FINAL PROJECT REPORT

MUSKRAT HARVEST AND MANAGEMENT ON OLD CROW FLATS

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1.0 INTRODUCTION

Muskrat trapping on the Old Crow Flats is a traditional activity for the Vunta Kutchin; a social ritual considered equally as important for cultural reason as for economic opportunities (Murphy 1986). The people of Old Crow have traditionally re-located to the Old Crow Flats each early spring when the days become longer and the weather more hospitable. The public school closed early for summer holidays simply due to a shortage of students (Stephen Frost, pers. comm.). Historically, access to the Flats was by dog team, and later by snowmobile, in April and May. Most of the people returned to the community mid to late June by boat. Today much of the travel is by bush plane.

Families occupy traditional "ratting" camps each year. Trapping activities are concentrated in the central flats. Some of the trappers visit the area during early winter to mark the pushups that will be obscured by snow in spring (Charlie Peter Charlie, pers. comm.). In addition to muskrat harvesting, the people also hunt big game animals and waterfowl. Muskrats were traditionally a major part of the people's diet this time of year (Murphy 1986) and are still consumed on occasion. Equally as important, though, is the cultural and social value of being on the Flats and simply enjoying the arrival of spring.

The number of trappers (family members) "ratting" has decreased in more recent years as has the number of muskrats harvested (Table 1). Employment options for young adults has increased with a surge in the local construction industry. Also, Murphy (1986) reported that with increased access to bush planes, less time was being spent ratting by individual trappers. The annual muskrat harvest from the Old Crow Flats has constituted up to 75% of the total value of the Old Crow fur harvest as well as 75% of the total Yukon muskrat harvest. In recent years the harvest has been 10–20,000 animals (Table 1), while harvests over 30,000 were common prior to 1930.

TABLE 1 Muskrat harvest and value, and number of trappers on the Old Crow Flats, 1977-78 to 1987-88.

Season	Harvest	Avg. Pelt Value ($)	Total Value ($)	# of Trappers
1977-78	9,192	4.0	36,768	66*
1978-79	15,277	5.7	87,079	64*
1979-80	7,876	6.0	47,256	11
1980-81	11,002	6.0	66,012	52
1981-82	10,852	2.8	30,386	31
1982-83	18,639	3.3	61,508	30
1983-84	11,693	2.8	32,740	30
1984-85	7,467	3.0	22,401	24
1985-86	5,204	2.8	14,571	17
1986-87	8,192	4.8	39,322	27
1987-88	4,364	4.8	20,947	17

* Total number of licensed trappers in Old Crow. As indicated by other years, not all licensed trappers went spring "ratting". On the other hand, many licensed muskrat trappers are accompanied by unlicensed trappers ≤ 16 years of age.

The muskrat harvest potential of the Flats and the impact of the present harvest regime have never been assessed. Basic to the management of the Old Crow Flats muskrat population is an understanding of basic demographic and reproductive features of the population and the development of a reliable technique for monitoring the population levels. Although Slough (1982) and Slough and Jessup (1984) have used aerial surveys of muskrat pushups to assess muskrat densities, the reliability of the technique has not been tested. Similarly, the effects of harvest pressure on northern muskrat population dynamics have never been assessed. Finally, improper harvesting and pelt handling techniques by Old Crow trappers, including the late spring trapping season have been blamed by fur auction houses for resulting in significant economic loss.

The objectives of this study, therefore, were:

1) to test the validity of the muskrat censusing technique presently used in the Yukon;

2) to document the demographic and reproductive characteristics of the Old Crow Flats muskrat population;

3) to assess the muskrat population response to harvest;

4) to report changes in pelt quality and value relative to time of harvest and harvest method; and

5) to provide recommendations for future muskrat harvest management for the Old Crow Flats.

Sections 3.0 to 7.0 will deal with these objectives individually.

2.0 STUDY AREA

The Old Crow Flats is a 518,000 ha lacustrine basin located in northern Yukon (Figure 1) (68° 05' N, 140° 05' W). A brief biophysical description is given by Oswald and Senyk (1977). The basin is about 305m a.s.l., surrounded by uplands up to 600m elevation. Average annual precipitation varies from 170–250mm and the mean annual temperature is -9C to -12C. Drainage of the flats is by the Old Crow River, a tributary of the Porcupine River, the current and historical water route to the Flats from Old Crow, 80 km south of the study area. Indians of Old Crow are Loucheux Indians of the Vunta and Tukkuth Kutchin tribes, a sub-group of the Northern Athapaskan Indians. The 1983 population was approximately 236 people, including 169 Indians, 48 Métis and 19 Whites (Murphy 1986).

Terrestrial vegetation of the area consists primarily of black and white spruce (*Picea mariana* and *P. glauca* respectively). Paper birch (*Betula papyrifera*), balsam poplar (*Populus balsamifera*) and trembling aspen (*P. tremuloides*) are abundant in successional stands adjacent to some lakes. Shrub birch (*B. glandulosa*) and willow (*Salix* spp.) form extensive thickets throughout the basin and extend above treeline. Treeline roughly bisects the Flats, NW to SE.

Old Crow Flats has approximately 389,000 ha of small thermokarst lakes which are suitable for muskrat habitation due to adequate water depth and the presence of abundant submergent vegetation, dominated by *Potomogeton* and *Myriophyllum* spp. Emergent vegetation is *Carex* spp. Waterfowl are also abundant in the wetlands. A typical boreal forest fauna is present, however barren ground caribou (*Rangifer tarandus pearyi*) is a migratory inhabitant in the spring and fall seasons.

Figure 1 Old Crow Flats Study Area.

3.0 USE OF AERIAL PUSHUP COUNTS AS AN INDEX OF MUSKRAT POPULATION DENSITY.

3.1 Introduction

Determination of population densities is one of the most critical, and difficult aspects of species management (Norton-Griffiths 1978). For the muskrat, this problem is exacerbated by the small body size and its crepuscular, semi-aquatic nature (Perry 1982). Counts of muskrat pushups and houses have been used as an index of population size, and status (Dozier 1948; Parker and Maxwell 1980, 1984; Proulx and Gilbert 1984). Counts usually include numbers of occupied nesting houses and feeding huts, and may be from the ground, air, or with remote sensing (Mackay 1976) using a variety of sampling strategies. Densities are often determined by counting houses and multiplying by the mean number of animals/house as determined from relevant live-trapping studies. Generally, it is recognized that although house counts may be useful as a relative index to monitor yearly variation in population numbers within defined areas, or to indicate potential harvest regions, they cannot be used to empirically determine densities due to annual variation in the mean number of muskrats/house. Cowan (1948) proposed that the number of pushups on the MacKenzie Delta may be directly related to muskrat population size. Pushups differ from houses in being temporary feeding structures utilized only during the winter (see Stevens 1953 for a description) to increase the foraging radius of muskrats. In northern areas muskrats build pushups only, in response to the scarcity of house-building materials, thus eliminating the problem of distinguishing between houses and pushups. As well, the pushup technique does not ignore the burrow dwelling component of the population as is the case with house counts.

Recently there has been extensive effort invested in using aerial surveys of muskrat pushups (Slough 1982, Slough and Jessup 1984) to assess muskrat densities. To date however, the validity of this technique has not been assessed, and its usefulness has been questioned due to variation in the proportion of pushups actually used by muskrats, and variation in the number of muskrats using each pushup (Stevens 1953). The ability to detect pushups accurately may vary between years at the same sites. There are no empirical data available to evaluate the accuracy of pushup counts as a means of estimating muskrat populations. The objective of this portion of the study was to assess the validity of using aerial counts of muskrat pushups as an independent measure of muskrat abundance. First, the nature of the relationship between aerial and ground counts of pushups was determined. Second, the relationship between known muskrat numbers and aerial and ground counts of pushups was investigated, along with an assessment of pushup use by muskrats.

3.2 Methods

Aerial counts of pushups were conducted on May 29, 1985 and June 6, 1986 when snow melt was sufficient to reveal the pushups before the ice had melted. Pushups were recognized from the air by the presence of a plunge hole and aquatic vegetation on the surface (Stevens 1953). Two observers made total counts of pushups on 30 selected lakes or delineated portions (eg. bays) of lakes, from a Cessna 185 flying at a mean altitude of 90 m, and airspeed of 145 kph. The technique used was similar to that used when censusing the entire study area (Section 4.2). The number of pushups counted was then compared to the known number of pushups as determined by surveying the selected areas on foot and counting all pushups.

The numbers of muskrats present were determined by livetrapping on six of the areas aerial and ground surveyed for pushups April through September 1985 and 1986. Single door Tomahawk livetraps (15.2 x 15.2 x 45.7 cm) were baited with apple. During the ice-free periods (June –Sept.), traps were placed on feeding sites along the shore of the lakes and in the vicinity of burrow openings. During the periods of ice cover, traps were placed within the pushups themselves and then covered with snow. Traps were checked every eight hours and remained set for 24 hours each day. Captured animals were marked with a numbered #1 monel ear tag (National Band and Tag Company, Newport, KT), weighed with a Pesola spring scale, sexed and released at the capture site. Traps remained set until >70% of captures were animals previously captured during the current trapping session. Removal trapping was done during the 1986 spring season on 11 of the 30 areas surveyed from the air. Victor #1 longspring and coilspring traps were placed within the pushup. Traps were checked every eight hours over a 72-hour period. All captured animals were weighed and sexed.

Estimates of minimum number alive were based on the number of known individuals present at each site. Population estimates were calculated using a variable capture probability model (White *et al* 1982). Livetrapping sessions varied from 5-11 days during which minimal dispersal occurred, therefore justifying the use of a closed population model to estimate density.

3.3 Results

There was a significant positive relationship between the aerial and ground counts of pushups (Figure 2; for 1985, R^2= 0.92, P=0.001 and for 1986, R^2=0.85, P=0.001). A comparison of slopes indicated the relationship was significantly different between years (t=5.63, $P < 0.001$). Pushup ground counts were significantly correlated with the minimum number of muskrats alive in spring (R^2=0.46, P=0.045, n=8). Ground pushup numbers and muskrat population estimates also were correlated significantly (R^2=0.58, P=0.028, n=8). Aerial pushup counts and population estimates were also significantly correlated (R^2=0.57, P=0.03). From ground counts of 11 additional areas, 19.15 to 92.86% ($\bar{x}$=53.95%) of pushups found were active with open plunge holes.

Assessment of pushup use data for 90 livetrapped individuals indicated that muskrats use 1-6 pushups ($\bar{x}$=2.13), with the majority of individuals feeding at 1–3 pushups (Figure 3). During kill trapping, 40 of 57 (70.2%) of the pushups trapped yielded only a single animal (Figure 4), whereas 23.6% of the livetrapped pushups yielded just one animal. This difference is attributed to the greater trapping effort (ie. >72 hours) devoted to livetrapping. The number of individual muskrats livetrapped at a single pushup ranged from 1 to 10 (Figure 5; $\bar{x}$=4.67)

3.4 Discussion

Counts of muskrat houses and pushups are widely used as an index of population density by wildlife managers. However, the validity of this technique has been questioned due to the problems in 1) obtaining an accurate count of the structures, 2) distinguishing between houses and pushups, 3) variation in the number of muskrats utilizing each structure, 4) biases introduced by variation in pushup freeze-out (Stevens 1953, Ruttan 1974).

Figure 2 Relationship between ground and aerial counts of muskrat pushups.

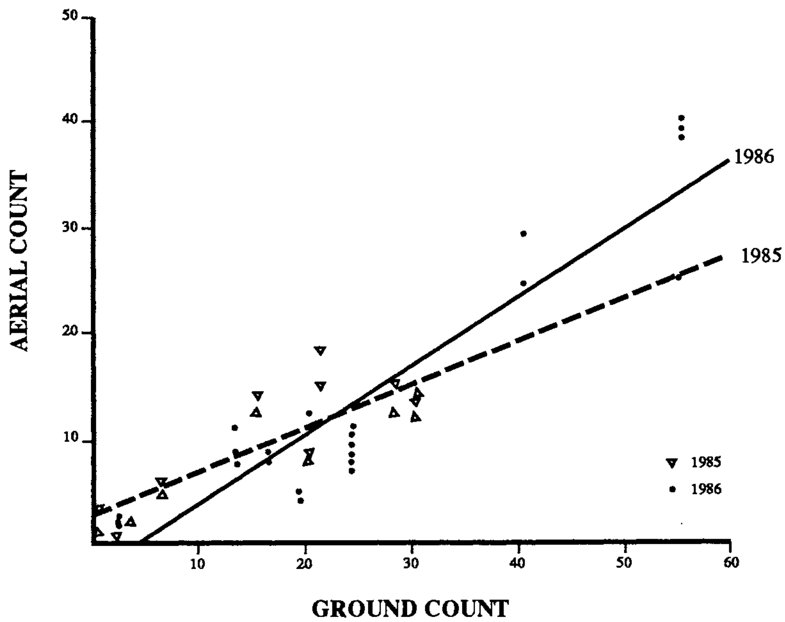


Figure 3 Number of pushups at which individual muskrats were live-captured.

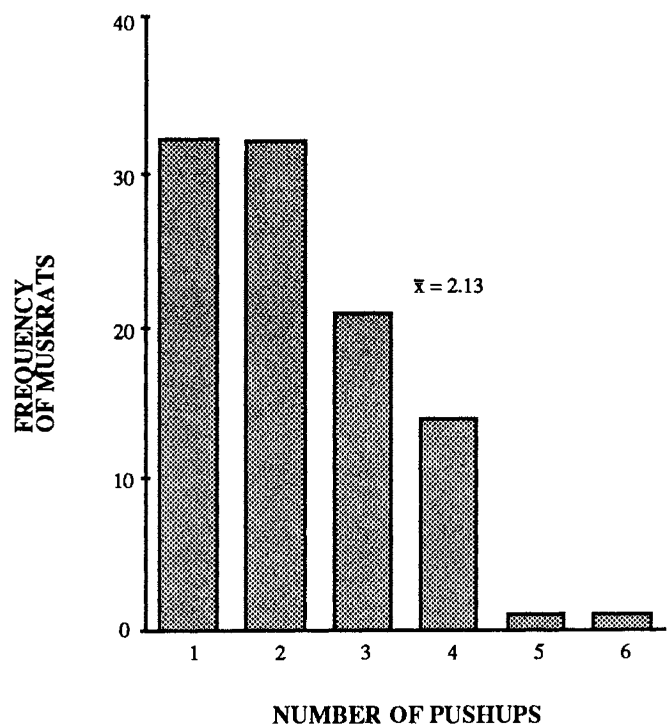


Figure 4 Number of muskrats removed/pushup over a 72-hour period.

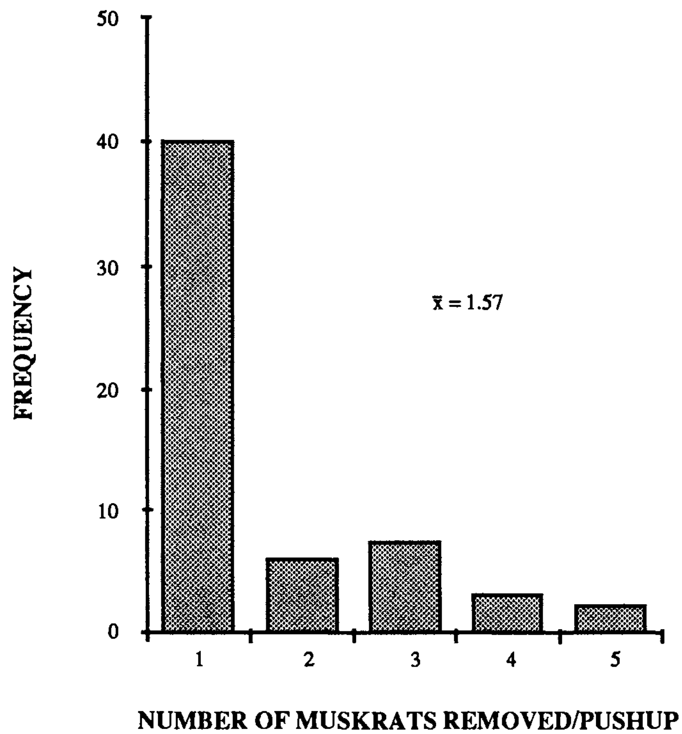
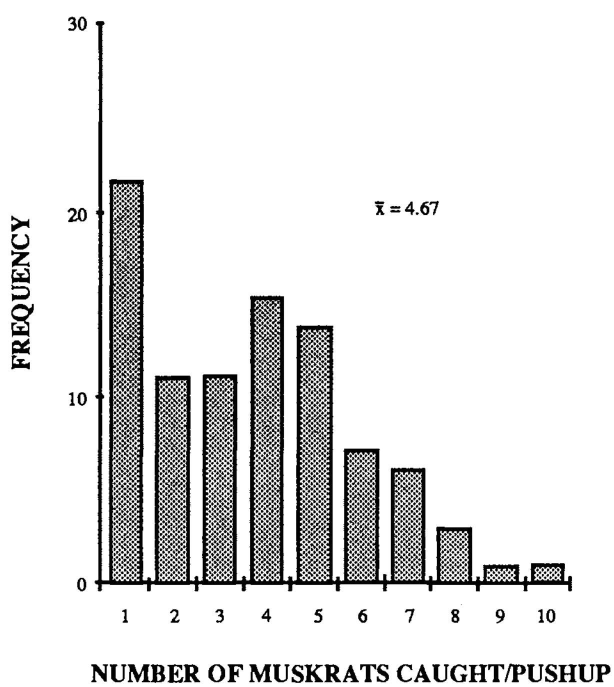


Figure 5 Number of muskrats caught at one pushup during livetrapping.



We found that an accurate count of muskrat pushups in the spring was possible on Old Crow Flats using aerial surveys. Timing of the surveys was critical in order to coincide with the period of snow melt, when pushups were highly visible on the ice. An advantage of using pushup counts over house counts (used in southern management areas) was increased accuracy. All muskrats dwell in bank dens and use pushups as feeding structures at Old Crow. Therefore, counts of pushups do not exclude a portion of the population as does the use of house counts, which doesn't account for the bank dwelling portion of the population.

Stevens (1953) found that 1 to 16 (x=6.0) muskrats used each active pushup on the MacKenzie Delta while an individual muskrat may use as many as three pushups within a radius of 120m. Pushups on Old Crow Flats were utilized by 1 to 10 muskrats (x=4.67) and individual muskrats used as many as six pushups, which is similar to Ruttan's (1974) findings for the same area.

Freeze-out of muskrat pushups will occur if they are not maintained by constant use (MacArthur 1978), or if the insulative snow/ice barrier is disturbed. Stevens (1953) reported that only 33 to 48% of the pushups were active on the MacKenzie Delta. Westworth (1977) reported 44 to 55% active in the same area in late winter. Similarly, Ruttan (1974) found that less than 50% of the pushups were active on Old Crow Flats; similar to the 53% of active pushups found in this study. The majority of pushups which were frozen in this study showed signs of disturbance by mink (*Mustela vison*), fox (*Vulpes vulpes*) or caribou.

Utilization of pushup counts as a rough index of spring population size for monitoring large variations in population numbers within defined areas appears feasible. It is possible to obtain accurate counts of pushups from aerial surveys by the correlation between ground and aerial counts of pushups. Although useful as an index, aerial counts alone cannot be used to accurately calculate the actual densities of muskrats. The difference between air and ground counts of pushups between 1985 and 1986, indicated that annual ground surveys are necessary before one can compare differences between years. The relationship between pushup numbers and the minimum number of muskrats alive was significant, but only 46% of the variation was explained by the regression line. Similarly, although the relationship between aerial/ground pushup counts and the muskrat population estimates was significant, only 57-58% of the variation about the regression was explained.

The unexplained variation around the regression lines can probably be attributed to the variation in the number of muskrats per pushup, and variation in the number of pushups used per animal. These factors, as well as the difficulty in identifying active and frozen pushups from the air, make density estimates based upon simple conversion factors inaccurate. There is still no method to accurately determine muskrat densities without intensive livetrapping studies.

4.0 DEMOGRAPHY OF THE NORTHWESTERN MUSKRAT ON OLD CROW FLATS

4.1 Introduction

The demographic and reproductive features of the Old Crow Flats muskrat population were determined through livetrapping and systematic aerial surveys. The findings are discussed relative to those of previous studies of the northwestern muskrat.

4.2 Methods

Livetrapping was conducted at the six areas described in Section 3.2 from June through August 1984, and April through September 1985 and 1986, and at five other areas on the Flats in 1984. Density of muskrats was calculated using the Jackknife (White *et al.* 1982) estimates of population size. Production of juveniles was determined from *in utero* embryo and placental scar counts of trapper-killed females. The initiation of breeding was determined by the reproductive status of the livetrapped individuals. This was assessed in females by the presence/absence of conspicuous teats, and the condition of the vagina (perforate/non-perforate), and in males by the position of the testes (scrotal/abdominal). Age was determined by pelage characteristics; the adult pelage is a characteristic brown colour with long guard hairs, whereas juveniles have a gray-brown pelt (Schwartz and Schwartz 1959). The emergence of juveniles from the burrow was assumed to coincide with dates when they were first trapped. Growth rates of livetrapped adults and juveniles were calculated from the difference in weight between successive captures. Similarly, muskrat movements were calculated from the linear distance between pushup capture sites. Estimates of minimum overwinter survival rate were calculated by the number of tagged individuals surviving overwinter to be captured the following spring.

Eighteen systematic north-south aerial transects, five km apart, and 40 to 70 km in length were flown in 1984, 1985 and 1986 over the entire Old Crow Flats (Figure 1). Transects were flown when snow melt was sufficient to reveal the pushups before the ice had melted (May 24-25, 1984; May 28-29, 1985; June 5-6, 1986). Transects were flown in a Cessna 185 fixed-wing aircraft, flying at 145 km/h and an average altitude of 90m. Transect boundaries were defined by metal rods placed on the wing struts through which the observer could delineate the sample area. Transect width was standardized at 250–300m by flying over ground markers spaced at 25m intervals and adjusting the height above the ground accordingly. The number of pushups observed within the transect were recorded at two minute intervals to obtain a geographic trend in pushup numbers across the Flats. Data from the transect counts was analyzed by the Jolly technique (Norton-Griffiths 1978) for unequal sample units, to account for variability in transect length and, hence, area. To derive a rough estimate of muskrat numbers, the number of pushups was multiplied by a conversion factor of 2.19 which accounts for the mean number of muskrats utilizing one pushup and the mean number of pushups used by each muskrat (as presented in Section 3.3). Association of transect counts between years was analyzed using the Spearman rank correlation coefficient (Daniel 1978), to discern any trend in muskrat abundance over the Flats.

4.3 Results

Spring muskrat population densities in 1985 and 1986 varied from 0.93 animals/ha to 4.46 animals/ha between years (Table 2), and were not significantly different. Sex ratios in the livetrapped areas varied between sites, ranging from 62-270 males per 100 females (Table 3). Overall, the sex ratio of livetrapped animals was 103 males per 100 females. The sex ratio of harvested spring muskrats was 130:100 males per females. On Site two the number of juveniles per adult female increased between 1985 and 1986 (Table 4), whereas this ratio decreased on the other sites.

Breeding on the Flats was initiated at the beginning of June in all three years. Females in the kill-trapped sample had well developed embryos ($\bar{x}$=7.5 ± 0.79, n=11 in 1984 and $\bar{x}$=7.86 ± 0.64, n=8 in 1985) at the conclusion of the spring trapping season (June 15). In 1985 and 1986, the breeding season appeared to be delayed; most females showed younger embryos by the end of the spring harvest. Production (estimated from placental scars) indicated a mean number of offspring per adult female of 7.75 ± 2.6 in both 1985 (n=59) and 1986 (n=44) (Figure 6). None of the juveniles removed in the spring from trapped areas showed placental scars.

In 1984, juveniles first appeared in the livetrapping sample on August 6. In 1985 and 1986, juveniles first appeared on August 11 and August 7 respectively. Weight of juveniles at first capture was 308 ± 0.06 g (n=14) (Figure 7). Adult muskrats had a lower growth rate ($\bar{x}$=3.98, n=50) than juveniles ($\bar{x}$=4.11, n=63) (F=9.54, P=0.003). There was no significant effect of sex on growth rate.

TABLE 2 Muskrat Density Estimates

JACKKNIFE DENSITY ESTIMATES (muskrats/ha)

	1985		1986	
SITE	SPRING	FALL	SPRING	FALL
1	3.65	7.67	4.46	8.95
2	2.33	2.56	1.67	3.33
3	-	5.15	0.93	2.69
4	-	8.88	3.28	4.00
average	2.99	6.07	2.58	4.74

MNA DENSITY ESTIMATES (muskrats/ha)

	1985		1986	
SITE	SPRING	FALL	SPRING	FALL
1	1.05	5.49	4.47	5.56
2	1.22	2.17	1.67	2.56
3	-	3.62	0.93	1.95
4	-	5.52	1.60	2.52
average	1.14	4.20	2.17	3.15

TABLE 3 Sex ratios of livetrapped populations (males/100 females)

	1985			1986		
SITE	JUV	ADULT	BOTH	JUV	ADULT	BOTH
1	94	92	94	170	102	126
2	60	64	62	143	88	113
3	187	113	161	133	100	106
4	85	67	79	69	100	84
average			99			107.4

TABLE 4 Juveniles captured per adult female

SITE	1985	1986
1	6.08	3.22
2	1.78	6.33
3	5.25	0.80
4	4.10	1.83

Figure 6 Frequency distribution of the number of placental scars of female muskrats removed on Old Crow Flats. Data for 1985 and 1986 combined.

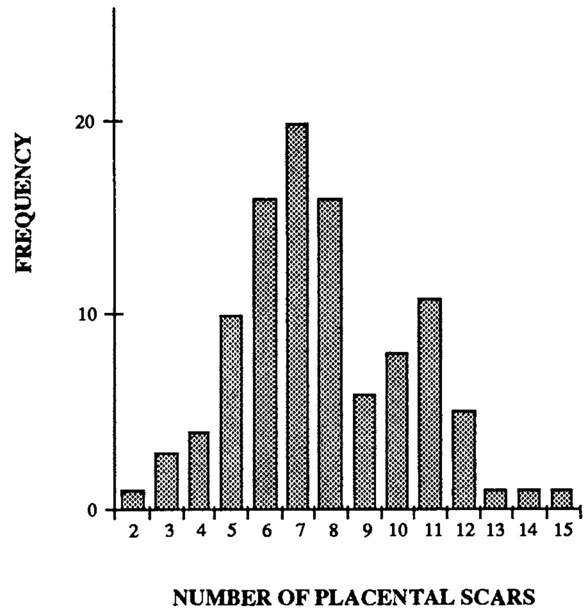
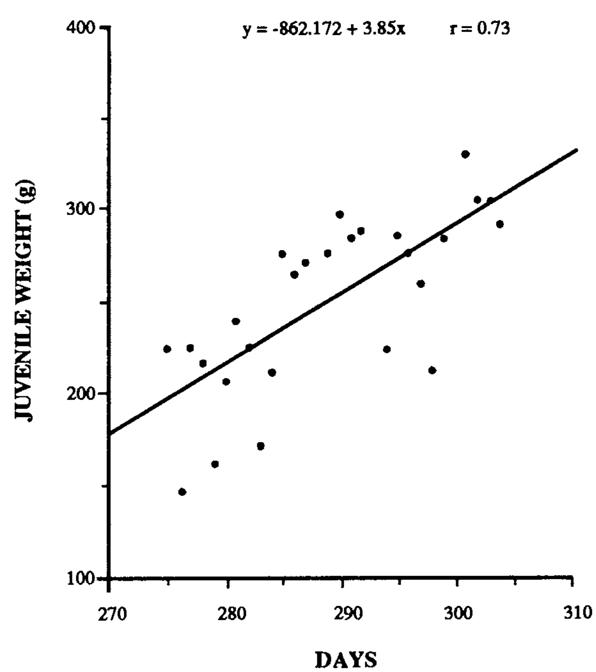


Figure 7 Trend in juvenile weight change, August 1-29, 1986.



Overwinter survival varied from 12 to 43% between areas ($\bar{x}$=28.29%). Mean juvenile survival (35.6%, n=212) was higher than mean adult survival (21.2%, n=113).

Mean distance between pushups was 66.2 m (10.5–248.6 m; Figure 8). The mean distance moved by muskrats between pushups was 53.77m (10.5 to 152.8m).

There was no significant difference in the number of pushups counted on Old Crow Flats in 1984 and 1985 (Table 5). However, there were significantly more pushups recorded in 1986 than in either 1984 or 1985. Estimates of the total muskrat population ranged from approximately 170,000 ± 31,600 in 1984 to 490,000 ± 164,000 in 1986.

There was no significant difference between years in the pattern of muskrat abundance across the Flats (Table 6). The geographic distribution of transect pushup counts over the Old Crow Flats is displayed in Figure 9. High pushup numbers were found in the central Flats in 1984 and 1986, however this trend was not evident in 1985.

4.4 Discussion

Muskrat population density varies between vegetation/habitat types and geographic areas (Errington 1963). Reported densities range from 49 muskrats/ha in cattail (*Typha* spp.) marshes (Errington 1948) to 2.8 muskrats/ha in farm ponds (Beshears and Haugen 1953). Ruttan (1974) reported densities on Old Crow Flats, based on the minimum number alive, of 2.02 muskrats/ha. Population densities determined in this study were high; closely resembling those reported by Butler (1940) of 7.4/ha for sedge habitat. The mean interpushup distance of 66.2m was greater than that reported by Stevens (1953) (36.6m) or MacArthur and Aleksiuk (1979) (38.7m) for the MacKenzie Delta.

TABLE 5 **Census estimates of pushups and muskrats**

YEAR	N[1]	SE(Y)	Pushups/km^2	Y[2]	95%C.I.[3]	No. Muskrats[4]
1984	20	8322.49	16.08	77,545.8	18.6%Y	170,018.26
1985	20	7263.97	13.62	89,414.0	17.0%Y	196,039.15
1986	20	34051.00	33.80	221,812.5	33.8%Y	486,321.30

1. N=the number of transects flown.
2. Y=the push-up estimate derived from the analysis.
3. 95% C.I.=the 95% confidence interval around the estimate when expressed as a % of the estimate.
4. Calculated by multiplying the pushup estimate Y by 4.67 and dividing by 2.13. See text for explanation.

TABLE 6 **Spearman rank correlation coefficients for association of transect counts across the Flats.**

YEAR	1985	1986
1984	0.787	0.853
1985	-	0.794

Figure 8 Distribution of interpushup distances.

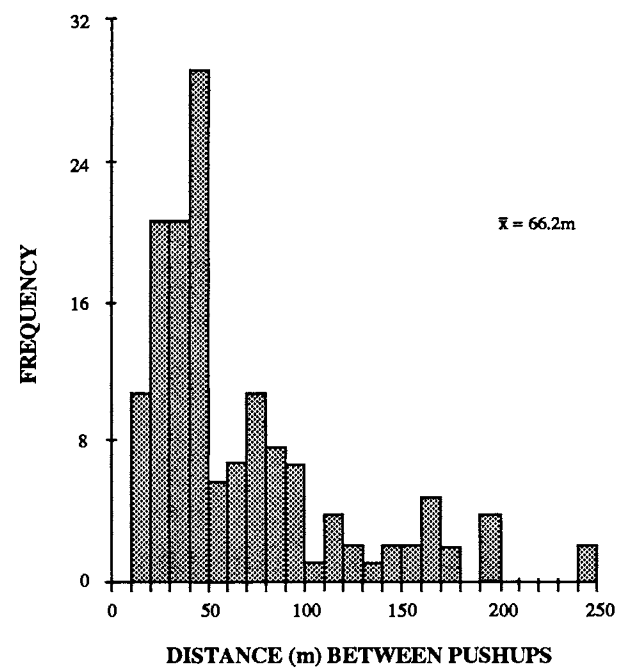
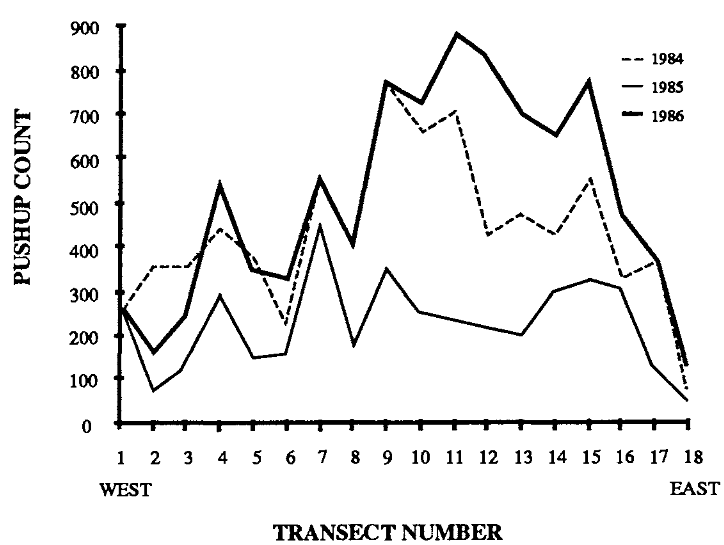


Figure 9 Geographic trends in pushup numbers on aerial survey transects on Old Crow Flats.



Male biased sex ratios are normally reported in muskrat populations (Perry 1982). Though variable in this study between sites and between years (62-161:100 for combined adults and juveniles), overall livetrapping sex ratios were close to unity (103:100). Ruttan (1974) found that sex ratios in livetrapped populations on Old Crow Flats varied from 89.7 - 131.7 males per 100 females. Male biased sex ratios in the spring harvested animals (130:100) on Old Crow Flats during this study compare to the sex ratios found on the Flats in the 1970s (113:100, 134:100, Ruttan 1974) and on the MacKenzie Delta (113:100, Stevens 1953). The male-biased sex ratio in harvested animals likely reflects the method of capture; Old Crow trappers usually attract muskrats by imitating the female call (Ruttan 1974). Males may also be moving greater distances during the breeding season.

Ruttan (1974) reported that the initiation of breeding on Old Crow Flats occurred in late May, with large numbers of embryos found in the females during the second week of June. The results of this study indicated that breeding began a few days later in 1985 and 1986 than in 1984 as suggested by the absence of embryos in trapped females. Onset of breeding is later on Old Crow Flats than on either the MacKenzie Delta (Stevens 1953) or the Peace-Athabasca Delta (Fuller 1951). This delay in breeding may be related to ice break-up. In the MacKenzie Delta, the ice moves out in the third or fourth week of May (Jelinski 1984), which is 3-4 weeks earlier than break-up on the Old Crow Flats.

Muskrat litter size and number of litters are considered to be influenced by latitude (Boyce 1977). Fewer but larger litters of young are expected in northern areas. Ruttan (1974) reported two litters per year on Old Crow Flats, which is similar to that reported by Stevens (1953) on the MacKenzie Delta. Stevens (1953) found, that yearling females produced one litter between mid-June and mid-July and that older females may have two. Precocial breeding did not occur on Old Crow Flats during the study and, contradictory to Ruttan's (1974) findings, we found that females produced only one litter per year. Due to the limited duration of the growing season, it appears that the production of more than one litter is not common, and precocial breeding is poorly adapted for the Flats.

Weight of juveniles at emergence was the same as that reported by Ruttan (1974). Parker and Maxwell (1980) in New Brunswick reported a similar mean weight of juveniles (200g) at first capture which is thought to approximate size at 30 days of age (Errington 1963). Growth rates in New Brunswick were higher than those found in this study (3.98g/day for combined sexes), being 10.7 and 6.7 g/day for males and females respectively. Lower growth rates in Old Crow may reflect the quality of habitat and food available, the submergent *Potomogeton* spp. in Old Crow being of lower nutritional value than the cattail (*Typha* spp.) present in the New Brunswick marsh. This study found no sexual bias in weight gain nor in weight at emergence.

Hawley (1968) reported overwinter survival of 20-40% on the MacKenzie Delta which is similar to that found in this study (28%). Stevens (1953) indicated that 50% of the juveniles perished at freeze-up on the MacKenzie Delta and reported that variation in overwinter survival between study areas is expected due to the variation in lake depth and ice formation.

Prior to this study, the data available on which to base management decisions for the Old Crow muskrat population were limited to that collected by Ruttan (1974). It now appears that the population dynamics of muskrats on Old Crow Flats is not as closely related to those of the MacKenzie Delta population as previously thought (Slough 1982). Most notable are the differences in the number of litters produced per year, and the timing of breeding. Management implications are discussed in Section 7.0.

5.0 MUSKRAT POPULATION RESPONCE TO HARVEST

5.1 Introduction

Few studies have examined the effects of harvest pressure on muskrat population dynamics (Parker and Maxwell 1984, Smith *et al.* 1981) and none have studied northern populations. Muskrats are considered by many wildlife mangers to be resilient to harvest (Lay 1945, Smith and Jordan 1976). It is believed that between 50 to 75% of the fall population can be harvested without deleterious effects on the population (Dozier 1948, Alexander 1955, Smith and Jordan 1976).

At present, the resiliency of muskrat populations to the effects of harvest (Errington 1963, Smith *et al.* 1981) is thought to occur by any of four mechanisms; increased precocial breeding (Parker and Maxwell 1984), increased litter production of adults (Olsen 1959), increased survival of remaining individuals (Errington 1963), or by increased immigration (Errington 1940). The objective of this portion of the study was to examine which, if any, of the above mechanisms may operate in the Old Crow muskrat population.

5.2 Methods

Four study sites were selected on the Old Crow Flats. In two cases, muskrats were removed to simulate the native harvest; on the other two areas, muskrats were not disturbed. Each trapped area was within 1 km of an untrapped area, and all areas were located within a 10 km radius (Figure 1). Prior to, and following the harvest treatment, all four areas were livetrapped using Tomahawk livetraps baited with apple. Two areas, one of each harvest treatment, were trapped simultaneously. Livetrapping was initiated in April and early May, continued until June 15 of 1985 and 1986, resumed in late July, and continued until September. Trapping sessions varied from 5-11 days, and ended when ≥70% of the animals previously trapped were recaptured. Traps were then moved to a new site. Each study site was trapped for at least two sessions during both the spring and fall periods. Trapping and handling methods, including sexing and aging, are given in Sections 3.2 and 4.2. An index of immigration was calculated by dividing the number of new adults captured (adults not previously counted) by the area (ha) of the study site.

Muskrats were removed from the two harvested areas during April, May and June of 1985 and 1986 and September 1986, by trapping muskrats in their pushups with #1 Victor longspring leghold traps, and by shooting. At least 50% of previously live-captured animals were removed on both areas. The tag number and age of each harvested animal were recorded. Weight was measured to the nearest five grams. Sex and reproductive condition were also recorded, as well as the number of embryos or placental scars present. The number of scars/female and the number of young livetrapped/adult female were used as measures of productivity. Carcasses of study area muskrats, obtained from native trappers in the spring of each year, were used to obtain embryo counts and to determine litter size.

5.3 Results

None of the 384 juveniles (young-of-the year) livetrapped in 1985 and 1986 had reproduced, nor did any juveniles removed in spring from trapped areas have placental scars. Mean placental scar counts were 9.2 ± 2.2 and 7.7 ± 2.4 on trapped and untrapped areas respectively, indicating that the number of juveniles produced by females, was not significantly different between trapped and untrapped areas (t=0.433, P=0.668). The overall mean was 8.47 ± 2.5 placental scars. More new adults were tagged on trapped than untrapped areas (Table 7). The immigration index for the two untrapped areas were 0.75 and 0.33; for the trapped areas these indices were 1.6 and 1.7 (Table 7). The difference between treatment means was significant (t=5.143, P=0.036). Overwinter survival was significantly greater on unharvested areas, than on harvested areas (Table 7).

TABLE 7 Number of new adults (captured for first time), immigration index (new adults/size of area) and overwinter survival for harvested and unharvested areas.

SITE	# new adults	area (ha)	Immigration index	Overwinter survival
Harvested	20	12.50	1.60	12.96%
	18	10.78	1.67	21.60%
Unharvested	10	13.30	0.75	43.30%
	3	9.00	0.33	35.30%

5.4 Discussion

The hypotheses of compensatory reproduction, precocial breeding and increased survival as mechanisms of population resiliency in northern muskrat populations were rejected. Trapped areas were repopulated by immigrating individuals, thus supporting the immigration hypothesis.

Precocial breeding has frequently been reported in muskrat populations. Parker and Maxwell (1984) noted precocial breeding occurred in 5% of juveniles sampled in a New Brunswick marsh. Similarly, Errington (1963) reported levels of precocial breeding as high as 5.3%.However, Smith *et al* (1981), in accordance with our findings, did not record precocial breeding in the Quinnipiac estuary near New Haven, Connecticut. At present, the existence of precocial breeding in muskrat populations is questionable (Moses and Boutin 1986).

Increases in muskrat litter size or in number of litters related to decreases in population density have been reported by Errington (1951) and by Olsen (1959). Compensatory reproduction has been proposed as a major mechanism of population regulation in muskrats. However, there was no significant difference in litter size between harvested and unharvested areas for the Old Crow population. Similar results were found by Parker and Maxwell (1984) in New Brunswick. Mean production estimated from placental scars indicated a mean number of offspring per female of 8.47 ± 2.5. This is not significantly different from the 7.8 ± 3.6 reported by Ruttan (1974) in another region of Old Crow Flats. However, annual production/female is significantly lower on Old Crow Flats when compared to more southern populations of muskrats where two or three litters per year are produced (Perry 1982). Therefore, though compensatory reproduction may be a mechanism for population maintenance in southern populations of muskrats, the constraints imposed by the length of the reproductive season make it unlikely in northern environments.

Based on predictions of the survival hypothesis, survival rates on harvested areas are expected to be greater than on unharvested areas (Errington 1963). Reduced overwinter survival on trapped areas in this study may indicate that a minimum population density is required to ensure overwinter survival. MacArthur (1978) found that access to winter forage was dependent upon maintaining active pushups. This, in turn, was facilitated by constant use of the pushup by muskrats on a rotational basis. Lower densities may, therefore, reduce winter foraging ability by limiting the number of open plunge holes. As indicated by Errington (1940) immigration into areas of reduced density may compensate for trapping mortality. The appearance of new adults in harvested areas after spring dispersal (Errington 1940) allows for repopulation of these areas without altering the reproductive schedules of resident animals. Mathiak and Linde (1954) found that repopulation of vacant muskrat habitat through immigration was unimportant in Wisconsin. Their study showed that less than one percent of tagged refuge individuals moved outside their area of capture. However, Parker and Maxwell (1984) estimated 20% of the spring population immigrated from trapped compounds in New Brunswick, indicating that spring dispersal may be of substantial benefit to areas of reduced density. The significantly higher influx of adult muskrats into the trapped areas of the present study indicated that refuges may have a significant impact on population maintenance. This could be especially important in populations where the short growing season precludes production of multiple litters or precocial breeding. The lack of immigration into trapped areas found in other studies may be a density dependent response, whereby the local higher densities block normal dispersal movement into those areas.

Dispersal and immigration are effective mechanisms by which low density northern areas can be quickly repopulated. Selected areas should therefore remain unharvested to act as refuges from which dispersing individuals can “seed” harvested areas. This trapping regime is different from that presently used by trappers on the Old Crow Flats, where the muskrat harvest is uniformly distributed within the trapping grounds within a trapping season.

6.0 TEMPORAL VARIATION IN MUSKRAT PELT QUALITY AND VALUE

6.1 Introduction

Although the northwestern muskrat, *Ondatra zibethicus spatulatus*, is smaller than either the *O.z. osoyoosensis* or the *O.z. alba* found in southern Canada, it's pelt is valued for its rich dark pelage and dense underfur (T. Pappas, president, Western Canadian Raw Fur Auction Sales Ltd., Vancouver, B.C., pers. comm.). However, improper harvesting and pelt handling techniques, combined with a late spring trapping season have often made the fur auctions comment on the money lost by late spring "ratting" techniques. Mr. Pappas (ibid.), considers the ideal season for muskrat trapping to be March through May (Table 8). He has repeatedly asked the Yukon Department of Renewable Resources to adjust the season to more accurately reflect pelt primeness. He has also encouraged the Yukon Trappers' Association to concentrate training workshops in Old Crow in an effort to enhance pelt handling techniques and harvesting methods.

TABLE 8 Seasonal variation in muskrat pelt quality

Season	Pelt Description	1984 Average Pelt Price
Early Winter (pre-March)	dark leather, light weight short, thin fur	$3.00
Late Winter/ early Spring (March, April, May)	heavy leather, colour is sharp, thick fur	$5.00
Late Spring (June)	thin leather, shedding, loss of colour, pelt damage due to fighting	$1.00

Source: Ted Pappas, Western Canadian Raw Fur Auction Sales Ltd., unpubl. data. Prices are estimated averages for Yukon and N.W.T. muskrats.

The most commonly used trap is the #1 1/2 single longspring leghold. It is placed inside the pushup near the plunge hole so that the muskrat retreats back into the water when caught and drowns due to the weight of the trap. A lighter trap (#1 or 0) fails to hold the animal down, thereby, increasing its chance of escape. However, the large majority of muskrats are harvested by shooting in open water in June with a .22 calibre rifle when the pelts are losing primeness and are often scarred from intra-specific fighting. Bullet damage further reduces pelt value. In addition, the spring muskrat harvest takes place after considerable overwinter mortality has occurred. Ideally, a fall or early winter harvest could remove a greater harvestable surplus (Parker and Maxwell 1984).

The objectives of this portion of the study were; 1) to examine pelt quality from September through June, and 2) to study the harvest methods employed in an effort to recommend new harvest strategies that will increase the revenue to trappers per muskrat and, ensure optimal utilization and conservation of the muskrat resource.

6.2 Methods

Muskrat pelts were collected during the fall, late winter and spring seasons to determine quality variation in pelt. Samples were obtained from kill-trapped study animals as well as from the harvest of several Old Crow trappers. All pelts were shipped to the Western Canadian Raw Fur Auction Sales Ltd. in Vancouver, British Columbia where they were professionally graded and sold.

Indian harvest techniques were observed during the late winter and early spring, 1985 to determine whether improvements could be made to the harvest efficiency and quality of the harvested pelt.

6.3 Results and Discussion

Although our September sample size was small (Table 9, n=10), there was no hesitation of the part of the fur grader to make a recommendation against an early fall season for muskrats. Mr. Pappas (pers. comm.) stated that he "was not very impressed with them. They are caught far too early and should be left alone for at least another month." An autumn season beginning in mid-October was recommended for New Brunswick by Parker and Maxwell (1984). They found that although autumn pelts were smaller, they realized a comparable monetary return to spring pelts, which had a high frequency of damage caused by fighting during the breeding season.

TABLE 9 Pelt grade and value for muskrats harvested during September 1985 from the Old Crow Flats.

Date Harvested	Sample size	Pelt grade	Value
10	1	very little fur, poor	$1.75
13	2	regular fur, fair	$2.75
15	1	regular fur, fair	$2.75
16	2	light coloured leather fair to poor	$2.75
18	2	large, poor fur	$1.75
		small, poor fur	$.50
26	2	very little fur, poor	$1.75

Poor fur quality is only one reason why a fall muskrat season is not practical. The lack of snow makes ground travel to the Old Crow Flats impossible this time of year. As well, bush planes are generally changing from floats to skis at this time, eliminating the option to fly to the Flats. The people of Old Crow are also busy hunting caribou that are migrating south, fishing and gathering firewood, all very much traditional, and necessary aspects of winter survival in this northern community. It is for this reason that a fall muskrat season, even if it were both practical and economical, would never be adopted (Stephen Frost, pers. comm.).

The pelts submitted by trappers during April through June could not be used to determine variance in pelt quality because the capture dates were lost during the grading process at the auction. However, the 72 muskrat pelts trapped from April 29 to May 31, 1986 by project staff were graded for pelt quality. There was no significant price difference between pelts taken before May 15 ($\bar{x}$=$4.74) and those take after May 15 ($\bar{x}$=$4.99) (Table 10). Several factors, including pelt size, quality (based on environmental conditions), and market demand could influence this. Our sample size was too small to make any definite conclusions.

TABLE 10 Price for muskrats harvested April – May 1986 from the Old Crow Flats.

Pelt Price	$6.35	$5.50	<$5.50		
Date	% Of Pelts			Mean	n
April 29 – May 14	30.4	17.4	52.2	$4.99	46
May 15 – May 31	15.4	50.0	34.6	$4.74	24

However, there are reasons why pelt quality should not start to deteriorate to any great degree until the end of May. Unlike the MacKenzie Delta where the ice breaks up in late May, most of the Old Crow Flats is frozen until early to mid June. This would certainly affect color and fur density as the muskrats, for the most part, are still under the ice and sheltered from the sun. There is also a delay in breeding and the pelt damage that breeding behaviour causes on the Old Crow Flats relative to the MacKenzie Delta (Section 4).

The muskrats taken during this study (Table 10) were also trapped; none were shot. Shooting is responsible for much of the damage inflicted on muskrat pelts taken late in the season. Shooting takes place more frequently after break-up in June. The average price for muskrat pelts harvested by Old Crow trappers, including those taken throughout June 1985 was $3.23 (Source: Western Canadian Raw Fur Auction Sales Ltd.). This is considerably lower than the average paid for our sample pelts trapped during April and May ($4.83).

According to Joe Desmond, (Fur Technician, Hudson's Bay Raw Fur Sales Division, Edmonton, Alberta, pers. comm.) the least valuable "rats" that come from the MacKenzie Delta are harvested during the months of May and June. As much as 70% of the Delta harvest could be graded as damaged pelts (Table 11). Similar pelt quality changes do not occur on the Old Crow Flats until after the ice has left the lakes in early June.

TABLE 11 Muskrat pelt size and average value for the 1984-85 harvest from the MacKenzie Delta.

Pelt Size	Late Fall December	Early Winter Jan./Feb.	Late Winter/ Early Spring Mar./Apr.	Late Spring May/Jun.
Ex. lge.–lge.	$4.70	$5.00	$5.10	$4.50
(damaged)	$2.70		$5.10	$2.00
Lge.–med.	$4.20	$4.40	$4.50	$4.00
(damaged)	$ .92		$3.70	$1.30*
Med.	$3.00	$3.50	$3.50	$3.00
(damaged)			$1.50	$ .80*
Small	$2.00	$3.10	$3.00	$2.30
(damaged)			$1.20	$ .30
% Pelts damaged	5	0	7	35
est. n	2,000	4,000	8,000	40,000

* Represents the bulk of the harvest for this time of year.

Source: Joe Desmond, Hudson's Bay Raw Fur Sales Division, unpubl. data.

The #1 1/2 leghold trap was quite effective when used as a drowning set. Problems arose when the muskrat could not submerge (ie. trap was too large for the plunge hole) or when it resurfaced (ie. the trap was not heavy enough) after capture. The animal could often escape as a result. Although there was some experimentation going on with quick-kill devices such as the #110 and #120 Conibear traps, the majority of trappers were using leghold traps. According to Charlie Peter Charlie, an elder in Old Crow and a seasoned muskrat trapper, the Conibear has potential to be an effective trap but most trappers will likely continue to use the leghold trap because of their large investment in these devices. The longspring traps are effective in drowning sets in pushups, wheras Conibears are suited to setting at burrow entrances or other underwater locations. The ice thickness on the Flats (.66–1.0m) makes underwater sets impractical.

Traps such as the submersible cone or sets such as the floating log set that are used successfully in southern Canada (as described in the Canadian Trappers Manual, published by the Canadian Trappers Federation, North Bay, Ontario) would not work on the Old Crow Flats because of the ice conditions. There is inadequate space for a submersible trap in the plunge holes which muskrats use to access pushups through the ice. A floating log set would not be effective until after the ice has melted and pelt quality has begun to deteriorate.

6.4 Recommendations

The fluctuation in the numbers of muskrat trappers and the numbers of muskrat pelts harvested on the Old Crow Flats in not influenced solely by the muskrat population nor does it seem to be influenced by market values. Howard Linklater, (band manager, Old Crow Indian Band, pers. comm.), stated "that there would always be trappers going to the Flats even if the market for the pelts disappeared". This certainly suggests that spring ratting is more important for social and culture reason than for economic gains.

The economic potential of the annual muskrat harvest can be significant to a small community such as Old Crow. There will continue to be fluctuation in the numbers of people participating in spring ratting depending on the availability of other economic opportunities in the community. With the recent purchase of it's own air charter base, Old Crow band members will also be assured of quick, easy access to the Flats.

In an effort to generate the maximum remuneration per unit effort and unit cost as well as to ensure a continued harvestable muskrat population, the following harvest strategies and management options are recommended based on pelt quality considerations:

1) The muskrat trapping season on the Old Crow Flats should be concentrated between March 1 and May 31. A regulation change reducing the open season to May 31 from June 30 is recommended. This will ensure that only the most prime muskrat pelts are harvested. A later harvest of muskrats would be strictly a subsistence (domestic use pelt and food gathering) activity.

2) Muskrats should only be trapped. Shooting contributes to the pelt damage and is effective only in late spring when the pelts are least prime. Effective drowning sets or quick-kill traps checked twice daily, are recommended. Attempts should be made to access the Flats in early winter to mark the pushups that will otherwise be difficult to find under the snow in the spring.

3) All trappers in Old Crow should be encourage to participate in the trapper education programs offered by the Yukon Trappers Association and the Government of Yukon. A trap exchange program should be initiated to assist Old Crow trappers to change their leghold traps for the more publicly acceptable quick-kill type devices.

By implementing the above recommendations, the trappers of Old Crow will likely harvest fewer, but better quality muskrats, thereby equalling or surpassing historical economic returns. Also, the harvest will not be exhaustive as is normally the case when shooting replaces trapping in June. This will aid muskrat population recovery that occurrs primarily by immigration (Section 5) and will ensure a sustainable muskrat harvest at traditional ratting camps.

7.0 CONCLUSIONS AND MANAGEMENT CONSIDERATIONS

The use of aerial pushup counts as an index of muskrat population density was investigated. Due to the variability in the number of muskrats per pushup, and in the number of pushups used per animal, estimates of muskrat populations are inaccurate. The aerial counts of muskrat pushups can be used to produce crude estimates of population size but can reliably detect only large changes in density. Annual ground counts of pushups and intensive live-trapping studies are necessary before accurate muskrat densities can be determined. We still consider the aerial pushup census technique a relatively inexpensive and simple technique for monitoring muskrat population status.

The Old Crow Flats study sites had muskrat densities up to 4.46 muskrats/ha in spring and 8.95 muskrats/ha in fall with a total spring muskrat population estimate of ≤ 490,000 ± 164,000. The highest densities were in the central flats in the vicinity of the study sites. Adult females began breeding in early June and had a mean of 7.75 ± 2.6 offspring. They had only one litter per year and juvenile females did not breed. The mean overwinter survival rate was 28%.

The extent of a harvestable surplus depends both on the population size and the resiliency of the population to annual harvest. A comparison of life history strategies with those of previously studied muskrats of southern latitudes will place the characteristics of the Old Crow population in perspective. Although harsh, the climate of the north is more seasonal and, thus, predictable. Overwinter survival is greater, reproduction more conservative and growth slower on the Old Crow Flats (Simpson 1987). In addition, the muskrats of the Flats did not compensate the trappers' harvest with increased reproduction (ie. litter size, number of litters or precocial breeding) or increased survival. In fact, harvested areas appear to have lower overwinter survival, possibly as a result of the increase of pushup freeze-out, which would limit winter foraging ability. Even the MacKenzie Delta provides a more favourable environment for muskrats, as reproduction can be initiated earlier, and two litters per year may be produced.

The main mechanism the Old Crow muskrats employ to repopulate trapped areas is through the immigration rate, which increased two to five times following trapping. To accommodate the need for immigration, untrapped areas, or refuges, must be interspersed with harvested areas. Uniformly distributed harvest pressure is detrimental to the annual post-harvest recovery of the population.

The timing of the harvest was also reviewed from biological and economic perspectives. A fall harvest may be able to compensate for the high winter mortality rates (78.8% for adults, 64.1% for juveniles), however pelt quality was low at this time. Pelt primeness peaked March through May which should therefore be the target period for harvesting muskrats. Pelt primeness deteriorated by June and quality was further reduced with breeding season behaviour (intra-specific combat) and by the shooting method of harvest. The abandonment of shooting will avoid the problem of exhaustive harvesting and its subsequent negative effect on population resiliency.

The recommended harvest strategy involves trapping muskrats in pushups in late winter/early spring. The pushups could be marked in early winter with stakes, for easy location in the late winter, when snow may still cover them. Drowning sets should be checked twice a day. A trap exchange program will be put in place to encourage trappers to use quick-kill traps instead of small leghold traps. There should be no hunting of muskrats for their pelts in June. If there is, trappers should leave untrapped lakes or portions of lake around trapped areas. These recommendations are not intended to effect the subsistence use of muskrats.

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