ECOLOGY OF MALE BLACK DUCKS MOLTING IN LABRADOR

By

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A THESIS

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Most waterfowl undergo an annual simultaneous wing molt and are flightless for 3-5 weeks. Information on the molt for black ducks (*Anas rubripes*) is lacking. This study provides baseline information on the ecology of male black ducks during the wing molt. During the summers of 1983-1986, I captured molting black ducks by hand in Okak Bay, Labrador. No black ducks were found nesting and 98% of all ducks captured were male. Flightless black ducks were found most often in willow (*Salix* sp.)(40% of all sites), but also were frequently located in shoreline cavities (14%) and emergent herbaceous vegetation (14%) near freshwater wetlands. Only 12% used saltwater habitats. Sites used by molting black ducks were often far from open water (e.g., $\overline{X}$ = 12 m for willow sites). Male black ducks may use certain microhabitats and remain sedentary during the wing molt to avoid predators, benefit thermodynamically, and conserve energy needed for the growth of new flight feathers.

To calculate rates of feather growth, I measured primary feathers of all molting black ducks, and recaptured some ducks later during molt. Rates of growth were most

consistent for the 5th, 6th, 7th, and 8th primaries, and were higher during early molt than in late molt. Male black ducks could fly when their primaries were 82% of the definitive length. I estimated the flightless interval for black ducks as 27-30 days. Molt chronology was highly synchronous among years, and peak flightlessness (e.g., the highest proportion flightless) occurred about mid-July each year. About 50% of all black ducks became flightless within a one-week period in each year. Mean body weight declined 24% during wing molt, with an average daily weight loss of 12.2 g. No birds were observed feeding during the molt. Body weight increased by 37% within 7 weeks of completion of wing molt. Black ducks at Okak Bay seemed to meet the energy demands of molt by: (1) increasing fat stores before the wing molt, (2) remaining sedentary during molt, thereby reducing energy demands, and (3) catabolizing fat and muscle tissue.

In 1986, I radio-marked 26 male black ducks to study survival and movements during wing molt. Twelve ducks remained in the area where they were marked, but 10 ducks moved to different watersheds (4 slipped radios or their status was unknown). Marked ducks moved an average of 0.21 km/day for 2-4 day observation intervals. For ducks that were monitored to the end of the wing molt, the average distance between the initial capture site and the most distant location was 1.82 km (range = 0.46-6.80 km). At least 2 radio-marked ducks were killed; both had left the watershed where they were captured. I estimated the molt-period (29 days) survival rate at 0.874 (95% confidence interval = 0.68-0.987) using the Mayfield method. This survival rate should be considered a minimum because my disturbance (i.e., capture, handling, banding) may have caused some birds to move and become more susceptible to predation. Rates of feather growth and weight loss were not different for radio-marked ducks and for unmarked ducks, suggesting there was minimal to no effect of the transmitters on ducks.

Fidelity of black ducks to molting areas was documented. Twenty-nine banded male black ducks were captured molting on the study area in 2 different years, and 3 molting birds were captured in 3 consecutive years. Of those ducks recaptured, 52% molted on the same pond where they molted in a previous year. When assumed natural mortality and crippling loss are considered, an estimated minimum of 10% of the surviving ducks returned to the molting area 1 year after banding. Returning birds not observed would raise this figure even higher.

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CHAPTER I

WETLANDS USED BY MOLTING MALE BLACK DUCKS IN OKAK BAY, LABRADOR

INTRODUCTION

Most waterfowl molt all their primary feathers simultaneouly and are flightless for 3-4 weeks during the summer. Before this molt, birds may fly to specific areas where they congregate to spend the flightless period (Salomonsen 1968). Molting waterfowl are difficult to study because their movements are often to remote areas, and their behavior is secretive. Information on habitat use and behavior by molting waterfowl is generally lacking (Frederickson and Drobney 1977, Gilmer et al. 1977).

The decline of black duck (*Anas rubripes*) populations since the 1950's has increased the need to more thoroughly understand their biology. Several molting areas for black ducks are known (Bellrose 1976, Barrow 1983, F. Payne, Nova Scotia Department of Lands and Forests, pers. comm.), but no studies have focused on the ecology of molting black ducks or the characteristics of the wetlands used during the molt. This chapter describes a molting area in Labrador and the habitats used by molting male black ducks.

STUDY AREA

The study area, located in Okak Bay on the northern coast of Labrador (Fig. 1), is at the northern limit of forest growth, although black spruce (*Picea mariana*),

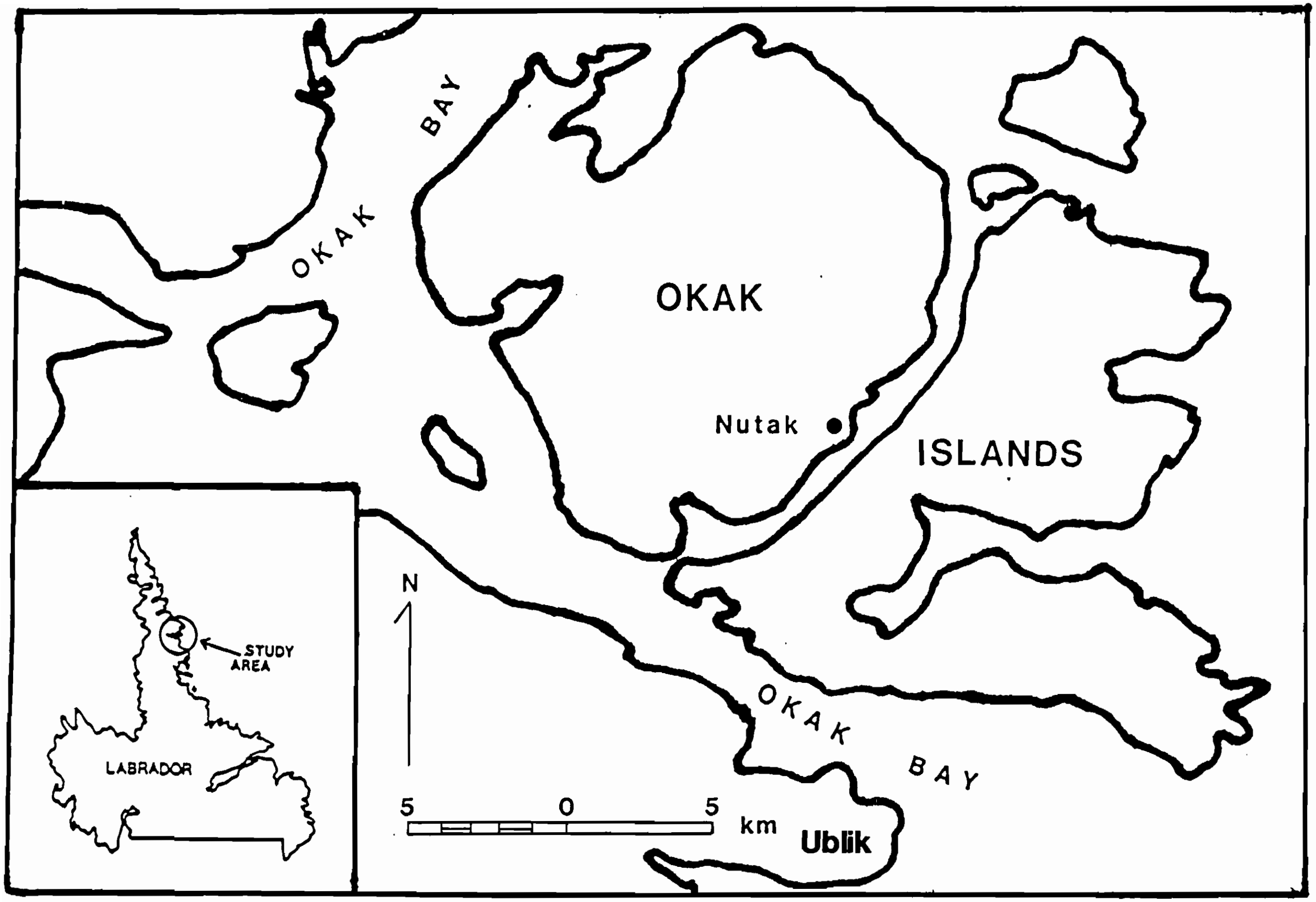


Figure 1. Location of study area

tamarack (*Larix laricina*), and white spruce (*Picea glauca*) occur in river valleys and sheltered areas. Most of the study area was tundra and barren, rocky, mountains with elevations to 600 m. Watersheds were simple and short, and typically consisted of one or more ponds interconnected by a stream; usually the entire stream was < 10 km. Most freshwater wetlands were < 1 m deep, became ice-free by mid-June, and froze again in late September. Water levels in ponds fluctuated < 10 cm during the summers 1983-1986. Saltwater wetlands were intermittently jammed with pack ice through mid-July. Daily ambient temperatures averaged 13 to 18° during summer.

Where vegetation bordered ponds, willow (*Salix cordifolia* and *Salix planifolia*) predominated, but dwarf birch (*Betula glandulosa*) and sedges (*Carex* spp.) grew commonly. There was little submerged vegetation in the ponds. A gelatinous alga (*Nostoc* sp.) grew in some ponds, and was abundant in some areas. Upland vegetation included crowberry (*Empetrum* spp.), blueberry (*Vaccinum* spp.), willow and dwarf birch.

Tides in Okak Bay ranged from 1 to 2.5 m. At low tide, extensive tidal flats were exposed in some areas. Common marine vegetation included *Fucus* sp., eelgrass (*Zostera marina*), and kelp (*Laminaria* sp).

Black ducks, Canada geese (*Branta canadensis*), green-winged teal (*Anas crecca*), and red-breasted mergansers (*Mergus serrator*) commonly molted in Okak Bay.

Other waterfowl species that molted were less numerous. The most abundant breeding waterfowl were Canada geese, green-winged teal, common eiders (*Somateria mollisima*), and oldsquaws (*Clangula hyemalis*), however, black ducks do not breed there.

Potential predators of dabbling ducks included, in order of abundance, rough-legged hawk (*Buteo lagopus*), gyrfalcon (*Falco rusticolus*), short-eared owl (*Asio flammeus*), and peregrine falcon (*Falco peregrinus*). Mammalian predators included red fox (*Vulpes vulpes*), black bear (*Ursus americanus*), mink (*Mustela vison*), and wolf (*Canis lupus*).

Molting areas were disturbed little by humans during the summer. Okak Bay was accessable only by float plane or boat, and human activity was restricted to small commercial fishing camps on the Labrador coast during summer. Fishermen rarely travelled to inland areas and natives did not hunt the molting waterfowl.

METHODS

I used the occurence of black ducks on water, or shed primary feathers along shorelines as an indication of molting activity. Most ponds at low elevations (< 30 m) and with some surrounding vegetation (willow, spruce, etc.) contained molting black ducks.

Three to 4 persons systematically searched all ponds with evidence of molting activity and others that were likely used by molting ducks. We searched all vegetation within approximately 30 m of the shoreline or to open tundra. When we found a duck, all persons surrounded it to prevent its escape and one person grabbed or netted the duck with a dip net. Molting black ducks rarely flushed when approached slowly and were easily caught. We captured molting black ducks on saltwater areas by driving flocks ashore using a boat.

I banded each duck, determined its sex by cloacal examination, recorded the microhabitat (e.g. willow, shoreline cavity, emergent herbaceous, etc.) and estimated the distance to open water for each bird captured.

Aquatic invertebrates were sampled weekly on 3 ponds during July. During each sampling session, I made one standard length (1 m) sweep using a sweep net at 3 shoreline sites on each pond in the water column and in benthos. Invertebrates were identified to genus or a higher taxon. Representative samples were stored in the invertebrate depository at the Wildlife Department, University of Maine.

RESULTS

From 1984 to 1986, I captured 324 flightless male black ducks and recaptured 67 of those within the same year. Within Okak Bay, most (88%) molting black ducks were found on freshwater ponds <30 ha on the Okak Islands and Ublik Peninsula (Fig. 2). I classified most wetlands in Okak Bay as Palustrine Unconsolidated Bottom or Palustrine Moss-Lichen

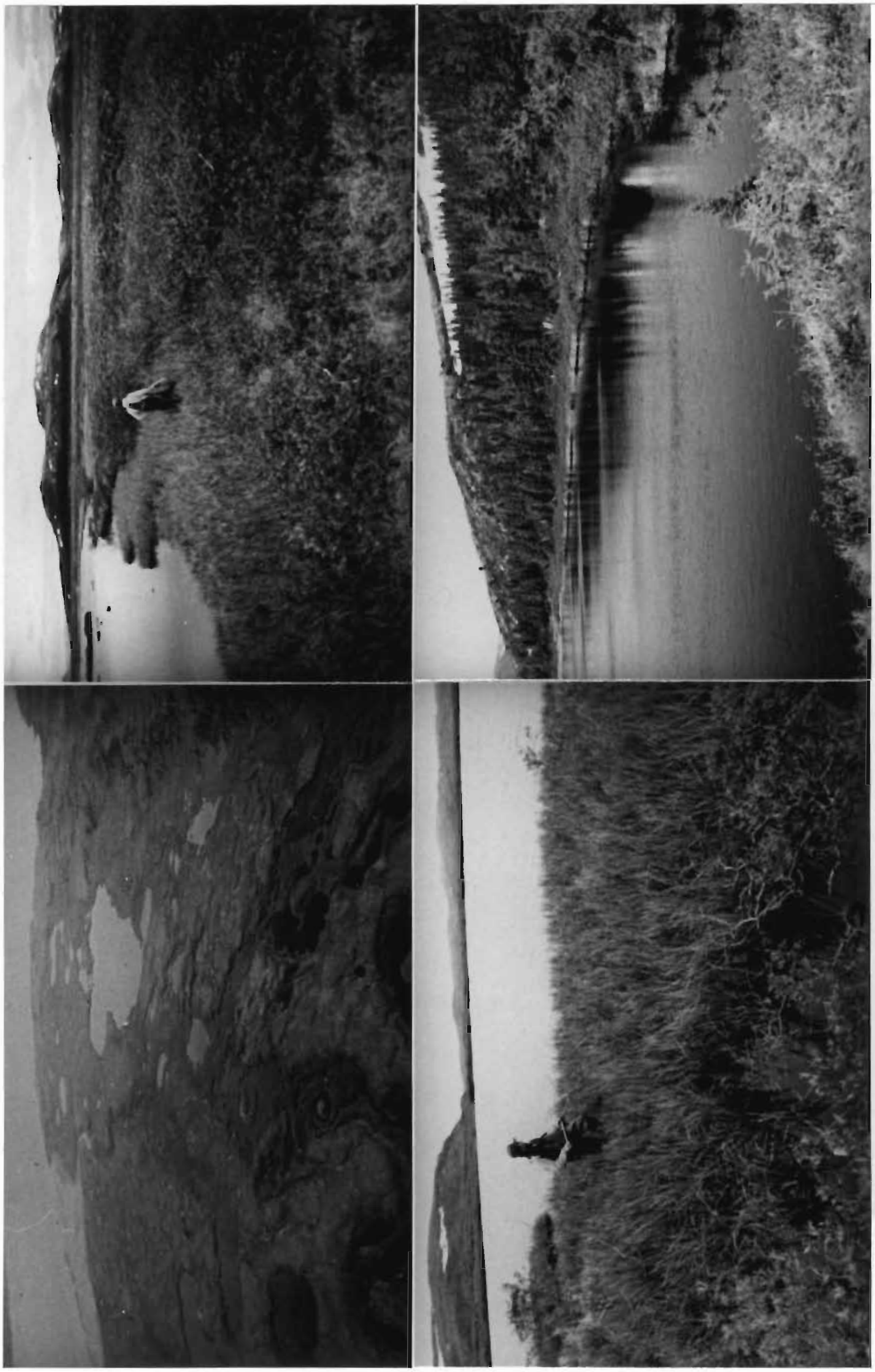


Figure 2. Examples of freshwater wetlands in Okak Bay, Labrador

wetlands (Cowardin et al. 1979). Black ducks were found most often in willow (40%), shoreline cavities (14%), and emergent herbaceous vegetation (14%) (Fig. 3). Only 12% of all molting black ducks captured used open, saltwater habitats. This pattern of habitat use was consistent throughout the molt each year. Molting black ducks were found in willow more than any other vegetational type even in late June and early July when willows were leafless.

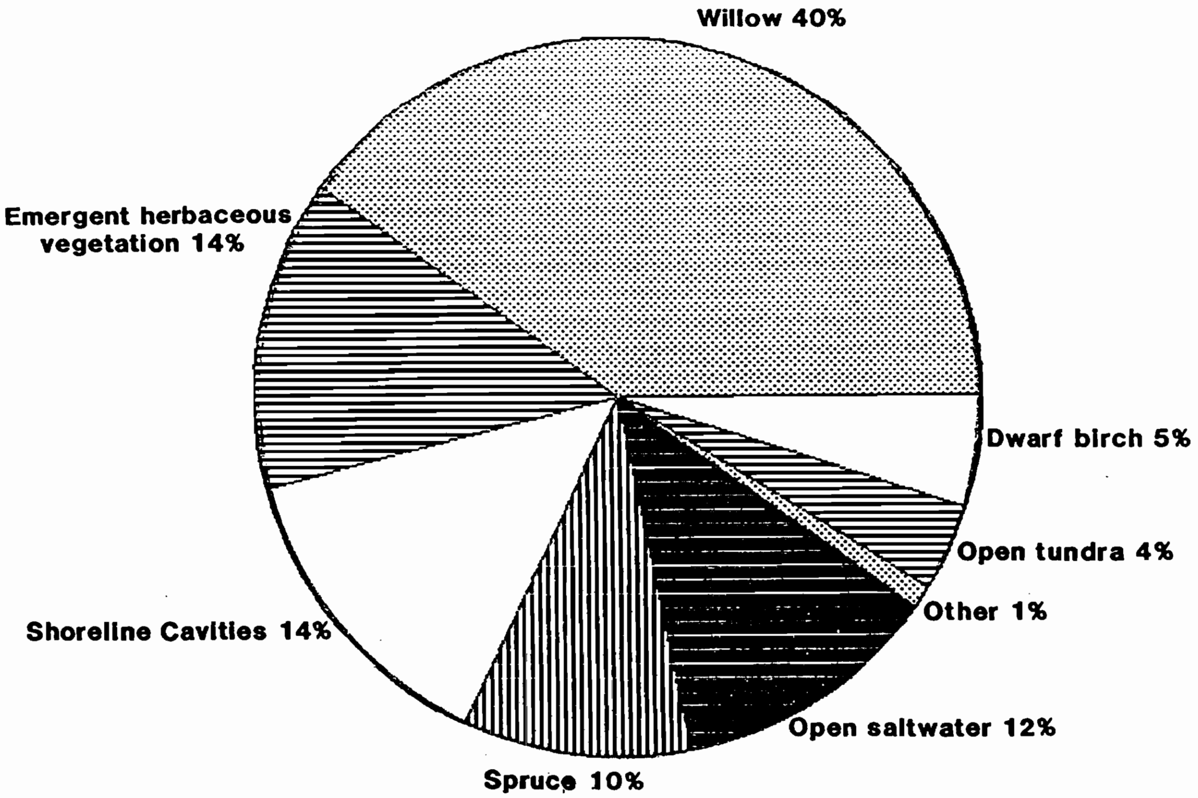
Black ducks used sites that were often far from open water (i.e., ponds or saltwater) (Table 1). Although most cavities used by black ducks were along shorelines, sites in willow (the most used cover type) averaged 12 m from open water.

The number of aquatic invertebrate taxa and abundance in ponds changed little during July (Table 2). Fairy shrimp (Eubranchiopoda) were extremely abundant in one pond.

DISCUSSION

Although molting black ducks used willow more than other cover types, the proportion of ducks that used willow may be underestimated. Willow grew so densely that it was often difficult to move through it and see ducks in it, and these areas were often not as thoroughly searched, especially after foliage was well developed. I could not determine habitat "selection" because I did not sample equally all habitat types.

Figure 3. Habitats used by molting male Black Ducks in Okak Bay, Labrador, 1984–1986.[1]



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[1] all habitats were associated with freshwater wetlands except 'open saltwater'

Table 1. Mean distances to open water of sites used by molting male black ducks caught in Okak Bay, Labrador, 1984-1986.

Habitat type	No. birds captured	Distance (m) to open water	
		Mean	Range
Willow (*Salix* sp)	155	12	0-300
Emergent herbaceous vegetation (e.g., *Carex* sp)	45	14	0-120
Spruce (*Picea* sp)	39	16	0-50
Dwarf birch (*Betula glandulosa*)	21	8	2-25
Open tundra	15	15	0-60
Cavities[a]	54	0	0-2

[a] includes shoreline cavities and den-like depressions up to 10 m from water.

Table 2. Numbers of invertebrates, by taxa, collected in 1 m sweeps using sweep nets in 3 freshwater ponds in Okak Bay, Labrador, 1985.

					East Pond				West Pond				Little West Pond			
Phylum	Class	Order	Family/Subfamily/Tribe	Genus	7/5	7/13	7/23	7/31	7/5	7/15	7/22	7/30	7/5	7/15	7/22	7/31
Annelida	Oligochaeta			un-ID				1	7	7	16	9				2
			Glossiphoridae	*Helobdella*						1						
Arthropoda	Crustacea	Eubranchiopoda		un-ID									6	50	89	44
		Cladocera		un-ID				1							5	
		Amphipoda	Gammaridae	un-ID						27	6	1			1	
	Insecta	Coleoptera	Haliplidae	*Peltodytes*								1				
				Haliplus					1	2	1					
			Dytiscidae	un-ID						3	2				1	2
				Agabus			2			2	4				2	7
				Hydroporus											1	
		Trichoptera	Molannidae	*Molanna*	2		1	2	1							
			Phryganeidae	*Agrypnia*								1				
			Limnephilidae	un-ID	1		1				2	3		1		
				Grensia					1	1			2			
				Limnephilus						1	3	2				2
				Asynarchus						1					2	4
				Nemotaulius			1									
		Diptera	Chironomidae	un-ID			2	4		6		1			5	2
			Chironominae													
			Chironomini [1]	un-ID	12	10	7	2	14	13	14	5	28	36	15	51
			Tanytarsini	un-ID		6	31		16	45	11		11	2	27	32
			Orthocladinae	un-ID	5	3	16	2	1	2				5	4	1
			Tanypodinae	un-ID	3	10	8	4	4	3	6	7	32	9	8	9
			Culicidae	un-ID											2	
			Ceratopogonidae	un-ID	3		2		1		1	1				1
		Hemiptera	Corixidae	un-ID						1						
	Arachnida			*Hydracarina*			1		5	1	4	6	3		4	2
Mollusca	Gastropoda		Planorbidae	*Helisoma*												1
				Gyraulus					1	1			2		3	7
			Lymnaeidae	*Stagnicola*			2									
			Sphaeriidae	un-ID	2	2		2	18	27	12	5				

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[1] counts are not truely quantitative because of the small size of the organism.

Molting black ducks in Okak Bay used dry, upland cover types (e.g., willow) more extensively than do other waterfowl species in previously studied areas. Flightless mallards (*Anas platyrynchos*) and wood ducks (*Aix sponsa*) in Minnesota use emergent vegetation along lakes and river-streams during the molt (Gilmer et al. 1977). Flightless mallard hens in Vermont preferred dense stands of wild rice (*Zizania aquatica*) (J. Longcore, USFWS, Pers. comm.). Molting black ducks in Maryland use clumpy tracts of needlerush (*Eleocharis* sp.) (Stotts 1959).

The feeding behavior and types of foods eaten during molt is unknown for black ducks. In 4 years of study in Okak Bay, I never observed molting black ducks feeding. If they fed, it either was of short duration or they fed only during the short, summer nights. Because diets of molting black ducks are unknown, the aquatic invertebrates collected during July (Table 2) represent only potentially available foods. Some aquatic invertebrates in freshwater were large and abundant (e.g., fairy shrimp), and could be important foods.

The habitats used and sedentary behavior by flightless black ducks may be attributed to avoidance of predators. Observations of molting black ducks (Chapter III) confirm that most were sedentary and secretive during the wing molt. Flightless wood ducks and mallard hens in Minnesota behave similarly (Gilmer et al. 1977). Sedentary behavior during molt may help conceal the birds from predators. It is not known how often predators kill flightless ducks (Oring 1964). In 4 summers of intensive field work, I found the remains of only 3 molting black ducks that were killed by predators. Most predators in Okak Bay were raptors that hunted diurnally. By hiding in habitats with dense overhead cover, and being sedentary during molt, black ducks may reduce the risk of being killed by these birds.

A secondary advantage of using these densely vegetated habitats may be that black ducks receive thermodynamic advantages by using microhabitats that reduce convective heat loss (Jorde 1986, Jorde et al. 1984). If the microhabitats used during molt help conserve energy, black ducks may compensate for the reduction in time spent feeding and reduced energy intake.

Because Okak Bay is outside the breeding range for black ducks, and because of the high (98%) proportion that were male, black ducks undoubtedly migrated to Okak Bay to molt. The reasons for molt migration are not understood, but Salomonsen (1968) hypothesized that the molt migration may reduce competition for food on the breeding grounds. Gilmer et al. (1977) and Gordon (1985) proposed that adult males and nonbreeders seek habitat for molting that is more suitable, and unavailable on breeding areas. Molt migration may be an adaptation to high variability in water permanence on wetlands, especially in the prairies. Gordon (1985) believed that molting mallards, with their restricted mobility, cannot readily move to new areas when a wetland dries, and must seek molting habitats with stable, predictable water regimes. However, habitats used for breeding by black ducks are more stable than those used by prairie waterfowl, thus a molt migration is not necessary to locate permanant water. Based upon my observations of wetlands used by molting black ducks and descriptions of molting areas for other waterfowl (Sterling and Dzubin 1967, Salomonsen 1968, Hay 1974, Gilmer et al. 1977, Gordon 1984), I believe that the primary advantage is related to increased survival resulting from low densities of predators and lack of disturbance on molting areas. Compared to nesting hens, males and nonbreeding females may still have relatively large energy reserves after the nesting period, and it may be advantageous for the bird to use those reserves for a northward migration if that movement increases its chances of survival.

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CHAPTER II

WEIGHT CHANGES, FLIGHTLESS INTERVAL, AND CHRONOLOGY OF WING MOLT FOR MALE BLACK DUCKS (*Anas rubripes*) IN OKAK BAY, LABRADOR

INTRODUCTION

Most waterfowl undergo an annual simultaneous wing molt and are flightless for 3-5 weeks. Before the wing molt, many waterfowl (especially males and nonbreeders) migrate to special areas, often far outside their breeding range, where they congregate to spend the flightless period (Salomonsen 1968). Few areas used for molting are known for male black ducks (*Anas rubripes*) (Bellrose 1976, Barrow 1983): most of those identified are near Hudson Bay or the Ungava Peninsula in northeast Canada. Because black ducks seek secluded areas for molting and their behavior is secretive, studies during molt are difficult.

Information on the length of the flightless interval and the physical changes of free-living black ducks during the molt is needed to estimate energy and nutrient requirements for molt (Fredrickson and Drobney 1977). The purpose of this study was to determine the flightless interval for wild male black ducks, document chronology of wing molt at a northern molting area, and document body weight changes of ducks during the wing molt.

STUDY AREA

The study area, located in Okak Bay on the northern coast of Labrador, is at the northern limit of forest growth, although black spruce (*Picea mariana*), tamarack (*Larix laricina*) and white spruce (*Picea glauca*) occur in river valleys and sheltered areas. Most of the study area is tundra and barren rocky mountains with elevations to 600 m. Within Okak Bay, I studied molting black ducks primarily on small (<10 ha) freshwater ponds on the Okak Islands and Ublik Peninsula. A more detailed description of the study area is presented in Chapter I.

METHODS

From late June to early August in 1984, 1985 and 1986, I captured flightless black ducks by hand, using a retrieving dog, or using a boat to drive flocks ashore from saltwater areas. Molting black ducks were rarely observed on open water. Most ducks hid in vegetation (e.g., willow (*Salix* sp.), dwarf birch (*Betula* sp.)) surrounding ponds, often far from water, where they remained relatively sedentary and were reluctant to flush when approached. I banded each duck, determined its sex by cloacal examination, and weighed each duck to the nearest 10 g using a 1500 x 20 g spring scale. The lengths of all 10 primary feathers were recorded (measured, to the nearest mm, from the tip of feather to the point of insertion in the fleshy sheath), and I noted the occurrence of blood in feather shafts. The esophagus of each duck was palpated to determine if foods were present. Some individuals were recaptured and I repeated all measurements on each duck when recaught. From mid-August to mid-

September, I caught black ducks capable of flying using traps baited with corn.

I calculated rates of feather growth for 48 individuals that were recaptured at least 4 days after their initial capture. To avoid bias in calculations of rates of growth, individuals were excluded if either the developing feathers had not emerged from any of the sheaths or if any of the primary feathers were fully grown and devoid of blood in the shaft. Rates of growth for all primary feathers were calculated; the 5th, 6th, 7th, and 8th primaries were most consistent in rates of growth, and I used the combined amount of primary feather growth for these primaries as an indicator of the stage of molt. Unless otherwise noted, all references to feather growth or rates of growth later in this paper refer to the feather length or average rate of growth of the 5th, 6th, 7th, and 8th primaries combined. I separated the molt period into two parts (early molt vs late molt) because mean rates of growth were higher (t-test, $P < 0.005$) during early molt (2 to 288 mm feather growth) than in late molt (260 to 477 mm feather growth) (Table 1). Rates of feather growth were used to determine: 1) the date on which each duck started growing new primary feathers, 2) the length of the flightless interval, 3) the dates to retrieve radio-marked black ducks, and 4) the date of death for radio-marked ducks that were killed.

I assigned each black duck a status of molt condition based on the following definitions: (1) Premolt--duck that had not shed its remiges but behaved like a typical flightless molter. Birds in this category may or may not have been capable of flight when tossed upwards. Ducks in this stage often lost wing feathers as they flapped across the water; (2) No visible growth--flightless duck that had recently shed its remiges, but new remiges had not yet emerged from the feather sheaths; (3) Molting nonflyer--flightless duck with a measurable amount of new remige growth; (4) Molting flyer--hand-caught duck that had regrown its flight feathers enough to sustain induced flight and potentially leave the molting area (I tossed each duck upwards and made a subjective judgement of its flight capability); (5) Postmolt--duck that had completed the wing molt and was capable of flight.

I defined the length of the flightless period as the sum of 3 molt stages: premolt, no visible growth, and regrowth. I used a value of 3 days of no visible growth to extrapolate to the date of remige loss. Using growth rates for early and late molt, I calculated the number of days each bird had spent in each period (early and late) of molt.

To examine changes in body weight during molt, I separated the molt into 10 classes (premolt, no visible growth, and 8 classes of feather regrowth). Each class corresponded to about 3 days. In 1986, I also weighed postmolt black ducks that I captured in corn-baited traps. To minimize the potential effects of extended feeding on corn by black ducks caught with bait, body weights were recorded only the first time they were trapped. I used a subjective corn index (0= no corn in esophagus, 1 = 1 to 10 kernels, 2 = 11 to 20 kernels, and 3 = more than 20 kernels) to adjust body weights of ducks that had ingested corn.

Twelve black ducks were collected by shotgun after the molt period to obtain body weights and determine the foods eaten by ducks during that period. Foods were removed from the esophagus and proventriculus and preserved in alcohol.

RESULTS

From 1984 to 1986, I captured and examined 324 flightless male black ducks. For recaptured birds, the average interval between captures was 8.4 days. The average rate of growth for primary feathers was 6.2 mm per day (Table 1).

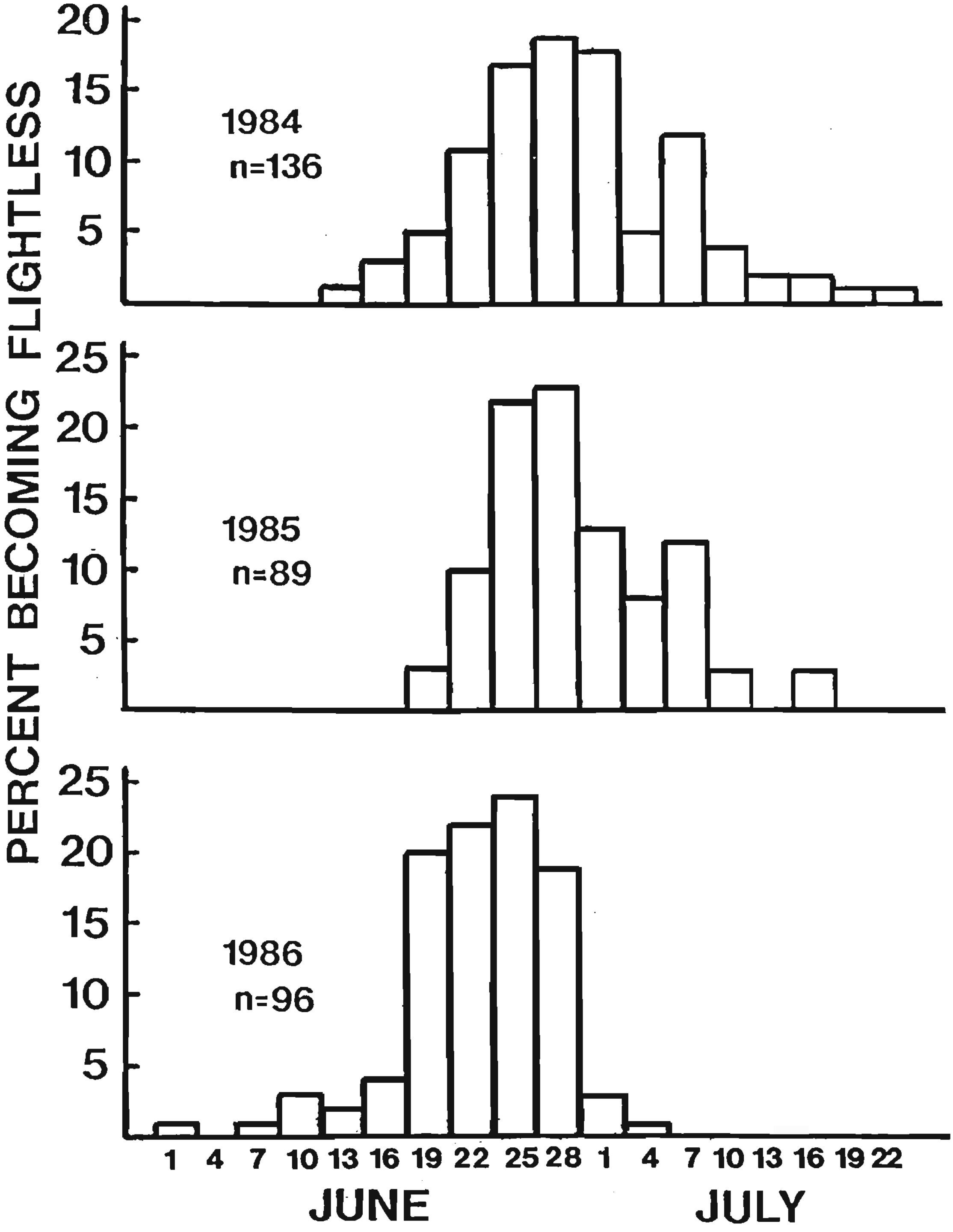
The timing of the wing molt for most ducks was similar in 1984 and 1985, but was about 1 week earlier in 1986 (Fig. 1). In 1984 and 1985, 75% of all black ducks captured were flightless by July 5, but the same proportion was flightless by June 28 in 1986. Peak flightlessness (i.e. the highest proportion flightless) occurred about mid-July in all years. The span between the time when the first and the last ducks became flightless was 28 days in 1984 and 1985, and 32 days in 1986. About 50% became flightless within a 1-week period in each year.

Black ducks showed no uniform succession in shedding their flight feathers. Proximal flight feathers developed

Table 1. Average rates of growth for primary feathers of black ducks captured more than once during molt.

	$\bar{X}$ Rate of Growth, mm/day (C.V.)		
Primary Number	Early Molt N = 7	Late Molt N = 8	All molt N = 32
1	5.5 (3.9)	4.8 (6.6)	5.2 (12.1)
2	5.9 (3.0)	4.8 (6.6)	5.5 (11.1)
3	6.1 (4.6)	5.3 (4.3)	5.7 (9.7)
4	6.5 (3.2)	5.6 (6.8)	6.0 (9.8)
5	6.4 (1.5)	5.7 (7.3)	6.1 (8.4)
6	6.4 (3.9)	5.8 (7.3)	6.2 (8.2)
7	6.4 (4.0)	5.9 (7.9)	6.2 (7.5)
8	6.4 (5.6)	6.0 (5.7)	6.1 (8.6)
9	6.2 (6.7)	5.4 (16.3)	5.9 (10.8)
10	5.0 (10.1)	5.2 (9.2)	5.3 (9.2)
$\bar{X}$ of Sum 5-8	6.4 (3.1)	5.9 (6.4)	6.2 (7.4)

Figure 1. Molt chronology for male black ducks in Okak Bay, Labrador, 1984-1986.



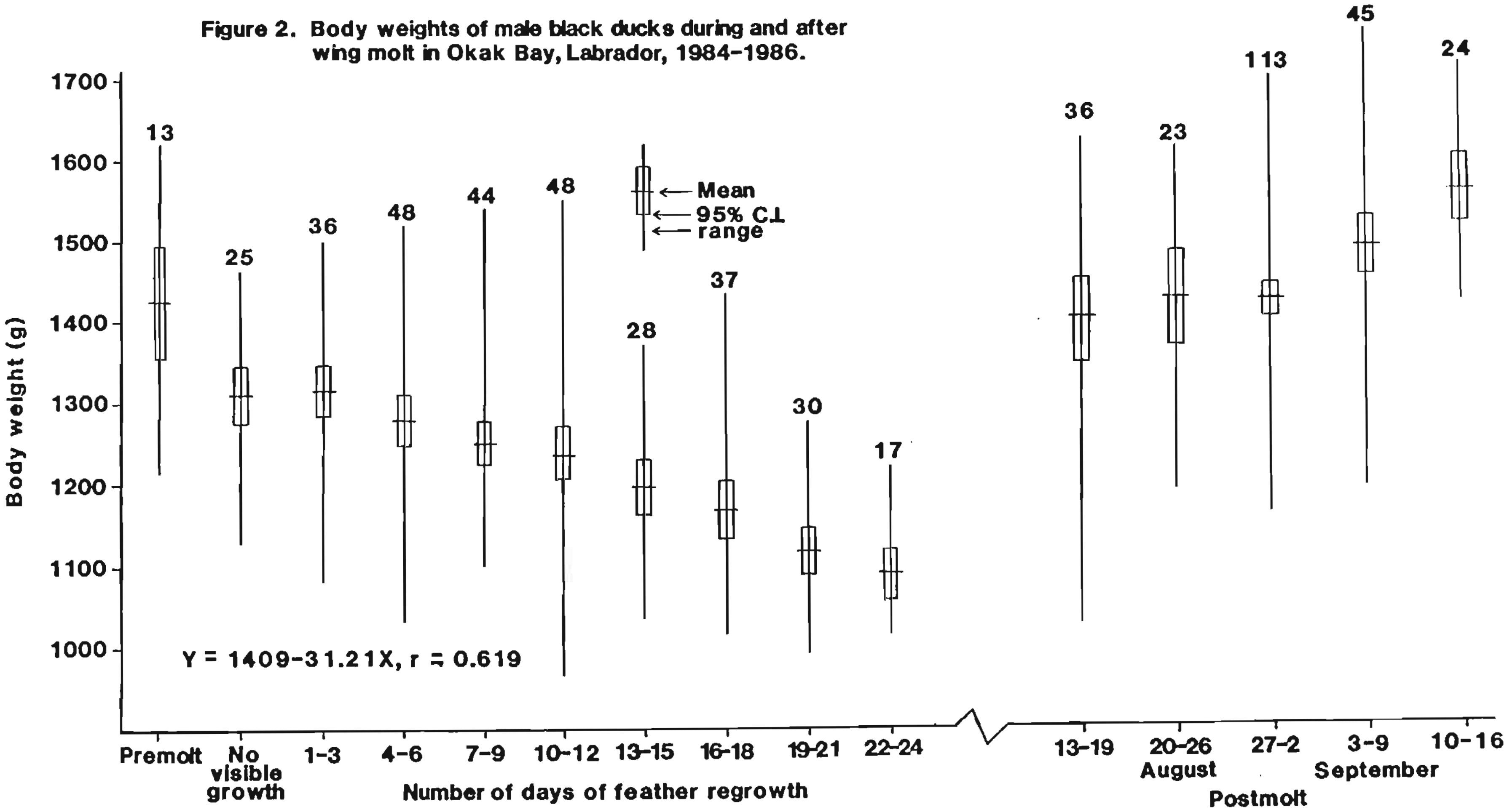
slightly sooner than distal primaries, but usually all new feathers emerged from the sheaths on the same day. Proximal primary feathers reached full maturity before distal primaries. These observations are similar to those reported for mallards (Anas platyrhynchos) (Young and Boag 1981) and redheads (Aythya americana) (Weller 1957).

Based upon observations of 1 black duck that I held captive, I estimated the duration of the premolt period as 2-3 days. After remiges were shed, there was a 2-4 day period before the new feathers emerged from the fleshy sheaths. Other studies of black ducks (Stotts 1959), and mallards (Balat 1970) indicated that 2 to 4 days elapsed between the shedding of the remiges and the appearance of new primary feathers. About 23 days were required for feather regrowth. I combined the 3 stages of molt (premolt, no visible growth, and regrowth), and estimated that the flightless interval for most male black ducks was 27-30 days.

Mean body weight of black ducks was correlated ($r = 0.619$, $P < 0.0001$) with molt class (Fig. 2). Body weight declined 24% during the wing molt, with an average daily weight loss of 12.2 g. This weight loss was higher than that reported for gadwall (Anas strepera) (12%) (Hay 1974, Oring 1969) and for mallard and lesser snow geese (Anser caerulescens) (no significant weight losses) (Young and Boag 1982, Ankney 1979) during molt.

Body weights of male black ducks increased greatly during the postmolt-premigratory period and exceeded the average

Figure 2. Body weights of male black ducks during and after wing molt in Okak Bay, Labrador, 1984-1986.



body weight of premolt black ducks (Fig. 2). Body weights increased to an average of 1487 g during the period of September 1-16, 1986, which represented a 37% increase in body weight from black ducks at the completion of the wing molt.

Black ducks were never observed feeding and I did not detect food in the esophagus of any duck captured. Nine of 12 black ducks collected after the wing molt contained food. Marine gastropods, amphipods, dipteran larvae, and isopods occurred most frequently in the esophagus and proventriculus (Table 2).

DISCUSSION

To consider these results representative of undisturbed black ducks, I assumed that feather growth rates were not affected by my handling of birds. Owen (1979) found that the feather growth rates of mallards caught 3 or more times did not differ from those caught only twice.

Owen (1979) found a significant correlation between early feather growth rate and body weight in molting male mallards. I was unable to test for that correlation because of small sample size, but I found no significant relationship ($r=0.27$, $P < 0.12$) between date of molt initiation and body weight for molting male black ducks.

The flightless interval for the black duck has been is estimated at 10 days (Wright 1947) and 28-32 days (Stotts 1959). For mallards, estimates of the flightless interval

Table 2. Foods eaten by 9 male black ducks collected after wing molt in Okak Bay, Labrador, 1985 and 1986.

	Duck number								
Food type	85-2	85-3	85-4	86-6	86-8	86-9	86-10	86-11	86-12
Gastropods		237	178	10	2		7	1	169
Amphipoda									
(Gammaridae)		123	171						
(un-ID)									12
Diptera									
(Scathophagidae)				264	11		142		
(un-ID maggots)	74								
(un-ID pupa)	1								
(Muscidae)						3			
(Culicidae)					1				
Oligochaeta	196								
Isopoda		15	3			14		74	22
Pelecypoda		5						118	
Plant tubers						285			
Decapoda			2						
Arachnida (mite)				1					

are 24-26 days (Boyd 1961), 29-33 days (Balat 1970) and 33-36 days (Owen 1979). The variability in those estimates may result partly from different definitions of the flightless period by researchers, and because of differences between captive and free-living birds. I defined the flightless period for free-living black ducks as the sum of three stages: premolt, no visible growth, and regrowth. Although the periods of no visible growth and regrowth are recognized by other authors (Owen 1979, Balat 1970), the premolt period of behavioral flightlessness is mentioned only for Canada geese (*Branta canadensis*) (King and Hodges 1979). This period may be a preparatory stage for birds entering molt, when the old primary feathers are too loose to withstand flight. Because I captured many molting black ducks in this condition, I included this period in the flightless interval.

Another likely period of behavioral flightlessness occurred at the end of the wing molt when black ducks had regrown primaries enough to sustain flight, but still remained in hiding. Black ducks could be induced to fly when the feather growth was as low as 561 mm (82% of their definitive length, and primaries 7-10 still vascularized), although I captured one duck with feather growth of 617 mm (90% grown), a difference in growth that would require about 2 days. A delay of several days would increase the efficiency of flight, reduce potential damage to developing quills, and be advantageous to the duck if its survival were not jeopardized by remaining in hiding. Male gadwalls could fly when their new primaries were 66% grown, but remained in molting flocks until their primaries were 83% grown (Hay 1974). Because my method of tossing the bird into the air and observing its flight capability was a crude measure of flight capability, and was probably influenced by local conditions (e.g., a bird may fly more easily downhill in a headwind than a duck on flat terrain with no wind) I did not include this period in calculations of the flightless interval. Therefore, my estimate of the flightless interval may slightly underestimate, by 1-3 days, the actual period of flightlessness for wild black ducks.

Molt chronology was highly synchronous among years and within any given year (Figure 1). The advanced molt observed in 1986 could be attributed to my reduced searching effort in mid- to late July that year, which may have underestimated the proportion of black ducks that initiated wing molt in mid- to late July. However, molt was earlier in 1986 because a greater proportion of black ducks was observed flying by late July, 1986, than in earlier years, and because more black ducks initiated molt in early to mid- June in 1986--an observation that would have been recorded in all years regardless of searching effort in mid- to late July.

During the annual cycle, fat and protein reserves are stored to the limits set by the physiological needs and feeding efficiency of the individual, and by food abundance and other environmental conditions (Wishart 1979). An increased demand for energy and nutrients during molt is related to an increase in metabolic rate and demand for protein (Sturkie 1976, Payne 1972) and a presumed decrease in the insulative capacity of the plumage (King 1974, Young and Boag 1982). If adequate food were available, maintaining unnecessary fat stores would be energetically inefficient. The high body weights of premolt black ducks (Fig. 2) may reflect premolt fattening and compensate for reduced feeding time during molt. An increase in body weight just before molt is documented for northern shovelers (Anas clypeata) (22%) (Dubowy 1980), gadwalls (15%) (Hay 1974), and mallards (11%) (Folk et al. 1966). Black ducks lost a higher proportion (24%) of their body weight than did gadwalls (12%) (Hay 1974) and mallards (no significant weight loss) (Young and Boag 1982) during wing molt suggesting that black ducks rely more on endogenous reserves to meet the energy demands of molt. Although gadwalls (Hay 1974) and mallards (Gordon 1985) feed more during molt, I never observed a molting black duck feed during 4 years of intensive study. Dubowy (1980) reported that molting northern shovelers in Manitoba also were sedentary and secretive, and the birds he collected contained little food. He suggested that shovelers lived on stored lipids and protein while molting. I believe that flightless black ducks in Okak Bay also lived on stored lipids and protein. All black ducks in the late stages of wing molt had a prominent sternum and little pectoral muscle mass, suggesting that black ducks catabolized pectoral muscle to obtain protein or energy. The fall migration for black ducks in Okak Bay was about 6 weeks after molt. High body weights of ducks during the postmolt period (Fig. 2) indicate that endogenous reserves depleted during molt were replenished. Most foods eaten by black ducks after molt (gastropods, amphipods) (Table 2) were highly predictable and abundant. These marine foods were available to black ducks throughout the molt, but few ducks used marine wetlands while flightless. Although these foods may not be used during molt, they may be used for pre-molt fattening and are used during the post-molt period before fall migration.

At the completion of the wing molt, when body weights reached their minimum, and new, more efficient wing feathers had developed, ducks were able to fly before their primary feathers were fully grown, possibly increasing their chances of escaping predators. A decrease in body weight may reduce wing-loading for ducks and allow them to fly earlier than if they remained at a heavier weight.

Birds may compensate for increased energy demands during molt by: (1) increasing daily nutrient uptake, (2) reducing other nutrient-demanding activities, or (3) catabolizing body tissue (Ankney 1979). Black ducks at Okak Bay seemed to meet the energy demands of molt by: (1) increasing fat stores before the wing molt, (2) remaining sedentary during molt, thereby reducing energy demands, and (3) catabolizing fat and muscle tissue. The energy requirements for molt of wild black ducks are unknown. More information is needed to document changes in fat and protein composition during the molt and determine the importance of feeding and diet.

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CHAPTER III

SURVIVAL AND MOVEMENTS OF MOLTING MALE BLACK DUCKS IN OKAK BAY, LABRADOR

INTRODUCTION

A constant decline in the black duck (*Anas rubripes*) population over the past 20-30 years has prompted studies to identify the causes of the decline and to obtain information on the ecology of the black duck throughout its life cycle. The importance of non-hunting mortality to black ducks is not well understood. Annual survival rates estimated from banding data do not reflect the seasonal importance of natural mortality because of low band reporting rates during non-hunting periods and the difficulty of detecting deaths of wild, unmarked ducks.

Using radio-equipped ducks, Ringleman and Longcore (1983), and Kirby and Cowardin (1986) estimated survival of adult hens during the breeding and post-breeding period. Ringleman and Longcore (1982) determined survival of juvenile black ducks until fledging. Studies of survival during winter (M. Conroy, USFWS, pers. comm.) have been completed recently and studies during the post-fledging period (J. Longcore et al, USFWS, pers. comm.) are now being conducted. Although much knowledge has been recently gained there are still periods of the year for which no information on black duck survival is available (e.g., molt, post-molt, migration).

The activities and behavior of flightless molting ducks are poorly known, especially for the black duck. The ducks' movements to isolated secluded areas at high latitudes and their secretive behavior during molt have discouraged intensive research efforts. Frederickson and Drobney (1979) emphasized the need for research on post-breeding waterfowl including foods and nutrition, habitat use, physiology and condition, behavior, and time and energy budgets. In this study, I estimate the survival rate of male black ducks during the wing molt, and document movements of radio-marked black ducks during this period.

METHODS

From late June to late July, 1986, flightless molting black ducks were captured by hand near freshwater ponds in Okak Bay, Labrador. A description of the study area is included in Chapter I. I radio-marked 26 molting male black ducks using an adjustable harness similar to that described by Dwyer (1972). Each duck was weighed, and all primary feathers were measured to determine the stage of wing molt. I selected black ducks with no or little primary feather growth for telemetry studies to maximize the monitoring period. Three molting black ducks were radio-marked before they shed remiges, and I clipped their feathers to ensure that they could not fly from the capture site. All radio-marked black ducks were released in the pond in which they were captured.

Ducks were relocated using hand-held H-type antennae and

AVM receivers about every 3 days to determine if they were alive or dead, and determined the birds' exact locations. Most ducks were sedentary and hid in vegetation near water. Radio-marked black ducks were disturbed as little as possible, and they rarely flushed when we located them. When radio-marked ducks moved and could not be located, I climbed nearby mountains to increase the receiving ranges, and attempted to triangulate on the transmitter signal.

Based upon the amount of remige growth at the time of marking, and upon primary feather growth rates (see Chapter 2), I calculated the date at which each black duck would regain flight, and removed the radio transmitters just before this date. The primary feathers of all dead ducks were measured and I determined the date of death by back-calculating using feather growth rates.

Survival rates were calculated using the Mayfield (1961, 1975) method. The unit of exposure was the molt-day, equivalent to one flightless day for a single duck. There were about 29 molt-days during the flightless period (i.e., day 1 was the first day of flightlessness; day 29 was the day before the duck regained flight). I assigned the date of capture for each duck to a specific molt-day based upon the combined lengths of the 5th, 6th, 7th, and 8th primary feathers at the time of capture. Molt-days 1 and 2 included black ducks in premolt flightless condition; molt-days 3-5 included ducks that had shed remiges but showed no primary feather growth; molt-days 6-29 included ducks in progressive stages of feather replacement.

Using the Mayfield (1961,1975) method, the probability of survival for the molting period is the product of the daily survival rates for the 29 molt-days of the wing molt (i.e. $S_d = (1-r)^D$ where 1-r equals S,the daily survival rate per molt-day, and D equals the number of days in the molt period).

RESULTS

Radio-marked ducks travelled an average of 0.21 km/day for 2 to 4-day intervals (N = 72 intervals for 19 ducks). The maximum distance travelled for any 2 to 4-day interval was 2.5 km/day. These were straight-line distances and represent minimum distances. Actual movements would likely be nonlinear because of irregular shorelines, mountains, and large expanses of barren tundra between relocation sites.

Of 22 radio-marked ducks that I relocated during the molt period, 12 remained in the same watershed. These birds moved little during the molt (Fig. 1), often only around the periphery of a pond or along feeder streams or adjacent potholes. One duck remained in the same location for at least 15 consecutive days, but all other black ducks moved between observations.

There was no consistent directional pattern of dispersal for the 10 birds that left the watershed in which they were captured. Ducks that moved to different areas

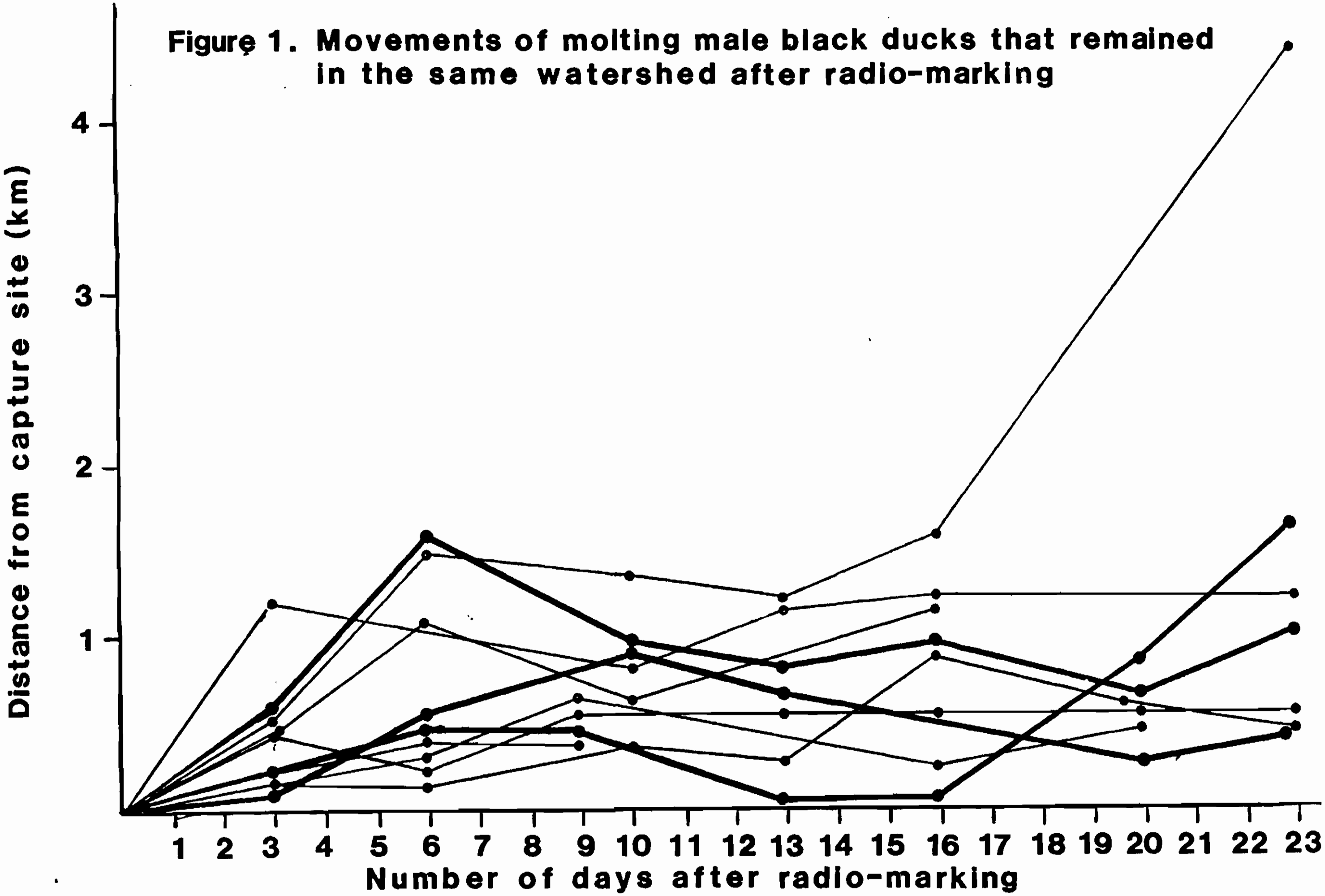

Figure 1. Movements of molting male black ducks that remained in the same watershed after radio-marking

after marking often remained in that area for the remainder of the wing molt (Fig. 2). Most of these ducks moved to areas that were connected to the banding area by streams, saltwater, willow runs, or wet sedge meadows, or a combination of those habitats. Some ducks travelled overland to reach different areas.

For black ducks that were monitored until the end of the wing molt, the average distance between the capture site and the most distant location was 1.82 km ($\bar{X}$ = 3.47 km for ducks that moved to new watersheds, $\bar{X}$ = 0.92 km for ducks that remained in the same watershed [range: 0.46-6.80 km]).

Of 26 radio-marked black ducks, only 1 was not relocated after release. Another duck died within 1 day and was not included in survival estimates because I believed that it was affected by our disturbance. Therefore, my analysis is based on a sample of 24 ducks. Of 24 ducks that were used to estimate the survival rate, I knew the fate of all except one, and included the interval between the date of marking and the last date that duck was known alive. Two ducks were not relocated during the molt period but were recaptured in baited traps during August; obviously surviving the wing molt. Another radio-marked duck that I did not locate during the flightless period was relocated by triangulation 3 days after the date I calculated it would regain flight; I assumed that it left the study area and later flew back to it, and therefore survived the molt. For black ducks not confirmed killed during the molt, the average

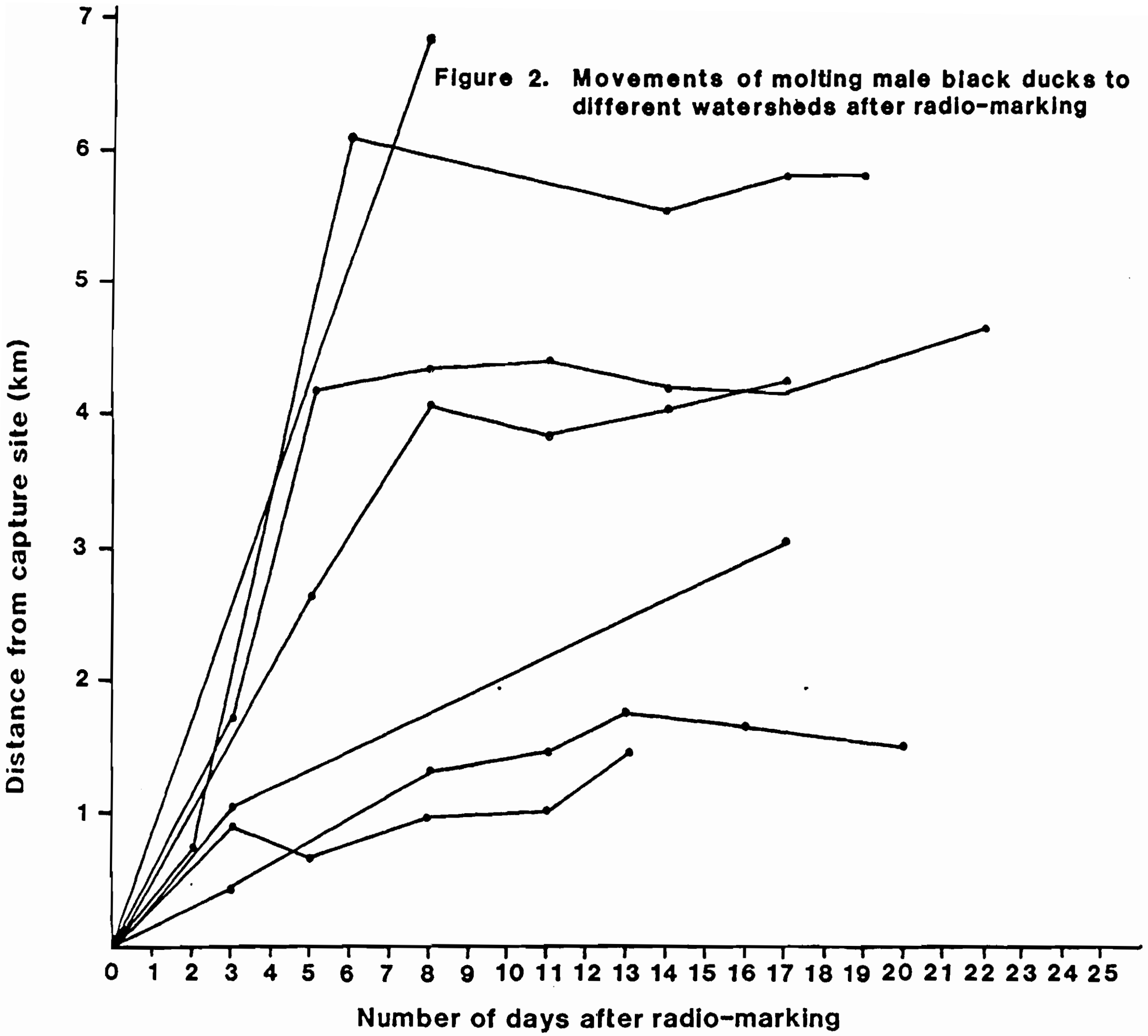
Figure 2. Movements of molting male black ducks to different watersheds after radio-marking

monitoring period was 18 days.

At least 2 radio-marked black ducks were killed during the study. One duck was found decapitated, and submerged in a shallow pond. Another duck was found stuffed inside a den (0.6 m in diameter with several entrances 6 to 10 cm in diameter) of moss and lichen on a forested hillside 30 m from water; it was presumably killed by a mink.

Using the Mayfield method (1961, 1975), I calculated a daily survival rate of 0.995 (95% confidence interval = 0.9868-0.9996) for molting black ducks. This corresponds to a period survival rate of 0.874 (N= 24, 95% confidence interval = 0.680 to 0.987) for a 29 day interval. The period survival rate (0.728, N= 10) for ducks that moved away from the watershed where they were captured was not different (Z-test [Bart and Robson 1982], P= 0.767) from that of ducks that remained in one watershed (1.000, N=13), but sample sizes were small. All ducks that remained in the same watershed throughout the molt survived, whereas, at least 2 of 10 that left the drainage were killed.

DISCUSSION

For these results to represent survival and behavior of undisturbed black ducks, the radio transmitters and the trauma of capture must be assumed to have had no effect on the ducks' behavior or physiology. However, some ducks may have been affected by my disturbance, because most ducks that left the watershed where they were radio-marked settled into different watersheds and remained there for the remainder of the wing molt (Fig. 2). This suggests that my disturbance caused them to move. These movements were often to areas where we found few other black ducks, although habitats seemed similar; possibly these areas were not as suitable for black ducks as other molting areas. Movements of unmarked birds were not as easy to determine, but usually, fewer black ducks were caught during a second search of a molting area, suggesting that some unmarked birds also moved after disturbance.

The effects of my disturbance (e.g., capture, handling, banding) are difficult to separate from the effects of radios. However, the mean rate of feather growth for radio-marked ducks (6.05 mm/day) was not different ($P > 0.25$) from that of unmarked ducks (6.16 mm/day), and there was no difference (Wilcoxon Rank Sum test, $P = 0.77$) in the rate of weight loss ($\overline{X} = 14.21$ g/day for 15 radio-marked birds, $\overline{X} =$ 13.21 g/day for 19 unmarked birds) between these 2 groups. Even among ducks that moved to new watersheds, the mean rate of feather growth (6.04 mm/day, $N = 3$) was not different from rates for ducks that remained in the same watershed (6.06 mm/day, $N = 6$). From these data, I could not detect any effect of radio-marking on ducks.

Movements by molting waterfowl as a result of human disturbance has been noted for Canada geese (Sterling and Dzubin 1967, William Andersen III, Labrador Wildlife Division, pers. comm.), but their effect on survival is unknown. If my disturbance caused some ducks to move and predisposed them more to predation, the calculated survival rate (0.874) may underestimate that of undisturbed black ducks. For this reason, and because 95% confidence limits on the calculated survival rate were wide (0.6799-0.9873, N= 24), I believe that the survival rate of undisturbed black ducks is higher.

A high survival rate would provide an advantage favoring the molt migration. The calculated survival rate is high, and may be attributed to low densities of mammalian predators on the study area. Although I commonly saw raptors near wetlands used by molting black ducks, I saw a mammalian predator (black bear (*Ursus americanus*)) only once near wetlands. Flightless black ducks used sites with dense overhead cover, often far from water, suggesting that raptors posed a greater threat than did mammalian predators.

We searched in and near many raptor nests and fox dens on the Okak Islands and found no remains of black ducks. Most remains of prey at nests were of small mammals and ptarmigan (*Lagopus lagopus*). Pehrsson (1986) reported that duckling production by oldsquaws in Sweden was related to the abundance of small rodents, and he explained his observations by the alternative prey hypothesis. High abundance of small mammals on the Okak Islands (pers. observation) may reduce the magnitude of predation on molting black ducks. During 4 years of intensive study, we found the remains of only 3 unmarked black ducks that were killed while molting.

The Dwyer (1974) type radio-package may not be appropriate for molting ducks because at least 3 of the molting ducks that I radio-marked slipped out of the harness used to attach the transmitter (2 were later caught in baited traps without radios). All transmitters were loose on marked ducks recaptured at the end of the wing molt because of loss of pectoral muscle mass. Few researchers have used radio-telemetry during molt. J. R. Longcore (pers. comm.) however, used the Dwyer harness on 8 molting hen mallards and 1 hen black duck in Vermont with no loss of transmitter during the approximate 30-day molt period. The females he studied may not have lost as much weight and they were known to feed at corn-baited sites--it was unknown if they fed on natural foods. Gordon (1985) used a bill-mounted transmitter on molting mallards and noted no ill effects. Perhaps this type of transmitter package is more appropriate for use on molting waterfowl.

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CHAPTER IV

SITE FIDELITY OF MALE BLACK DUCKS (*Anas rubripes*) TO A MOLTING AREA IN LABRADOR

INTRODUCTION

Many waterfowl migrate to traditional areas where they congregate and spend the flightless period (Salomonsen 1968). This post-breeding dispersal is composed mostly of males and nonbreeders, and may end at a destination outside the breeding range for some waterfowl. Few areas for molting are known for male black ducks (*Anas rubripes*) (Bellrose 1976, Barrow 1983, P. Dupuis, Canadian Wildlife Service, Quebec, pers. comm.). Although homing to breeding areas is well known for many waterfowl (Bellrose 1976), homing to molting areas is documented only for female buffleheads (*Bucephala albeola*) (Erskine 1961), and Canada geese (*Branta canadensis*) (Sterling and Dzubin 1967). Homing tendencies of male black ducks to a molting area in Labrador are discussed in this paper, based on evidence from recaptured, banded, black ducks.

STUDY AREA

Black ducks, Canada geese, American green-winged teal (*Anas crecca*), and red-breasted mergansers (*Mergus serrator*) used Okak Bay as a molting and staging area; other species occurred in fewer numbers. Nearly all (98%) molting black ducks in Okak Bay were male, and I found no evidence of black ducks breeding in this region. The study area was about 100 km^2. For a more detailed description of the Okak Bay, Labrador study area, see Chapter I.

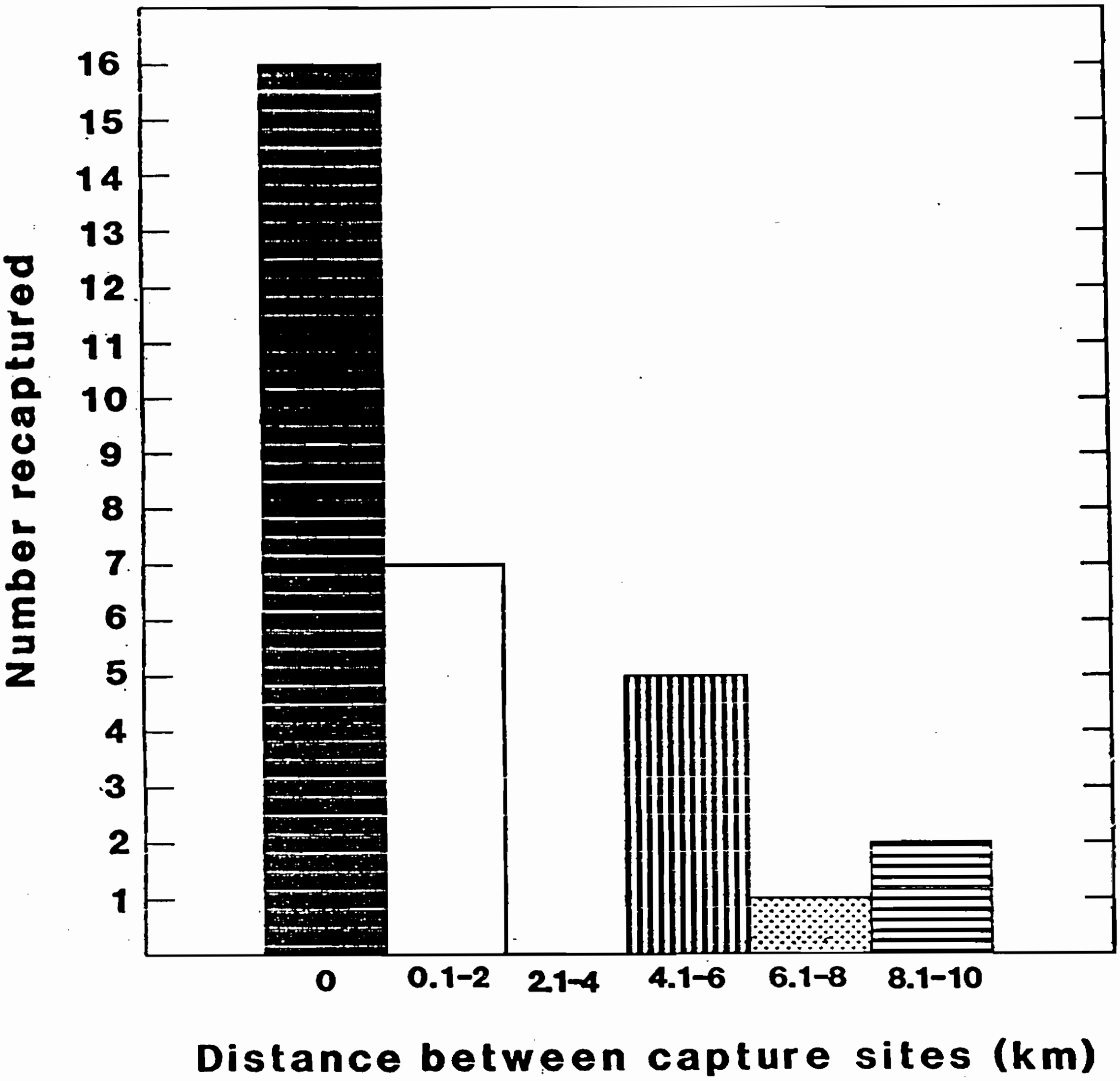
METHODS

From late June to early August in 1983-1986, molting black ducks were captured by hand, using a retrieving dog, or using a boat in saltwater areas and driving flocks ashore. I banded each black duck, and recorded the capture site. Most flightless black ducks were captured on freshwater ponds < 10 ha, including some ducks that were banded in previous years. I marked the locations of capture-recapture sites on maps and calculated the distance between capture sites for each duck. For molting black ducks that were captured on different ponds, I measured the minimum distance between ponds.

RESULTS AND DISCUSSION

From 1983 to 1985, I banded and released 310 molting male black ducks, and also recaptured and released 58 foreign-banded molting male black ducks. Only 5 molting female black ducks were found during these years. During the summers of 1984-1986, I recaptured 29 male black ducks (2 were captured in 3 consecutive years; each was captured on the same pond in 2 of the 3 years). I did not recapture any females that were molting when banded. The average distance between capture sites for molting black ducks caught in more than 1 year was 1.9 km. Of those recaptured, 52% molted on the same pond where they molted in a previous year, and 71% molted within 2 km of their original molting site (Fig. 1). This suggests a

Figure 1. Distance between capture sites for molting Black Ducks captured in more than 1 year in Okak Bay, Labrador, 1983-1986.



high homing ability of male black ducks to this molting area. Although more than 400 black ducks have been banded at other molting areas in Labrador, none have been recaptured at Okak Bay in different years.

It was impossible to confidently estimate the proportion of male black ducks that returned to molt on the study area because of differences in the number and intensity of searches on molting areas. However, I used an annual survival rate of 0.69 (estimated by Blandin (1982) for adult male black ducks from the Labrador--Eastern Quebec reference area) to estimate the number that survived 1 year, and calculated the proportion recaptured of the number of ducks available for homing. Recapture rates were 9.7% for 1 year after banding, 8.8% for 2 years, and 0% for 3 years (Table 1). Several black ducks that were banded as molters were recaptured in subsequent years in baited traps, after they had completed the wing molt; some of those birds probably molted near Okak Bay, but outside the actual study area, and were not detected. When I included these ducks in estimates of the proportion that returned to molt, the recapture rates were slightly higher--10.2% for 1 year after banding, 10% for 2 years, and 3.3% for 3 years (Table 1). These recapture rates represent the minimum proportion of ducks that returned to molt on the study area because I undoubtedly did not capture all molting black ducks that returned.

No other published information on rates of fidelity to molting areas is available for black ducks or other waterfowl.

Table 1. Estimated return rates of male black ducks banded while molting at Okak Bay, Labrador, 1983 to 1985, and recaptured molting in subsequent years. Numbers in parentheses include ducks recaptured in baited traps.

Year of banding	No. banded	Estimated no. alive 1 year after banding[1]	No. recaptured after 1 year N	%	Estimated no. alive 2 years after banding[2]	No. recaptured after 2 years N	%	Estimated no. alive 3 years after banding[2]	No. recaptured after 3 years N	%
1983	90	62	6	9.7	43	3 (4)	7.0 (9.3)	30	0 (1)	0 (3.3)
1984	139	96	8	8.3	66	7	10.6			
1985	91	63	7 (8)	11.1 (12.7)						
	Estimated % returning:		Mean=	9.7 (10.2)		Mean=	8.8 (10.0)		Mean=	0 (3.3)

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[1] estimated number alive equals number banded X 0.69 (annual survival rate (Blandin 1982)).

[2] estimated number alive equals estimated number alive in previous year X 0.69.

Some female black ducks in Nova Scotia molted on the same wetland in different years (F. J. Payne, Nova Scotia Department of Lands and Forests, pers. comm.)

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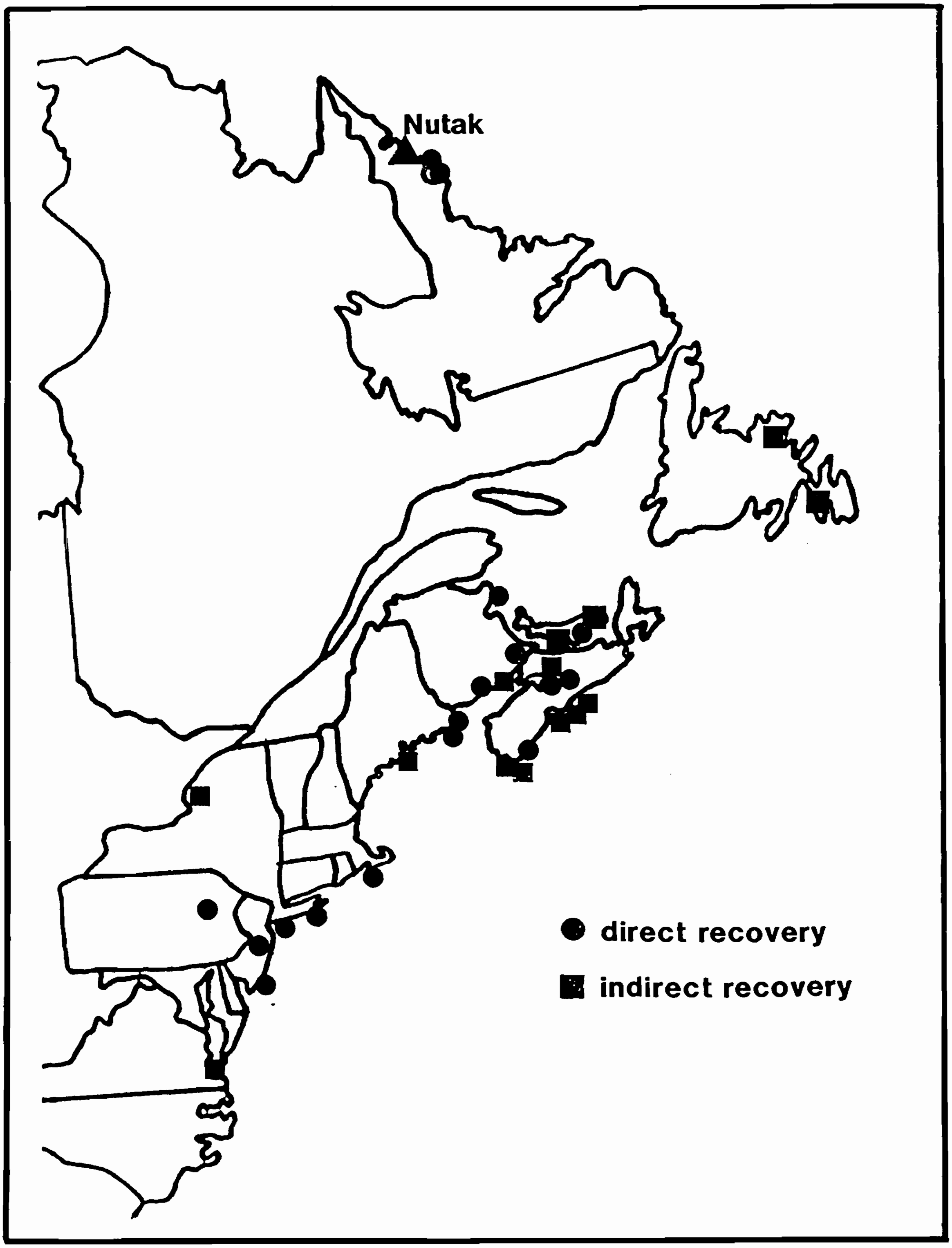
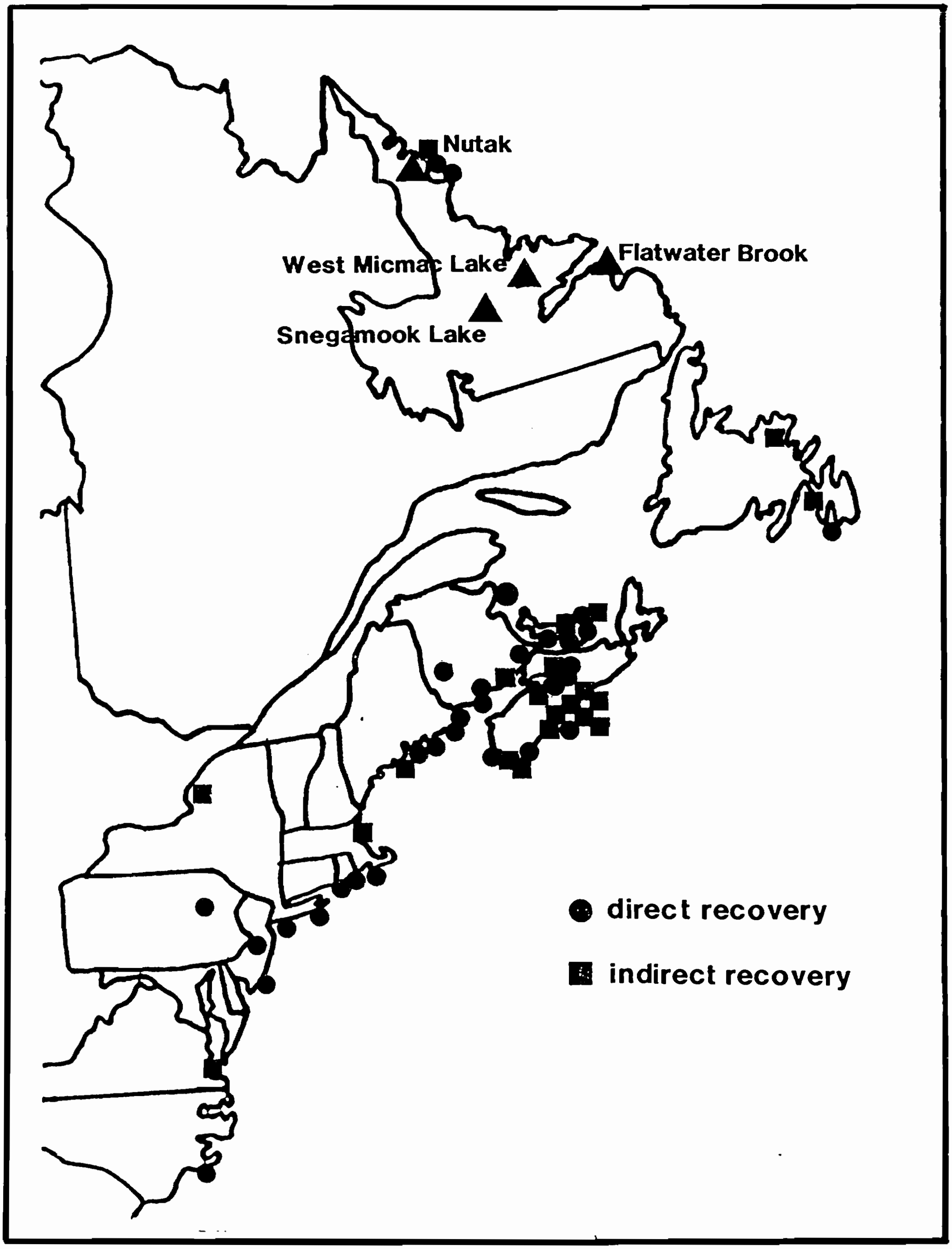
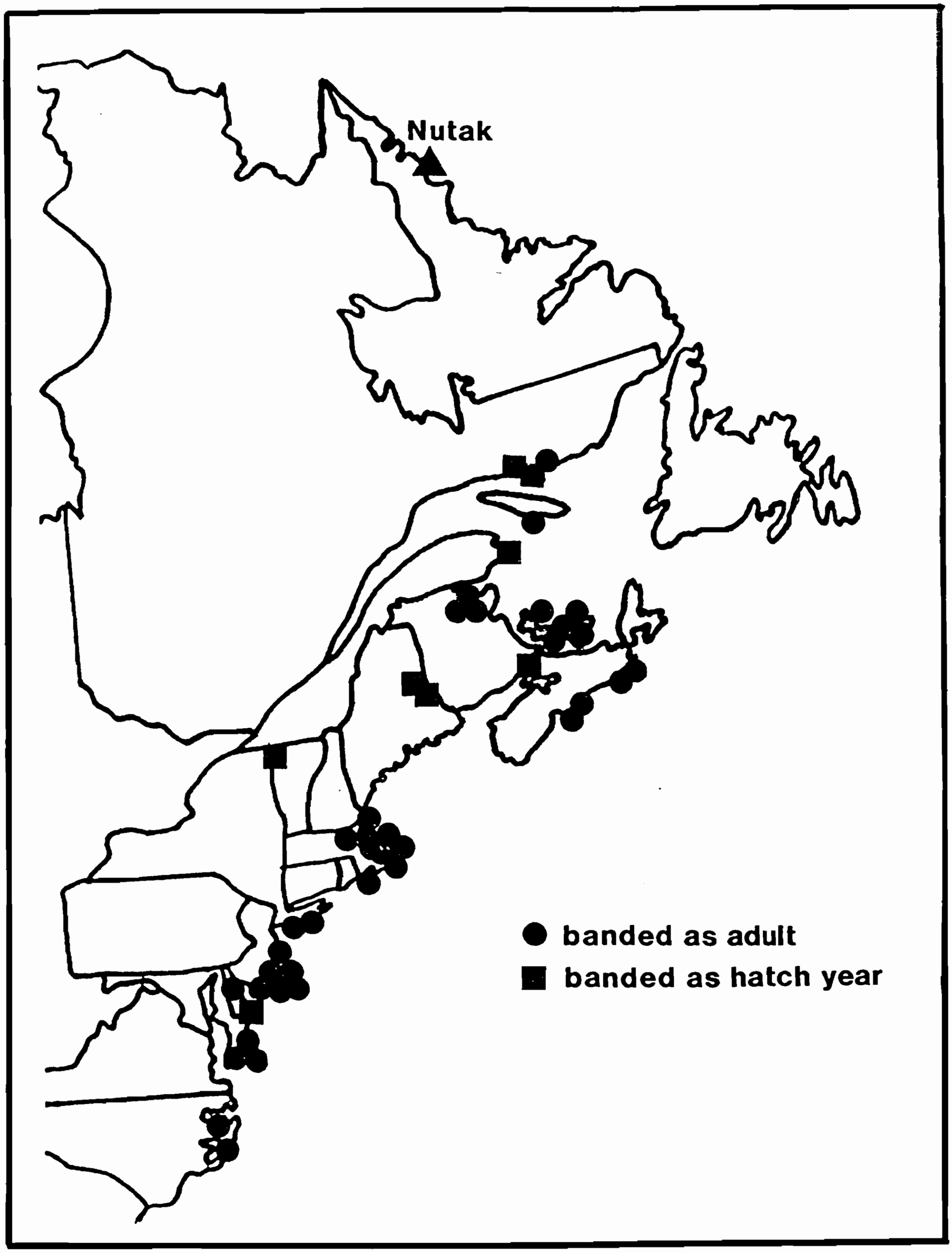
APPENDICES



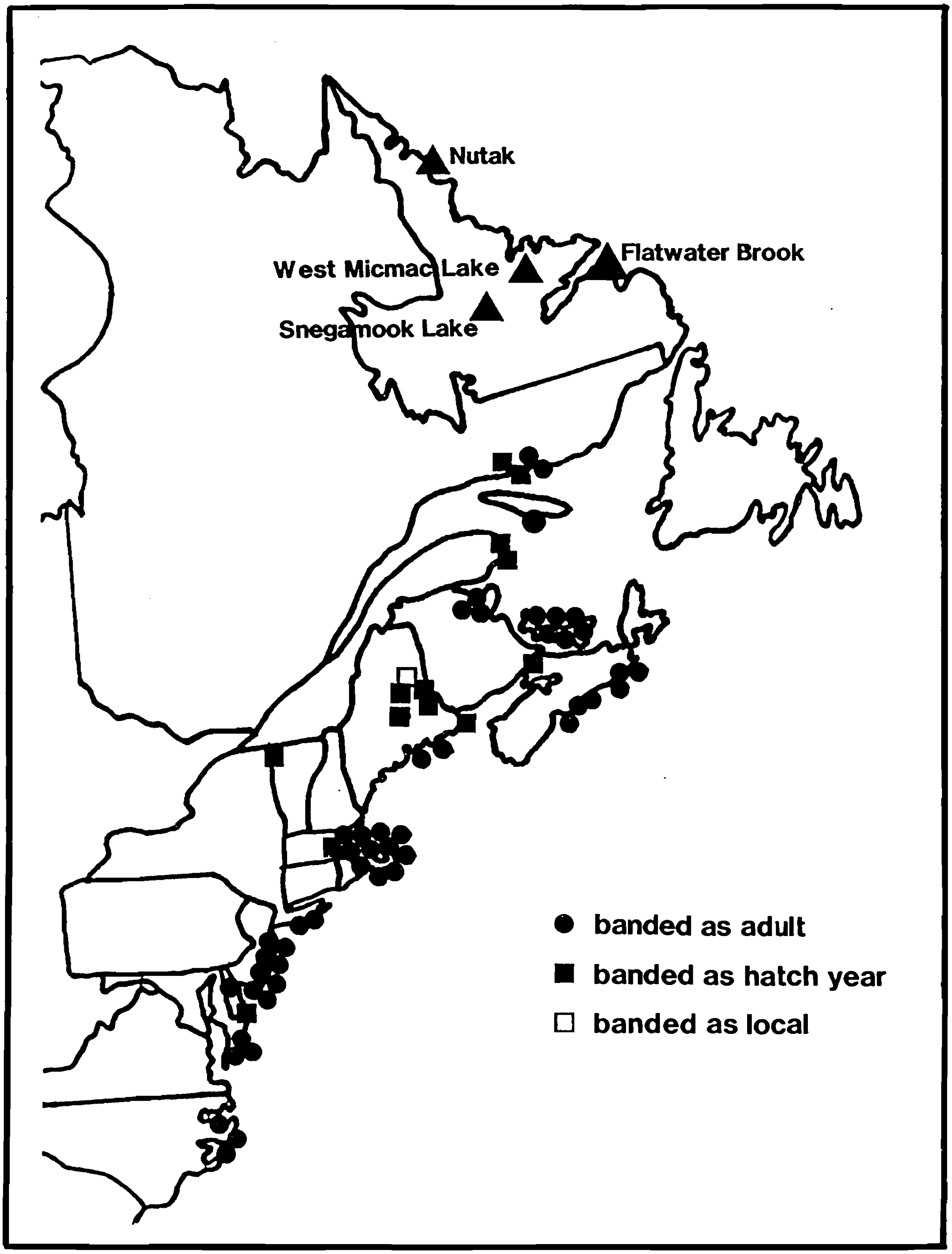
Appendix I. Harvest locations of all male black ducks banded at Nutak, Labrador



Appendix II. Harvest locations of male Black Ducks banded as molters in Labrador



Appendix III. Banding locations of male Black Ducks recaptured at Nutak, Labrador



Appendix IV. Banding locations of male Black Ducks recaptured in Labrador

BIOGRAPHY OF THE AUTHOR

Timothy D. Bowman was born in Rochester, N.Y. on July 8, 1959. He attended public schools in Webster, N.Y. and graduated from R.L. Thomas High School in 1977.

He enrolled in the wildlife management program at the University of Maine at Orono in 1977, and received his Bachelor of Science degree in December 1981. From 1982 to 1984, he worked on various wildlife projects for the Canadian Wildlife Service, Maine Department of Inland Fisheries and Wildlife, and the University of Maine.

In September 1984, he began graduate study at the University of Maine in the Wildlife Department, During his candidacy, he was the recipient of the Frederic Griffee Memorial Scholarship. He is a candidate for the Master of Science degree in Wildlife Management from the University of Maine in May 1987.