for 2.6% (1 of 39 eggs) and 1.7% (1 of 58 eggs) of eggs in 1977 and 1978, respectively. Because I did not go onto the nesting islands but counted eggs opportunistically through a spotting scope until all sample nests were accounted for, some early egg mortality may have been missed.

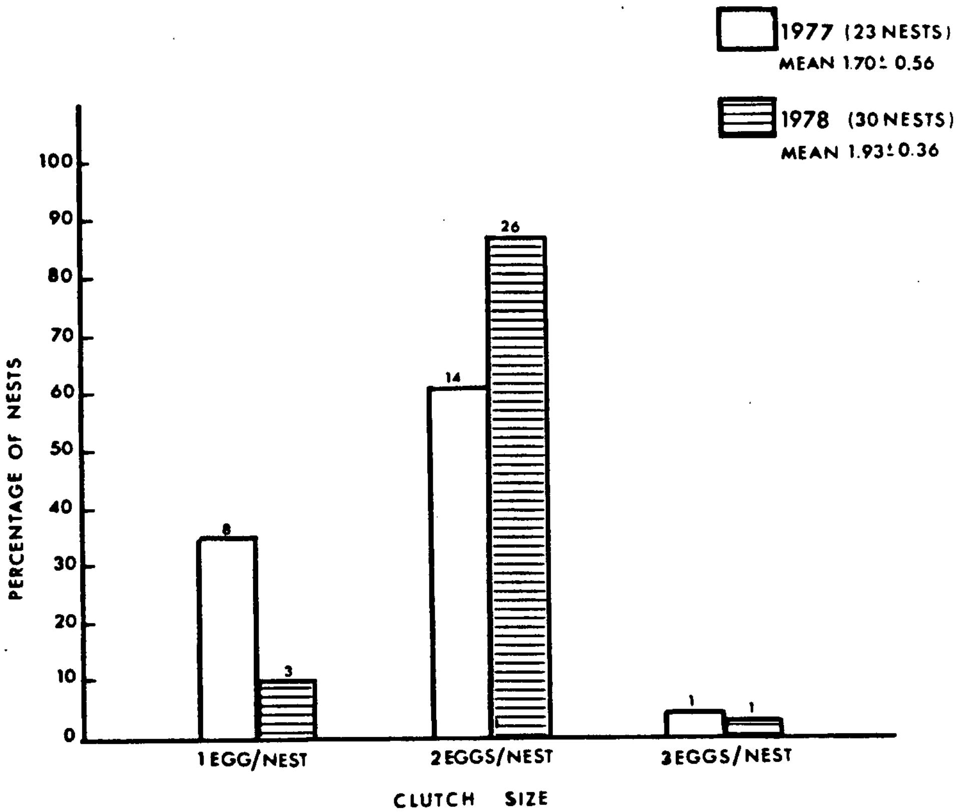

Figure 21. Clutch size frequencies of white pelicans at Stum Lake during 1977 and 1978.

Once eggs were hatched, nestling mortality claimed a further 26% of the eggs laid in the sample nests (average nestling mortality was 28% in 1977 and 24% in 1978). Major causes of nestling mortality at Stum Lake appear to be due primarily to sibling rivalry and/or starvation. In 17 of 22 nests (77%) that contained two young, only the smaller nestling died. In the five other nests, the surviving and dead nestlings appeared to be of similar size.

Only one incident of herring gull predation upon a nestling was observed during the 1977 and 1978 breeding seasons. Avian predation did not represent a major mortality factor among young pelicans at Stum Lake.

Fledgling mortality represented a further 20% loss of the eggs laid in the sample nests. Average fledgling mortality was 17% in 1977 (7 dead fledglings out of 39 eggs laid) and 22% in 1978 (13 dead fledglings out of 58 eggs laid). Mortality was greatest in the early fledging stage when young were smaller and beginning to aggregate in small groups. Sibling rivalry and/or starvation again appeared to be the major mortality factor during this period. Very few deaths were observed during the late fledging stage. The total mortality for the 1977 and 1978 breeding seasons was 56% of all eggs produced (Fig. 22) or conversely a survivorship of 44% (0.44 successfully fledged young/egg laid).

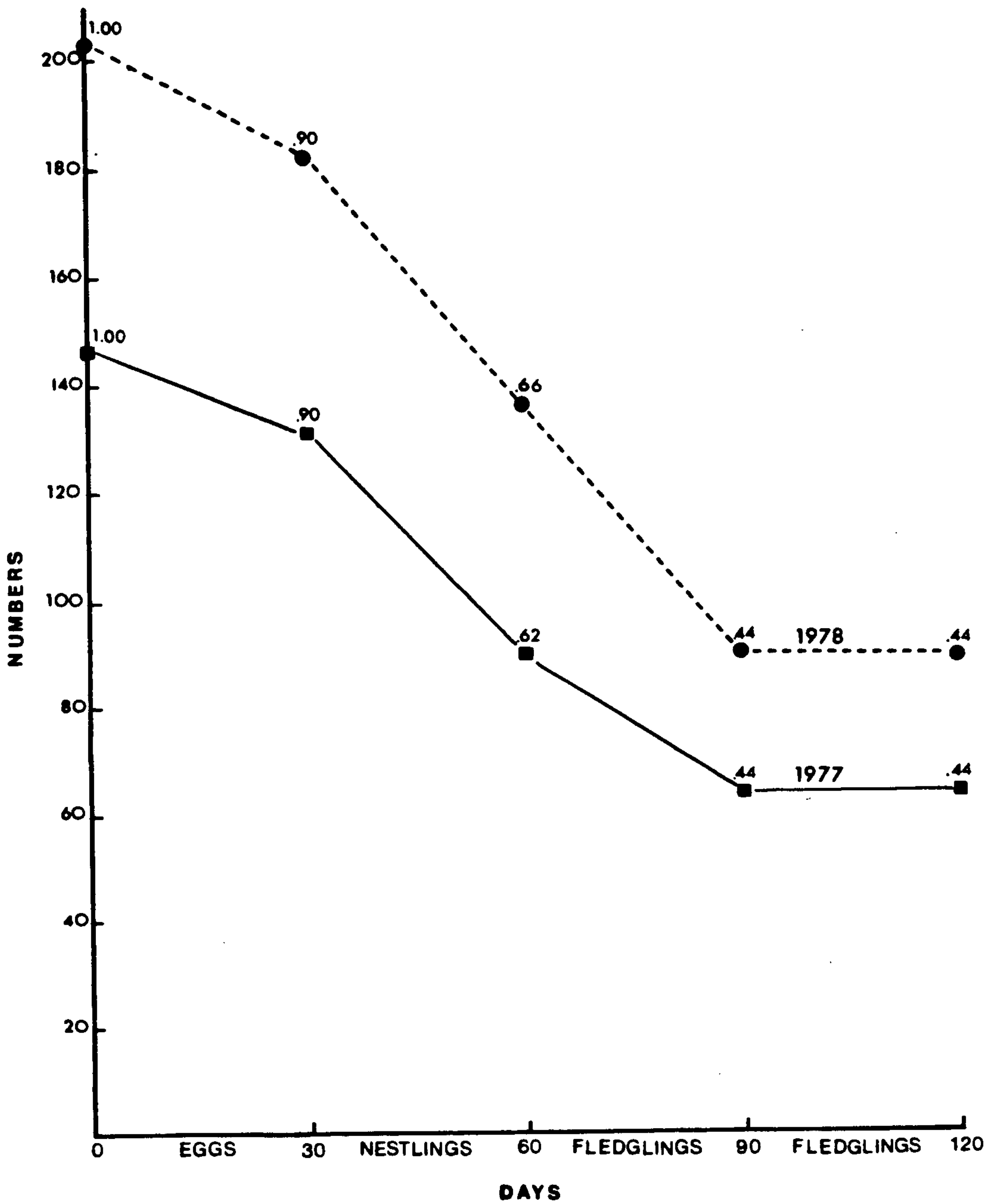

Figure 22. Survivorship of white pelicans at Stum Lake, British Columbia during 1977 and 1978.

In summary, in years with no disturbance during or after incubation (n = 309 nests), the Stum Lake colony averaged 0.74 fledged young per nest or 0.44 young per egg laid (Table 2).

6.3.6 Predation

The effects of predation on colony productivity ranged from insignificant to catastrophic. Avian predation under natural conditions had very little effect on the breeding population at Stum Lake. I observed predation by birds on only two occasions during my study at Stum Lake. On one occasion, a common crow was observed eating an egg at an abandoned nest site. The nest was 7.3 m from the nearest nesting group. On a second occasion, a herring gull attacked and ate a small nestling. Neither of the nestling's parents was observed at the colony during the attacks. Gulls and crows did patrol the periphery of subcolonies; however, eggs and young were generally well protected during their vulnerable periods. During a major disturbance, however, gulls and crows could potentially consume many of the eggs and nestlings left unattended in their nests. Both adults could safely leave the colony once the young fledged at about 28 to 30 days after hatching. At this stage, the young were mobile and large enough to deter avian predators on their own.

Mammalian predation can have a much more serious impact on productivity and survivorship of young than does avian predation. In 1979 and 1980, while ice still covered the lake, coyote harassment forced pelicans to re-nest on three and two separate occasions, respectively. Aside from the undesirable increased energy costs to the birds, egg laying, the incubation period, and time of fledging were delayed by 8 days in 1979 and 11 days in 1980. Productivity was not determined for 1979; however, in 1980, productivity was only 0.52 young/nest. Coyotes also attacked the colony early in the nesting season during 1973 (Ryder 1973). Productivity for that year was only 0.64 young fledged/nest. Combining 1973 and 1980 data, the mean productivity was 0.58 ± 0.08 (SD) (n = 238 nests), compared with a mean productivity of 0.80 ± 0.08 (SD) during 1977 and 1978 when no disturbances occurred (n = 191 nests).

Coyote predation midway through a nesting season can have even more dramatic results. In 1972, coyotes swam the short distance (84 m) to Island Two and caused almost total destruction of the eggs and young (Ryder 1972). Only 10 young were successfully fledged that year (Table 2). The overall productivity of the colony for this season was dramatically reduced to 0.09 young fledged/nest (n = 116 nests) compared with the average productivity in years without disturbance of 0.80 ± 0.08 (n = 191 nests).

6.3.7 Human Disturbance

Human disturbance has occurred frequently at Stum Lake. Again, the timing of the disturbance is critical. Disturbance during the early stages, such as courtship and nest site selection, appears to have only minor effects. Twice during the spring survey in 1979 a helicopter flew low over Stum Lake (altitude approximately 200 m) while pelicans were present. On both occasions, courting birds and those with nesting sites left the islands, but returned within 30 minutes of the disturbance. The disturbance to courting birds, although not prolonged, may have delayed the breeding schedule slightly through disruption of the pair-bonding process.

Productivity can be severely reduced, however, by human-induced disturbance during the incubation and early nestling stages. At Stum Lake, human disturbance (low flying aircraft) dramatically reduced the productivity of the colony during the 1974 breeding season (Ryder 1974). Adult pelicans crushed eggs and young (white pelicans incubate their eggs with their feet) in their attempt to escape from a low flying airplane. Only 24 young survived (Table 2). The overall productivity for that breeding season was 0.22 successfully fledged young/nest (n = 108 nests), well below the average of years without disturbance or predation (0.80 young/nest).

Human-induced disturbance later in the nesting season, after most young have fledged, reduces productivity only slightly. During 1971, an aircraft overflight caused mortality in only a few nestlings and smaller fledglings (Ryder 1971) and resulted in an overall productivity of 0.74 successfully fledged young/nest (n = 104 nests), only slightly below the average of years without disturbance or predation (0.80 young/nest).

6.3.8 Survivorship and Productivity in relation to Clutch Size

The survivorship of young white pelicans and the productivity of individual nests differ dramatically depending on the initial clutch sizes of those nests. When reproductive data for 1977 and 1978 are combined, 11 nests with single-egg clutches successfully fledged 9 young. Survivorship in these nests was highest compared to nests with two and three eggs (0.82 young fledged/egg laid, Fig. 23). However, these single egg nests were the least productive when measured as number of young produced/nest.

Survivorship of young in nests with a clutch size of two eggs/nest (n = 43 nests) was lower (0.65 young fledged/egg laid); however, nest productivity was greater (1.30 young fledged/nest) compared with single egg nests (Fig. 23). The survivorship of nests with a clutch size of three (n = 2 nests) was even lower (0.33 young fledged/egg laid) compared with nests with one and two egg clutches; however, the average productivity for these nests was still greater (1.0 young fledged/nest) than nests with a clutch of only one egg (Fig. 23).

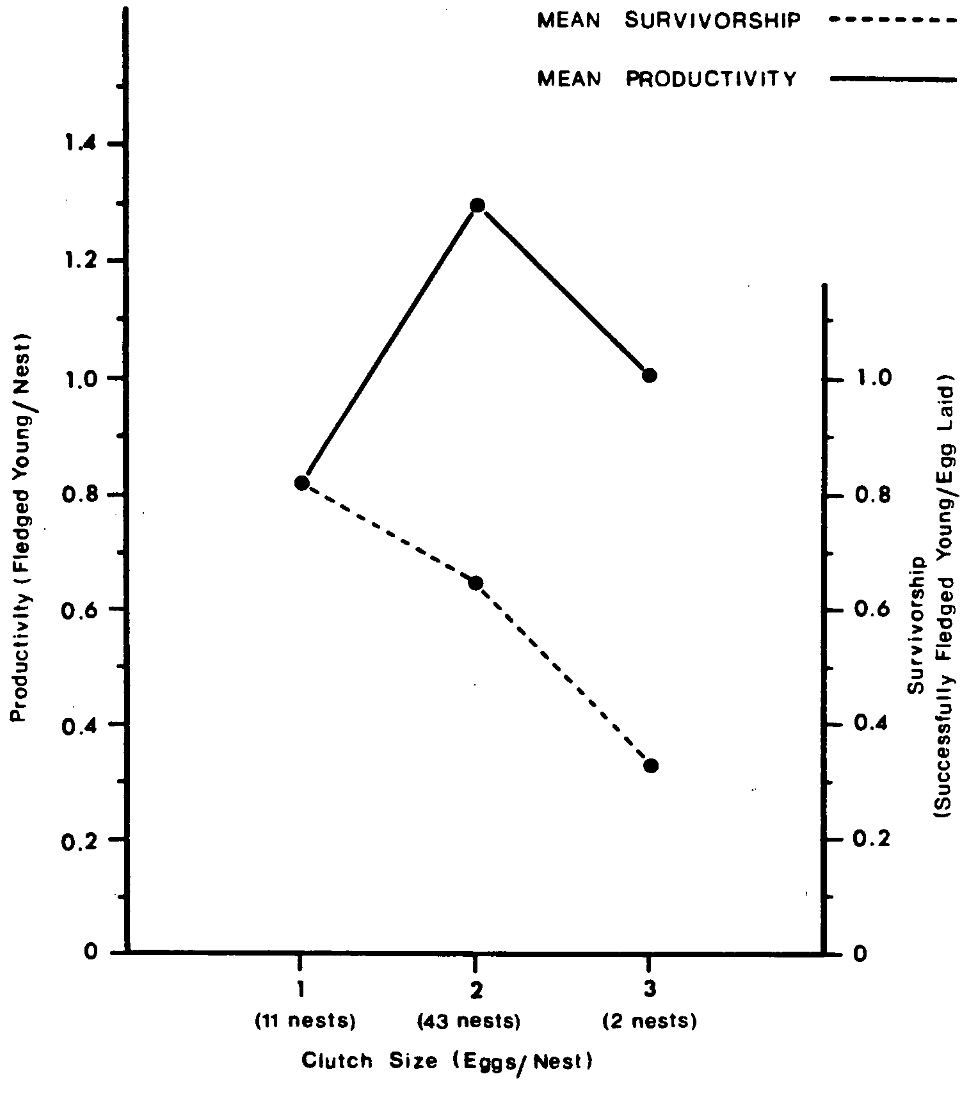

Figure 23. Clutch size in relation to productivity and survivorship of young at Stum Lake, during 1977 and 1978.

6.4 Discussion

6.4.1 Comparison of Reproductive Success with other White Pelican Colonies in North America

Mean clutch size of white pelicans at Stum Lake during years without disturbance (1.95 ± 0.21) does not differ markedly from observations reported for other white pelican colonies in North America and lies in the middle of the reported range. Mansell (1965) reported a mean clutch size of 1.81 ± 0.10 for white pelicans at Lake of the Woods, Ontario, and Johnson (1976) obtained similar observations during his 4-year study at Chase Lake, North Dakota (1.86 ± 0.18 eggs per nest). At a small colony in South Dakota the average clutch size of 29 nests was 1.97 eggs per nest (McCrow 1974). Knopf (1975) found the mean clutch sizes at Great Salt Lake, Utah, were 2.02 eggs per nest, while Schaller (1964) reported mean clutch sizes of only 1.69 eggs per nest at Yellowstone Lake, Wyoming.

Mean egg mortality during years without any disturbances at Stum Lake was about 10% of the eggs laid in the sample nests. Nest abandonment was the major mortality factor during 1977 and 1978, resulting in half of the egg losses. Infertile eggs (or eggs with arrested embryonic development) and egg displacement were the cause of the remaining egg mortality. In other white pelican colonies in North America, nest abandonment has had much greater effects on egg losses compared to those at Stum Lake. Human disturbance however, appears to have been a major influence in those colonies recording high rates of nest abandonment. At Chase Lake, North Dakota, a researcher studied the colony from a blind situated only 30 m from the colony, checked nest contents weekly, and tagged newly fledged young. During the two year study, nest abandonment accounted for an average of 53% of all nests. Losses of between 60 and 80% of all eggs laid were recorded. Knopf (1975) indicated that nest abandonment (26% of nests during incubation) was the largest source of egg mortality at Great Salt Lake, Utah. Egg losses through displacement from nests was the second highest source of mortality at Great Salt Lake, accounting for 9% of all eggs.

Nestling mortality claimed a further 26% of the eggs laid in the sample nests during 1977 and 1978 at Stum Lake. The major cause of mortality appeared to result from sibling rivalry and/or starvation. When chick mortality was observed in nests occupied by two nestlings, the smaller chick died much more frequently than the larger nestling (77% of those nests).

Knopf (1975) found that 29% of the eggs laid were lost during the nestling stage at Great Salt Lake, Utah. Knopf noted that, of the nests in which two eggs hatched, the second chick to hatch usually died during the nestling period. He frequently observed aggression between the nestlings and felt that the major mortality factor during the nestling stage was a consequence of sibling rivalry and/or starvation. Johnson (1976) at Chase Lake, North Dakota, also felt that the major mortality factor for nestlings was either starvation or physical abuse by a larger nestling. He noted that the smaller young in a normal two egg nest died at a rate approaching 100 percent.

At Stum Lake, the mean fledgling mortality accounted for an additional 20% loss of eggs laid. Sibling rivalry and/or starvation again appeared to be the major mortality factor.

The total mortality of young for the 1977 and 1978 breeding seasons at Stum Lake was 56% of the eggs produced. Overall productivity and survivorship of young at Stum Lake, in years without disturbance, (0.80 young/nest and 0.44 young/egg laid respectively) does not differ greatly from other white pelican colonies in North America. Palmer (1962) stated that a 50% mortality rate of young is common for white pelicans. Based on 1323 nests at Great Salt Lake, Utah, white pelicans produced 0.85 young/nest and fledged 0.42 young for each egg laid (Knopf 1975). White pelicans at Medicine Lake, Montana, produced 0.77 young/nest (n = 1140 nests) during 1963, and another colony of about 500 nests on South Bird Island, Texas, produced approximately 0.9 young/nest (Lies and Behle 1966). A colony of 105 nests at Riverside Reservoir, Colorado, fledged a mean of 0.75 young/nest during 1963 (Ryder and Grieb 1963). During 1976, however, the same colony produced 1.17 young/nest, the highest ever recorded for the species (Miller and Ryder 1977). They noted that the success resulted from high hatchling survival rather than hatching success.

6.4.2 Effects of Predation and Disturbance at White Pelican Nesting Colonies

The effects of predation and disturbance at white pelican nesting colonies are extremely variable. Under normal conditions at Stum Lake, avian predation has very little effect on the survival of young. Combined with human disturbance however, avian predation can be a major problem. During 1971 and 1974 a low flying aircraft caused pelicans to temporarily abandon their nests at Stum Lake. During the adult's absence, eggs and small nestlings were consumed by gulls and crows (Ryder 1971, 1974). Johnson and Sloan (1976) observed similar phenomena during their research activities at Chase Lake. They found that California and ring-billed gulls (<u>Larus delawarensis</u>) were more tolerant of human activity than pelicans and moved freely in the colony consuming pelican eggs and young while the researchers were present. Houston (1962) and Sanderson (1966) also observed egg predation by gulls when pelicans were disturbed off their nests in Saskatchewan. In general, white pelican young are most vulnerable to avian predation throughout the incubation period (30 days) and during the early brooding period (first 10 to 15 days).

The effects of mammalian predation are usually much more severe than avian predation at breeding colonies of white pelicans. At Stum Lake, while ice still covered the lake, coyotes harassed nesting pelicans on several occasions, causing increased energy expenditures for the nesting birds, as well as delays in breeding ranging from eight to eleven days. These delays potentially could affect the reproductive success of the colony. At Great Salt Lake, Knopf (1975) found that the reproductive success of white pelicans declined as the breeding season progressed. Decreased production reflected greater losses of eggs and chicks resulting from eggs rolling from nests, nest abandonment, and increased chick mortality. G. Miller (pers. comm. 1980) also indicated that delays in the breeding season reduced reproductive success of pelicans at Riverside Reservoir in Colorado. Lower productivity at Riverside Reservoir appeared to result from smaller clutches being laid as the season progressed. In a colony of Cassin's auklets (Ptychoramphus aleuticus), Manuwal (1979) found that the reproductive success was lower in auklets that laid eggs later in the breeding season. Furthermore, growth rates and fledglings weights were lower, and nestling periods longer among young hatched later in the season.

Mammalian predation midway through a nesting season can cause even greater damage to a colony. At Stum Lake in 1972, coyotes caused almost total destruction of eggs and young (Ryder 1972). Mammalian predation also has been a major factor limiting the productivity of other white pelican colonies in North America. Blokpoel (1971) reported little to no production of young primarily because of fox predation at Canada's largest pelican breeding colony at Primrose Lake, Saskatchewan (2,459 nests in 1970). Coyote predation also resulted in the complete nesting failure at Malheur Lake in eastern Oregon during 1960 (Scott 1960). Young pelicans are vulnerable to coyote predation from the beginning of egg laying until they are able to swim. Schaller (1964) reported that young normally enter the water at one month of age. However, at Chase Lake, one month old young were observed to enter the water only when disturbed (Johnson and Sloan 1976). They noted that these young became rapidly waterlogged and chilled. At Stum Lake, young first entered the water at about 60 days of age.

White pelicans are extremely intolerant of human activity during the breeding season. When disturbed, they readily abandon their nests, exposing eggs and young to physical stress and predation by gulls and crows. Entire colonies may be destroyed as a result of human disturbance (Houston 1962, Carson 1966, Vermeer 1970a). In the last two decades, at least 10 colonies have disappeared from Canada because of direct human interference or because of habitat changes made by man (Vermeer 1971). At Stum Lake, disturbance during the early stages, such as courtship and nest site selection, appears to have had only minor effects. However, repeated disturbance during the initial stages of reproduction could cause the birds to totally abandon the colony for the year (Committee on the Status of Endangered Wildlife in Canada 1979).

Human disturbance during incubation and early nestling stages can severely limit the productivity of a colony. During 1974 at Stum Lake, a low flying aircraft caused pelicans to crush many eggs and young as they attempted to escape. In addition to the direct mortality caused by the adults, abandoned eggs and young were preyed on by gulls and were subject to temperature stress. Unprotected eggs and naked nestlings can quickly succumb to direct sunlight (Bartholomew *et al*. 1953). At Chase Lake, naked young died within five minutes when exposed to high temperatures (Johnson and Sloan 1976). The period when young pelicans are most vulnerable to human disturbance occurs throughout the incubation period until they have fledged (about 28 to 30 days). Human disturbance after young have fledged caused only a minimal reduction in productivity at Stum Lake during 1971 (Ryder 1971).

6.4.3 Implications of Clutch Size

Data collected at Stum Lake support Lack's (1966) hypothesis that in nidicolous birds the normal clutch size is that which, on average, results in the largest number of surviving young. The mean clutch size at Stum Lake during years without disturbance (1977, 1978) or when disturbance occurred after the completion of courtship and egg laying (1971, 1972) was 1.95 ± 0.21 (n = 411). In both 1977 and 1978, the most frequently occurring clutch size was two eggs per nest (75% of the clutches had two eggs). Nests with two egg clutches at Stum Lake produced, on average, more successful young (1.3 young/nest) than single egg clutches (0.82 young/nest). Lack (1966) also stated that the addition of eggs to make larger than normal broods should result in fewer, not more, young surviving per brood. At Stum Lake, nests with three egg clutches produced fewer successful young (1.0 young/nest) than more common clutches with two eggs (1.3 young/nest).

Apparently the best strategy for white pelicans to maximize their reproductive output is to lay a clutch of two eggs/nest. In an undisturbed condition, a clutch of two eggs/nest will result in an intermediate amount of mortality (increased sibling rivalry with larger clutches) compared with one and three egg clutches, and, on average, will result in the maximum number of offspring/nest.

CHAPTER 7.

BEHAVIOUR OF WHITE PELICANS AT STUM LAKE

7.1 Introduction

Intraspecific and interspecific behaviour were monitored at Stum Lake to determine their effects on the colony's nesting success. Intraspecific behaviour was examined to assess the possibility that upper limits to the colony were being established by the pelicans themselves. I recorded aggressive interactions betweem adults, adult aggression directed at young, and sibling aggression.

Observations also were made of interspecific relations and potential predation by Corvids and herring gulls. I also tried to determine whether there was any competition for nesting sites between herring gulls and white pelicans. Specific objectives were:

1) To document adult white pelican aggression at Stum Lake during the breeding season;

2) To document sibling aggression at Stum Lake; and,

3) To describe the behavioural interactions of white pelicans with other species, such as crows, gulls, coyotes, and humans.

7.2 Methods

Due to the sensitivity of white pelicans to human disturbance, all behavioural observations were recorded from the mainland with the aid of a 20 to 45X spotting scope. Although adult birds could not be marked, both physical and behavioural features of the birds made it possible to identify many individuals. For example, males are generally larger than females (Palmer 1962) and during courtship exhibit many behavioural diffences. In addition, the fibrous plate on the upper mandible of both sexes during the early phases of the breeding season, and the plumage characteristics of the crown (post-nuptial molt) during incubation and later phases of the breeding season were highly variable between individuals.

I monitored intraspecific behaviour at the colony during all four breeding seasons. During the 1979 and 1980 breeding seasons, emphasis was placed on courtship and early nesting behaviour, and during 1977 and 1978, on incubation and brooding behaviour.

I used focal-animal sampling to study intraspecific behaviour. Using this sampling method, all occurrences of specified (inter)actions of an individual are recorded during a sample period (Altmann 1974). A total of 387.2 hours of intraspecific behaviour was recorded. Sample sessions began at pre-determined times during the day (generally on the hour) and were terminated after one, two, or three hours. Sessions also were terminated when the focal individual was no longer in view. Focal individuals were selected either randomly or on the basis of some behavioural criterion; for example, the first bird to 'stretch'. Only readily-visible individuals were chosen for behavioural studies. Durations of activities were timed using an 'activity board' which contained three stopwatches measuring 0.01-min intervals.

Interspecific interactions of white pelicans with potential avian predators were recorded opportunistically throughout the pelican incubation and brooding periods in 1978. Observation periods began when an avian predator landed on the nesting island and terminated when the bird departed. These observation periods ranged from 0.5 to 4.4 min in duration. The total sample size of avian interspecific interactions was 34 min containing 270 crow- or gull-pelican interactions.

7.3 Results

7.3.1 Intraspecific Interactions

Aggressive activity among adult white pelicans at Stum Lake was greatest while the birds were courting and selecting nest sites (Fig. 24). The mean number of agonistic encounters for males and females combined during this period was 11.5 aggressive interactions/hour. This rate declined dramatically once incubation began (6.2 aggressive interactions/hour), and once again when the young hatched (1.3 aggressive interactions/hour). There was no change in the mean agonistic rate from the brooding period to the post-brooding period.

Throughout the entire breeding season, males had more aggressive encounters/hour than females. This was especially

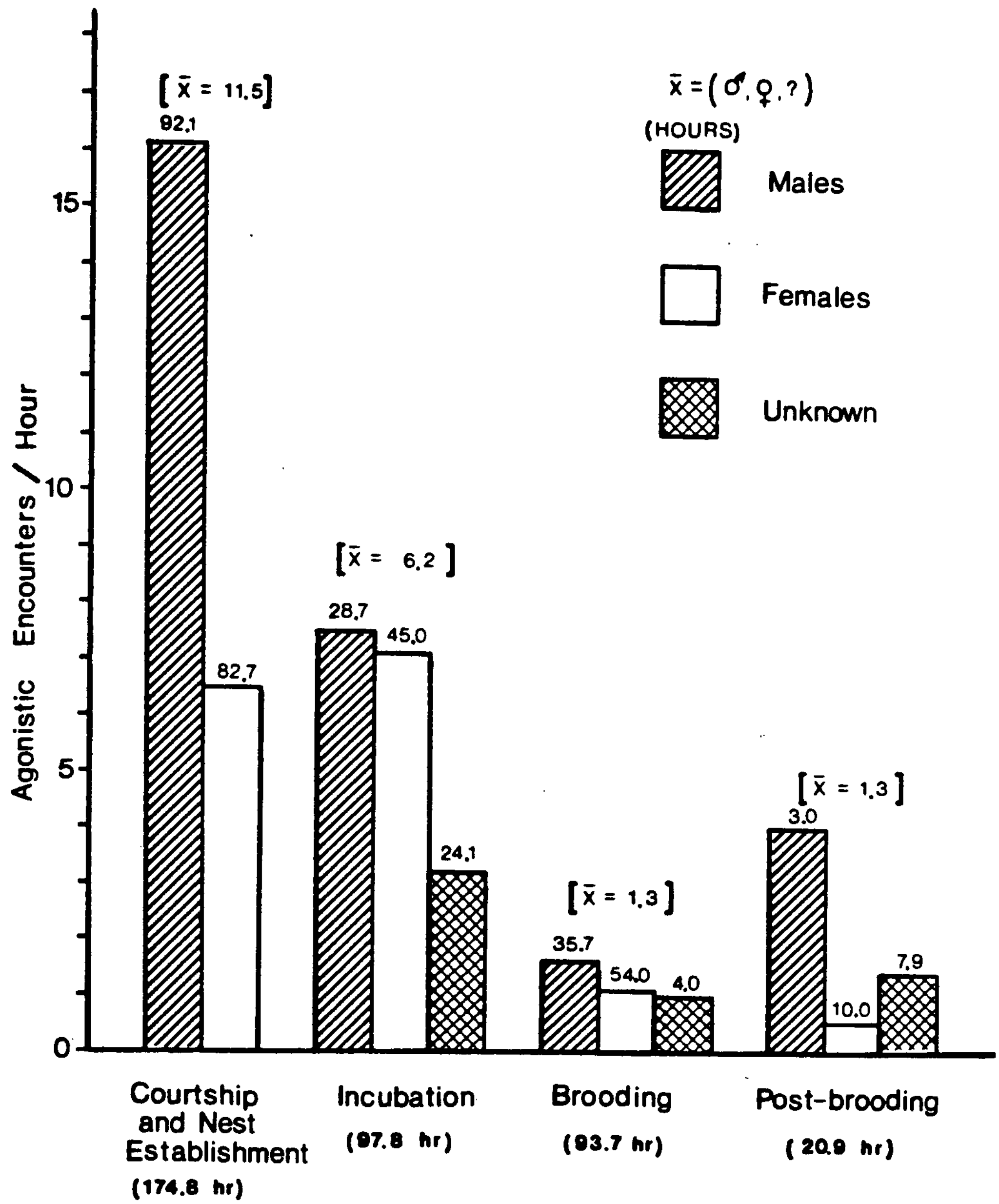

Figure 24. Aggressive interaction rate among adult white pelicans at Stum Lake, British Columbia.

evident during courtship and nest selection (Fig. 24). The mean number of agonistic encounters for males and females during this period was 16.1 and 6.5 aggressive interactions/hour, respectively. During the incubation and brooding periods, differences between male and female agonistic encounter rates were only slight. Agonistic encounters for males and females were 7.5 and 7.1 interactions/hour, respectively during incubation and 1.6 and 1.1 interactions/hour, respectively during brooding. The differences observed between males and females during the post-brooding period may not give an accurate representation of aggressive activity for two reasons. The total observation period for males was small (three hours) and one male accounted for more than half of all agonistic encounters observed (seven of the twelve aggressive interactions).

Adult aggressive behaviour directed at young was observed infrequently at Stum Lake. During one instance, an adult on the periphery of a nesting group tossed a nestling into the surrounding vegetation. I could not determine if this young belonged to the adult, or if it came from another nest. During the post-brooding stage, when fledglings were left unattended, I observed several attempts by adults to mount young. During these copulation attempts the young were repeatedly bitten and pecked by the adult. The copulation attempts generally were of short duration (10 to 30 seconds) and did not appear to result in serious injury to the fledglings.

Intraspecific aggression between young occurred frequently throughout the brooding period. Agonistic behaviour was especially common in nests occupied by two young. In nests where one sibling was larger than another, nearly all of the aggressive interactions were initiated by the larger nestling. Attacks were nearly always directed at the head and neck region. For example, in a nest studied intensively during 1977, one egg hatched at least 24 hours prior to the second egg. At four days of age, the larger nestling (about twice the size of the smaller) continually harassed the smaller chick. Nearly all of the pecking was directed at the head and eyes of the smaller nestling. By seven days of age (larger young), the smaller chick was frequently forced to retreat outside the nest. In addition, the two chicks were not fed equally. The larger young usually fed directly from the adults pouch, while the smaller chick fed only on what dropped to the ground. Occasionally the adult regurgitated food into the nest, but the larger nestling was faster and picked up food more quickly. At 14 days of age (age of larger chick), only the larger nestling was observed in the nest.

In nests with siblings of equal size, intraspecific aggression was also intense; however, both young usually obtained some food. During mid August, I frequently observed adults arrive at the lake, feed two young of equal size, and then depart.

7.3.2 Interspecific Relations

Effects of interspecific interactions on the productivity of white pelicans at Stum Lake have been discussed (Chapter 6). The few observations of behavioural interactions of white pelicans with other species are described briefly.

I recorded interactions with other birds, particularly potential predators on eggs and young, such as herring gulls and common crows. Interactions frequently occurred whenever a gull or crow landed near the nesting birds. Anti-predator defence behaviour by nesting pelicans, such as a 'bill lunge', usually occurred when the predator approached to within a certain distance.

I found that gulls and crows visited peripheral nests much more frequently than would be expected in terms of their availability relative to central nests (Chi-Squared One Sample Test, $P < 0.001$). Nearly all of the interactions recorded (264 of 270) involved pelicans nesting on group peripheries (84 of the 105 nests were considered as peripheral nests). The interaction rate of peripheral nesting pelicans with avian predators was 7.8 interactions/min of observation, while that of the central nesting pelicans, was 0.2 interactions/min of observation. Five of the six central birds that interacted with a predator were adjacent to a peripheral nest and were assisting a peripheral bird. The other center-nesting bird that reacted to a predator snapped its bill at a crow flying overhead. All of the 270 interactions involved threatening behaviour by nesting pelicans.

I did not observe any interspecific competition for nesting sites between pelicans and herring gulls at Stum Lake. When pelicans first arrived during the spring, herring gulls had already established nesting sites on Island One and Scaup Island. The gulls did not appear disturbed by the courting pelicans. Pelicans utilized all three islands during their courtship, and the presence or absence of gulls did not seem to cause any deviations from their normal behaviour. Interactions between the two species were not common. Those interactions observed usually involved pelicans which had either displaced or threatened a passing gull. Only on one occasion was a gull observed threatening a pelican.

Mammalian interactions with nesting pelicans generally had more dramatic consequences than did avian interactions. I observed five coyote disturbances during the courtship and early nesting periods while ice still covered Stum Lake. Disturbances during these periods caused pelicans to abandon the lake for one or two days. Pelicans typically flew from their islands when coyotes came within 150 m. Herring gulls always left the islands several minutes before pelicans did. Both species circled the island for periods ranging from five to ten minutes, while coyotes searched the nesting sites. Generally, the birds landed on the ice near the island, only after the coyotes had left. Small flocks of pelicans then began to leave the lake, and by sunset, most had departed. It was difficult to determine if disturbed birds returned the next day, as migrating flocks arrived each day during the spring.

Coyote disturbance during the incubation and brooding periods caused pelicans to abandon Stum Lake for three or four days (Ryder 1972). Adults burst into the air from their nests and immediately began leaving the lake in small flocks. The young scattered in many directions and some of these became entangled in the vegetation. Many of the young not killed immediately by the coyotes, eventually died of either starvation or physical stress (exposure). When adult pelicans returned to the lake, most landed on another island and only flew briefly over the nesting island.

Human-induced disturbance appeared to cause similar results to that of coyote disturbance. During a nest survey in 1969, incubating pelicans immediately abandoned their nests when a boat was beached on the breeding island (Wright and Wright 1970). The pelicans circled the island several times, then left the lake.

The outcome of disturbance by low-flying aircraft during 1974 appeared similar. In late June, a low-flying aircraft flew over Stum Lake and caused all incubating and brooding adults on Island Two to abandon their nests. Eggs and young were crushed by stampeding adults during the incident. Adults did not return to the nesting island for six or seven days (G.R. Ryder Pers. Comm.). As a result, many of the young that survived the initial effect of the disturbance, starved during the adults absence.

7.4 Discussion

Adult intraspecific aggression was observed at Stum Lake throughout the breeding season. The mean number of adult agonistic encounters (males and females combined) was greatest during the courtship period (11.5 interactions/hour) and declined rapidly once incubation began (6.2 interactions/hour). This reduction in aggressive activity may be a function of the decrease in pelican density associated with the onset of incubation. Once the female of a pair lays an egg, the male leaves the colony for several days to forage. This effectively reduces the pelican population on the breeding island by about half. Prior to laying, both the male and female occupyed the nest site.

The decline in the agonistic rate from the incubation period (6.2 interactions/hr) to the brooding period (1.3 interactions/hr) may have resulted from an increase in the amount of time the adults spent caring for (feeding) their young. Newly hatched young were fed five or six times per hour with feeding bouts ranging between 0.5 and 5.0 minutes. Agonistic activity did not change between the brooding and post-brooding period.

In general, adult intraspecific aggression did not appear to adversely affect the breeding success of white pelicans at Stum Lake. In fact, all of the nest sites abandoned at Stum Lake during 1977 and 1978 (8 of 191 nests) were situated in areas of low density where aggressive interactions were few; that is the nests were either solitary or on group peripheries.

It is possible that intraspecific aggression among adult white pelicans during incubation may stimulate nest-attentiveness and reduce the potential for nest abandonment. Pomeroy (1978) suggested that, in marabou storks (Leptoptilos crumeniferus), the closer nests are to each other, the more frequently the parents are reminded of leaving them unguarded. Tenaza (1971), studying Adélie penguins (Pygoscelis adeliae), found that central nests were less likely to be left exposed than were peripheral ones. He suggested that one advantage of central nesting is that the tendancy to remain on the nest is increased by neighbours' hostility.

Adult aggressive behaviour directed at young was rarely observed at Stum Lake and appeared to represent only a very minor source of mortality. Intraspecific aggression between young in the same nest however, was frequent and appeared to account for a high percentage of mortality in both nestlings and fledglings. In nests where the size of the siblings differed, the smaller nestling received the majority of the aggressive attacks.1 In 17 of 22 nests that contained two young, only the smaller nestling died. In the five other nests, the surviving and dead nestlings appeared to be of similar size.

Observations at Chase Lake, North Dakota, also reveal poor survival of second born young. No nests were observed that contained two young over three weeks of age (Johnson 1976). The majority of the mortality at Chase Lake resulted from either starvation or physical abuse by the larger nestling. Knopf (1975) also noted that the major source of mortality was death of the smaller chick in nests where two chicks hatched. Knopf

(1980) found that the incidence of both chicks surviving in the same nest declined with an increase in the interval between hatching of the eggs.

Interspecific interactions of white pelicans with potential predators on eggs and young were examined. Gulls and crows visited peripheral nests much more frequently than would be expected in terms of their availability relative to central nests. Coulson (1968) and Vine (1971) hypothesized that individuals at the centers of nesting groups would be at a lesser risk than those at the edges. In addition, peripheral nesters should also experience greater stress from the higher number of predator contacts (Barnett 1964). Data collected at Stum Lake appear to support these hypotheses. At Stum Lake, the higher interaction rate of avian predators with pelicans nesting on peripheries (7.8 interactions/min of observation) compared with those in group centers (0.2 interactions/min of observation) indicate that the risk of predation and the possiblity of greater stress was greater in peripheral nests.

Bird predation at Stum Lake, however, was only a minor mortality factor, unless combined with human disturbance. Combined with human disturbance central nests were as vulnerable as peripheral nests.

Abandonment of eggs and young appeared to be the primary strategy of white pelicans in the event of either mammalian predation or human disturbance. In relatively long-lived species, such as white pelicans (17 years), the survival of the adults is almost as important as the survival of the young (Klomp 1970, Charnov and Krebs 1974). If by abandoning eggs or young during a disturbance, the adult's chances of survival are increased, then it becomes beneficial for the species to do so (Goodman 1974). Goodman (1974) described this as the advantages of future fitness outweighing those of present fitness.

CHAPTER 8.

MANAGEMENT RECOMMENDATIONS AND RECOVERY PLAN FOR WHITE PELICANS IN BRITISH COLUMBIA

8.1 Introduction

8.1.1 Background

The white pelican is considered a 'threatened' species in Canada largely because of its vulnerablity as a colonial nester. Available data suggest that the population of white pelicans in Canada has slowly declined over many years, but has been relatively stable during the last decade (Committee on the Status of Endangered Wildlife in Canada 1979). Human disturbance at the breeding colonies appears to have been the major cause of the population decline.

The population of white pelicans in British Columbia is also highly vulnerable. There is only one nesting location. At present less than 300 pelicans nest at the colony. Three early nest records at Stum Lake (1953, 1964, and 1967) indicate that the breeding population was historically larger than present levels. Under the criteria to designate threatened and endangered species for British Columbia, the white pelican ranks near the top in degree of 'endangerment'. In March, 1980, the white pelican was officially designated as an endangered species in B.C. by the Lieutenant Governor in Council.

8.1.2 Need and Justification For Protection

There are many reasons for protecting the colony of white pelicans at Stum Lake. I list six.

(1) Protection of Pelecaniformes, including white pelicans is now mandated by the British Columbia Wildlife Act.

(2) We have a moral obligation to counter human-induced population declines.

(3) The general public desires to prevent endangered species from disappearing. Society values the diversified wildlife heritage of British Columbia.

(4) Preservation of all species is important, especially prevention of the loss of genetic diversity.

(5) Because they are at the top of the food chain, white pelicans are especially vulnerable to pesticides and therefore are biological indicators of environmental contamination.

(6) White pelicans are of recreational importance to the general public and bird watchers. Pelicans represent a rare and 'fulfilling' sighting.

8.2 Suspected Or Proven Reasons For Changes In Status

The two most important factors that are limiting the growth of the white pelican population in British Columbia, and that continue to threaten the colony, appear to be human-induced disturbance and coyote predation. Table 3 summarizes the years during which coyote predation and forms of human disturbance have occurred at the Stum Lake colony. Available data suggest that human-induced disturbances have been much more frequent than coyote-related disturbances. The colony has been disturbed by humans during at least nine breeding seasons since its discovery. These include occasions where eggs were collected, eggs and young photographed, nests surveyed, and young banded, as well as incidents of low-flying aircraft (Table 3). Coyote predation and harassment during the early nesting period occurred during at least four breeding seasons. Undoubtedly, the many documented disturbances (Table 3) and other unknown incidents have limited the pelican population's growth in British Columbia. Both kinds of disturbance (humans and coyotes) can dramatically reduce the survivorship of young and the overall productivity of the colony.

Available data suggested we could characterize at least four kinds of disturbance. They were: aircraft early in the nesting site (before or during incubation); aircraft-late in the nesting season (after incubation); coyote-early; and coyote-late. A simulation model was designed (using a modified Leslie Matrix) to explore the rates of change in the simulated population under the four different kinds of disturbances at various frequencies. A more detailed discussion of the model and the mathematical

TABLE 3. Chronology of disturbances to the white pelican colony at Stum Lake, British Columbia.

Year	Date	Nesting stage[a]	Factor[b]	Incident
1939	July 1	In, Br	HD	Islands visited, eggs and young photographed
1950	May 21,28	In	HD	Eggs collected on two occasions
1959	June/July	In, Br	HD	Eggs, nests, and young counted
1960	May 25	In	?	239 nests found abandoned
1964	June 22	In, Br	HD, AW	Eggs collected, waves washing eggs from nests
1967	June 19	In, Br	HD	Eggs, nests, and young counted
1968	July 20	In, Br	HD	Nests counted, young banded
1969	June 22	In, Br	HD	Eggs, nests, and young counted
1971	July 3	In, Br	HD	Aircraft overflight
1972	July 2	In, Br	PD	Coyote predation
1973	late May	In	PD	Coyote predation
1974	June 9	In, Br	HD	Aircraft overflight
1979	late April	Ct	PD	Coyote harassment
1980	late April	Ct	PD	Coyote harassment

[a] Ct = courtship, In = incubation, Br = brooding (young in nest)

[b] HD = human disturbance, PD = predation, AW = adverse weather

formulations employed are given in Bunnell et al. (1981) and in the appendix of Bunnell and Tait (1980), respectively. Most variables used to simulate the consequences at specific frequencies of empirically derived effects are summarized in Table 4. The model assumes no birds live longer than 15 years. Observed mortality rates (Strait and Sloan 1974) yield fewer than 2 birds/100 after age 15 years. Sixteen age classes were employed. The first age class represented survivorship from egg to immediately prior to fall migration (44% during undisturbed conditions, this study); the second, from that latter age until the first birthday (to allow incorporation of data of Strait and Sloan 1974); all other age classes were at yearly increments for a total of 15 years. All adults were assumed to breed at three years of age. The clutch size for the control population was that derived from those years in which disturbance, if it occurred, occurred after the completion of courtship and egg laying (1.95 eggs per clutch, this study).

Using band returns from the Chase Lake population of North Dakota, Strait and Sloan (1974) estimated survivorship from post-fledging until the first birthday (age class 2 or 'subadult' of Table 4) at 59%. For the remaining subadults and adults ('adults' of Table 4) they estimated 78.7% survivorship, but argued that these values were too low as they did not incorporate known band losses. The model utilized 'subadult' survivorship of 60%, incorporated the maximum young per egg survivorship (44%, Table 4), and examined the sensitivity of the population to changes in 'adult' survivorship. For the simulations illustrated, an 'adult' survivorship rate of 82.5%,

TABLE 4. Parameter values employed in the simulation model and associated rates of change in the simulated population.

Disturbance type	Clutch size	Survivorship			Rates of change/year[a]				
					Frequency of disturbance/20 yr				
		Young/ egg	Sub-adult	Adult	0	1	2	4	5
None	1.95	0.44	0.60	0.80	-0.005				
	1.95[b]	0.44	0.60	0.825	0.017				
	1.95	0.44	0.60	0.85	0.037				
	1.90	0.44	0.60	0.825	0.012				
	1.90	0.44	0.60	0.85	0.033				
Aircraft-early	1.84	0.12	0.60	0.825		0.003	-0.003	-0.016	-0.023
Aircraft-late	1.95	0.39	0.60	0.825		0.015	0.014	0.012	0.011
Coyote-early	1.62	0.29	0.60	0.825		0.008	0.004	-0.004	-0.008
Coyote-late	1.95	0.04	0.60	0.825		0.0003	-0.007	-0.022	-0.03

[a] Computed solution to $N_t = N_o e^{rt}$, value tabulated is r.

[b] Values in this row used for undisturbed population of Figures 25 and 26.

which produced an annual growth rate of about 1.7% (Table 4), was used.

Results of the simulation runs are summarized in Figures 25 and 26. The frequencies selected ranged from 1 to 5 times per 20 years. Under the conditions stated, an undisturbed population at Stum Lake would slowly increase at about 1% per year (Table 4). Disturbance by low-flying aircraft after incubation (late) had little effect on the population growth (Fig. 25-B). Disturbance by aircraft during incubation had more pronounced effects (Fig. 25-A). Disturbance more frequent than once in 20 years would cause a decline in the population (Table 4).

The effects of coyote disturbance were important whether they occurred early or late in the breeding season (Fig. 26). Early disturbance occurring more than once in 7 years forced the population to decline (Fig. 26-A). If such a disturbance occurred as frequently as once in 4 years, the population would decline at an annual rate of about 1% (Table 4). The impact of late coyote disturbance was more dramatic (Fig. 26-B). Available data suggest that if the colony is disturbed by late coyote predation only once every 20 years, it would just remain stable. Two such disturbances every 20 years induced an annual rate of decline of about 0.7% (Table 4). All simulation results are accurate only to the degree that empirically derived values of reproduction and survivorship represent actual conditions.

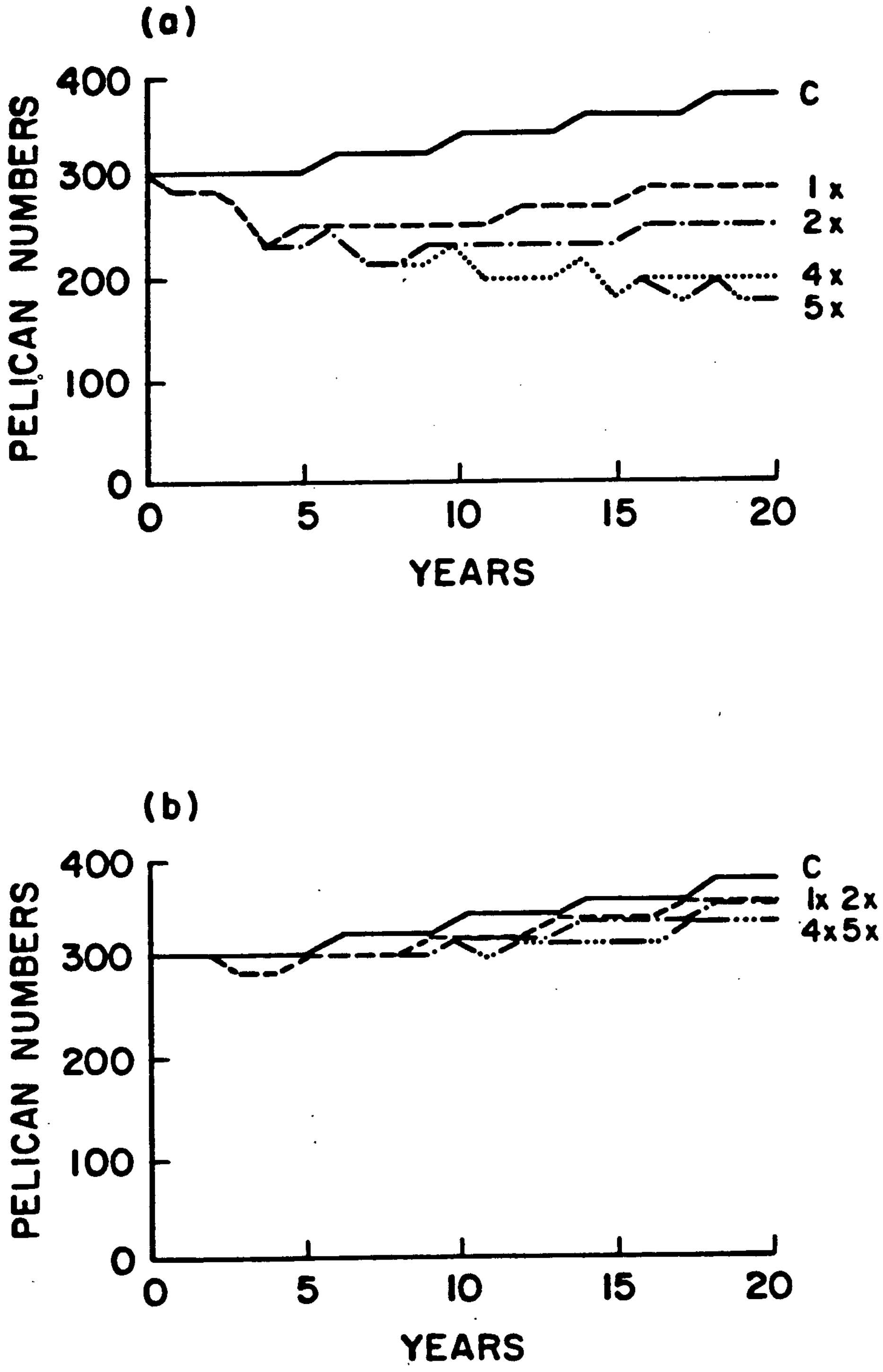

Figure 25. Simulated changes in pelican numbers resulting from aircraft disturbance at different frequencies. A) Represents disturbances during incubation; B) disturbances after completion of incubation. Numbers indicate the frequency of disturbance during a 20-year period; C) indicates control or undisturbed population.

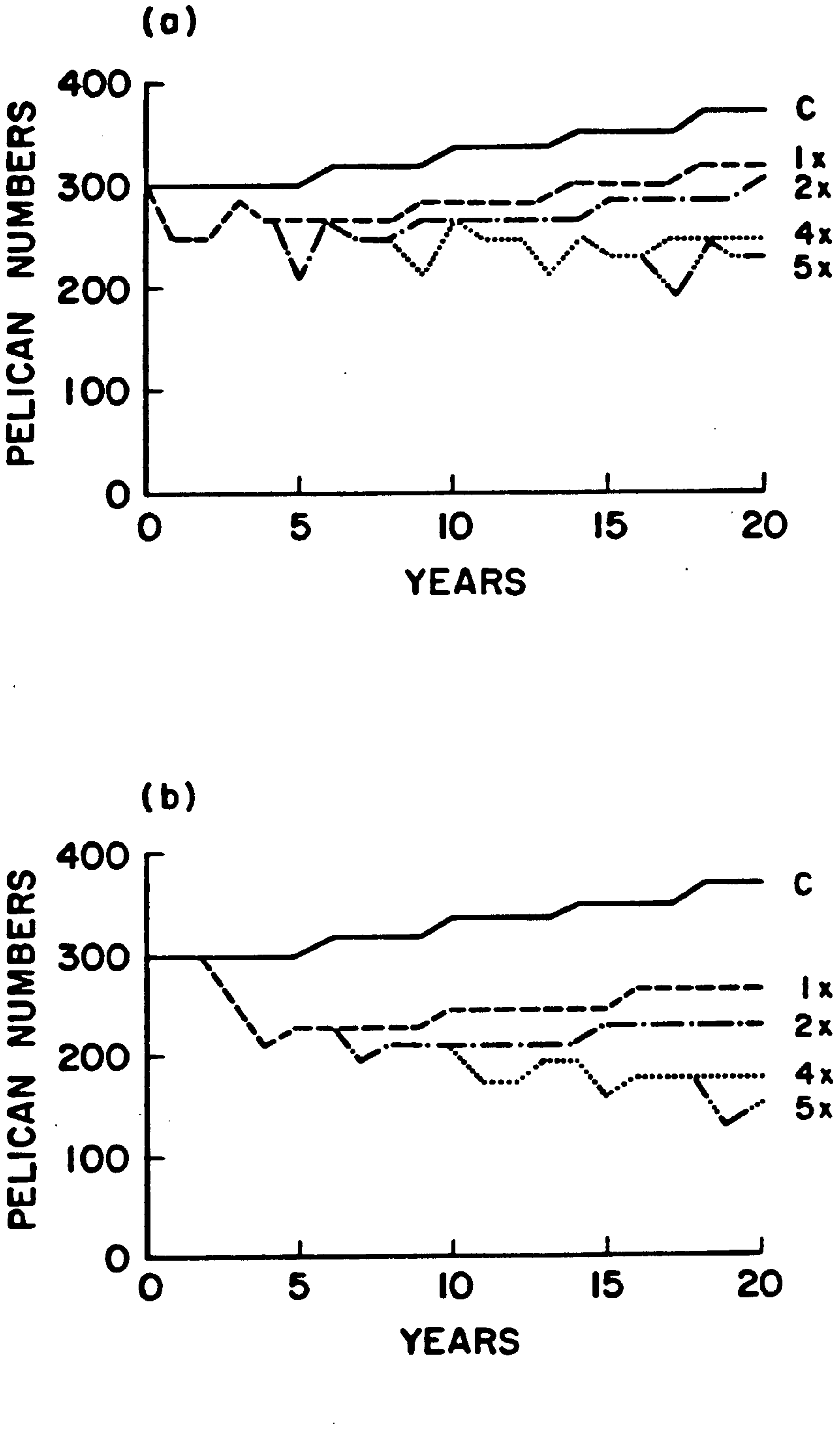

Figure 26. Simulated changes in pelican numbers resulting from coyote predation at different frequencies. A) Represents disturbances during incubation; B) disturbances after completion of incubation. Numbers indicate the frequency of disturbance during a 20-year period; C) indicates control or undisturbed population.

In the absence of management other than the present park restrictions, the future of the white pelican population in B.C. does not appear optimistic. At present, the lake is closed to boating, fishing, and to the discharge of firearms during the critical breeding season from 1st March to 31st August. Aircraft are discouraged from flying over the park below 610 m during the same period. Despite these restrictions, violations occur frequently.

As human settlements and development continue to expand outward into more remote areas of the Cariboo, the likelihood of human disturbance at the colony will also increase. Between 1971 and 1974, Ryder (1974) noted that the number of visitors to the park nearly doubled (34 visitors in 1971 and 63 visitors in 1974). Access to Stum Lake is continually being improved. Since 1976, two all-weather, logging roads have been constructed that pass within 12 km of the lake.

Aircraft disturbance also continues to be a problem. During the courting and egg laying periods of 1980, a twin engine aircraft (Bella Coola Airlines) passed regularly over the lake below the legal altitude of 610 m. During the following breeding season, a small float plane landed on the lake while pelicans were present (Tony Petal pers. comm.). Greater protection and enforcement of the present restrictions are necessary to prevent future population declines of white pelicans at Stum Lake. Increased enforcement could also provide us with better information concerning the population dynamics of the colony.

Predation by coyotes, although not a new influence, has been a major factor limiting the reproductive success of pelicans in British Columbia. Coyote harassment during the courtship period and predation during the incubation and nestling periods will continue to occur if controls are not initiated.

Without further management, the colony will, at best, fluctuate around 100 nesting pairs. Unfortunately, it is more probable that the population will decline as human populations grow in the Cariboo.

8.3 Recovery Plan Of White Pelicans In British Columbia

White pelicans are considered endangered in British Columbia. The population requires special protective and enhancement measures to counteract the poor reproductive success the colony has experienced recently as a result of human disturbance and coyote predation. Enhancement measures also should be initiated to buffer future impact at the present breeding location. The overall objective of this recovery plan is to remove the white pelican in British Columbia from the 'endangered' category to either 'threatened' or 'rare'. The recovery plan is treated in three inter-related sections. Section 8.3.1 discusses the basic restrictions and requirements necessary to ensure conditions that allow successful breeding of the pelican population. It forms the basis for all further manipulative and management-oriented activities at the colony. Section 8.3.2 deals with various enhancement techniques both at the breeding colony and outside the park. Section 8.3.3 describes techniques to increase the population and number of breeding colonies in British Columbia through introductions from areas outside of the province.

8.3.1 Protection And Maintenance Of The Stum Lake Pelican Colony

In May 1970, Stum Lake and the islands within Stum Lake were declared a 'wildlife sanctuary' under authority of Section 78 contained in the Wildlife Act, 1966. The purpose was to protect the pelicans from disturbance through trespass on water, in the air, or by discharge of firearms, for a period from 1 March to 31 August each year. In 1971 the establishment of the White Pelican Provincial Park provided the means for enforcing restrictions to limit human activity during the breeding season. However, protection of the colony and enforcement of present restrictions have been negligible. Despite the many violations that have occurred, there have been no convictions or fines levied to date. Understandably, many of the violations have occurred through ignorance rather than malicious intent; however, motives make no difference to the pelican population. In order to provide full protection for the Stum Lake pelican colony several recommendations have been formulated:

1. The park restrictions closing Stum Lake to boating, angling, and to the discharge of firearms from 1 March to 31 August are completely acceptable. However, existing restrictions on aircraft are not compulsory and must be strengthened. All aircraft, excepting in emergencies, should be prohibited from flying over the park below 610 m (2000 feet) from 1 March to 31 August. Aircraft restrictions are especially

critical during the early breeding season, from mid-April to late June.

2. Enforcement of the four restrictions (boating, angling, firearms, and overflights) is essential. The value of all restrictions can be increased by an active, well rounded program of education, patrol, and law enforcement (Wilbur 1975).

Educational emphasis should center on our understanding or our lack of understanding of the colony and the justification for restricted use of their nesting area. A program to increase public awareness of the sensitivity of the pelican colony during the breeding season and of the 'endangered' status of white pelicans in British Columbia should be initiated. Pamphlets, posters, and annual status reports should be published and displayed in B.C. Fish and Wildlife Branch offices and at local naturalist clubs. All publications should stress how easily white pelicans are disturbed during the breeding season. Large visible posters placed in local airports might help to prevent further aircraft disturbances at the colony site. The Notam (Notice to Airmen) should also be re-issued with somewhat more detail and the correct location. Information signs at the breeding lake are inadequate at present. Clearly visible signs should be posted at the park entrance. These should stress the sensitivity of the colony and list the present restrictions at the lake. If possible, the Anahim Indian Band should be consulted to provide input regarding wording.

Patrols should be conducted to reduce the potential for violations of restrictions. These could be conducted on a regular basis or opportunistically. Local conservation officers might provide this service.

Diligent law enforcement will act to deter further violations. Increased penalties and fines must be levied to deter human activity within the park during the critical breeding season.

3. A systematic inventory plan is necessary to monitor and evaluate the productivity and viability of the colony. Census data should include a non-destructive survey of nests in mid-May and a survey of young to obtain the colony's overall productivity conducted in mid-August. Surveys should be conducted annually during initial management phases of the project and every two years once the colony appears more stable. It should be necessary to determine clutch sizes and survivorship of young only if the colony begins to decline.

Two methods could be employed to determine the number of nests. Aerial surveys are efficient in terms of cost and time constraints, however they may bias counts slightly upwards and could present a risk of disturbance to nesting birds. Ground censusing, using a spotting scope situated on the mainland is more time-consuming and costly, but the risk of disturbance is greatly reduced and nest counts are more accurate. For this reason, I recommend that only the ground-census method be used at present.

Surveys usually should be conducted between 10th May and 30th May, regardless of the method used to count nests. The actual dates of the nest survey should commence approximately two weeks after ice break-up at Stum Lake. This should allow breeding birds time to establish their nests, and also will minimize the number of courting birds present at the colony during the survey. To increase accuracy of aerial surveys, nest counts should be conducted when colony activities such as nest relieving and the number of loafing birds are minimal. In Alberta, Beaver and Lewin (1981) found that colony activity and the number of loafing birds were at a minimum between 16:00 and 22:00 hours. Roney (1979) found that aerial surveys conducted from a small fixed-wing aircraft, such as a Supercub or Cessna 172, flying 230 m (750 ft) above ground level, produced no visible signs of disturbance to nesting white pelican colonies in Saskatchewan. Aerial photographs were taken using a hand-held camera (with 200 mm lens) out the window of the aircraft. Counts were taken directly from slides when viewed under a microscope. Beaver and Lewin (1981) found that projections of colour transparencies (Kodak Ektachrome 160), taken at 300 m (1,000 ft) above ground level with a 200 mm lens, provided excellent resolution. In order to eliminate potential bias during aerial surveys of nests, they suggested that a concurrent ground count be conducted.

Ground censusing would involve several days of observing the colony with a 20-45x spotting scope. To minimize disturbance, all ground observations must be conducted from vantage points on the adjacent mainland. An accurate count of nests can be recorded in two or three days, but several weeks of observations may be necessary to determine an accurate sample of eggs per nest. Clutch sizes can best be obtained during nest relief and generally between 10:00 and 14:00 when colony activity, such as preening and shifting, is greatest.

In the event that no nests are found at the breeding colony, I recommend that an intensive aerial survey of the lakes on the Fraser Plateau be initiated. Locations of pelicans and/or new nesting sites should be monitored. Investigations should also be conducted at Stum Lake to determine why the site was abandoned.

Overall productivity should be obtained approximately three months after the nest survey, usually between 10th August and 30th August. The number of successfully fledged young can easily be determined by boat during this period. The young are adult-size at this stage, however their plumage is greyish-white, they lack the orange coloration on their bills and legs, and most are still unable to fly.

During the mid-August survey of young, the natal island should be examined for whole eggs and partial egg shells. Shell thicknesses should be calculated and pesticide residue analyses conducted on whole eggs. These could be compared with data collected by K.Vermeer during 1968. Ten eggs taken from ten nests at Stum Lake in 1968 yielded pesticide residues of 1.46

ppm DDE, 0.184 ppm dieldren, 0.314 ppm DDD, and 0.121 ppm DDT. These levels are low for fish-eating aquatic birds such as pelicans (K. Vermeer Pers. Comm.).

4. Additional aerial surveys should be conducted on the Fraser Plateau to identify potential lakes that could be enhanced to support a second pelican colony. A second nesting area near Stum Lake could also be used by pelicans if factors prevented nesting at the original breeding colony.

8.3.2 Enhancement Techniques

8.3.2.1 Maintenance And Enhancement Of Present Feeding Lakes

During the breeding season, white pelicans from Stum Lake are entirely dependent upon a few lakes surrounding the colony since no prey species occur in Stum Lake. These few feeding lakes used by the birds during the spring and summer are essential for the production of eggs and the survival of young. As human populations continue to grow in the Cariboo, an increasing number of conflicts can be expected. These might include land-use decisions that affect pelican feeding lakes, increased competition between fishermen and pelicans for fish, or simply the disruption of foraging patterns of pelicans by back-country recreationalists.

To counteract these anticipated problems, I have suggested several management prescriptions:

1. Summer foraging lakes should be identified during aerial surveys and should be classified by pelican-use (light, moderate, heavy). If possible, 'heavily-used' lakes should be acquired and protected.

Aerial surveys should also be conducted during the spring to determine important spring foraging lakes, presently unknown.

2. Water levels at heavily used lakes should be maintained to provide proper water depths for foraging pelicans and for the preservation of important species of prey fish.

Special management considerations should include the protection and enhancement of Chilcotin Lake (52°19'N, 124°3'W). At present, unauthorized channelization of this lake is causing improper water depths for important species of prey fish in the western half of the lake (Ed Hennan Pers. Comm.). Natural water levels should be restored at this important feeding lake.

3. Human-caused disturbance should be minimized at important feeding lakes. Signs should be posted informing the public to avoid disturbing groups of foraging pelicans. The use of outboard motors on important feeding lakes should also be curtailed.

8.3.2.2 Stocking Stum Lake With Suitable Coarse Fish

Stum Lake contains no important prey species of fish for pelicans. Pelicans travel as far as 142 km (Towdystan Lake) from the breeding colony to forage, although the majority forage at Chilcotin Lake (approximately 70 km from the colony). It is possible that the colony's productivity is being limited by energy constraints. At present, the hatchling survival of young and the overall productivity of nests at Stum Lake, even in the absence of coyote or human-induced disturbances, is only 44% and 0.80 young/nest, respectively. Miller and Ryder (1977) noted a productivity of 1.17 fledged young/nest at Riverside Reservoir, Colorado - the highest ever recorded for the species. They observed that this success resulted from high hatchling survival (89%) rather than hatching success. Mortality factors, such as starvation, fluctuating water levels, predation, and human disturbance, were minimal (Miller and Ryder 1977). They attributed this high hatchling survival to the abundant supply and close proximity of food. The reservoir was well stocked with species on which pelicans feed, and nesting birds did not have to leave the breeding lake to forage elsewhere. Not only would an abundant supply of food be important to the production of eggs and survival of dependent young, but juveniles probably would learn to forage independently much earlier than young would in colonies lacking a food supply at the breeding lake.

I recommend that a program of stocking suitable coarse fish, such as squawfish, be carried out at Stum Lake. It seems likely that the overall productivity of the colony and the survival of young could be increased by such an introduction. Dr. Tautz of the British Columbia Fish and Wildlife Branch (Pers. Comm.) felt that the lake characteristics could support a viable population of coarse fish. However, he noted that it is not the policy of the British Columbia Fish and Wildlife Branch to introduce coarse fish into lakes. Unfortunately, the introduction of game fish would not be desirable at Stum Lake as it probably would attract fishermen to the lake, resulting in disturbance to nesting birds. Nor would game fish be as accessible to pelicans because of the greater depths at which such fish are found.

Another possible problem of introducing fish into Stum Lake is that it may attract fish-eating predators, such as river otter (Lontra canadensis) and mink (Mustela vison), that may in turn prey on the eggs and young of pelicans. However it is unlikely that these species would become a serious problem to pelicans, since fur-bearers are heavily trapped in the park.

8.3.2.3 Improvement Of Present Breeding Habitat At Stum Lake

Present breeding habitat at Stum Lake can be improved in at least two ways: habitat manipulations to the islands and control of water levels.

Manipulation of vegetative and physical features of existing island habitat could increase nesting site availability. White pelicans generally avoid areas of dense vegetation during nesting, and select instead more open, barren areas. The vegetated areas on Island 2 could be cleared to increase the number of potential nesting areas. Although white pelicans do not appear to be limited by the number of nesting sites at present, this may be an important tool in the future if the population increases in size.

Removal of physical obstacles should provide a useful service for the birds. Several fallen snags on Island 2 appear to interfere with courtship activities and generally restrict movement at the colony. Removal of these snags would facilitate movement within the crowded sub-colonies and provide several new breeding sites. I recommend that only limited habitat manipulations take place at present, concentrating on fallen-snag removal.

Water levels can influence the availability of nesting habitat for island-nesting breeding birds such as white pelicans. When water levels are too high, nesting habitat can become partially or completely submerged. That occurred at Stum Lake in 1964 when waves washed eggs from nests on Island One. If water levels are too low, islands can become contiguous with the mainland, thereby exposing breeding birds to mammalian predation. Water levels at Stum Lake must be more strictly regulated.

Recently a conflict of interests occurred between the Anahim Indian Band (who control the water rights for Stum Lake) and the British Columbia Fish and Wildlife Branch. The Anahim Band wanted to lower water levels at Stum Lake for irrigational purposes downstream. The British Columbia Fish and Wildlife Branch felt that water levels at Stum Lake should be maintained at existing levels. Fortunately, outside water interests appear to coincide relatively well with the biological needs of the nesting white pelicans. Nesting white pelicans require that water levels remain relatively high until late July. After this time, young are no longer vulnerable to mammalian predation. Water can then be drawn off to irrigate areas downstream and to dry the meadows at Stum Lake for haying. It is recommended, however, that a control structure be built on the outlet at the south-east corner of the lake.

8.3.2.4 Predator Control

Controls should be undertaken on the coyote population within the park to prevent further losses of eggs and young, such as have occurred in the past. Selective lethal and non-lethal methods should be considered. An effective and selective technique for removing coyotes from local depredation areas is the 3N Victor Trap used in the Federal Animal Damage Control Program of the United States (Connolly 1978). Other lethal methods include the use of poisons, such as sodium fluoracetate (1080), placed in baited meat.

Alternative non-lethal methods for preventing coyote predation are fencing and 'charcoaling'. Thompson (1979) evaluated 34 fence patterns to determine the most effective deterrent to coyotes. DeCalesta and Cropsey (1978) field tested the selected fence and found it highly successful. Such a fence could be constructed on the mainland adjacent to the nesting colony at Stum Lake to prevent coyotes from reaching the nesting colony during mid-season. The cost (not including labour) for a fence 350 m long would be about $500.00 (1978 prices).

However, during the spring, while ice still covers the lake, fencing would offer no protection. At this time, the ice around the colony could be sprinkled with charcoal to induce melting. This could be done manually or from a light aircraft before pelicans arrive in the spring. Coyote controls at Stum Lake therefore could involve both lethal and/or non-lethal methods.

8.3.3 Recovery Techniques for White Pelicans

In the event of either severe population declines suggesting possible extinction or a desire to increase our present white pelican population, it may be necessary to initiate a long-term restocking program. A restocking effort would require the cooperation of several provincial agencies and would involve transplanting young from other more productive and stable sites to locations in British Columbia. Colonies such as Primrose Lake, Sask. (4,007 nests), Old Wives Lake, Sask. (3,084 nests), and Lavallee Lake, Sask. (3,019 nests) would make ideal capture sites. Young birds between 8 and 11 weeks old can easily be herded by canoe into funnel shaped wire traps (Steve Elafant

Pers. Comm). At this age the young birds are old enough to swim but still too young to fly. It is recommended that captured birds be banded and marked with patagial wing tags to enable observers to identify them from a distance. Efforts to introduce pelicans can be enhanced by selecting birds with the least number of parasite infections (Humphrey et al. 1978).

Ideally, release sites should have several predator-free islands suitable for roosting and/or breeding. Such islands could be either man-made structures or modified naturally occurring islands. The lakes must be isolated from human disturbance (probably the primary nesting habitat requirement for white pelicans) and contain an abundant food supply. The capture-release program should be carried out for a minimum of five years and preferably for about 10 years. In a restocking program in Louisiana (young transported from Florida to Louisiana), direct release with two daily feedings was found to be the most effective method for establishing brown pelicans (Nesbitt et al. 1978).

Attempts to create a second white pelican breeding colony in Colorado were unsuccessful (Gary Miller pers. comm.). Young were captured at the natal colony (Riverside Reservoir) and transplanted to another lake approximately 30 km away. Nearly all young survived without supplemental feedings as the lake had an abundant supply of fish. During the following breeding seasons, however, the transplanted young returned to their original natal colony. An attempt to restock young pelicans from Saskatchewan to a new site in British Columbia would not necessarily ensure a second breeding colony, although surviving birds would enhance the total population of white pelicans in British Columbia. The chance of pelicans colonizing a second breeding location probably would be much greater after several years of introducing white pelicans.

The creation of new nesting habitat at other locations on the Fraser Plateau could potentially increase the breeding population and reduce the vulnerability of the pelican population in British Columbia. Although white pelicans appear traditional in their selection of nesting colonies, several studies (Mansell 1965, Lies and Behle 1966, Lapp 1976, Thompson and Littlefield 1979) have demonstrated the pelican's ability to establish new colonies when habitat becomes available. Potential breeding islands should be relatively barren, gently sloped, and at least 350 m from any adjacent mainland. The abundance of food in the lake is probably not a major factor. Islands already present at such undisturbed sites could be manipulated if they support a dense vegetation cover. In lakes lacking natural islands, man-made islands could be constructed. McCrow (1974) described an island constructed in South Dakota which was colonized and used for breeding by white pelicans. The island (47 x 26 m) was situated in shallow water, covered 0.12 ha (0.3 acres) and had an open surface of silt clay soil with a rocky periphery. Apparently this site may have been either too shallow or located too close to adjacent mainland. During one breeding season, all nests were abandoned when a white-tailed deer (<u>Odocoileus virginianus</u>) wandered onto the island.

Other types of islands occasionally used by white pelicans for breeding are islands of dredged material. White and brown pelicans have been known to use these in Texas (Landin and Soots 1977). Suitability of such islands as nesting sites were determined by factors such as island configuration, elevation, location, presence or absence of vegetation, and potential for human disturbance and mammalian predation.

In British Columbia, several lakes containing islands surveyed during 1977 could provide potential nesting habitat. These include Taharti, Tzazati, Temapho, Deerpelt, Nasko, and Tzenzaicut Lakes. However, further aerial surveys must be conducted to locate an ideal breeding site. The use of several pelican decoys on the selected island would probably increase chances of attracting pelicans. Wooden puffin decoys aided in the recolonization of an abandoned puffin colony on Eastern Egg Rock off the coast of Maine (Kress 1978). Another potential method to increase the population of white pelicans in British Columbia would be the establishment of a captive breeding program. The Tynehead Zoological Society near Vancouver has expressed a great deal of interest regarding this possibility (Paul Joslin pers. comm.). Such a program could incorporate methods from other current captive breeding programs such as those being conducted with the whooping crane (Grus americana) and peregrine falcon (Falco peregrinus). These captive breeding programs, however, do have severe limitations, one of which is successfully introducing captive-bred birds back into wild populations.

As more information on white pelicans becomes available, it may be necessary to modify or change entirely certain management recommendations. I suggest that the entire plan be reviewed at four or five year intervals.

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APPENDIX I. Foraging sightings of white pelicans recorded during three aerial surveys conducted in 1977.

Lake	Survey Date			Total Pelicans Observed
	27/6/77	5/8/77	25/8/77	
Alex Graham	0	0	3	3
Alexis	0	NS	0	0
Beaver	1	0	0	1
Charlotte	NS	NS	0	0
Chilcotin	10	14	16	40
Deerpelt	0	NS	0	0
Loomis	0	NS	0	0
Maxwell	1	NS	1	2
Nasko	2	NS	1	3
Nimpo	NS	NS	0	0
One	0	NS	0	0
Palmer	2	0	1	3
Plover	0	NS	0	0
Punti	0	0	0	0
Puntzi	0	0	0	0
Rosita	2	NS	18	20
Siwash	0	0	0	0
Skinny	0	0	0	0
Summit	0	NS	0	0
Taharti	1	NS	NS	1
Tautri	1	NS	0	1
Temapho	0	NS	0	0
Tunilkul	2	NS	0	2
Two	0	NS	0	0
Tzazati	0	NS	0	0
Unnamed (52°25'N, 123°15'W)	1	NS	0	1

NS - Not surveyed

APPENDIX 2. Foraging sightings of white pelicans obtained from the British Columbia Provincial Museum.

Lake	Distance from Stum Lake (Km)	Year	Comment
Alkali	78	1976	frequent in spring
Anahim	167	1961	10 feeding
Chezacut	71	1941	12 feeding - common
Chilanko Forks	71	1973	2 feeding - common
Comox (beach)	330	1930	5 flying - occasion
Courtney (beach)	326	1940	2 flying - occasion
Crescent Beach	362	1954	4 loafing - rare
Deerpelt	40	1973	2 feeding
Kalkamalka	354	1970	1 flying - rare
Kleena Kleen	132	1957	2 feeding - occasion
Klusquoil	127	1977	13 flying - rare
Nimpo	151	1975	1 feeding
Nulki	190	1947	1 flying - rare
Pantage	106	1968	3 swimming
Pelican (north)	125	1947	feeding - common
Pelican (west)	168	1961	1 loafing
Puntataenkut	74	1940	once common
Rush	312	1959	25 feeding - rare
Skaha	402	1963	65 flying south - rare
Towdystan	142	1977	feeding - occasion
Tzenaicut	45	1947	breeding on island?
Vaseaux	426	1966	1 feeding - rare
Williams	68	1963	15 swimming