THE DISTRIBUTION, FORAGING BEHAVIOUR, AND ALLIED ACTIVITIES OF THE WHITE PELICAN IN THE ATHABASCA OIL SANDS AREA

by

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Environment Canada

Canadian Wildlife Service

for

ALBERTA OIL SANDS ENVIRONMENTAL RESEARCH PROGRAM

LS 22.2 (TF 2.2)

November 1979

The Hon. J.W. (Jack) Cookson
Minister of the Environment
222 Legislative Building
Edmonton, Alberta

and

The Hon. John Fraser
Minister of the Environment
Environment Canada
Ottawa, Ontario

Sirs:

Enclosed is the report "The Distribution, Foraging Behaviour, and Allied Activities of the White Pelican in the Athabasca Oil Sands Area".

This report was prepared for the Alberta Oil Sands Environmental Research Program, through its Land System, under the Canada-Alberta Agreement of February 1975 (amended September 1977).

Respectfully,

W. Solodzuk, P.Eng.
Chairman, Steering Committee, AOSERP
Deputy Minister, Alberta Environment

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THE DISTRIBUTION, FORAGING BEHAVIOUR, AND ALLIED ACTIVITIES OF THE WHITE PELICAN IN THE ATHABASCA OIL SANDS AREA

DESCRIPTIVE SUMMARY

BACKGROUND

The potential impact of oil sands development on avifauna can be attributed to:

1. Direct impact--resulting from destruction or contamination of breeding and/or foraging habitat;
2. Indirect impact--resulting primarily from disturbance, which can be attributed to an increased recreational utilization of wilderness area.

In terms of avifaunal concerns, both forms of impacts will require mitigative measures; however, it is the indirect impacts which may be the most significant, will require the most study, and present the greatest problems in accurately assessing the potential impact on avifauna.

The White Pelican is one of the more sensitive bird species which inhabit the oil sands area. This sensitivity has been manifested by desertion of a breeding rookery following a single visitation to the rookery by inquisitive fishermen at a very critical time in the breeding cycle. Identification of critical times in the breeding cycle requires that detailed behavioural investigations must be conducted on this species.

Because of the nature of the impact created by oil sands development (direct and indirect), the necessity for incorporating avian behavioural studies into the Alberta Oil Sands Environmental Research Program became obvious.

The final report on the White Pelican is presented in two volumes:

1. Breeding Distribution and Behaviour of the White Pelican in the Athabasca Oil Sands Area, by R. Beaver and M. Ballantyne; AOSERP Report 82; and

2. The Distribution, Foraging Behaviour, and Allied Activities of the White Pelican in the Athabasca Oil Sands Area, by D. Ealey; this report.

ASSESSMENT

This report represents a preliminary attempt to develop an adequate methodology which would delineate foraging behaviour and habitat preferences of White Pelicans. This portion of the project is intended solely to provide the foundation from which a more intensive study can be designed and conducted.

It is the opinion of AOSERP Management that both volumes contribute significantly to an understanding of baseline avifauna behaviour in the oil sands area.

The Alberta Oil Sands Environmental Research Program is satisfied with the scientific and technical quality of these reports and deems them suitable for wide distribution.

S.B. Smith, Ph.D
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ABSTRACT

From mid- to late summer, 1977, an investigation was made of the distribution and foraging of White Pelicans in the Birch Mountains. This study was linked with a breeding investigation, undertaken at the pelican rookery, as part of the Alberta Oil Sands Environmental Research Program. Aerial surveys, ground observations, prey analysis, and prey sampling were conducted.

Pelicans were observed to regularly use foraging/loafing areas up to 69 km from the rookery. Timing of diurnal arrivals and departures from all locations showed that the birds belonged to the same population. A shift in concentrations of the pelicans was detected over the summer. Reasons for this shift were advanced.

Trends in diurnal and seasonal activities were determined for the pelicans, away from the rookery. Basic behaviour seemed comparable to that observed at the rookery. The behavioural observations indicated the importance of foraging areas, and loafing bars. Habitat features varied considerably for these locations, but basic criteria were established for each. The locations of the foraging/loafing areas were determined for lakes in an intensive study area.

The diet of juvenile pelicans included brook stickleback, northern pike and lake whitefish. The total fish consumption of the Birch Mountains population of White Pelicans was estimated at between 19.7 and 24.8 tonnes during the 1977 season.

It is recommended that this investigation of distribution and foraging of White Pelicans be continued.

ACKNOWLEDGEMENTS

I wish to express my gratitude to Richard Fyfe for initial supervision of the project, Rick Beaver for introducing me to the pelicans, and Barry Munson for supervision at the production stages of the project report.

I thank Ken Zurfluh for both his able field assistance and comradeship. The field research was conducted in liaison with Rick Beaver and Maggie Ballantyne at the pelican breeding rookery. I appreciated the information on pelican sightings provided by other AOSERP field operatives.

I am thankful for the constructive criticisms of the final report that were given by the above-named persons. Bryan Chubb prepared the figures of the report.

This research project LS 22.2 (TF 2.2) was funded by the Alberta Oil Sands Environmental Research Program, a joint Alberta-Canada research program established to fund, direct, and co-ordinate environmental research in the Athabasca Oil Sands area of northeastern Alberta.

1. INTRODUCTION

Considerable investigation of White Pelican (*Pelecanus erythrorhynchos*) breeding colonies has attested to a high sensitivity of this species to human and natural disturbance (Henshaw 1879; Houston 1962; Schaller 1964; Mansell 1965; Lies and Behle 1966; Sanderson 1966; Anderson and Bartonek 1967; Vermeer 1969, 1970; Boeker 1972; Evans 1972; Johnson and Sloan 1976). Studies of foraging behaviour and diet, however, have been few and largely concerned with basic life history data (Lamb and Howell 1913; Bent 1922; Hall 1925; Cottam and Uhler 1937; Low et al. 1950; Bartholomew et al. 1953; Brown and Urban 1969; Trottier and Breneman 1976). No documentation of the effect of disturbance upon foraging White Pelicans has been made, nor is there much known concerning the relationship between these birds and the fish populations which constitute their diet (see Hall [1925] for the most complete information prior to this investigation). In addition, it appears that most of the information regarding foraging behaviour, *per se*, is largely anecdotal and conjectural.

In order to complement a concurrent study of White Pelicans at their breeding site (see AOSERP Report 82), this study of pelican foraging and distribution was executed. The pelicans of Birch Lake do forage upon the rookery lake, but are more frequently observed flying toward other lakes (Beaver and Ballantyne 1979). Periodic observations determined the repeated occurrence of pelicans on Mink, Grew, Gardiner, Big Island (local name) and Eaglenest Lakes (Beaver and Ballantyne 1977) which range between 31 and 69 km from the rookery. These observations indicated that the probable distribution of members of the breeding population was quite extensive; the primary purpose for these peregrinations was presumed to be foraging.

Long trips to reach foraging habitat are not uncommon in other areas (Low et al. 1950; Schaller 1964; Knopf 1975; Johnson 1976; Trottier and Breneman 1976); however, in the case of pelican rookeries which were situated on very large lakes, the pelicans were often required to fly a considerable distance from the rookery, to find waters suitable for foraging. Furthermore, a number of these rookery lakes were alkaline or saline and, consequently, devoid of fish. In contrast, the movements of pelicans to distant foraging areas in and around the Birch Mountains appeared to be related to selection of specific habitat (Beaver and Ballantyne 1977). This selection was not satisfied by the shallows of the rookery lake nor by a number of shallow lakes near Birch Lake. Clearly, more was involved than selection for the nearest shallow waters.

The primary objectives of this investigation were to:

1. Determine the nature and variability of pelican distribution and movements in the Birch Mountains area;
2. Establish critical habitat requirements for White Pelicans in the Birch Mountains area, specifically for the purpose of mapping habitat potentially suitable for activities away from the rookery, and to explain observed distribution of the pelicans;
3. Determine the relationships of pelicans to fish, by discovering the species composition of the diet, response of the birds to fish movements, and extent of harvesting of fish populations;
4. Indicate the potential effect of human disturbance in the foraging areas upon the pelicans, specifically in relation to increased fishing and recreational use of these areas; and
5. Suggest further research and make recommendations regarding efforts required to mitigate any adverse effects upon the White Pelicans resulting from increased human use of their foraging areas.

In this preliminary investigation, the emphasis was upon establishing or indicating basic patterns of White Pelican foraging biology and outlining methods which would enable ongoing research to fulfill the primary objectives presented above.

2. STUDY AREA

2.1 LOCATION AND DESCRIPTION

Detailed observations of White Pelican movements, foraging, and related activities were conducted on the Gardiner Lakes and on an unnamed lake (local name - Big Island Lake) at the approximate latitude-longitude location of 57°35'N, 112°30'W (Figure 1). Both lakes are located within the Birch Mountains, a series of uplift hills 80 km to the northwest of Fort McMurray. The predominant vegetation of the area is mixed aspen-spruce climax forest. Local aspect and soil moisture determine variations from the mixed forest. Sparsely vegetated spruce bogs occupy the low-lying, poorly drained regions but, in general, the Birch Mountains are heavily forested. Most of the lakes of the region are surrounded by hills up to 100 m above lake level. The lakes intensively studied averaged about 200 m higher in elevation than the pelican rookery lake (Birch Lake), which is approximately 530 m above sea level.

A base camp was established on the east shore of Upper Gardiner Lake to avoid disturbance of pelicans at the key locations of Gardiner Narrows (between Upper and Lower Gardiner Lakes) and Big Island Lake. This location allowed observation of the pelicans flying from one gathering area to another.

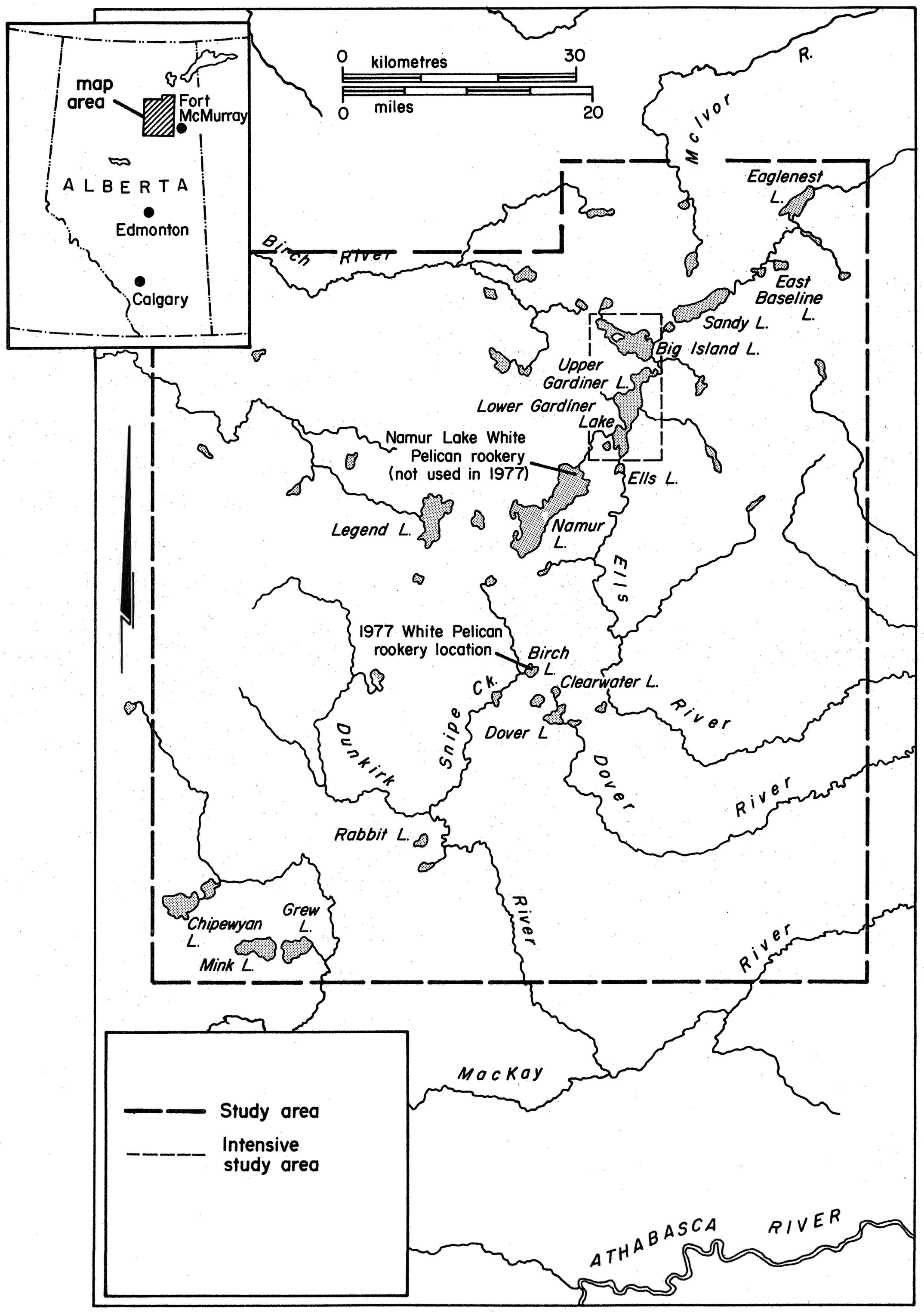

Figure 1. The study area.

3. METHODS

Research efforts included aerial surveying, monitoring of pelican flights, detailed observations of foraging and loafing birds, collecting of regurgitations, and sampling of fish populations. Work on foraging activity and associated sampling was carried out from 20 June to 27 September 1977. Some data were obtained, primarily aerial survey observations, from Beaver and Ballantyne (1979) earlier in the 1977 season.

3.1 DISTRIBUTION OF PELICANS

Six aerial surveys were conducted in the study area (Table 15). These surveys followed the basic procedure of earlier work (Beaver and Ballantyne 1977) which was to follow the shoreline for small lakes and to fly transects as well as shorelines for large lakes. A Cessna 185 on floats was flown at an altitude of 100 to 200 m above the ground and at about 120 km/h; two observers, in addition to the pilot, recorded White Pelican locations. This procedure provided accurate counts of pelicans present. Additional observations of pelicans on lakes were obtained during flights for supplies and from other AOSERP personnel in the area. Before detailed observations of White Pelican behaviour could be made, loafing areas and other concentrations of pelicans had to be located; surveys from boats were necessary as the birds often flushed before being sighted from the air. Numbers of birds, their locations and their response to disturbance were recorded during census efforts. Times of surveys varied, although most were conducted during the morning period. Photographs of loafing bars were taken during the aerial censuses.

3.2 FLIGHTS BY PELICANS

We monitored pelican traffic between the rookery and foraging/loafing locations and also local movements among these latter areas. Such monitoring was effected by conducting skywatches from camp, noting casual observations of flights, and recording departures and arrivals from foraging/loafing areas during intensive observations.

Skywatches were 15 min periods during which continuous scanning of the horizon and the visible sky was undertaken, using 10 x 50X binoculars and a 15-60 variable power spotting scope. As a result of the location of the camp, and the discovery that the pelicans, when travelling to and from Big Island Lake, often flew along either the west or east shore of Upper Gardiner Lake, a number of observations of birds in transit were made (Table 16). These observations were primarily used in recording arrival and departure times to and from loafing areas.

3.3 OBSERVATIONS ON FORAGING AND LOAFING BEHAVIOUR OF PELICANS

After concentrations of pelicans were located by aerial or boat surveys, intensive observations were undertaken. Eleven observation posts were set up over the summer to follow changes in distribution and local movements of the pelicans (Figures 8 and 9). The pelicans were observed from under cover of vegetation or from a blind (the latter only at Gardiner Narrows) using 10 x 50X or 8 x 40X binoculars and a 15-60 variable power spotting scope. Because of the wariness of the birds, it was difficult to closely approach most groups. As a result, detailed observations of specific behaviour patterns were frequently impossible. Primarily, efforts were expended on determining general activity patterns, group size, movements, and location.

Travel to and from the observation posts was conducted by inflatable boat with motor and on foot. Early experience indicated that the noise of the motor would disturb the pelicans as the boat approached. Subsequently, the boat often had to be rowed and the last few hundred metres to some of the observation posts had to be covered on foot. Observations of the pelicans' response to the approach provided some data on the potential effect of disturbance, although we attempted to keep such disturbance to a minimum. A total of 116 observation hours were undertaken between 21 June and 28 August 1977.

The local distribution of pelicans was mapped and related to activity. To do this quantitatively, a grid system was devised with 25 ha grids for Big Island Lake. The locations of pelicans were plotted from the precise field observations and allocated to respective grid squares. One pelican-hour was the unit of measure employed; it referred to one pelican being observed within one grid for the period of 1.0 h.

3.4 FORAGING SITE AND LOAFING BAR DESCRIPTION

In order to establish critical habitat requirements, the characteristics of all foraging sites and loafing bars used were recorded. We noted for each location: depth and turbidity of water, aspect (the ability of the pelicans to see from all sides), relative protection against rough waters, extent of foraging area or loafing bar, substrate, amount of use, and proximity to other use areas. The values for these characteristics represent subjective assessments of the typical conditions throughout the study for loafing bars and at the times of actual use for foraging locations. Superficially suitable areas, which were apparently unused, were also described in this manner for comparison. Both used and unused locations were mapped for the intensive study area. Comparison was made with aerial photographs to determine the utility of remote sensing in assessing foraging and loafing habitat for White Pelicans.

3.5 DIET ANALYSIS

As a behavioural response to disturbance, young pelicans have been known to regurgitate stomach contents when fleeing intruders (Hall 1925). On 19 August 1977, in conjunction with members of the Birch Lake pelican breeding study, a visit to the rookery island was made. During our visit, a total of six regurgitations were collected from the young pelicans, which ranged in age from 4 to 8 wk. One additional regurgitation was collected on 31 August 1977 when a second visit was made. More regurgitations could not be collected at that time or later because of the increasing ability of the young to swim or fly away.

The regurgitations were treated as indices of the food consumed in late August. For each regurgitation, the wet weight was obtained and the contents were identified and counted.

The proportions represented by various taxa were only estimated because of the amorphous nature of some of the contents. Observation of foraging behaviour was related to the regurgitated contents in order to determine how, and from where, the prey items might have been obtained.

3.6 SAMPLING OF FISH POPULATIONS

From 19 to 27 September 1977, a number of the lakes in and around the Birch Mountains were sampled, primarily to obtain fish composition data to supplement Turner's (1968) study. This effort was conducted in conjunction with M. Orr of the AOSERP Aquatic Fauna Project AF 4.3.2. We reached the lakes by float plane and set gill nets from the plane by placing them over the side of the upwind pontoon. These nets, which were standard research "gangs" having panels of different mesh sizes, were left overnight at most lakes. Seining of the shallows was also undertaken. From these sampling efforts, a fish species list could be compiled for every lake. Although it was recognized that short term sets and seines were inadequate to determine detailed population structure and species diversity data, it was deemed necessary to at least undertake some preliminary sampling to supplement earlier fisheries investigations, such as Turner's (1968) study.

4. RESULTS AND DISCUSSION

4.1 PELICAN DISTRIBUTION AND MOVEMENTS

4.1.1 Pelican Distribution

In 1977, White Pelicans were observed at several lakes in the Birch Mountains (Figure 2, Table 15) in addition to Birch Lake where the rookery was situated. Further observations were made at Mink and Grew Lakes, 46 km south (Figure 2) and McClelland Lake, which was outside the White Pelican study area 86 km northeast of Birch Lake (conversation with J. Francis and K. Lumbis, Candian Wildlife Service employees). Except for the singular observation of pelicans at McClelland Lake, this distribution approximately matches that observed in 1976 (Beaver and Ballantyne 1977).

The importance of a lake within the foraging distribution was determined by the degree of use by the pelicans over the summer (Figure 2). The lakes on which pelicans were observed were classified as little, moderately, or heavily used. Little use meant pelicans were observed only once or twice and always in groups with fewer than 10 individuals. Moderate use referred to observations of fewer than 50 pelicans. Heavy use meant that more than 50 individuals were found and that frequent observations of pelicans were made.

The area encompassed by the most frequently used points of distribution has been tentatively described as the "home range" (Figure 2) of the pelicans breeding at Birch Lake. This area was obtained by drawing straight lines between the farthest points of all lakes identified as being used by foraging pelicans and includes Namur Lake where the traditional rookery was located. Beaver and Ballantyne (1979) reported few pelican sightings outside the area in their surveys. Their documentation of flight directions for arriving and depositing flocks at Birch Lake further indicates the importance of these lakes northeast and southwest of

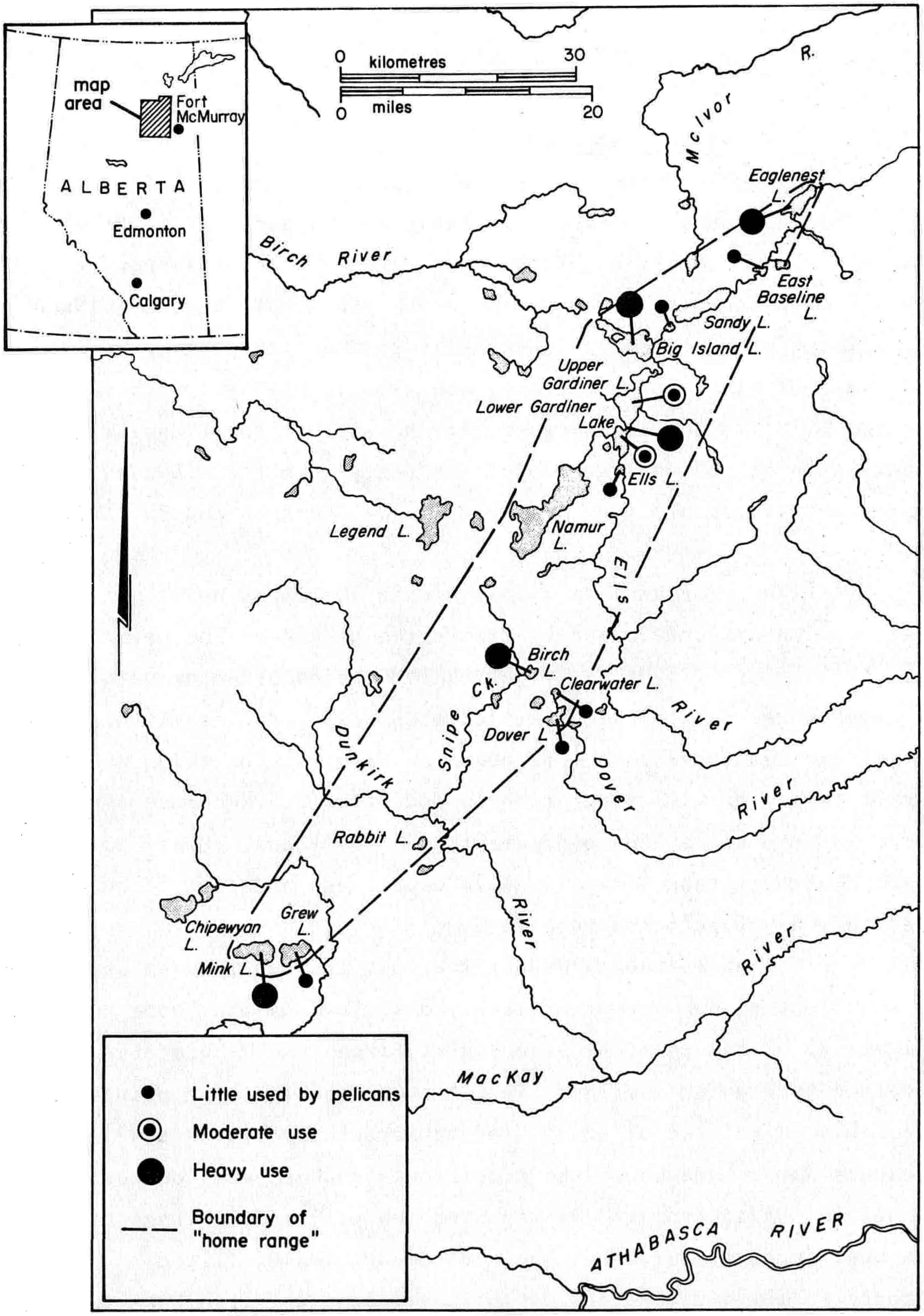

Figure 2. Boundary of "home range" and importance of lakes used by the pelicans.

the rookery. The total lake surface area amounts to 16 125 ha, in comparison with the maximum total area of the 12 lakes used by the pelicans (7180 ha). The "potentially available" lake area, which was not used in 1977, was considerable. Given the extensive ranging by pelicans that was observed, there appeared to be some habitat selection by the pelicans.

4.1.2 Movements Between Rookery and Foraging/Loafing Areas

At any given time, only one member of each breeding pair remained at the rookery to attend the eggs or small young. When the juveniles are a few weeks old, often both parents would be away from the rookery island. Detailed observations in the intensive study area revealed that arrivals and departures at loafing bars and foraging areas were usually from and toward the direction of the rookery, respectively. Only one or two flights were observed in other directions than toward or away from the rookery or known loafing areas. This suggested that the birds belonged to the same population; however, non-breeding birds were periodically observed at the rookery and were, at least twice, observed in the foraging/loafing areas. These non-breeding birds were much grayer and had darker, grayer bills than mature pelicans. Also, often there were far more pelicans either at the rookery or in the foraging/loafing areas than could be accounted for by the number of nests initiated. Therefore, it was necessary to determine whether the majority of the birds in transit were pelicans from the rookery.

There were several peaks in arrivals and departures at the loafing bars in the intensive study area. The peak in arrivals between 1300 and 1400[1] and that for departures between 1100 and 1200 appeared to account for the bulk of arrivals and departures (Figures 3 and 4). The arrivals of pelicans at the foraging areas studied were generally less than an hour later than

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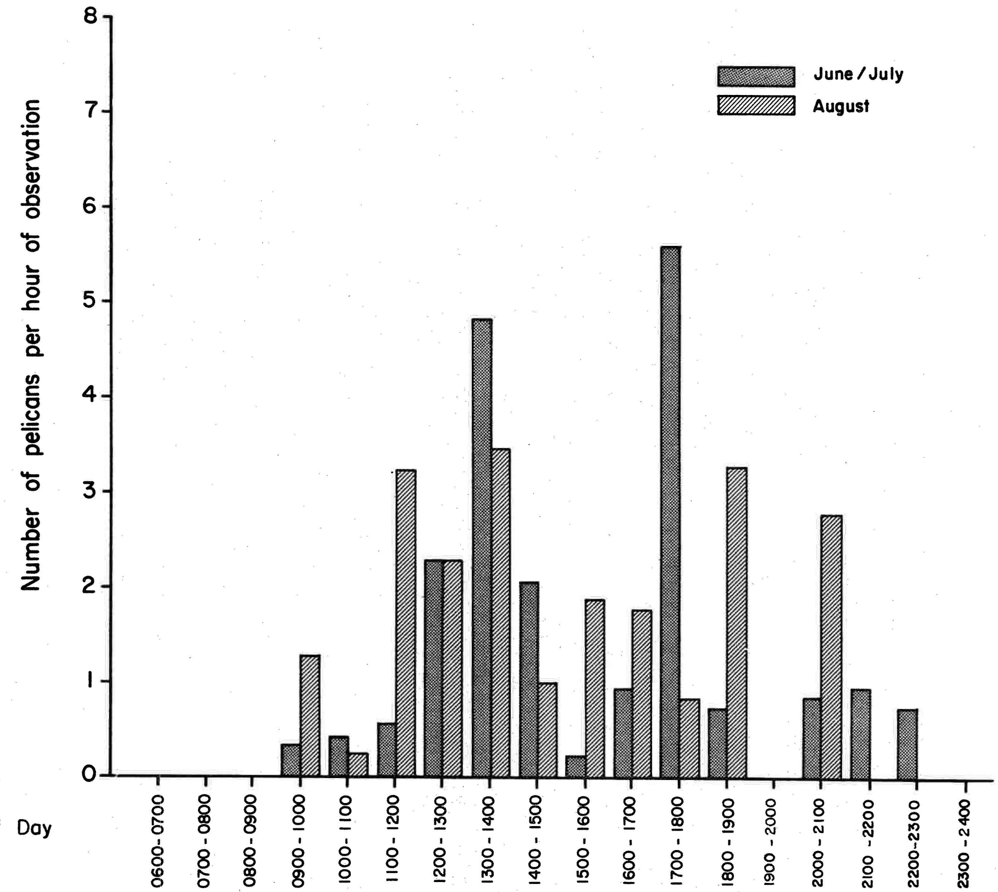
[1] All time of day referred to in this report are Mountain Daylight Savings Time.



Hours Observed:	0600-0700	0700-0800	0800-0900	0900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800	1800-1900	1900-2000	2000-2100	2100-2200	2200-2300	2300-2400
June/July	1.2	1.8	2.5	3.0	4.7	3.6	3.5	5.2	5.3	4.5	4.3	2.5	2.8	2.8	3.6	5.3	4.1	4.2
August	1.0	0.6	1.3	2.3	3.9	6.5	7.0	7.5	5.0	4.8	4.5	2.4	1.8	1.0	1.1	-	-	-

Figure 3. Arrivals of Pelicans at Foraging/Loafing Areas on Big Island and Gardiner Lakes from the Direction of the Birch Lake Rookery in 1977.

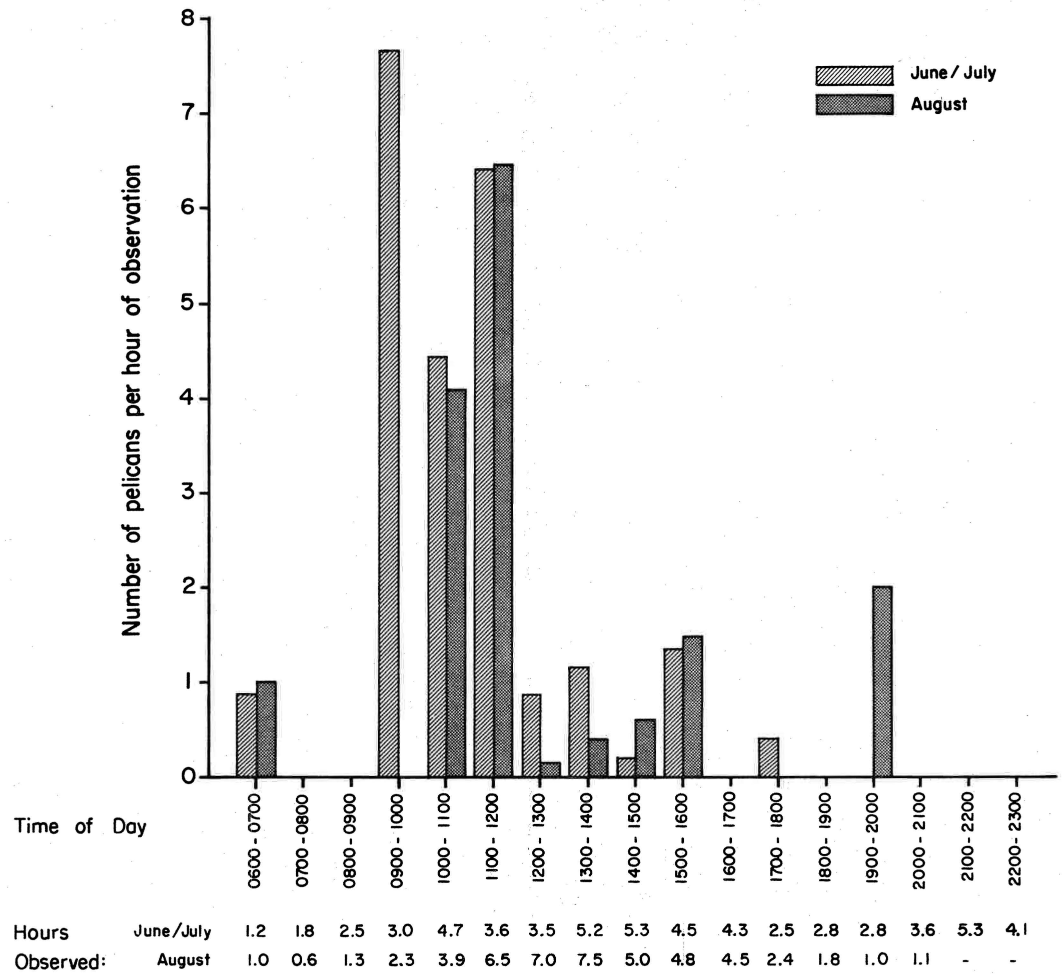


Figure 4. Departures of Pelicans from Foraging/Loafing Areas on Big Island and Gardiner Lakes toward the Birch Lake Rookery in 1977.

departures from the rookery. Likewise, the departures were a little earlier than arrivals at the rookery (Beaver and Ballantyne 1977, 1979). This time difference reflects the transit time involved and indicates that these pelicans were from the same population.

It seemed that the timing and character of the flights between the rookery and foraging/loafing areas varied with the weather, particularly the wind. On dull, foggy, excessively windy or rainy days, the pelicans often flew at lower altitudes and appeared to be flying consistently later in the day than on clear or moderately windy days when the development of thermals occurred early and the wind was not so strong as to hinder flights in one or both directions. The weather effects were also noted at the rookery, particularly with respect to the departures (pers. obs. and conversation with R. Beaver, Canadian Wildlife Service employee). Low et al. (1950) described similar effects of weather as did Brown and Urban (1969) for the Great White Pelican (*Pelecanus onocrotalus roseus*) in Africa. Low et al. (1950) also discovered that there were peaks in the numbers of pelicans returning to the rookery they studied, but that these peaks differed, being between 0830 and 0930 for 1937 and 1200 and 1300 for 1948. Hall (1925) found that many pelicans returned to the rookery from fishing areas after dark. In the Birch Mountains, there were some late night movements from foraging/loafing areas, but direction of flights often could not be determined. Some very late evening observations of pelicans returning to the rookery were made (see Beaver and Ballantyne 1979) which indicated a protracted activity period for the population under investigation. Further study of the effects of weather on the character of flights by pelicans would elucidate the factors of primary importance which were suggested here by a limited sample of observations.

The distances which the pelicans covered in flights from the rookery to foraging/loafing areas ranged from 30 km, one way, to Lower Gardiner Lake, to a maximum of 69 km, one way, to

Eaglenest Lake. These distances were comparable to those recorded for other breeding colonies of pelicans (Table 1). Several of the reported breeding colonies were either surrounded by alkaline or saline waters which were devoid of fish (Johnson 1976; Behle 1958; Low et al. 1950) or located near surrounding lakes which were thought too deep to provide good foraging areas (Trottier and Breneman 1976). There were several small, shallow lakes in the vicinity of the Birch Lake rookery but these have rarely been used by the pelicans. Very few pelicans were observed on these lakes in 1977 and only during the early summer.

4.1.3 Change in Distribution over the Summer

One of the objectives for this study was to determine the variability in the degree of pelican usage of the lakes within their foraging distribution. Were there any trends in habitat use which might reflect changing habitats over the summer, response to environmental changes (including distribution of fish) or other phenomena? To document habitat use throughout the summer, the general locations and numbers of pelicans were recorded for aerial surveys and from local counts in the intensive area (Figure 5).

One aerial survey, conducted on 26 April 1977, was not included in Figure 5 because of the presence of ice cover on a majority of lakes. During this early survey pelicans were only observed only at open water, particularly on an ice-free stretch of the Ell's River critical for pelicans at this time (see Beaver and Ballantyne 1979).

There appeared to be a shift from the Gardiner Narrows and Lower Gardiner Lake to Big Island Lake and Eaglenest Lake over the summer. Mink and Grew Lakes were also appeared to be used throughout the study period. There may have been a concomitant change in foraging behaviour, which will be discussed at length under Section 4.2.3. Briefly, the shift in location appeared to be accompanied by a change from social, nocturnal foraging at the Gardiner Narrows to solitary, diurnal foraging at Big Island Lake.

Table 1. Distances between foraging/loafing areas and rookery lakes of pelicans as reported in literature and observed in the Birch Mountains.

Rookery Location	One-way Distance to Foraging/Loafing Areas (km)	Reference
Great Salt Lake, Utah	80 to 121	Low et al. (1950)
Pyramid Lake, Nevada	96.6	Marshall and Giles (1953)
Great Salt Lake, Utah	48.3 to 161	Behle (1958)
Lake St. Lucia, Zululand	104.7	Feeley (1962)
Chase Lake, North Dakota	48 to 305.5	Johnson (1976)
Birch Lake, Alberta	30 to 69	This study

[a] For Great White Pelican (Pelecanus onocrotalus).

[b] Based upon return of fish tags -- does not consider likelihood of fish movement from point of tagging.

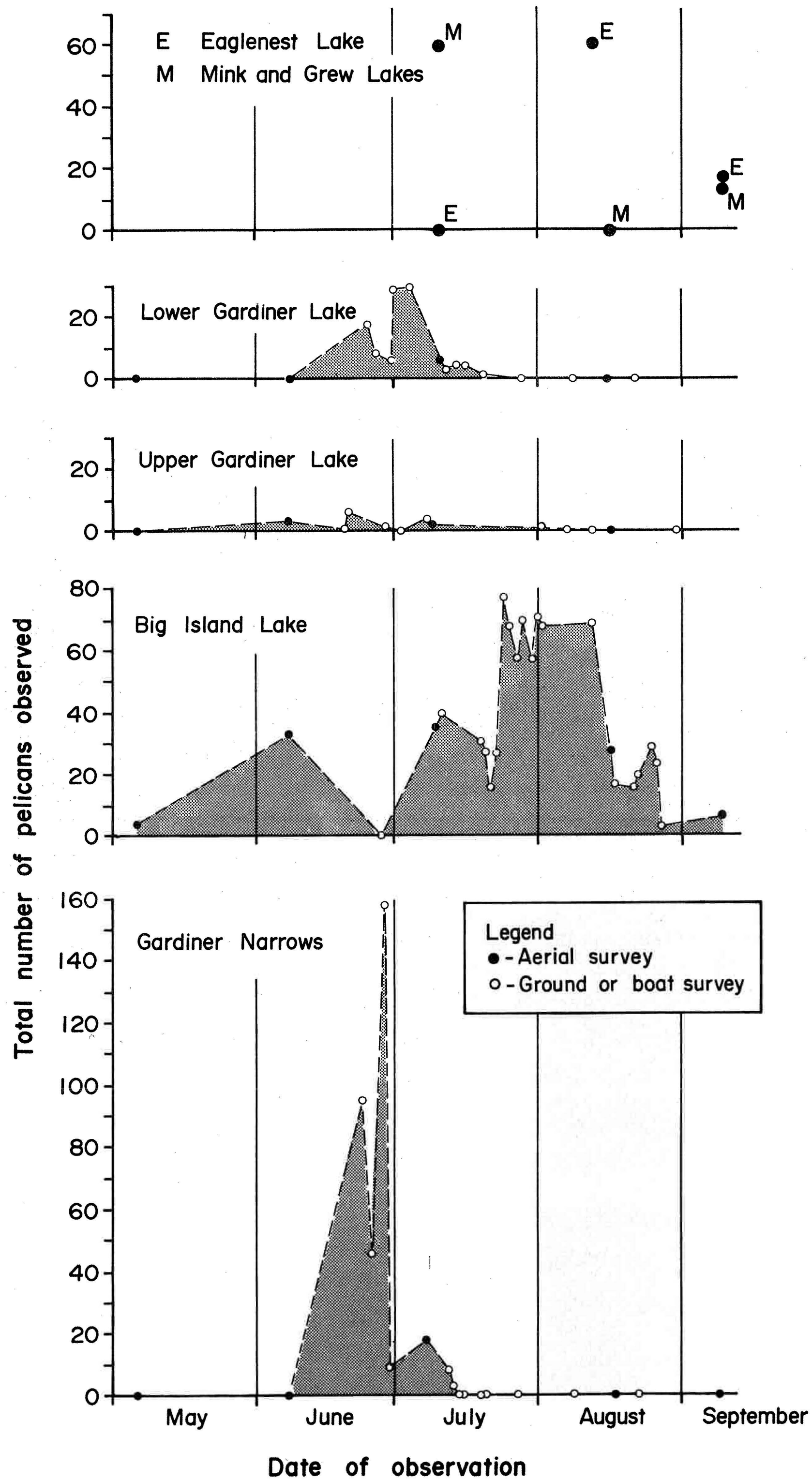


Figure 5. Change in pelican distribution over the study period, 1977.

4.2 NON-BREEDING ACTIVITIES OF PELICANS

There is very little known about the non-breeding activities of the White Pelican; most studies have focused on the rookery and activities of the birds while within sight of the breeding area. The observations that have been made of activities away from the rookeries have been exclusively related to foraging; however, White Pelicans in the Birch Mountains spend a great deal of their time loafing when away from the rookery. A detailed analysis of this activity, as well as foraging behaviour, is necessary before the importance of various habitat characteristics can be discussed, i.e. one must known what the pelicans do in an area before the habitat's importance can be assessed.

4.2.1 Loafing Behaviour

When pelicans arrived at lakes distant from the Birch Lake rookery, they would either land at a loafing bar or in the water. Rarely would pelicans forage immediately upon arrival at a a lake; loafing dominated their time. Typically, a group of pelicans would occupy a loafing bar for several hours, during which time some birds would arrive, others would depart, a few birds would bathe nearby, and most birds would preen or rest.

Preening and resting accounted for nearly 100 percent of the pelicans' time when at the loafing bars. The proportion of pelicans engaged in these two activities varied throughout the day. From periodic counts it was found that, in the later hours of the day, the pelicans rested more than they preened, which contrasted with the morning period (Table 2). Additional observations were made of the loafing pelicans to determine dura-ation of each activity. Analysis of these latter data suggested that more resting was done in the mornings than later (Table 3) which contradicted the former conclusion based upon periodic counts of all birds and their activities (Table 2).

Table 2. Activities of White Pelicans at loafing bars[a] on foraging lakes.

Time Period	Mean Number of Pelicans Performing Activities					Ave. No. of Birds Counted	No. of Counts per Time Period
	Preen	Rest	Bathe	Gular Flutter	Unknown		
0800 - 1200	625(2.12)	2.75(3.33)[b]	0	0	0	9.88(3.87)[b]	8
1200 - 1600	16.5(11.2)	14.75(4.89)	0.5(0.76)	0.38(1.06)	0.63(1.19)	31.38(11.36)	8
1600 - 2300	9.11(5.80)	24.56(9.71)	0.44(1.01)	0.2	0	34.33(11.35)	9

[a] Counts determined for point-observations made once during each hour of observation.
[b] ±One standard deviation.

Table 3. Duration of activities performed by White Pelicans at loafing bars[a] on foraging lakes.

Time Period	Proportion of Each Observation Period Devoted to Activity		Number of Birds Observed During Time Period
	Preen (%)	Rest(%)	
0800 - 1200	18.3	81.7	10
1200 - 1600	44.4	55.6	8
1600 - 2300	51.3	48.7	3

[a] Duration determined from observations of individual pelicans for 10 min periods.

To determine duration of activities (Table 3), observations were made of one pelican initially seen resting or preening and then alternated to another pelican with the opposite initial activity. This procedure helped focus attention on single pelicans among the occasionally milling mass of pelicans. Although it was not apparent at the time, such a procedure probably biased the estimate of activity duration cosiderably. Another possible explanation of the discrepancy between periodic counts and duration observations of resting and preening pelicans is that summary counts were made of birds at all loafing bars, while only one bar was close enough to an observation post for continuous observations of individuals. Pelicans may have behaved differently at different loafing bars. Also, the small sample sizes may have resulted in insufficient variation being sampled. More observations are necessary to outline the periods of peak activity of the pelicans and to clarify the importance of various activities while at loafing bars. Also, because the observations presented here encompass all loafing observed in July and August, it would be necessary to gather further observations to determine the effects of time of season and weather on behaviour.

A further approach to the analysis of loafing behaviour involved the tabulation of the frequency of key activities observed during 10 min detailed observation periods (Table 4). It was believed that such information might provide a background of behavioural data more suitable for comparison with disturbed loafing birds or loafing birds at the rookery. These key activities were identical to those described under the same names by Beaver and Ballantyne (1979); the majority of the activity names were purely descriptive. The most frequent activities were vertical bill shakes, glottis exposures, wing ruffles, leg and wing stretches, and wing flaps (Table 4). The former three activities were all primarily related to preening, while the latter two were associated with changing position on the loafing bar (usually just a rising

Table 4. Frequency of key activities[a] performed by White Pelicans during loafing periods on foraging lakes.

Activity	Number of Observations of Activities per 1000 Pelican-Minutes[b] 0800 - 1200	1200 - 1600	1600 - 2300
Glottis Exposure	7.0	18.0	6.6
Bill Throw	8.9	12.7	4.6
Bill Shake (vertical)	27.2	41.2	40.5
Bill Shake (horizontal)	0	2.9	0.5
Head Scratch	7.9	11.9	7.1
Pouch Scratch	14.8	8.2	8.0
Aggresive Lunge	5.9	6.7	0.7
Agressive Threat	0	0.6	0
Wing Flap (change position)	24.3	19.8	18.5
Wing Flap (bathing)	3.0	0.5	1.8
Leg and Wing Stretch	8.9	10.2	12.2
Wing Ruffle	21.3	9.4	14.3
Head Shake (vertical)	0	1.0	0.5
Head Shake (horizontal)	13.3	0.7	3.3
Body and Head Stretch	0	1.1	0
Yawn	0	1.2	0
Bathing	0	0.5	2
Swim	0	0.9	0.7
Gular Flutter	0	1.4	0
Total Number of Observation Periods	3	7	7

[a] Key activities follow terminology of Beaver and Ballantyne (1979). Generally purely descriptive.
[b] Pelican-minutes are calculated by taking numbers of pelicans observed during period into account.

and resettling procedure). Of the remaining activities most were also related to preening efforts (Table 4).

Considering the high frequency at which preening was observed, one could conclude that it was an important activity for pelicans. If this was so, then an observation of any fluctuation in comfort movements and other activities during disturbance could be used to determine the potential response to disturbance. Insufficient data are available at present to establish baseline levels of overall activity, although the key activities described should provide, with further observations, a useful standard for experimental comparison.

4.2.2 Bathing and Swimming Behaviour

Aside from foraging behaviour, there were only two major types of activity that pelicans were observed to do on the water: bathing and swimming. Bathing occurred exclusively near loafing bars, and in some respects could be classified as a loafing behaviour. Swimming behaviour, which included occasional solitary foraging, occurred throughout the intensive study area, and was observed on most of the surface area of Big Island Lake (see Section 4.3).

The observations of bathing pelicans indicated that most bathing occurred between 1400 and 1500, and between 1600 and 1700. All bathing occurred between 1300 and 1900 (Table 5). This timing coincided with that observed at the breeding colonies (Beaver and Ballantyne 1977) and further supported the conclusion that bathing occurred during the warmest part of the day. Generally, only a small proportion of the pelicans present at a bar bathed during the loafing period, similar to the occurrence of bathing near the rookery where part of the island served as a loafing bar. Therefore, on the basis of timing and frequency, there appeared to be no difference in the importance and function of bathing at the loafing areas compared with the rookery.

Table 5. Frequency of bathing of White Pelicans at loafing bars at foraging lakes.

Time Period	Average No. of Bathing Birds/hour	No. of Observation Hours When Pelicans at Loafing Bars
0800 - 0859	0	1.5
0900 - 0959	0	1.8
1000 - 1059	0	0.5
1100 - 1159	0	1.2
1200 - 1259	0	3.3
1300 - 1359	0.9	4.3
1400 - 1459	4	4.0
1500 - 1559	2.8	4.0
1600 - 1659	3.6	2.5
1700 - 1759	2.4	1.8
1800 - 1859	1	1.0
1900 - 1959	0	1.0
1000 - 1059	0	1.0
2100 - 2159	0	1.0
2200 - 2259	0	0.5

Pelicans were frequently observed swimming, particularly on Big Island Lake. From observations of these pelicans over 10 min activity periods, the average duration of various activities was determined (Table 6). It was found that swimming or simply floating comprised their major activity when pelicans were observed on the water. Often the pelicans would fly during the time they were being observed. This flying did not include flights to loafing bars but merely flights from one swimming location to another. As shown by the duration of activities, foraging comprised a very small proportion of each hour. Preening was certainly less important during swimming than during loafing periods on bars. Further data are required to determine the range of activities during swimming and whether there is any fluctuation with weather or time of day.

It is practically impossible to determine the amount of time spent swimming by an individual pelican in the course of a day because the birds cannot be individually marked; however, further observations should enable an attempt at estimation. The swimming periods may be quite important from the standpoint of potential disturbance because the pelicans are distributed over a wider area than when loafing or foraging socially and the probability of at least a few pelicans coming into contact with disruptions would be higher. It may be quite important for the pelicans of a rookery to have a large home range to search for adequate food supplies.

4.2.3 Foraging Behaviour

A primary purpose for long-term flights of pelicans during the breeding season is to reach foraging areas (Hall 1925; Marshall and Giles 1953; Behle 1958). This also seemed to be the case in the Birch Mountain area.

There were two types of foraging observed: social foraging and solitary foraging. Other authors refer to social foraging almost exclusively (Bent 1922; Hall 1925).

Table 6. Duration of activities executed[a] by pelicans while swimming on Big Island Lake.

Activity	No. of Minutes Activity Observed
Swim	195.8
Float	24.7
Fish	0.6
Preen	3.2
Fly	14.7
Total No. of Minutes of Observation	239.0

[a] Duration determined for observation periods, usually 10 minutes in length, of pelicans observed on the water (socially foraging pelicans were excluded from these observations).

Social foraging involved a group of swimming pelicans, often forming a semi-circle of U-shape, which moved back and forth through shallow waters, driving a school of small fish in front. When the fish were finally driven into restricted shallows, the pelicans would dip their heads simultaneously and begin scooping up the fish. A successful foraging run was identified by numerous pelicans swallowing fish.

Social foraging, which was observed only four times during the daylight hours, occurred at four different locations and did not continue for a long period of time during each observation. Social foraging in the evening was observed only at Gardiner Narrows and, in contrast, lasted for extensive periods of time. Continuous foraging runs south through the Narrows were made for up to 2 h. Foraging throughout the night occurred frequently at the Narrows (conversation in July 1977 with Cort Sims, Department of Anthropology, University of Alberta, Edmonton, Alberta).

The evening foraging bouts usually followed a standard pattern (Figure 6). Pelicans began by loafing on a shallow bar at the south end of the Narrows, sometimes for an hour or more before foraging (Figure 7). They then flew, together, to the north end of the Narrows and began chasing fish in the shallows, first back and forth, and then south through the Narrows. At various points in the rapids, the pelicans would simultaneously dip their heads under water. Usually the foraging bouts were successful but, if not, then the pelicans would fly back to the north side before completing the pass south through the rapids. The successful foraging runs (six were observed) took from 3 to 11 min to complete, the average time being 7.2 min.

The pelicans may have foraged at the Narrows for a considerable time prior to the establishment of our camp on Upper Gardiner Lake. It would be valuable to know the real extent of their use of the Gardiner Narrows and to determine the variation

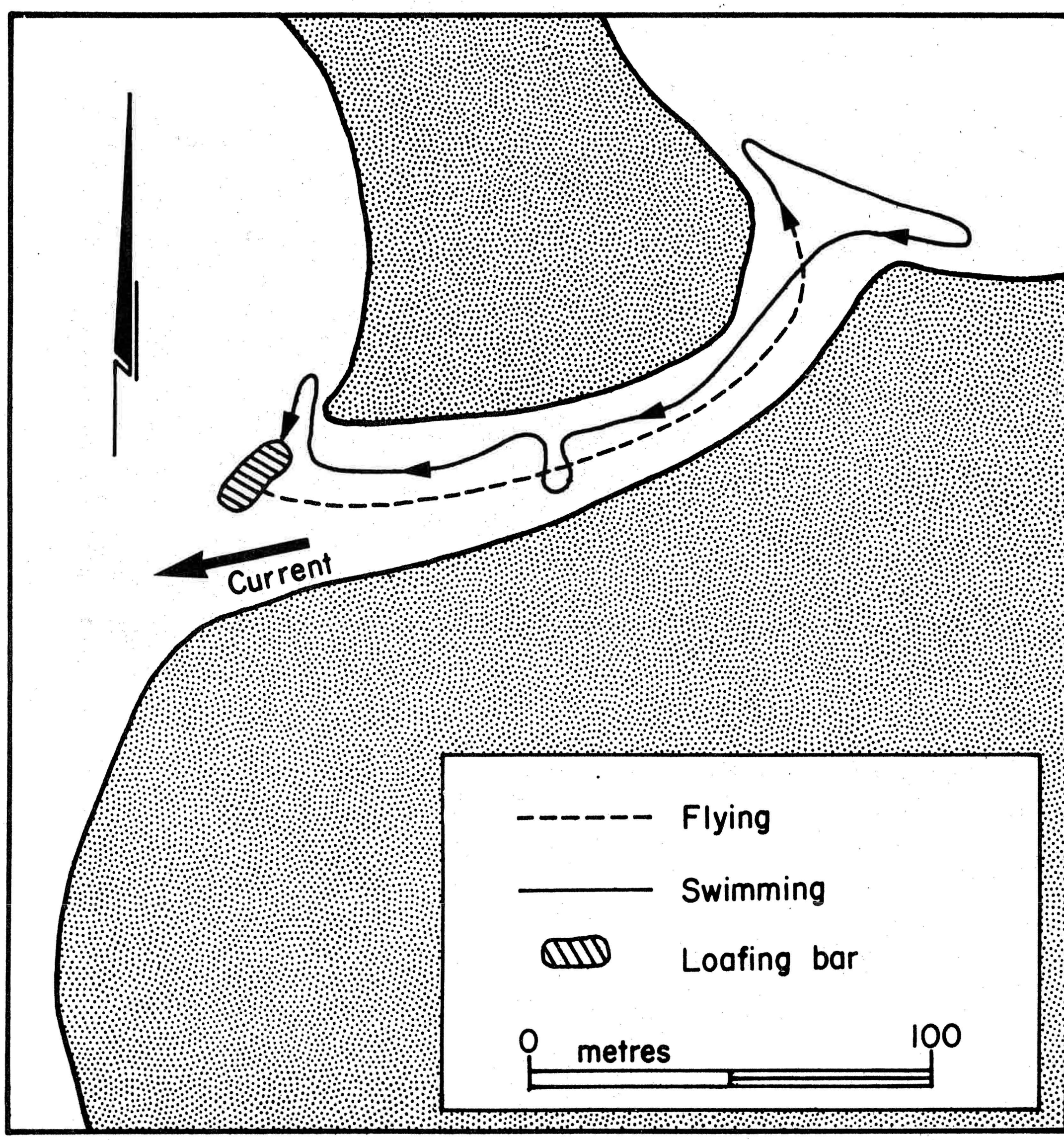


Figure 6. Typical route of a successful foraging run by pelicans at Gardiner Narrows.

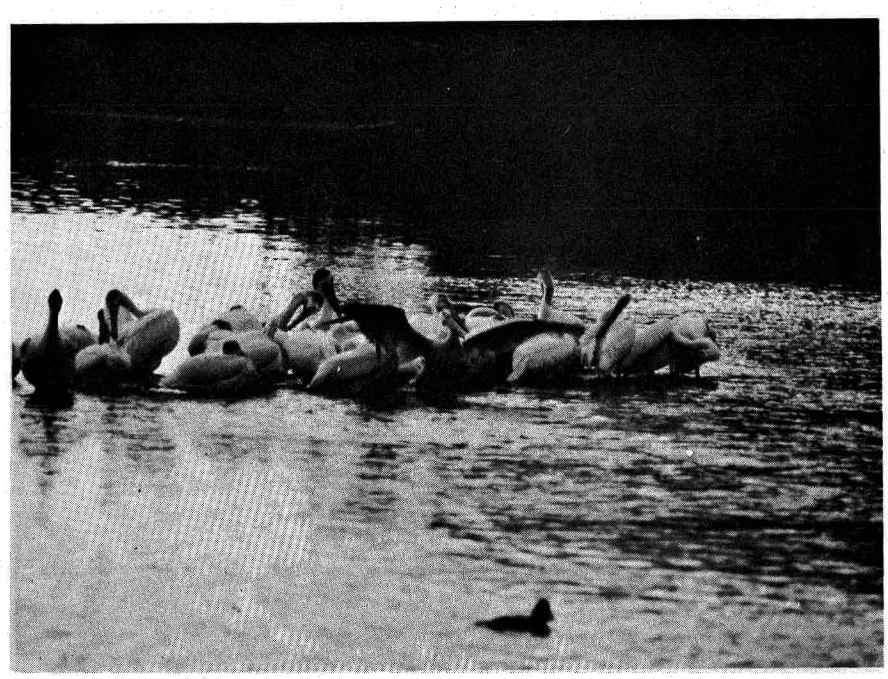


Figure 7. Loafing pelicans at Gardiner Narrows.

in timing and success of foraging runs. Such information would indicate the efficiency of the pelicans at fishing and also the potential for damage that could be caused by disturbance of a local foraging area.

Social foraging may have occurred in the evening at Big Island Lake throughout the summer, although we did not observe such foraging or any apparent preparations for foraging by late evening. The majority of the foraging observed at Big Island Lake was solitary. Whether this trend from social to solitary foraging over the summer is a regular occurrence should be determined by further study.

Solitary foraging took several forms (Table 7). Frequently, it was truly solitary and an individual swimming pelican would be seen to dip or to lunge under the water surface with its bill. Generally, propulsive force for the lunge was provided by pushing backward quickly with both feet. Pelicans varied their lunges, presumably to suit the prey being attacked; at times the lunge was directed forward, and at other times the head was tilted and the lunge was slightly off to the side. There were two times when a loose flock of 5 to 11 swimming pelicans was observed foraging in this manner, but the infrequent, asynchronous lunges indicated that these were merely opportunistic associations, not co-operative ones. Confirmed scavenging of dead fish by a swimming pelican was observed only once.

Another rare, solitary fishing technique documented was stalking. A pelican was observed to swim through fog to a point close to a shore and begin to slowly stalk toward a group of feeding walleye (*Stizostedion vitreum vitreum*)[1] in the early morning. The stalking observed was deliberate but unsuccessful; it appeared as though the walleyes turned and swam away at the approach of the pelican. The pelicans made frequent attempts at such schools of larger fish, especially during the peak of fish foraging activity.

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1 Nomenclature for fish species in this report from Paetz and Nelson (1970).

Table 7. Frequency of types of solitary foraging performed by White Pelicans on Big Island and Gardiner Lakes.

Foraging Type	Number of Observations
Surface fishing	17
Lunges	7
Head dip	8
Surface scavenging	1
Stalking	1
Drop from air	11
Oust gull	3
Opportunistic	8

The noise made by the walleyes while close to shore was quite loud, carried far at night and in the early morning, and may have aided the orientation of stalking attempts although the pelicans may have also been stalking the same prey as the walleye.

Pelicans also foraged by dropping from the air -- stalling when several metres high -- and picking up dead fish from the surface of the water. This type of foraging was one of the most frequently observed solitary foraging techniques. The pelicans performed this technique flying in circles from one swimming location to another. Occasionally, they would fly to where a gull or group of gulls was scavenging and displace one, pick up the gull's fish, and then usually fly elsewhere. Often, however, the pelicans did not find a fish where the gull had been. Other authors mention the occurrence of scavenging by pelicans (Mills 1925; Behle 1958).

The range of solitary foraging techniques indicates that the pelicans are extremely opportunistic. There may be times of the day, particular locations, or certain weather conditions favouring specific strategies; however, at present, there are insufficient data to warrant conclusions regarding these.

4.3 HABITAT CHARACTERISTICS

4.3.1 Habitat Use

There were sufficient observations of pelicans at Big Island Lake that an attempt was made to quantify their use of proportions of the lake by using a grid system. Swimming pelicans were observed throughout the lake, while both foraging and loafing pelicans were observed at more restricted locations (Figure 8).

The grids were classified as to total use by pelicans thus: 1 to 10 pelican-hours (low), 11 to 50 pelican-hours (moderate), and greater than 50 pelican-hours (heavy). Total

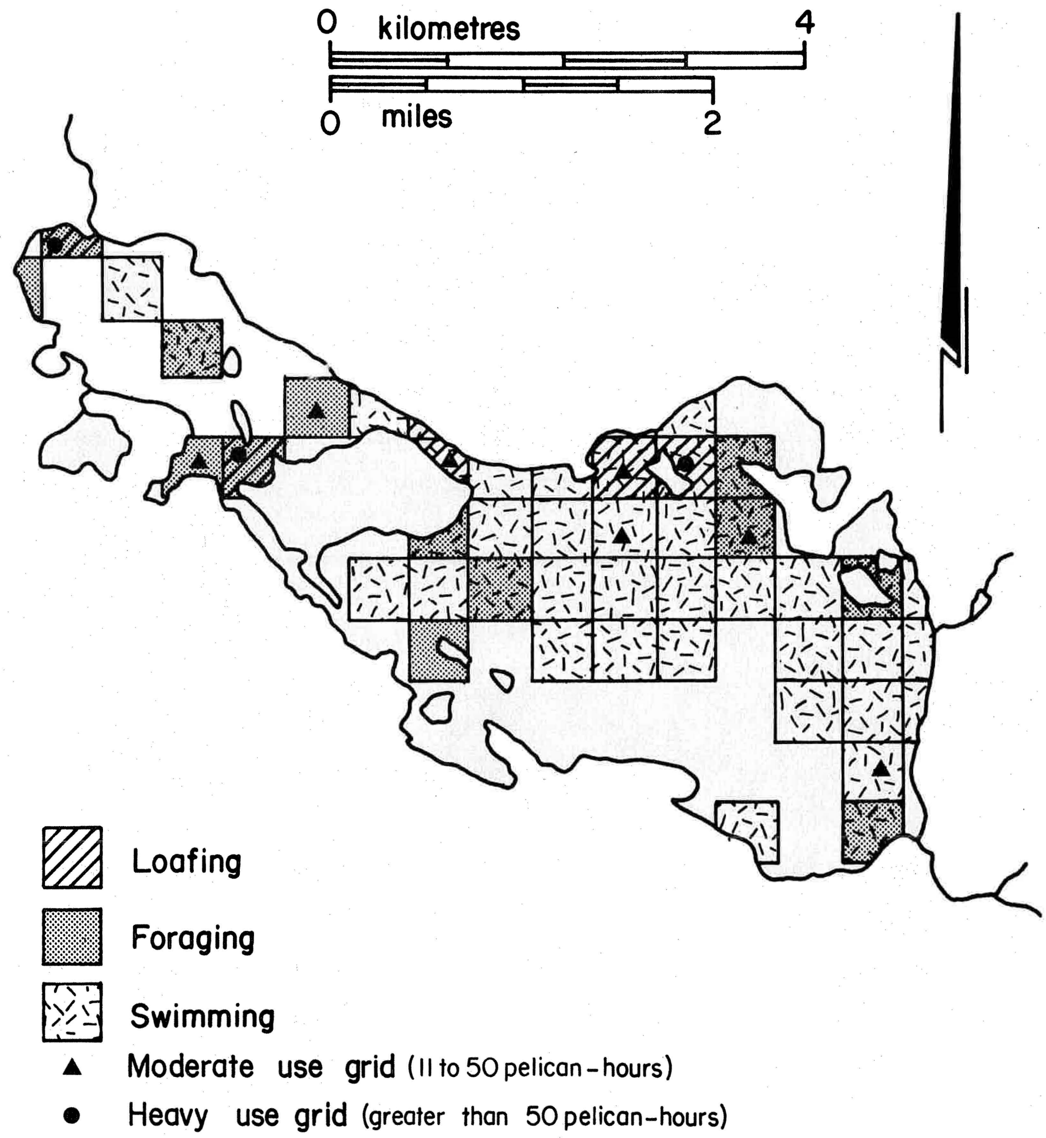

Figure 8. Locations and activities of pelicans observed on Big Island Lake, late summer, 1977.

observation hours for each half of the lake were approximately the same (41.02 hours of observation of all grids on the west, 47.58 hours on the east). There were 34 grids that had a low frequency of use while 7 and 3 grids had a moderate and a heavy frequency of use, respectively (Figure 8). Therefore, there were particular locations at which pelicans concentrated. Determination of critical locations like these are necessary prerequisites to outlining management recommendations.

A further analysis of swimming pelican locations revealed that there was a difference between the proportion of lake area covering certain depths and the proportion of observations over these same depths (Table 8). Pelicans were observed swimming over most depths at the same frequency as that depth was represented in the total lake area; however, there were significantly fewer observations of pelicans swimming over depths greater than 13.2 m and slightly more observations of pelicans swimming over depths between 6.6 and 9.9 m and between 9.9 and 13.2 m than those depths represented in the total lake area. In addition, there were likely some swimming pelicans in the shallow bays that were hidden from all of the observation posts (some pelicans were observed flying from such bays). Therefore, there would probably be more pelicans in the shallowest water than presently indicated (Table 8). There was a significant proportion of foraging pelicans (solitary as well as social) among those seen swimming in shallow waters (Table 8). The shoreline waters may be considered more important than mid-lake waters to the pelicans.

Loafing bars and foraging areas were mapped for pelicans on the Gardiner Lakes and Big Island Lake (Figures 9 and 10). Although direct comparisons may not be reasonable -- pelicans could very well have used parts of the Gardiner Lakes more intensively during the early summer -- it would appear that loafing and foraging areas were more abundant at Big Island Lake.

Table 8. Number of sightings of swimming pelicans related[a] to depth of water in Big Island Lake.

Observations	Depths (m)					Totals
	0-3.3	3.3-6.6	6.6-9.9	9.9-13.2	13.2-13.2+	
All sightings	99.75	79.25	44.45	28.95	6.6	259
Only foraging[b] pelicans	43.75	3.75	1.75	0.75	0.0	50
% of all sightings	38.5	30.6	17.2	11.2	2.5	100
% of foraging observations	87.5	7.5	3.5	1.5	0.0	100
% of lake area enclosed	37.7	29.9	12.8	7.9	11.7	100
hectares of lake area enclosed[c]	296.0	472.0	202.0	125.0	184.0	1579

[a] Locations on lake surface plotted relative to depth contours of Turner (1968). Pelicans were located on grid squares which frequently overlapped depth contours; each pelican was assumed to have moved over the entire grid during the hour between recording these point observations. Therefore, a pelican could proportionately use, for example, 0.5 of each of two depth ranges, or 0.33 of each of three depth ranges included within a grid square , etc.

[b] This category includes socially foraging pelicans, as well as solitary foraging ones.

[c] Determined from Turner (1968).

Results of chi-square tests:

χ^2 for comparison of all observations with area of lake enclosed $= 25.9$ $P < 0.001$

χ^2 for comparison of foraging observations with area of lake enclosed $= 53.0$ $P < 0.001$

χ^2 for comparison of foraging observations with all observations $= 40.6$ $P < 0.01$.

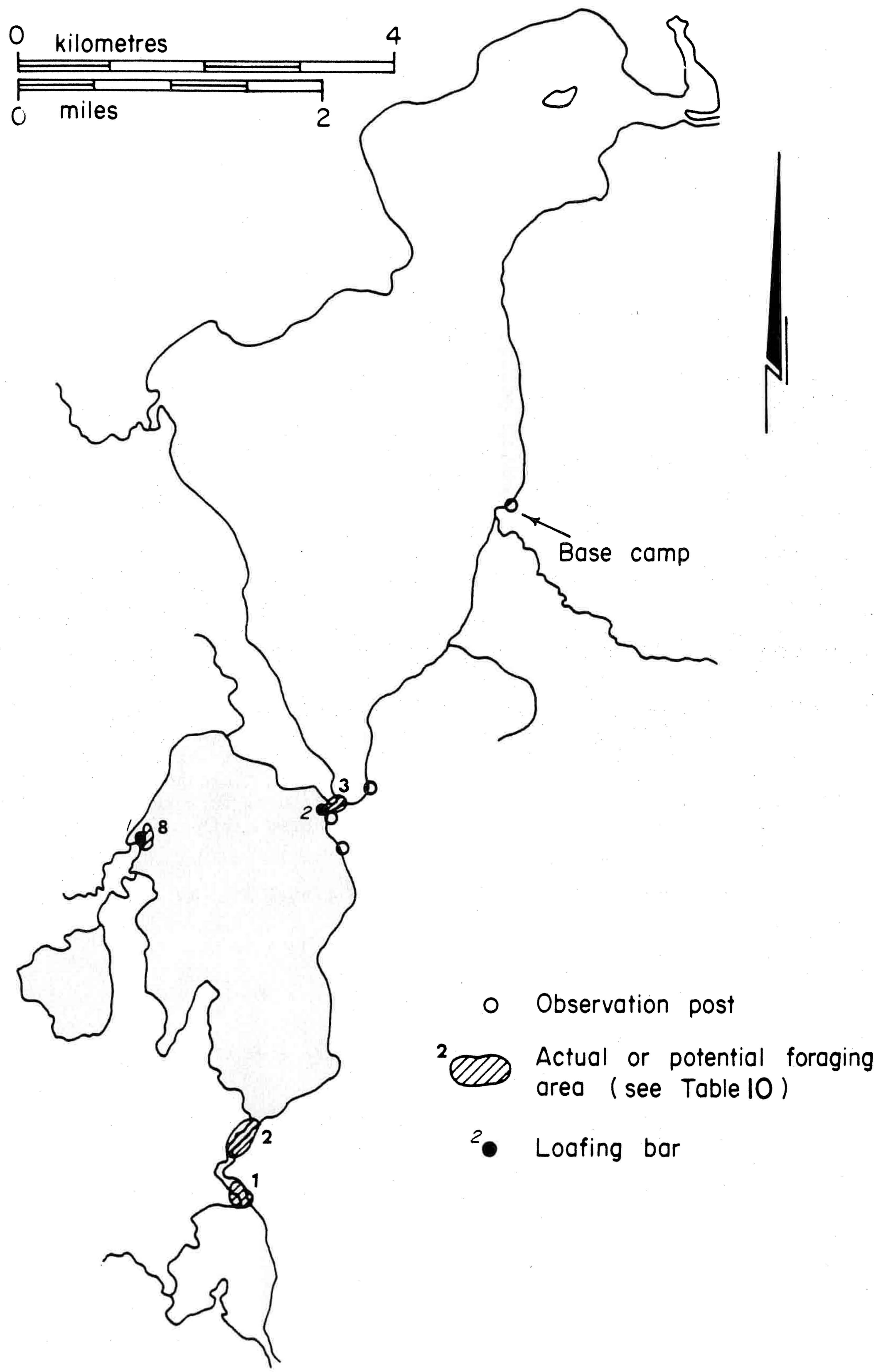

Figure 9. Locations of foraging/loafing areas, observation posts and base camp on the Gardiner Lakes, late summer, 1977.

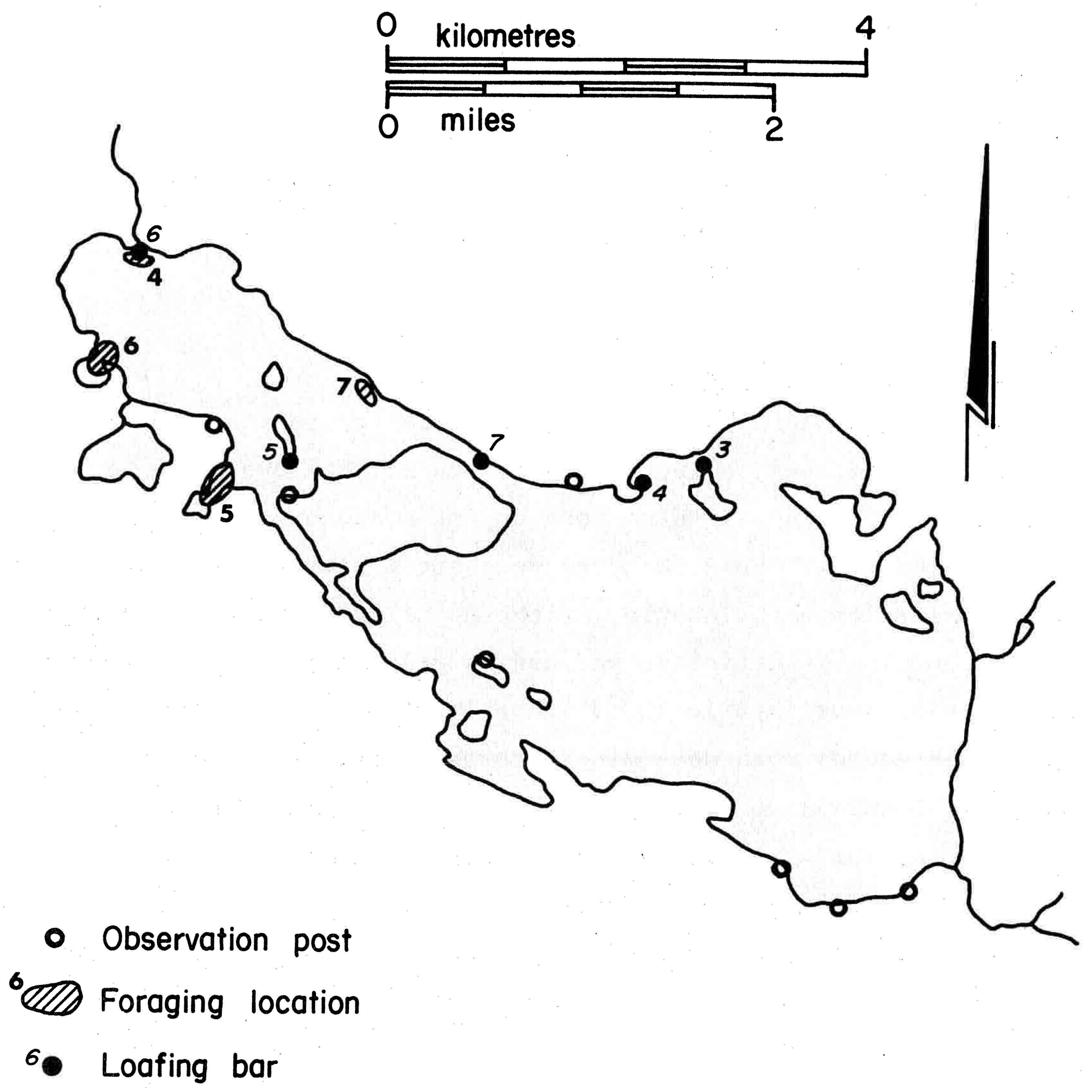

Figure 10. Locations of foraging/loafing areas and observation posts on Big Island Lake, late summer, 1977.

However, the high numbers of pelicans (up to 158) which were observed foraging a few times at Gardiner Narrows indicated that parts of the Gardiner Lakes may be critically important for the pelicans.

Aerial observations of pelicans at other lakes did not show consistent use of precise locations, so that assessments of habitat features are presently based upon observations on Big Island Lake and the Gardiner Lakes.

4.3.2 Habitat Features

The physical parameters of a number of pelican foraging and loafing locations, as well as some unused shallows, were recorded to determine if there were any predominant characteristics (Tables 9 and 10). These features were not monitored over the entire summer for each location, although it was noted that changes in depth, expanse, turbidity, and use by pelicans did occur over the summer at some locations and probably at all. As a result, the "average" features were determined from subjective assessments made during all observation visits. The variability makes it more difficult to assign selection of a habitat type, for a particular activity, on the basis of one or two features.

Loafing bars appeared to provide some basic requirements; i.e. they must include solid substrate and, if not exposed, must be in very shallow water. The most frequently used loafing bars were composed of exposed, rocky spits, extending from islands. It appeared as though the reduced wave action around one loafing bar (number 3 in Figure 10) promoted its selection during a period of windy weather, over a much more frequently used, but more exposed bar (number 5 in Figure 11). Further observations would help greatly in the characterization of critical pelican habitat; selection in the early summer may bear no resemblance to that of late summer when the added responsibility of feeding the young arises.

Table 9. Characteristics of loafing bars[a] observed on Big Island Lake and the Gardiner Lakes.

Location	Depth (m)	Turbidity	Field of View	Protection vs. Rough Waters	Extent (m)	Substrate	Degree of Use	Proximity to Other Use Areas (km)
1. Namur River	0.2–1.0	mod. murky	open	calm	15+	silty/sand	moderate	2.0
2. Gardiner Narrows	0.05–0.3	clear–sl. murky	limited	variable usu. calm	11–15	rubble	moderate	2.0
3. N-central Island, Big Island Lake	0	exposed	restricted	calm	10–15	rubble	moderate	2.0–3.6
4. Bay opposite #3	0	partially exposed	very restricted	calm	5–10	rubble	slight	2.0–3.6
5. W Island, Big Island Lake	0	exposed	very open	rough	30–50	rubble	heavy	1.6–2.1
6. NW Stream, Big Island Lake	0.1–0.3	clear–sl. murky	open	calm–mod. rough	15–20	gravel/silt	moderate	2.1
7. NW Channel, Big Island Lake	0.0–0.2	clear–sl. murky	restricted	calm	5–10	gravel/silt	slight	1.6–2.0

[a] Figures 8 and 9 show the locations for these loafing bars.

Table 10. Characteristics of foraging areas[a-b] observed on Big Island Lake and the Gardiner Lakes.

Location	Depth (m)	Turbidity	Field of View	Protection vs. Rough Waters	Extent (m)	Substrate	Degree[c] of Use	Proximity to Other Use Areas (km)
1. Ell's Lake Channel	0.1-1.0	not recorded	restricted	prob. calm	400	rubble/silt	none	3.8-4.0
2. Lower Gardiner Lake Channel	0.2-2.0	not recorded	restricted	prob. calm	600	rubble/silt	none	3.2
3. Gardiner Narrows	0.2-1.5	clear-sl. murky	limited	variable, usu. calm	200-250	rubble	moderate	2.0
4. NW Stream, Big Island Lake	0.2-1.0	clear-sl. murky	open	calm-mod. rough	50-80	gravel/silt	slight	2.0
5. SW Bay, Big Island Lake	0.3-1.0+	mod.-very murky	restricted	calm	500	silt	slight	0.5
6. W Bay, Big Island Lake	0.5-1.0+	very murky	limited	calm	300	silt	none	1.0-1.8
7. NE Shore, Big Island Lake	0.0-3.3	clear-mod. murky	open	mod. rough	200	rubble/sand	slight	0.8
8. Namur River - foraging observed but characteristics not recorded for extent of foraging area.								

a Includes some areas examined as potential foraging areas.
b Figures 8 and 9 show the locations for these foraging areas.
c Relative amount of foraging by pelicans, observed at location.

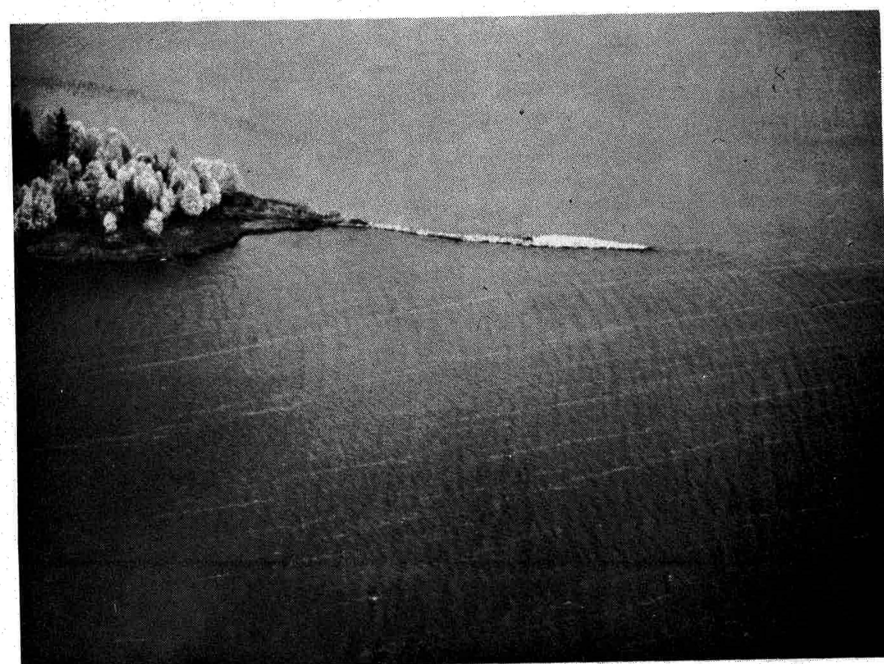

Figure 11. Loafing bar with pelicans.

Foraging locations were related to the type of foraging attempted. Only locations where social foraging was observed, and locations classified as potential foraging areas, that were superficially similar, were examined (Table 10). Solitary foraging was most frequently observed in shallow waters (Table 8), but such opportunistic foraging, probably for dead fish, would not be resticted to the specific criteria observed for social foraging. Social foraging required shallows where the pelicans could chase large numbers of schooling fish until the fish were "cornered" against very shallow banks. The Gardiner Narrows, where most observations of social foraging were made, was ideally suited to such foraging because there was a corridor of shallows through which the fish could be chased until they reached the very shallow areas, where they were then "trapped". In addition, there was a broad expanse of shallows along the shore and across the north end of the Narrows where the pelicans could gather the fish. The rocky substrate at this rapids area may have helped the pelicans detect the outlines of the fish by providing a contrasting, uneven background. This latter feature undoubtedly could have been important for late night foraging (Figure 12).

4.4 FISH AND PELICAN INTERRELATIONS

4.4.1 Diet

A total of seven regurgitations were collected from juvenile pelicans during two visits to the rookery island in late August. There were several whole, or nearly whole, fish in some of the regurgitations so that identification of species consumed was possible. Three species of fish were discovered, as well as a varied assortment of invertebrates and detritus (Table 11). The invertebrates were minor components of the pelicans' diet, certainly at the time when samples were collected. Each of northern pike

Figure 12. Aerial view of Gardiner Narrows, facing north.

Table 11. Contents of regurgitations obtained from juvenile pelicans at the Birch Lake rookery, August 1977.

Item	Number of Specimens Found in Each Regurgitation							
	1	2	3	4	5	6	7	%[a]
Lake Whitefish	1	0	0	0	0	1	1	0.3
Northern Pike	1	2	1	0	1	0	0	0.5
Brook Stickleback	55	46	650	285	0	0	0	99.1
Unid. fish fry	0	0	2	0	0	0	0	0.1
Amphipoda	8	0	3	0	0	0	0	0
Dytiscidae	2	2	0	1	0	0	0	0
Corixidae	0	1	1	0	0	0	0	0
Gastropoda	1	2	3	5	0	0	0	0
Nematoda	0	0	1	0	0	0	0	0
Cestoda	0	0	3	1	0	0	0	0
Aquatic vegetation	few pces.	few pces.	few pces.	few pces.	few pces.	few pces.	few pces.	0
Pebble and tiny sticks	0	0	few	0	0	0	0	0
Feathers (tiny)	0	0	few	0	0	0	0	0
Total weight (g)	400	404	484	218	72	5	205	

[a] Percentage of samples based upon numbers, for fish species only.

(*Esox lucius*), lake whitefish (*Coregonus clupeaformis*), and brook stickleback (*Culaea inconstans*) accounted for a substantial proportion of the diet. Numerically, the brook stickleback was the predominant item in the diet, however, the average whole stickleback weighed about 0.8 g, while an individual whitefish or pike, collected for the essentially undigested regurgitations, weighed from 100 g to 250 g. The diet of juvenile White Pelicans in the Birch Mountains area, during late August, appeared to be roughly equally composed of the three species of fish, on the basis of an estimated biomass. Two major limitations of this method of diet analysis were the amorphous nature of digested prey which accompanied all but the least digested regurgitations and the small sample size.

4.4.2 Fish Sampling on Pelican Foraging Lakes

A number of lakes were sampled using gill nets and seines. The fish fauna lists obtained for these lakes were quite varied (Table 12). The lists obtained for the Gardiner Lakes chain agree with those of Turner (1968). The lake whitefish in the diet of the pelicans were likely obtained from the larger lakes of the Birch Mountains, because this fish species was not found in the samples from Birch Lake or Clearwater Lake (local name of lake near Birch Lake). The species-abundance list compiled for Big Island Lake suggested that cisco (*Coregonus artedii*) also formed part of the pelicans' diet, because this species was far more abundant than lake whitefish. It was probably represented among the silvery fish that the pelicans were observed to scavenge, on this particular lake.

Further work on fish sampling, in conjunction with regurgitation collection, if carried out in the future, would allow more detailed analysis of fish populations and determination of the effect of pelicans on these populations.

Table 12. Fish species obtained from lakes of the Birch Mountains in September 1977.

Species	Number of Fish Sampled											
	Namur		Gardiner		Big Island[a]		Eaglenest[a]		Birch		Clearwater	
	g[b]	s[b]	g	s	g	s	g	s	g	s	g	s
Cisco (Coregonus artedii)	1	0	2	0	18	0	0	0	0	0	0	0
Lake Whitefish (Coregonus clupeaformis)	2	0	1	0	1	0	26	0	0	0	0	0
Northern Pike (Esox lucius)	0	0	2	0	2	0	13	0	17	0	0	0
Longnose Sucker (Catostomus catostomus)	3	1	0	0	0	0	0	0	0	0	0	0
White Sucker (Catostomus commersonii)	0	0	0	0	0	1	3	5	3	0	0	0
Burbot (Lota lota)	1	0	0	0	0	0	0	0	0	0	0	0
Brook Stickleback (Culaea inconstans)	0	0	0	0	0	0	0	0	0	12	0	36
Yellow Perch (Perca flavescens)	0	0	1	0	0	24	0	0	0	0	0	0
Walleye (Stizostedion vitreum vitreum)	0	0	7	0	5	0	0	0	0	0	0	0

[a] Gill nest left set for 2 nights instead of 1.
[b] Two types of sampling methods were used: g - gill nets; s - seines.

4.4.3 Fish Utilization by Pelicans

In order to complete the assessment of fish-pelican interrelations it is necessary to compare the diet with the observed processes of food procurement. It is also necessary to determine the impact of pelicans on the fish populations within the former's home range.

At the time of collection of the regurgitations, the adult pelicans had been foraging socially rather frequently in the shallows of Birch Lake. From seining attempts near this foraging location we found a number of brook sticklebacks (Table 12). Also, the pike which were caught in the gill nests at the same lake were found to have numerous sticklebacks in their stomachs. These observations would account for sticklebacks, and possibly part of the pike portions of the pelicans' diets. However, at the same time, the pelicans were continuing to make long distance trips, for foraging, to Big Island and Eaglenest Lakes. Solitary foraging, i.e. scavenging, presumably led to the presence of large fish, such as pike and whitefish, in the diet.

White Pelicans, in general, have been recorded to consume primarily rough or nongame fish and occasionally amphibians, but may consume game fish, such as trout, when other food sources are unavailable (Hall 1925; Thompson 1933; Bond 1940; Marshall and Giles 1953; Schaller 1964; Mansell 1965; Johnson 1976). In the Birch Mountains, pelicans did eat some pike, but these were small compared with the considerable size that pike achieve in the lakes of that area (Turner 1968). The other species of fish (lake whitefish and brook stickleback) found in juvenile pelican regurgitations may not actively be sought by sports fishermen.

Reported estimates of total fish consumed per pelican during a breeding season have varied considerably with species of pelican examined and location of study (Hall 1925; Korodi-Gal 1961; Brown and Urban 1969). The only attempt to estimate fish consumption by White Pelicans was that made by Hall (1925), who calculated that it would take 68 kg of fish to raise one juvenile to the stage where it could fly. The weight of the most complete regurgitations collected from Birch Lake's juvenile pelicans ranged from 0.40 to 0.48 kg. At the same stage of development of the pelicans (8 wk), Hall estimated that full meals consisted of about 0.9 kg of fish. He also observed that young were fed twice daily. Hall believed, although he presented no direct evidence, that the adults also fed themselves twice for a daily consumption of 1.8 kg of fish.

Korodi-Gal (1961) found that the average weight of stomach contents of the Dalmatian Pelican (*Pelecanus crispus*) was 1.3 kg, which he calculated from a total of 12 birds whose average weight was 10.6 kg. Romaseva (in Korodi-Gal 1961) estimated that the daily food requirement for the same species to be 1.1 kg. If Dalmatian Pelicans were assumed to take two meals per day, as Hall (1925) suggested for the White Pelican, this would amount to a daily consumption of 22 percent of body weight. Brown and Urban (1969) compare daily consumption rates for a Golden Eagle (*Aquila chrysaetos*) (6 to 7 percent of body weight; Brown and Watson 1964; Craighead and Craighead 1956) and a Marabou Stork (*Leptoptilus crumeniferus*) (13 to 14 percent of body weight; Kahl 1966), in order to estimate daily fish consumption at 10 percent of body weight for the Great White Pelican (*Pelecanus onocrotalus*).

It would appear that Hall's (1925) estimate for an adult White Pelican, of 1.8 kg per day (which is 36 percent of body weight) may be far too high. Hall also estimated that 8 wk old pelicans consumed 1.8 kg of fish daily. Estimates for this report indicated that, even if they were fed two full meals per day, juveniles at 8 weeks old were eating only 0.9 kg per day, or *half* of Hall's estimate.

An estimate of the total consumption of fish, by the breeding population of pelicans, can be made by multiplying duration of the breeding season and the development period of young by the daily consumption rate and then by the number of pelicans. The breeding season was approximately 120 d long for a total breeding population of 140 adults, while the post-hatching young had a development period of approximately 80 d. There were 55 young that survived until they could fly while 14 young died at early stages. On the basis of Hall's (1925) calculations, an estimate, modified by our observations, was made of 38.2 kg of fish for each pelican from hatching until flight. Similarly, for adult pelicans, if one assumes that an individual eats 0.9 kg per day (as much as an 8 wk old bird), then each adult would consume about 108 kg over the breeding season. The total amount of fish consumed by all breeding adults and their young over the breeding season would be 17 234 kg or about 17.2 tonnes.

An adult captive Brown Pelican consumed 17.5 percent of daily body weight (Schreiber 1976). If one assumes that adult White Pelicans consume the same proportion of body weight, which average 5 kg, then one can calculate a daily consumption of 875 g and a seasonal intake of 105 kg, very close to the 108 kg estimated above for a single White Pelican. Schreiber (1976) emphasized that the reduced activity of the captive adult in a small cage would result in a minimal estimate for daily consumption. Therefore, the estimate obtained using his calculations would likely be minimized for adult White Pelicans as well.

Two methods are available for comparison of the above calculations for juvenile intake with a captive juvenile's daily consumption. Greichus et al. (1976) found that the daily intake of growing juveniles was 1400 g until the asymptote of development was reached and thereafter 610 g of food were apparently adequate for daily maintenance. Schreiber (1976) discovered that, until the asymptote of development was reached, the daily intake of young captive Brown Pelicans was 29 percent of daily body weight, while the subsequent maintenance diet was only 17.3 percent of daily body weight. Using the growth curve provided by Greichus et al. (1976) for captive White Pelicans, it was possible to calculate the seasonal intake for an individual from Schreiber's (1976) observations of daily consumption as a proportion of daily body weight. The total seasonal consumption for all juveniles at the Birch Lake rookery was estimated to be 5.0 and 5.1 tonnes from the above two methods, respectively.

The total seasonal consumption for the adult White Pelicans breeding at Birch Lake, which were assumed to have the same consumption as a captive adult Brown Pelican, amounted to 14.7 tonnes. Total annual consumption for the breeding pelicans and their offspring was 19.7 to 19.8 tonnes based on captive bird data.

An estimated 2.5 to 5 tonnes of fish were added to the above estimate of consumption by pelicans in order to account for non-breeding pelicans observed in the study area; therefore the overall consumption estimated from the various techniques was from 19.7 to 24.8 tonnes.

Based upon the estimate of how much prey is consumed during a breeding season by the population present and upon the knowledge of their movements and utilization of lakes, it should be possible to estimate the proportion of the annual fish productivity that is harvested by the pelicans. The estimated annual productivity for Big Island Lake and the Gardiner Lakes was calculated by Turner (1968). Eaglenest Lake was similar in size and depth to Big Island Lake (pers. obs.) so that the postulated annual production of 5 pounds per acre (2.27 kg per acre) (Turner 1968) was used to estimate annual production for Eaglenest Lake (Table 13). The remaining lakes were all small, shallow, and highly eutrophic

Table 13. Estimated annual fish production for all lakes at which White Pelicans were observed in 1977.

Lake	Area (acres)	Total Production (kg/yr)
Big Island Lake (local name)	3 898	8 399
Gardiner Lakes	5 952	13 620
Eaglenest Lake	2 070	4 699
Grew Lake	2 020	20 705
Mink Lake	2 558	26 220
Birch Lake (local name)	421	2 455
Clearwater Lake (local name) (57°13'N, 112°40'W)	236	2 419
Dover Lake (local name) (57°10'N, 112°40'N)	825	8 456
Unnamed Lake (57°37'N, 112°27'W)	236	2 419
Unnamed Lake (57°42'N, 112°15'W)	185	1 896

and were much more similar to Grew Lake for which preliminary fisheries study had been completed (Anonymous 1969). From that preliminary study, it was possible to calculate a morpho-edaphic index (after Ryder 1965) and hence a productivity estimate of 10.25 kg/acre/year for Grew Lake. This estimate was used to calculate the annual production for all shallow lakes visited by the pelicans, except Birch Lake for which a water analysis indicated lower dissolved solids (133 ppm) than in Grew Lake (410 ppm) and therefore a lower morpho-edaphic index was calculated. The total annual production calculated for all lakes at which White Pelicans were observed was 91 228 kg. The estimated consumption of fish by pelicans was 19.7 to 24.8 tonnes which is equivalent to 22 to 27 percent of the estimated annual production.

Caution must be used in interpreting these estimates because the morpho-edaphic index of Ryder (1965) was primarily developed for much larger lakes. Also, the extrapolition of estimates based upon Big Island and Grew Lakes may not be completely accurate as a result of unknown differences in the mean depth and total dissolved solids for the lakes not investigated by a fisheries survey crew. Because of the estimated high productivity levels for the small, shallow lakes, it is possible that an over-estimate of total annual production has been obtained. The White Pelicans appear to be extremely important predators upon the fish population of Birch Mountains and nearby lakes. Refinements of this procedure of calculating proportion of prey base consumed would be possible with further study.

In 1977, <u>no</u> pelicans were observed at Namur Lake, even though that lake has a traditional rookery site (Vermeer 1969). A considerable annual production (11 250 kg) was estimated for Namur Lake (Turner 1968); however, with the considerable amount of sport-fishing activity on this lake, it is possible that the pelicans were disturbed too frequently to forage on this lake. It could also be possible that less expansive shallow areas at Namur Lake rendered fish prey less available to foraging pelicans.

4.5 DISTURBANCE AND EFFECTS UPON PELICANS

Although extreme caution was used in our approaches to pelicans, there were a few instances when pelicans were disturbed by research-related activities. These interactions provided data on low levels of disturbance and subsequent responses. Immediate responses were noted and were found to be quite varied (Table 14). It was found that swimming pelicans assumed an alert posture when a motorboat passed them at distances ranging from 175 to 450 m or they flushed when a motor boat passed at distances ranging from 200 to 800 m. Loafing pelicans were observed to flush when a motorboat passed at distances from 150 to 600 m. Nearby pelicans usually flushed or swam away when a float-plane approached within 1 to 2 km. They also flushed or swam away in response to being approached by humans on foot, between 30 and 200 m away; however, there did not appear to be sufficient disturbance for research related activities to cause long-term disruptions.

Other human activities may have been much more disruptive; however, the absence of foraging pelicans on Namur Lake may have been attributable to the frequent boating activity and other disturbance on that lake. The desertion of the traditional rookery on Namur Lake in 1975 was a direct result of human disturbance at the rookery island (see Beaver and Ballantyne 1979). Also, it was noted that large numbers of pelicans were visiting Gardiner Narrows nightly for foraging, prior to the July 1st holiday weekend, but after that weekend the numbers of pelicans observed were much smaller and continued to decline rapidly.

During that national holiday and starting on June 30, there was considerable increase in float-plane traffic and recreational activity. Flights were made for two canoeing expeditions, a

Table 14. Observations of pelicans disturbed during research efforts.

Disturbance	No. Pelicans in Group Each Encounter	Distance from Disturbance (m)	Activity of Pelicans Prior to Disturbance	Response
Motorboat	1,1, 2,1, 1,1	175,175, 450,200, 200,350	swimming	alert
	2,1, 1,1, 1,1, 1,3	500,300, 200,200, 400,500, 550,800	swimming	flush
	10,19, 46	150,150 600	loafing	flush
Floatplane	2	1000	swimming	swim away
	8,60	1000-2000	swimming	flush
	5,40, 60,68	1000-2000	loafing	flush
On foot	1	200	swimming	flush
	8	30	foraging	flush
	95	150	loafing	flush
	1	30	loafing	swim away

group of fishermen from the Namur Lake fishing lodge, an independent fishermen, and an archaeologist setting up camp at the Narrows. For all flights the plane landed and took off in the south arm of Upper Gardiner Lake, between 200 m and 500 m from Gardiner Narrows. Observations of pelicans were not made during the evenings of this weekend, partly due to the weather and our fear of further disturbing the birds.

Even though earlier observations had indicated that the pelicans did not arrive at the Narrows until late in the evening, a number of the pelicans were regularly observed loafing at the mouth of Namur River where it enters Lower Gardiner Lake, and could have been disturbed by the fishermen's activities and the planes. Directly following that weekend, the numbers of pelicans at the Narrows dwindled quickly. This avoidance may have been partly a result of the holiday activity, but other factors such as fish movements could have been involved in the shift to Big Island Lake by the pelicans. The degree of influence of disturbance can best be ascertained by further observations and closer monitoring of movement trends for the pelicans of the Birch Mountains.

5. SUMMARY AND CONCLUSIONS

Considerable new information on White Pelicans in general, and the breeding population in the Birch Mountains in particular, has been obtained by this extension of observation into their foraging and loafing areas. A number of aspects of the pelicans' activities away from the rookery have been examined, while previously the distribution and activities were largely subjected to conjecture.

In conjunction with a breeding study undertaken on Birch Lake (see Beaver and Ballantyne 1979), it was possible to show that the pelicans observed at scattered lakes of the Birch Mountains and several kilometres south were part of the same breeding population. The immense size of the home range of the Birch Lake population was found to be similar to other populations reported. The purpose of this widespread distribution appeared to be selection of the most suitable foraging and loafing habitat and abundant sources of prey, i.e. fish. The nature of this selection must depend upon the availability and distribution of these features of the local environment of each rookery and its surroundings. That such features may change, during a breeding season, was suggested by a shift in the distribution and activities of the Birch Mountains population over the summmer, although human disturbance could have been involved also.

Detailed observation of pelican activities away from the rookery showed that they expended much of their time in loafing. The loafing bars which were utilized seemed to be particularly important features of the habitat, and their abundance on a lake appeared to reflect the importance of that lake to the pelicans. There were few characteristics which were consistently observed for all loafing bars, but certain lakes had a disproportionately high number of locations which fulfilled the basic requirements.

Pelicans also spent much of their time swimming and, in doing so, coursed over much of the intensively studied lakes. Foraging pelicans, in particular, were observed to concentrate in the shallowest waters.

Over the summer, there appeared to be a shift in the pelicans' foraging pattern from social nocturnal fishing to solitary, diurnal scavenging. This may have been partly due to the disturbance of the birds by vacationers and planes during a busy holiday weekend, although other factors must also have been involved.

From a small sample of regurgitations of juvenile pelicans, three fish species were indicated to be almost equally important, on a weight basis, as prey items. The diet studies to date indicate that pelicans, in general, eat non-game fish and this may also prove to be true of the White Pelicans in the Birch Mountains with further study. Total fish consumption by pelicans was estimated to be from 22 to 27 percent of the annual fish production in the lakes at which pelicans were observed.

This preliminary study has suggested the occurrence of diurnal trends in activity and seasonal shifts in distribution and foraging. In addition, there is an indication that recreational activities may modify pelican distribution to some extent. It will be necessary to examine these periods further to establish the nature of, and factors responsible for, the fluctuations. It is clear that, prior to an experimental disruption of the pelicans (see Beaver and Ballantyne 1977), it is imperative to thoroughly understand their local behaviour and ecology.

6. RECOMMENDATIONS

6.1 RECOMMENDATIONS OF GENERAL SCIENTIFIC IMPORTANCE

1. Further study of the dispersal patterns of foraging pelicans, particularly during the early to mid-summer period, is strongly recommended to elucidate the nature of foraging strategies.
2. A specific goal of further analyzing the behaviours exhibited by pelicans in various locations throughout their distribution is deemed worthwhile to assess the importance of certain activities and to determine periods of peak activity. Responses of pelicans at foraging areas subjected to human related disturbance also requires further documentation.
3. The impact of White Pelicans upon fish populations should be more thoroughly examined through further controlled sampling of fish populations, observations of foraging birds and possibly the collection of more regurgitations, where disruptive disturbance can be kept to a minimum. Knowledge of fish movements, productivity and mortality factors which probably influence the availability of prey for foraging and scavenging pelicans are essential to more conclusively assess the impact of pelicans on the prey base.

6.2 RECOMMENDATIONS PERTINENT TO DEVELOPMENT OF THE ATHABASCA OIL SANDS DEPOSITS

The report by Beaver and Ballantyne (1979) has outlined the possible effects of actual oil sands resource development and thus further elaboration will not be necessary here. Although there is some speculation that potential detrimental effects could result from fouling of foraging waters or disturbance of foraging birds themselves, a definite need exists to increase our knowledge in these areas. The author therefore recommends a cautious approach in the design and location of planned development sites either connected with resource use or recreational pursuits in the Birch Mountains area until such data are collected.

The preliminary nature of the present study of White Pelican biology has not enabled the recommendation of clear mitigative techniques to protect this species at its foraging areas although such areas have been located and described. It is apparent, however, that the clear lake system of the Ells River headwaters is important in the ecological requirements of the Birch Mountain White Pelican population.

7. REFERENCES CITED

Anderson, D.W. and J.C. Bartonek. 1967. Additional observations on the status of North American White Pelicans. Condor 69:311-313.

Anonymous. 1969. Preliminary biological report. Unpublished files of Alberta Fisheries. 11 pp.

Bartholomew, G.A. Jr., W.R. Dawson and E.J. O'Neill. 1953. A field study of temperature regulation of young White Pelicans. Ecology 34:554-560.

Beaver, R. and M. Ballantyne. 1977. A preliminary study of the breeding behaviour and distribution of the White Pelican in the Alberta Oil Sands area. Prep. for Alberta Oil Sands Environmental Research Program by Fisheries and Environment Canada. Canadian Wildlife Service. 62 pp. (Unpubl.)

Beaver, R. and M. Ballantyne. 1979. Breeding distribution and behaviour of the White Pelican in the Athabasca oil sands area. Prep. for the Alberta Oil Sands Environmental Research Program by Environment Canada, Canadian Wildlife Service. Project LS 22.2 (T.F. 2.2). 93 pp.

Behle, W.H. 1958. The Bird Life of Great Salt Lake. Univ. of Utah Press, Salt Lake City. 203 pp.

Bent, A.C. 1922. Life histories of North American petrels, pelicans and their allies. Dover Publ. Inc., New York. 335 pp.

Boeker, E.L. 1972. A survey of White Pelican nesting colonies in 1971. Amer. Birds 26:24-25.

Bond, R.M. 1940. Birds of Anaho Island, Pyramid Lake, Nevada. Condor 42:246-250.

Brown, L.H. and E.K. Urban. 1969. The breeding biology of the Great White Pelican, *Pelecanus onocratalus*, at Lake Shala, Ethiopia. Ibis 111:199-237.

Brown, L.H. and A. Watson. 1964. The Golden Eagle in relation to its food supply. Ibis 106:78-100.

Cottam, C. and F.M Uhler. 1937. Birds in relation to fishes. U.S.D.A. Bur. of Biol. Survey. Wildl. Res. and Mgmt. Leaflet BS-83. 16 pp.

Craighead, J.J. and F.C. Craighead. 1956. Hawks, Owls and Wildlife. Harrisburg, Pennsylvania. Stackpole Co. 443 pp.

Evans, R.M. 1972. Some effects of water level on the reproductive success of the White Pelican at East Shoal Lake, Manitoba. Can. Field-Nat. 86:151-153.

Feeley. J.M. 1962. Observations of the breeding of the White Pelican, Pelecanus onocrotalus, at Lake St. Lucia, Zululand, during 1957 and 1958. Lammergeyer 2:10-20.

Greichus, Y.A., A. Greichus and D.J. Call. 1976. Care and growth of captive White Pelicans. Avic. 82:139-142.

Hall, E.R. 1925. Pelicans versus fishes in Pyramid Lake. Condor 27:14-160.

Henshaw, H.W. 1879. Ornithological reports from observations and collections made in portions of California, Nevada and Oregon. Appendix L. Ann. Rept. Chief Engineers for 1849. Ann. Rept. Geog. Surv. West 100th Meridian, by George M. Wheeler. 282-335.

Houston, C.S. 1962. Hazards faced by colonial birds. Blue Jay 20:74-77.

Johnson, R.F. 1976. Mortality factors affecting a White Pelican population, Chase Lake National Wildlife Refuge, North Dakota. M.S.F. thesis. Michigan Technol. Univ. 74 pp.

Johnson, R.F. Jr. and N.F. Sloan. 1976. The effects of human disturbance on the White Pelican colony at Chase Lake National Wildlife Refuge, North Dakota. Inl. Bird-Banding News 48:163-170.

Kahl, M.P. 1966. A contribution to the ecology and reproductive biology of the Marabou Stork (Leptoptilus crumeniferus) in East Africa. J. Zool. London 148:289-311.

Knopf, F.L. 1975. Spatial and temporal aspects of colonial nesting of the White Pelican. Ph.D. Thesis. Utah State Univ. 77 pp.

Korodi-Gal, I. 1961. Contributions à la connaissance de la biometrie et de la nourriture du pelican (Pelecanus crispus Bruch) du Delta du Danube. Bull. Inst. Cercet. Pisc. 20:90-95.

Lamb, C. and A.B. Howell. 1913. Notes from Buena Vista Lake and Fort Tejon. Condor 15:115-120.

Lies, M.F. and W.H. Behle. 1966. Status of the White Pelican in the United States and Canada through 1964. Condor 68:279-292.

Low, J.B., L. Kay and D.I. Rasmussen. 1950. Recent observations on the White Pelican on Gunnison Is., Great Salt Lake, Utah. Auk. 67:345-356.

Mansell, W.D. 1965. Present status of the White Pelican in Ontario. Ont. Field. Biol. 19:11-14.

Marshall, D.B. and L.W. Giles. 1953. Recent observations on birds of Anaho Island, Pyramid Lake, Nevada. Condor 55:105-115.

Mills, L. 1925. White Pelicans in Nevada. Condor 55:105-115.

Paetz, M.J. and J.S. Nelson. 1970. The fishes of Alberta. Queens Printer, Government of Alberta, Edmonton, Alberta. 282 pp.

Ryder, R.A. 1965. A method for estimating the potential fish production of north temperate lakes. Trans. Am. Fish. Soc. 94:214-218.

Sanderson, R.M. 1966. The colonial birds at Suggi Lake, Saskatchewan in 1966. Blue Jay 24:121-123.

Schaller, G.B. 1964. Breeding behaviour of the White pelican at Yellowstone Lake, Wyoming. Condor 66:3-23.

Schreiber, R.W. 1976. Growth and development of nestling Brown Pelicans. Bird-Banding 47:19-39.

Thompson, B.H. 1933. Hostory and prsent status of the breeding colonies of the White Pelican in the United States. U.S.D.I. Nat. Park, Service. Occ. Paper #1. 82 pp.

Trottier G.C. and R. Breneman. 1976. Population status and foraging distribution of White Pelicans breeding in Prince Albert National Park, Saskatchewan. Unpubl. report prep. for Parks Canada by the Canadian Wildlife Service. 98 pp.

Turner, W.R. 1968. A preliminary biological survey of waters in the Birch Mountains, Alberta. Survey Report No. 3. Alberta Fish and Wildl. Div. 138 pp.

Vermeer, K. 1969. Colonies of Double-crested Cormorants and White Pelicans in Alberta. Can. Field-Nat. 83:36-39.

Vermeer, K. 1970. Distribution and size of colonies of White Pelicans (Pelecanus erythrorhynchos) in Canada. Can. J. Zool. 48:1029-1032.

8. APPENDIX

In 1977 six aerial surveys (Section 3.1) were used to determine the distribution of White Pelicans on water bodies surrounding the rookery. Additionally, skywatches (Section 3.2) were conducted over a period of 11 d at the Gardiner Lake field camp to monitor local movements of pelicans there.

Table 15. Number of White Pelicans observed during aerial surveys.

Lakes[a]	Number of Pelicans Observed [b]					
	April 16	May 6	June 8	July 11	August 13,16	Sept.10
Birch Lake (local name)	5	n.s.[c]	70	n.s.	n.s.	62 (juveniles)
Mink Lake	n.s.	n.s.	n.s.	60	0	13
Grew Lake	n.s.	n.s.	n.s.	8	0	0
Ells Lake (local name)	28	0	0	1	0	0
Lower Gardiner Lake	0	0	0	6	0	0
Upper Gardiner Lake	0	0	3	0	0	0
Big Island Lake (local name)	0	4	33	40	70	0
Unnamed Lake (57°42'N, 112°15'W)	0	0	0	0	0	9
Eaglenest Lake	0	0	0	0	60	17

[a] All lakes at which White Pelicans were observed during at least one aerial survey over the summer. The survey area included the Birch Mountains and all the lakes extending southwards to Mink and Grew lakes (see Figure 1).
[b] All numbers refer to adult White Pelicans unless otherwise indicated.
[c] n.s. = Not surveyed.

Table 16. Dates, times, and observations for skywatches conducted from Upper Gardiner Lake camp, 1977.

Date	Time	Observation
July 19	1600–1615	2 pelicans fly south, 3 pelicans fly north.
	1804–1819	No pelicans observed.
	2040–2055	No pelicans observed.
July 20	1411–1426	2 pelicans soaring over Big Island Lake, leaving loafing area.
	1503–1518	5 pelicans fly south from Big Island Lake.
July 21	1005–1035	18 pelicans fly from Big Island Lake to south.
	1245–1300	No pelicans observed.
	1350–1405	No pelicans observed.
July 22	1400–1415	No pelicans observed.
July 24	0905–0920	No pelicans observed.
	1005–1020	No pelicans observed.
	1110–1125	No pelicans observed.
August 6	1340–1355	3 pelicans soar over Big Island Lake, leaving loafing ara.
	1512–1527	No pelicans observed.
	1635–1650	2 pelicans fly north arrive at Big Island Lake loafing area.
August 7	1105–1120	No pelicans observed.
	1300–1315	2 pelicans fly north, land at Big Island Lake.
	1505–1520	1 pelican flies north, lands at Big Island Lake. 1 pelican flies south from Big Island Lake.
	1615–1630	No pelicans observed.
	1745–1802	No pelicans observed.
August 8	0855–0910	No pelicans observed.
	1030–1045	No pelicans observed.
	1145–1200	3 pelicans flying north.
	1348–1403	No pelicans observed.
	1445–1500	No pelicans observed.
	1643–1658	No pelicans observed.
	2035–2050	1 pelican flies north to Big Island Lake.

continued...

Table 16. Concluded.

Date	Time	Observation
August 9	0750-0805	No pelicans observed.
	0845-0900	No pelicans observed.
	1020-1035	No pelicans observed.
	1130-1145	No pelicans observed.
	1300-1315	No pelicans observed.
	1420-1435	No pelicans observed.
	1545-1600	4 pelicans fly to Big Island Lake.
	1710-1725	No pelicans observed.
August 11	0947-1002	5 pelicans fly to south from Big Island Lake.
August 25	1103-1118	No pelicans observed.
	1314-1329	No pelicans observed.

9. AOSERP RESEARCH REPORTS

1.		AOSERP First Annual Report, 1975
2.	AF 4.1.1	Walleye and Goldeye Fisheries Investigations in the Peace-Athabasca Delta--1975
3.	HE 1.1.1	Structure of a Traditional Baseline Data System
4.	VE 2.2	A Preliminary Vegetation Survey of the Alberta Oil Sands Environmental Research Program Study Area
5.	HY 3.1	The Evaluation of Wastewaters from an Oil Sand Extraction Plant
6.		Housing for the North--The Stackwall System
7.	AF 3.1.1	A Synopsis of the Physical and Biological Limnology and Fisheries Programs whithin the Alberta Oil Sands Area
8.	AF 1.2.1	The Impact of Saline Waters upon Freshwater Biota (A Literature Review and Bibliography)
9.	ME 3.3	Preliminary Investigations into the Magnitude of Fog Occurrence and Associated Problems in the Oil Sands Area
10.	HE 2.1	Development of a Research Design Related to Archaeological Studies in the Athabasca Oil Sands Area
11.	AF 2.2.1	Life Cycles of Some Common Aquatic Insects of the Athabasca River, Alberta
12.	ME 1.7	Very High Resolution Meteorological Satellite Study of Oil Sands Weather: "A Feasibility Study"
13.	ME 2.3.1	Plume Dispersion Measurements from an Oil Sands Extraction Plant, March 1976
14.		
15.	ME 3.4	A Climatology of Low Level Air Trajectories in the Alberta Oil Sands Area
16.	ME 1.6	The Feasibility of a Weather Radar near Fort McMurray, Alberta
17.	AF 2.1.1	A Survey of Baseline Levels of Contaminants in Aquatic Biota of the AOSERP Study Area
18.	HY 1.1	Interim Compilation of Stream Gauging Data to December 1976 for the Alberta Oil Sands Environmental Research Program
19.	ME 4.1	Calculations of Annual Averaged Sulphur Dioxide Concentrations at Ground Level in the AOSERP Study Area
20.	HY 3.1.1	Characterization of Organic Constituents in Waters and Wastewaters of the Athabasca Oil Sands Mining Area
21.		AOSERP Second Annual Report, 1976-77
22.		Alberta Oil Sands Environmental Research Program Interim Report to 1978 covering the period April 1975 to November 1978
23.	AF 1.1.2	Acute Lethality of Mine Depressurization Water on Trout Perch and Rainbow Trout
24.	ME 1.5.2	Air System Winter Field Study in the AOSERP Study Area, February 1977.
25.	ME 3.5.1	Review of Pollutant Transformation Processes Relevant to the Alberta Oil Sands Area

26. AF 4.5.1 Interim Report on an Intensive Study of the Fish Fauna of the Muskeg River Watershed of Northeastern Alberta
27. ME 1.5.1 Meteorology and Air Quality Winter Field Study in the AOSERP Study Area, March 1976
28. VE 2.1 Interim Report on a Soils Inventory in the Athabasca Oil Sands Area
29. ME 2.2 An Inventory System for Atmospheric Emissions in the AOSERP Study Area
30. ME 2.1 Ambient Air Quality in the AOSERP Study Area, 1977
31. VE 2.3 Ecological Habitat Mapping of the AOSERP Study Area: Phase I
32. AOSERP Third Annual Report, 1977-78
33. TF 1.2 Relationships Between Habitats, Forages, and Carrying Capacity of Moose Range in northern Alberta. Part I: Moose Preferences for Habitat Strata and Forages.
34. HY 2.4 Heavy Metals in Bottom Sediments of the Mainstem Athabasca River System in the AOSERP Study Area
35. AF 4.9.1 The Effects of Sedimentation on the Aquatic Biota
36. AF 4.8.1 Fall Fisheries Investigations in the Athabasca and Clearwater Rivers Upstream of Fort McMurray: Volume I
37. HE 2.2.2 Community Studies: Fort McMurray, Anzac, Fort MacKay
38. VE 7.1.1 Techniques for the Control of Small Mammals: A Review
39. ME 1.0 The Climatology of the Alberta Oil Sands Environmental Research Program Study Area
40. WS 3.3 Mixing Characteristics of the Athabasca River below Fort McMurray - Winter Conditions
41. AF 3.5.1 Acute and Chronic Toxicity of Vanadium to Fish
42. TF 1.1.4 Analysis of Fur Production Records for Registered Traplines in the AOSERP Study Area, 1970-75
43. TF 6.1 A Socioeconomic Evaluation of the Recreational Fish and Wildlife Resources in Alberta, with Particular Reference to the AOSERP Study Area. Volume I: Summary and Conclusions
44. VE 3.1 Interim Report on Symptomology and Threshold Levels of Air Pollutant Injury to Vegetation, 1975 to 1978
45. VE 3.3 Interim Report on Physiology and Mechanisms of Air-Borne Pollutant Injury to Vegetation, 1975 to 1978
46. VE 3.4 Interim Report on Ecological Benchmarking and Biomonitoring for Detection of Air-Borne Pollutant Effects on Vegetation and Soils, 1975 to 1978.
47. TF 1.1.1 A Visibility Bias Model for Aerial Surveys for Moose on the AOSERP Study Area
48. HG 1.1 Interim Report on a Hydrogeological Investigation of the Muskeg River Basin, Alberta
49. WS 1.3.3 The Ecology of Macrobenthic Invertebrate Communities in Hartley Creek, Northeastern Alberta
50. ME 3.6 Literature Review on Pollution Deposition Processes
51. HY 1.3 Interim Compilation of 1976 Suspended Sediment Date in the AOSERP Study Area
52. ME 2.3.2 Plume Dispersion Measurements from an Oil Sands Extraction Plan, June 1977

53.	HY 3.1.2	Baseline States of Organic Constituents in the Athabasca River System Upstream of Fort McMurray
54.	WS 2.3	A Preliminary Study of Chemical and Microbial Characteristics of the Athabasca River in the Athabasca Oil Sands Area of Northeastern Alberta
55.	HY 2.6	Microbial Populations in the Athabasca River
56.	AF 3.2.1	The Acute Toxicity of Saline Groundwater and of Vanadium to Fish and Aquatic Invertebrates
57.	LS 2.3.1	Ecological Habitat Mapping of the AOSERP Study Area (Supplement): Phase I
58.	AF 2.0.2	Interim Report on Ecological Studies on the Lower Trophic Levels of Muskeg Rivers Within the Alberta Oil Sands Environmental Research Program Study Area
59.	TF 3.1	Semi-Aquatic Mammals: Annotated Bibliography
60.	WS 1.1.1	Synthesis of Surface Water Hydrology
61.	AF 4.5.2	An Intensive Study of the Fish Fauna of the Steepbank River Watershed of Northeastern Alberta
62.	TF 5.1	Amphibians and Reptiles in the AOSERP Study Area
63.	ME 3.8.3	Calculate Sigma Data for the Alberta Oil Sands Environmental Research Program Study Area.
64.	LS 21.6.1	A Review of the Baseline Data Relevant to the Impacts of Oil Sands Development on Large Mammals in the AOSERP Study Area
65.	LS 21.6.2	A Review of the Baseline Data Relevant to the Impacts of Oil Sands Development on Black Bears in the AOSERP Study Area
66.	AS 4.3.2	An Assessment of the Models LIRAQ and ADPIC for Application to the Athabasca Oil Sands Area
67.	WS 1.3.2	Aquatic Biological Investigations of the Muskeg River Watershed
68.	AS 1.5.3 AS 3.5.2	Air System Summer Field Study in the AOSERP Study Area, June 1977
69.	HS 40.1	Native Employment Patterns in Alberta's Athabasca Oil Sands Region
70.	LS 28.1.2	An Interim Report on the Insectivorous Animals in the AOSERP Study Area
71.	HY 2.2	Lake Acidification Potential in the Alberta Oil Sands Environmental Research Program Study Area
72.	LS 7.1.2	The Ecology of Five Major Species of Small Mammals in the AOSERP Study Area: A Review
73.	LS 23.2	Distribution, Abundance and Habitat Associations of Beavers, Muskrats, Mink and River Otters in the AOSERP Study Area, Northeastern Alberta
-	--	Interim Report to 1978
74.	AS 4.5	Air Quality Modelling and User Needs
75.	WS 1.3.4	Interim report on a comparative study of benthic algal primary productivity in the AOSERP study area

76.	AF 4.5.1	An Intensive Study of the Fish Fauna of the Muskeg River Watershed of Northeastern Alberta
77.	HS 20.1	Overview of Local Economic Development in the Athabasca Oil Sands Region Since 1961.
78.	LS 22.1.1	Habitat Relationships and Management of Terrestrial Birds in Northeastern Alberta.
79.	AF 3.6.1	The Multiple Toxicity of Vanadium, Nickel, and Phenol to Fish.
80.	LS 22.3.1	Biology and Management of Peregrin Falcons (*Falco peregrinus anatum*) in Northeastern Alberta.
81.	LS 22.1.2	Species Distribution and Habitat Relationships of Waterfowl in Northeastern Alberta.
82.	LS 22.2	Breeding Distribution and Behaviour of the White Pelican in the Athabasca Oil Sands Area.
83.	LS 22.2	The Distribution, Foraging Behaviour, and Allied Activities of the White Pelican in the Athabasca Oil Sands Area.

These reports are not available upon request. For further information about availability and location of depositories, please contact:

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