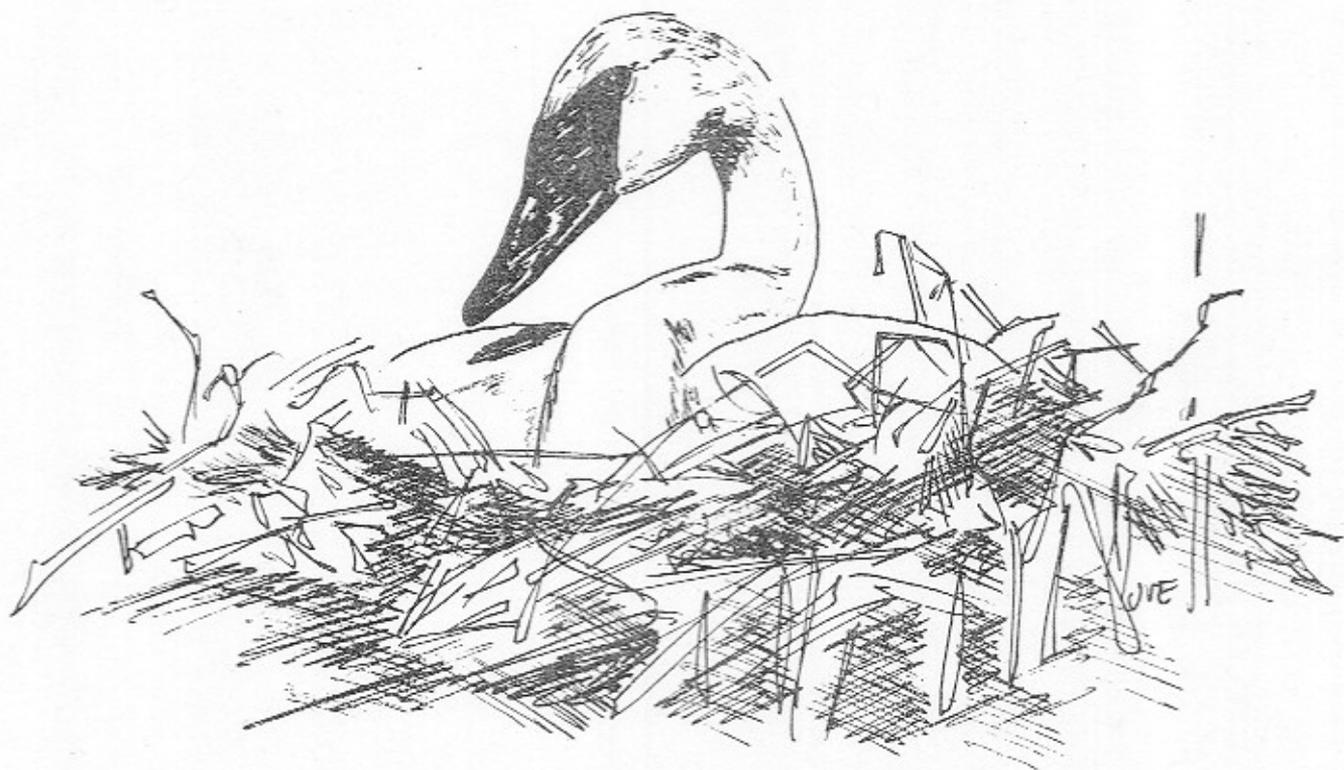


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SUMMER AND MIGRATORY MOVEMENTS OF TRUMPETER SWANS USING THE KENAI NATIONAL WILDLIFE REFUGE, ALASKA

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INTRODUCTION

The Pacific Coast Population of Trumpeter Swans (*Cygnus buccinator*) is the largest Trumpeter Swan population in North America. It comprises about 80 percent of the continent's approximately 12,000 Trumpeters. The breeding and nesting habitat of the Population is primarily in coastal and interior southcentral Alaska. Although the majority of this habitat occurs on lands not specifically dedicated to the conservation of wildlife, one area within south central Alaska established to conserve wildlife, including Trumpeter Swans, is the Kenai National Wildlife Refuge (NWR). In this report, information is provided on the movements of Trumpeter Swans on the Kenai NWR and their migratory route to wintering areas. Management implications, actions taken, and potential problems are discussed.

ACKNOWLEDGEMENTS

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STUDY AREA

The 7,972 km² Kenai NWR is situated in southcentral Alaska on the Kenai Peninsula. Initially designated the Kenai National Moose Range in 1941 and redesignated the Kenai NWR in 1980, this Refuge includes a vast lowland area of Trumpeter Swan nesting habitat. This lowland area contains over 4,000 lakes, ponds, and bogs, plus streams, all of which provide nesting habitat for 20 to 50 pairs of Trumpeter Swans. Typical vegetation surrounding these bodies of water is boreal forest dominated by white spruce (*Picea glauca*), black spruce (*P. mariana*), birch (*Betula papyrifera*), aspen (*Populus tremuloides*), alders (*Alnus* spp.), and willows (*Salix* spp.).

METHODS

Trumpeter Swans on the Refuge have been censused annually since 1957 (Bailey *et al.* 1986). Swans were captured from 1982 through 1985 during their flightless periods when they were either too young to fly (cygnets) or molting (adults).

Cygnets were captured in August and September and adults in July. Most swans were captured in the water using a long-handled (1.5 to 2.5 m) fish dipnet from the floats of a Piper PA-18 Supercub or Cessna 206 aircraft. Others were captured by hand along shorelines as they attempted to hide in dense vegetation.

Captured swans were weighed, sexed, and fitted with aluminum and plastic tarsus bands and a plastic collar. The plastic bands and collars were matched for color and code for each bird.

Some captured swans were also fitted with a small radio transmitter attached with a backpack harness. Swans fitted with radio transmitters were located by aircraft at 1-day to 4-week intervals before the birds left the Kenai Peninsula. One to four monitoring flights were made throughout the fall, winter, and spring of each year along the north Pacific Coast. Most of these flights were confined to Alaska between the Kenai Peninsula and Yakutat, but other flights occurred between Anchorage and Juneau, Alaska, and Seattle, Washington.

RESULTS

Numbers of Trumpeter Swans and locations

Forty-five Trumpeter Swans (20 cygnets, 25 adults) were captured and fitted with radio transmitters between 1982 and 1985 (Table 1). The known sex ratio of captured cygnets was 1 to 1, but captured adult females outnumbered adult males to 1 (Table 2). This high proportion of adult females probably reflected the period of capture. Males molt before female (Hansen *et al.* 1971) and 22 of 24 captures of adults identified sex occurred between 6 and 20 July after most male molted. [Editor's Note: Gillette (1982) reports that breeding males molt after the breeding female has regained flight (late July to mid-August). This schedule would also account for the greater proportion of adult females captured in this study.]

Twenty-nine of the captured swans were associated with families. Our study objective was to attach radio transmitters to only one cygnet per family in 1982, two cygnets per family in 1983, and one or more of the adults per family in 1984. One adult captured in 1984 and all 12 adults captured in 1985 were not associated with young or nesting territories and were assumed to be nonbreeders. Some members of a particular family group in a territory were captured each of the 3 years

Table 1. Numbers and ages of Trumpeter Swans fitted with radio transmitters and the number of times they were relocated on the Kenai NWR, Alaska, 1982 to 1986.

Year	Trumpeter Swans radio-monitored		Number of relocations
	Cygnets	Adults	
1982	5	--	34
1983	15	--	133
1984	--	13	137
1985	--	12	77
1986	--	--	5
Total	20	25	386

Table 2. Sexes of Trumpeter Swans fitted with radio transmitters on the Kenai NWR, Alaska, 1982 to 1985.

Age	Sex			Total
	Male	Female	Uncertain	
Cygnets	8	8	4	20
Adults	4	20	1	25
Total	12	28	5	45

while those in other family groups were captured only 1 year (Table 3). We were able to mark swans at 70 percent of the planned capture locations in 1983 and 1984 (Table 1). Of this 70 percent, 94 percent of the marking was accomplished from July through October.

SUMMER-FALL MOVEMENTS

Trumpeter Swan families

Movements of Trumpeter Swans between nest lakes and other bodies of water (lakes, ponds, bogs, or streams) was typical for 88 percent of the 24 Trumpeter Swan families monitored from July through October (Tables 4 and 5). Only swans on Windy, Fox, and Moose Lakes were observed only on their nest lakes during the entire monitoring period. Windy Lake is quite isolated with no other waterbodies within 2.7 km. Fox Lake had only one small pond 0.3 km away, and the 30,000 ha glacial-fed Tustumena Lake was only 0.4 km away, which the swans avoided. The swan on Moose Lake was monitored 66 days before she shed her transmitter harness; she was never located off her nest lake.

Trumpeter Swan families usually moved as cohesive units between bodies of water, and family members were seldom located alone. Monitored cygnets were with other family members during 85 percent of all cygnet sightings. Eighty-eight percent of the observations of adults were with the brood or the other parent. Among cygnets, there was no significant difference between the number of times male or female cygnets were observed alone. Capture bias favoring adult females

prevented a similar comparison between the movements of adult males and females of swan families.

Most swan families used one to seven other bodies of water in addition to their nest lake during July to October. This use of other bodies of water resulted in movements of swan families up to 44.5 km with an average of 3.4 km (Table 5). Some of these movements were apparently overland before cygnets were able to fly. Assuming some cygnets required only 90 days of development before being able to fly, and cygnets hatched as early as 4 June (Hansen *et al.* 1971), the earliest-hatched cygnets on the Kenai NWR would have been capable of flying in early September. Flightless cygnets in nine of 24 families (38 percent) exhibited movements between lakes: one of five families in 1982 (20 percent), two of eight families in 1983 (25 percent), and six of 11 families in 1987 (55 percent). Seven of these nine incidents (78 percent) were believed to be related to capture disturbance, because the movement of the flightless cygnets occurred 1 to 6 days following capture. During these periods, flightless cygnets moved 0.1 to 2.4 km overland; one family could have moved either 0.8 km overland or 1.4 km via a creek to reach a small pond near their nest lake.

The number and age of swans captured in family groups appeared to influence subsequent movements of flightless cygnets. When one cygnet from a brood was captured, 20 percent of the families moved flightless young overland to another lake. Even if two cygnets per brood were captured, a procedure which took more time and created a greater disturbance, only 25 percent of the families moved flightless young overland. However, if one of the adults was captured (almost always the female during our study), then 55 percent of the families immediately moved flightless young overland.

Three of seven pairs of monitored siblings from broods became temporarily or permanently separated from their families in 1983 before their families migrated from the Refuge. The family group on Phalarope Lake was last seen together (five cygnets, two with radio equipment) on 26 September. One of the monitored cygnets remained with the family until it migrated from the Refuge on 12 October. The other monitored bird was alone on 30 September, and remained alone until 19 October, the last date it was seen on the Refuge. This cygnet was 1.8 to 4.0 km away from the family group as it moved between three separate lakes during the 22-day period.

One of two monitored cygnets from the Hook Lake brood of five was alone the day after its capture on 18 August, rejoined the family by 24 August, was again alone on 26 September, rejoined the family by 30 September, and then remained with the family until they migrated from the Refuge sometime after 21 October. While separated, this lone cygnet used lakes 1.6 and 4.6 km from the lakes being used by the other family members.

One of two monitored cygnets from the Beaver Lake brood of five was alone the day after its capture on 16 August, remained separated until at least 2 October, rejoined the family by 12 October, and remained with the family until it migrated from the Refuge after 25 October. The other monitored cygnet stayed with the family until at least 16 September, was alone on 22 September, and remained alone until last seen on the Refuge on 19 October. The maximum distance of separation of this lone cygnet from his family was 30 km on 12 October (Figure 1).

Table 3. Trumpeter Swan nesting territories and sexes of cygnets and adults captured and fitted with radio transmitters on the Kenai NWR, Alaska, 1982 to 1984.

Nesting territory lake name	Cygnets 1982			Cygnets 1983			Adults 1984			
	Radio-monitored swans			Radio-monitored swans			Radio-monitored swans			
	M	F	U*	M	F	U	M	F	U	
Beaver				1	1					4
Campfire	1									
Camp Island			4							
Curlew				1	1		1			4
Donkey							1			2
Doroshin				1	1		1			1
Fox	1		5	1	1		1			5
Grebe				1	1					
Grey Cliff							1			1
Hook	1		4		2					
Moose				1			1			5
Nest							1			3
N. Pepper									1	4
Phalarope	1		3	2			1			4
Quill										4
Windy					2					1
Total birds being monitored	5		21	15			12			34

* M = male, F = female, U = unknown

Table 4. Monthly distribution of radio relocations of Trumpeter Swans on Kenai NWR, Alaska.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	0	5	4	2	1	56	93	108	105	5	6	386

Although the initial separation of a cygnet from the Hook Lake and Beaver Creek families was probably related to capture disturbance, both cygnets eventually rejoined their families 6 and 57 days, respectively, after separation. However, these Trumpeter Swan families, as well as the one from Grebe Lake, did leave cygnets behind that were capable of flying when they migrated.

Twelve captured adults from 11 family groups were monitored from July 1984 until they migrated from the Refuge in October. Of these, three (27 percent) from Donkey, Doroshin, and Moose Lakes were never separated from their families until monitoring contact was lost or they migrated. Adults from five other families (46 percent) were located alone or apart from their families on only one occasion, for maximums of 10 to 28 days, before they rejoined and migrated with their respective families. These included the Fox Lake female who remained with her family until at least 21 September, was separated from the brood but with six other adult swans 10 km from the nest lake on 5 October, rejoined the family and other families of swans at Watson Lake 35 km away by 18 October, and migrated soon after 23 October. Another female from Quill Lake stayed with her family until at least 6 August, was 0.4 km from the family on an adjacent lake (Decoy Lake) on 10 August, rejoined the family by 15 August, and remained with them until they migrated. A female from Curlew Lake was alone 1.6 km away from the family on 27 July, but had rejoined the family by 6 August and remained with the family until migrating. Similarly, a female from Nest Lake stayed with her family until 27 July, was alone on 10 August, and rejoined and stayed with the family after 7 September. Both monitored parents from the Pepper Lake family were 1.6 km away from their cygnets on 27 July, but rejoined by 6 August, and were always located together thereafter.

Adults from two (18 percent) of the 11 families that were monitored became permanently separated while on the Refuge. A female from Grey Cliff Lake stayed with her family through 8 August, was alone by 15 August, and was 30 km away and still alone when last located on 19 October. The male, who stayed with the brood, paired with another swan, presumably a female, during this period. The female from the Phalarope Lake family stayed with the family until 7 September, was alone on 17 September, and was never located again on the Refuge. However, in contrast to the Grey Cliff female, the Phalarope Lake female apparently rejoined her family before or during migration because she was observed near Burlington, Washington, on 2 December, with another adult and four cygnets, presumably her own.

A more complex association of an adult female and her family was exhibited by the female captured on Beaver Lake. She remained separated from her family for 12 days following capture on a very small pond 1 km from the nest lake. She was joined on the small pond by another adult, possibly her mate, from 25 to 27 July, was alone from 6 to 15 August, and returned

to her brood on Beaver Lake by 7 September. However, on 12 September she was alone on the nest lake, but rejoined the family 10.9 km away by 13 October. By 17 October, the family had moved 8 km to a staging area, and migrated with other swans sometime after 23 October.

Before departing the Kenai Peninsula, eight of 24 (33 percent) monitored swan families joined other swans including other families at staging areas before migrating. Staging areas were ice-free when most of the other lakes and ponds were frozen. The most-used staging area was a wide and shallow stretch of the lower Moose River, at the confluence of the Kenai River. Four of 11 families (36 percent) joined other swans at this location in mid-October prior to migration. This group included swan families from the Pepper Lake area, 40 km, Beaver Lake, 17.6 km, Donkey Lake, 11.2 km, and Doroshin Lake, 10.7 km away from the lower Moose River stretch. A minimum of 23 adults and 20 young-of-the-year were observed together with the radio-monitored swans on this stretch of the lower Moose River during October 1984.

Watson Lake was another staging area used by the Fox Lake family (38 km away) and other unmarked adults and cygnets. Small ponds within the eastern Chickaloon River Flats also served as staging areas for swans including the Campfire Lake family, 38 km away. Swans of the Hook Lake family joined another adult on King Lake, 17.6 km away, before migrating. Swans from the Quill Lake area joined others only 2 km away on the nearby Swanson River before departing from the Refuge.

Nonbreeding Trumpeter Swans

Thirteen nonbreeding adults captured in 1984 (1 swan) and 185 (12 swans) were monitored through 1986. In contrast to members of swan families, nonbreeders moved greater average distances (8.5 km vs. 3.4 km) and maximum distances (9.6 to 52.8 km) between lakes than members of swan families (0 to 44.5 km) during the July-through-October period (Table 6). Although eight of the captured nonbreeders were captured in pairs including two male-female pairs, one female-female pair, and one female-unknown pair, only the female-unknown pair remained together from mid-July to mid-October 1985. None of the three monitored pairs which became separated, rejoined during the monitoring period. Nonbreeders avoided territories used by families of swans, but were with other presumably nonbreeding swans during 67 percent of the 78 summer-fall observations. The only times monitored nonbreeders were located with cygnets were in the late fall at staging areas. An adult female from the Curlew Lake area was with a group of five adults and three cygnets at the outlet of the lower Russian River on 10 October 1985. Another adult female was located with a group of 36 adults and three cygnets on the lower Moose River on 9 October 1985.

Certain lakes on and adjacent to the Refuge attracted aggregations of nonbreeding swans. These included the lower

Table 5. Movements of Trumpeter Swan families on the Kenai NWR, Alaska.

Nest lake name	Cygnets				Adults				
	1982		1983		1983		1984		
	# of water bodies used	Maximum distance (km)	Average distance ¹ (km)	# of water bodies used	Maximum distance (km)	Average distance (km)	# of water bodies used	Maximum distance (km)	Average distance (km)
Beaver				7	24.5	5.3	2	10.9	4.2
Campfire	4	44.5 ²	1.9						
Camp Island	4	15.2	5.3						
Curllew				2	1.8	1.6	2	8.3	4.1
Donkey							2	11.5 ²	1.3
Doroshin				1	1.8	1.6	2	11.2 ²	0.3
Fox	0	0	0	2	11.0	7.6	3	35.2 ²	5.8
Grebe							5	20.0	6.7
Grey Cliff				5	30.1	8.4	0	0	0
Hook	4	20.2 ²	3.7	5	20.0	5.4	5	8.2	3.4
Moose							5 ²	34.4 ²	3.4
Nest							2	1.9	1.5
N. Pepper				6	8.0	2.9	4	3.0	1.7
Phalarope	3	7.8	4.9						
Quill				0	0	0			
Windy									

¹ Excludes movements to staging area.

² Movement to a staging area.

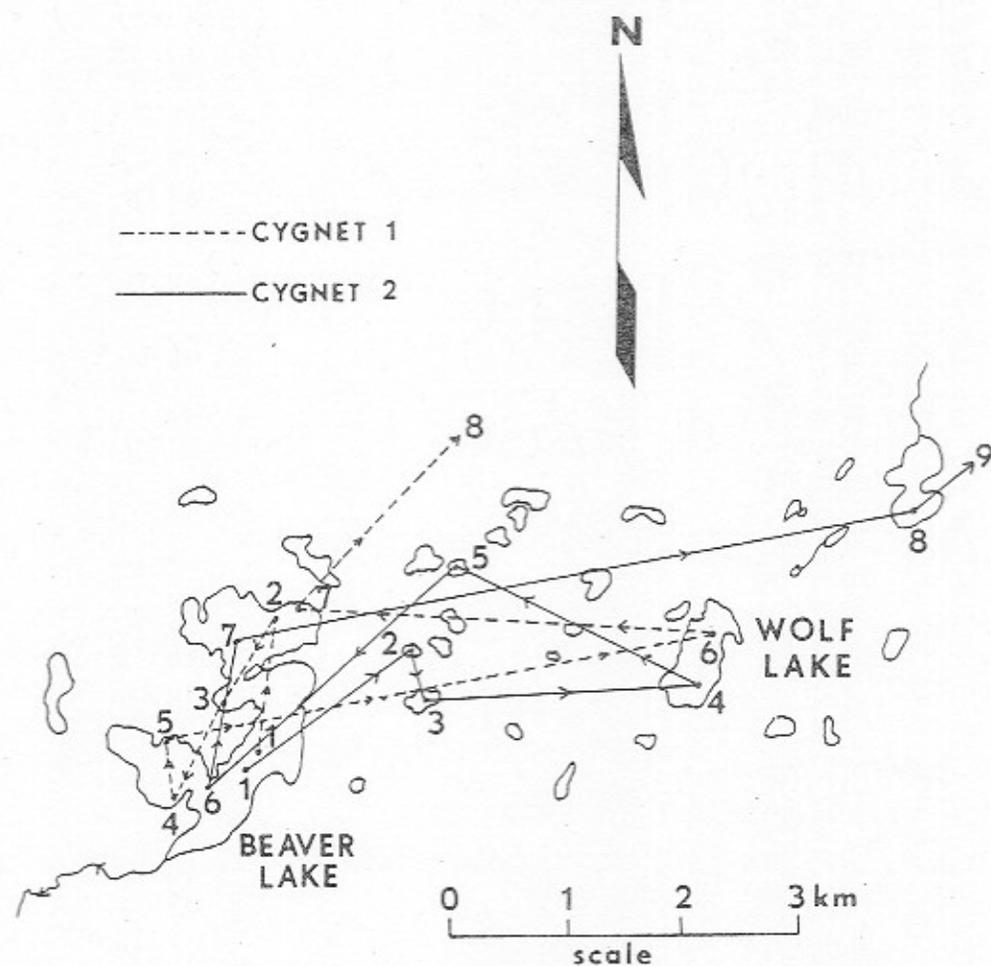


Figure 1. Sequential locations indicated by numbers showing lakes used by and movement patterns of Trumpeter Swan cygnets from the same brood on the Kenai National Wildlife Refuge, Alaska, August-October 1983. Location 1 is a brood capture site. Cygnet 1 was alone at locations 2-8 but joined adults 15.3 km away. Cygnet 2 was with adults at locations 1-4 but alone on subsequent locations.

Moose River (45 swans), Meadow Lake (14 swans), and a small unnamed lake northwest of Moose Lake (11 swans). These lakes were usually shallow, had abundant aquatic vegetation, were ice-free, and generally were not used by families of swans except in the fall. Flock size of nonbreeders appeared to increase throughout the summer. Aggregations of at least four swans were observed as early as 9 July, 11 swans by 9 August, 14 swans by 6 September, and 36 swans by 9 October.

Table 6. Movements of nonbreeding adult Trumpeter Swans on the Kenai NWR, Alaska, July-October, 1984-85.

Capture location	Number of lakes used in addition to capture lake	Distance moved	
		Maximum (km)	Average (km)
Hook	6	21.0	8.2
N. Curlew	4	18.2	7.6
NW Curlew	5	51.5	22.4
W. Tundra	5	52.8	19.1
Rabbit Foot #1	4	3.7	2.5
Rabbit Foot #2	3	10.7	4.0
Meadow #1	2	17.4	5.5
Meadow #2	4	12.6	6.8
Gooseneck	3	9.6	4.3
Flat #1	5	10.8	6.4
Flat #2	3	24.3	11.3
Grouse #1	3	11.5	4.5
Grouse #2	3	11.5	4.5

FALL MIGRATION MOVEMENTS

Twenty-five sightings of 19 migrating swans between 1982 and 1986 indicated a Pacific Coast Population coastal migratory route at least as far south as northwestern Washington (Table 7). Movement of swans from the Kenai Peninsula was in a northeasterly direction west of the Kenai Mountains to a pivotal point at the Chickaloon River Flats where swans abruptly turned east up the Turnagain Arm of Cook Inlet. They then crossed the Kenai Mountains in the vicinity of Portage Pass, to Prince William Sound. Once over Prince William Sound, some swans apparently flew directly across, stopping on Hinchinbrook Island to reach Cordova and the Copper River Delta. Swans from the Cordova-Copper River Delta area flew south along the coast stopping at Cape Suckling, Icy Bay, Malaspina Glacier, Yakutat, and Dangerous River. Once in southeastern Alaska, swans apparently took a route between the many islands with stops at least on Prince of Wales Island and in the Ketchikan area. From there, the next location of an observation was near Burlington and perhaps another (unconfirmed) from the Olympic Peninsula, Washington. Places of particularly high or extended use by swans along this migratory route, as identified in this study, were Eyak Lake at Cordova as well as the Copper River Delta and the Yakutat area including the Dangerous River Delta. Because of our infrequent and sporadic monitoring flights during the swan migration, it is likely that migrating Trumpeter Swans from the Kenai Peninsula also used many additional locations yet to be documented.

Although about 5,000 Trumpeter Swans from the Pacific Coast Population are believed to overwinter in British Columbia (McKelvey 1986), we did not detect a signal from any of the radio-collared Kenai NWR swans. However, because of the rugged terrain and flight path, such signals could have been missed. Most Trumpeter Swans previously banded on the Kenai NWR have been observed in the northwestern Washington area (Canniff 1986), but this may merely be a result of increased search effort and visibility in that locality.

Most migrating swans left the Kenai Peninsula by the second or third week in October (Table 8). Only a few swans remained the last week of October when most lakes were frozen. Swans observed during this late period were using small open water portions of ice-covered lakes (two swans), a large ice-free glacial lake (one swan), and the open outlet of a frozen lake (one swan). A swan still on the Refuge 17 October was at Cape Suckling, 350 km away, by 29 October. However, others were still further north in the Cordova area on 29 October. By 30 November, one swan was observed at Icy Bay having moved only 128 km from Cape Suckling in 30 days or less. Another swan had moved only as far southeast as the Malaspina Glacier by 23 December. Another swan, captured on Fox Lake and last seen on the Refuge on 23 October 1984, was at Prince of Wales Island at least 1,177 km away by 29 November. An adult female, captured on Kenaitze Lake and last observed on the Refuge on 17 September, 1984, was observed near Burlington, Washington on 2 December. She had made the entire trip of at least 2,257 km in no more than 76 days.

Only three of a total of 45 swans fitted with radio transmitters were located on the Kenai NWR the year after they were marked. A nonbreeding female captured near Hook Lake on 18 July 1984 was observed 10 July 1985 with three other adults near her previous year's capture site. Another nonbreeding female captured on Meadow Lake on 8 July 1985 was observed with another adult on 29 April 1986 near her capture site and was last seen, still nearby but alone, on 27 August 1986. An adult female from the Quill Lake family captured on 12 July 1984 shed her transmitter harness on the bank of the nearby Swanson River by 5 May 1986. She had been near Yakutat, Alaska, about 610 km away, on 27 March.

DISCUSSION AND MANAGEMENT IMPLICATIONS

An overview of the problems, procedures, and recommendations for managing the Pacific Coast Population of Trumpeter Swans (McKelvey 1986) indicated the two major management problems were loss or alteration of breeding, migration, and wintering habitat, and the need for more detailed life history information. We have attempted to address both of these problems on the Kenai NWR. However, as pointed out by Bangs *et al.* (1982), protecting wildlife and its habitat is a difficult task even on lands dedicated to wildlife conservation. Primarily because of our historical data and Trumpeter Swan studies, the Kenai NWR was successful in protecting nesting Trumpeter Swans and their habitat by instituting access regulations for aircraft use between 1 May and 30 September on all lakes used by nesting Trumpeter Swans and their broods. These regulations became effective in September 1986 despite opposition from the user group. The Refuge has also removed several aircraft taxi-operator and boat-equipped tent camps from Refuge lakes used by nesting Trumpeter Swans. Despite these measures at least two instances were documented where nesting Trumpeter Swans abandoned Refuge lakes

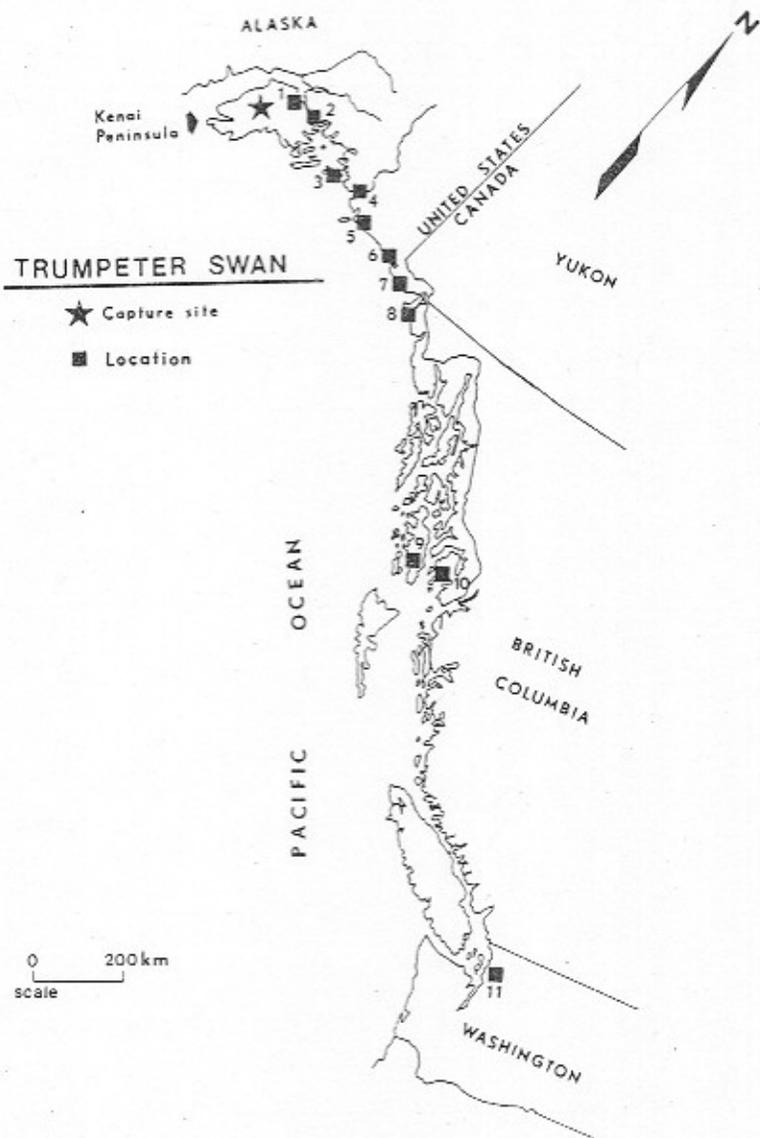


Figure 2. Relocations of migratory Trumpeter Swans fitted with radio transmitters on the Kenai NWR, Alaska, 1982-85. See Table 7 for description of numbered locations.

Table 7. Locations, straight line distances (km), observation dates, and numbers of Trumpeter Swans observed along migration routes from Kenai NWR to Washington State.

No.*	Area	Distance to next location (km)	Observation (month/day)	Number of individuals seen		
				Cygnets	Adults	Total
1	Chickaloon R.	56	10/9, 15	2	0	2
2	Portage Glacier	155	10/29; 11/4	1	1	2
3	Hinchinbrook Is.	32	10/29	0	1	1
4	Cordova/Copper River Delta	107	10/23, 29; 12/1; 5/19;	3	3	6
5	Cape Suckling	128	10/29	0	1	1
6	Icy Bay	67	11/30	0	1	1
7	Malaspina Glacier	64	12/23; 3/27	2	1	3
8	Yakutat/Dangerous R.	568	12/1; 3/27; 4/19; 5/16	3	3	6
9	Prince of Wales Is.	95	11/29	0	1	1
10	Ketchikan	985	1/8	0	1	1
11	Burlington, WA	0	12/2	0	1	1
Total		2257		11	14	25

See Figure 2.

Table 8. Fall migration periods of Trumpeter Swans on the Kenai National Wildlife Refuge, 1982-85.

Date	Numbers of monitored swans remaining on the Refuge*				
	1982	1983	1984		1985
	Cygnets	Cygnets	Breeders	Nonbreeders	Nonbreeders
October 1-7	5	9	11	1	12
October 8-15	5	8	10	1	12
October 16-23	1	8	9	1	3
October 24-31	1	1	0	0	1
November 1-7	0	0	0	0	0

*Excludes mortalities occurring on the Refuge.

boat occurred.

Our movement data on Trumpeter Swans suggests that water bodies adjacent to nest lakes may be just as important to successful reproduction for some families of swans as are their nest lakes. These bodies of water are serving as additional feeding areas and places to seek refuge from disturbance on the nest lake. We suspect that swans rearing cygnets on isolated nest lakes could experience lower productivity if food was limited and the family group was frequently disturbed.

Data also suggest that mortality rates may increase among cygnets if they are disturbed and are moved overland to an adjacent lake or if they spend considerable time along the shore of the nest lake attempting to hide in dense vegetation. Such behavior apparently exposes cygnets to increased predation.

Protection of staging and migratory stop-over areas located on

lands not dedicated to wildlife conservation is one of the great difficulties in habitat protection for Trumpeter Swans. For example, an important fall staging area for Trumpeter Swans nesting on the Kenai NWR is the lower Moose River adjacent to, but outside the Refuge. Increasing residential development and recreational use of the area makes the future use of this area by Trumpeter Swans unlikely. The long-term security of habitat used by Trumpeter Swans migrating from the Kenai Peninsula is unknown. Until now, many of these areas have retained their value for swans and other wildlife because of their remoteness and minimal disturbance. With increasing use by humans such values are likely to decline. Perhaps it is fortunate that some wintering Trumpeter Swans appear capable of adapting to new sources of food incidentally provided by man and to man-caused disturbance (Canniff 1986, Jordan 1986, McKelvey 1986). This characteristic may be a key to the survival of the Pacific Coast Population of Trumpeter Swans.

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