Dispersal, Home Range and Survival of Repatriated Mink in the Northern Coastal Marshes of South Carolina

J. W. Peeples, *Department of Aquaculture, Fisheries, and Wildlife Biology, Lehotsky Hall, Box 340362, Clemson, South Carolina 29632-0362*

T. T. Fendley, *Department of Aquaculture, Fisheries, and Wildlife Biology, Lehotsky Hall, Box 340362, Clemson, South Carolina 29632-0362*

O. E. Baker, III, *South Carolina Department of Natural Resources, Box 167, Columbia, South Carolina 29202*

J. W. Butfiloski, *South Carolina Department of Natural Resources, Box 167, Columbia, South Carolina 29202*

Abstract: Research conducted by the South Carolina Department of Natural Resources indicated that populations of mink throughout South Carolina were declining or had become rare in areas of previous abundance. In September 1998, we initiated a 3-year study within the Cape Romain National Wildlife Refuge in Charleston County, South Carolina, to determine the feasibility of re-establishing a wild mink *(Mustela vison)* population in the northern coastal marshes of South Carolina. We captured 62 wild mink with dip nets, cast nets, and live traps from tidal marshes near Edisto and Daufuskie islands, South Carolina. Dip nets and live trapping of family groups were the most effective capture methods. Nineteen mink were implanted with radio-transmitters before release, and the remaining mink were released in the CRNWR without transmitters. We located 14 mink on 902 occasions over a 15-month period. We obtained sufficient data for home range analysis on 4 males and 9 females. Gender-specific mean dispersal distances from their release sites were 3.61 $\pm$ 0.43 km for males, 1.1 $\pm$ 0.38 km for females with offspring, and 4.67 $\pm$ 0.43 km for females without offspring. While there was no difference in dispersal distance between males and females without offspring, dispersal distances of females with offspring were less than both males and females without offspring. Gender-specific mean home range sizes were 6.91 $\pm$ 1.41 km^2 for males and 2.28 $\pm$ 0.89 km^2 for females. Although male and female home range sizes differed, home range sizes were not different between females without offspring and females with offspring. Overlap in home range was evident between gender but not within gender, which suggests intra-sexual territoriality. There was an 89% survival estimate of radio-implanted mink to 125 days using the Kaplan Meier survival procedure, suggesting that repatriation of wild mink was successful. The success of this study has prompted SCDNR to continue mink restoration in the state's northern coastal marshes using capture techniques developed during the study.

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Historically, the North American mink *(Mustela vison)* was a prized fur-bearing species throughout North America. Once the object of great demand for trapping in the Southeast, mink populations have experienced less trapping pressure in recent years due to a decline in the fur market (Baker 1998). Although influenced by demand, historic harvest records indicate a possible decline in the South Carolina mink population (Novak et al. 1982). This is supported by a mail survey conducted by the South Carolina Department of Natural Resources (SCDNR) which revealed that 40% of trappers who caught mink during the 1988 trapping season perceived wild mink to be declining in upland areas (Furbearer Proj. Supervisor, SCDNR, per. commun.). This trapper-perceived reduction in South Carolina's wild mink population is supported by floodtide, spotlight surveys for mink by the SCDNR in the state's coastal marshes since 1990 (Baker 1998). Mink were consistently observed (45 of 51 surveys) south of Charleston, but rarely observed north of Charleston, South Carolina (1 of 16 surveys).

In addition to a general paucity of information about the species, knowledge of dispersal distance of released animals, home range size, and social interaction within the species would be beneficial to anyone contemplating mink restoration projects. Such information would aid in distribution of released animals to enhance survival and growth of the population by maximizing reproductive opportunities and reducing possible negative intra-sexual interaction. A study was designed to investigate the feasibility of re-establishing a wild mink population in the coastal marshes north of Charleston. Our objectives were to develop effective capture and handling techniques, determine dispersal distances from the release site to the geometric center of the new home range, home range size and shape, home range overlap, and survivorship of radio-transmitter implanted mink.

This study was conducted through the South Carolina Aquaculture, Fisheries and Wildlife cooperative, a research and educational unit of Clemson University, and the SCDNR. Project funding was provided by the Furbearer Project in the Wildlife and Freshwater Fisheries Division of SCDNR. Appreciation is extended to P. Shealy, DVM, Veterinary Specialists of the Southeast, North Charleston, South Carolina, and Savannah, Georgia. Thanks are extended to the staff of the Wambaw Ranger District, Francis Marion National Forest, U.S. Forest Service, and the officers of the SCDNR Law Enforcement Division. Appreciation also is extended to P. Morrison and B. Cuizio for their valuable assistance.

Methods

The study was conducted on the U.S. Fish and Wildlife Service's (USFWS) 25,898-ha Cape Romain National Wildlife Refuge (CRNWR) located between Mount Pleasant and Georgetown, South Carolina. The CRNWR was established in 1932 and was located in the Carolinian South Atlantic Bio-geographic Province (Mark Purcell, USFWS per. commun.).

The CRNWR was comprised of a combination of salt marsh/barrier island habitat that spanned approximately 32 km of the South Carolina coast. CRNWR included 12,096 ha of open water and 13,802 ha of brackish water impoundment, maritime forest, salt marsh, tidal creek, sand dune, and beach environments. CRNWR was isolated from the mainland by the intra-coastal waterway and only accessible by boat.

Elevations ranged from 0 to 3 m above mean sea level. Lower elevations were characterized by salt marsh with smooth cord grass *(Spartina alterniflora)* as the predominant vegetation. Needle rush *(Juncus roemerianus)* also existed in the transitional areas from salt marsh to higher elevations. Small hammocks dominated by saltwort *(Batis maritime)* and sea ox-eye *(Borrichia frutescens)* were interspersed throughout the marsh. Higher elevations were composed of islands with a pine-hardwood mixture. Tidal variation in creeks range from 1–2 m depending upon season. Raccoon *(Procyon lotor),* river otter *(Lutra canadensis),* marsh rice rats *(Oryzomys palustris),* and over 337 species of wading birds, short birds, waterfowl and raptors occurred in the refuge (M. Purcell, pers. commun.). Although CRNWR annual reports indicate mink harvest in the 1940s and 1950s, mink are not currently on the refuge's species list (M. Purcell, pers. commun.).

Capture and Handling

We captured wild mink south of Charleston in tidal salt mashes and creeks adjacent to Edisto and Daufuskie islands. While conducting spotlight surveys we observed mink loafing and/or feeding on floating dead spartina (tide wrack) mats or other debris during flood tide (tides 2.2 m above mean low water) periods of the month. Capture techniques were designed to capitalize on behavior of mink using tide wrack and other debris for refuge during flood tide periods. When located, mink were flushed from their refuge areas into open water, pursued until conditions were favorable for a capture opportunity, and captured either by cast net, dip net, or shove net.

We used live trapping when mink were inaccessible by boat, conditions were not favorable to attempt other capture methods or to capture family groups. Tomahawk, double=door live traps (14 × 14 × 48 cm) were placed on pieces of Styrofoam insulation. We passed a plastic pipe or steel rod vertically through a hole in the Styrofoam to anchor it into the marsh substrate. This allowed vertical movement of the Styrofoam during tidal fluctuations. Traps were most often baited with blue crabs *(Collinectes sapidus),* especially in situations were mink were observed feeding on a blue crab. We captured family groups (female and offspring) by dip netting the young and placing them in a closed trap adjacent to an open trap on the tide wrack or Styrofoam. The female was captured in the open trap when she returned to retrieve her young.

We transported captured mink to a veterinary clinic in Savannah, Georgia, or Charleston, South Carolina (Vet. Specialists of the Southeast, North Charleston, S.C.) for radio-transmitter implantation. Mink were anesthetized with iso-flurine gas while in a PVC tube designed for this purpose and then transferred to a muzzle cuff. While under anesthesia, mink were sexed, weighed, checked for health status, and dentition was inspected to aid in estimating age. We implanted healthy mink using techniques described by Stevens et al. (1997) by qualified veterinary surgeons with sterile, intra-peritoneal, mortality-sensing radio-transmitters weighing approximately 17 g. (Model 5902-ATS, 150 Megahertz, Advanced Telemetry Systems, Isanti, Minn.). The abdominal region was shaved, cleansed for surgery, and hair samples were collected and labeled for mercury contaminant analysis by the Clemson Institute of Environmental Toxicology. A 2-cm incision was made by the veterinary surgeon along the central midline of the abdomen and the transmitter was inserted. The incision was closed using 2 layers of 5 simple interrupted sutures.

We marked implanted mink with ear tags and a Passive Internal Transponder (PIT) and released them within 3–4 hours of surgery at different locations throughout the research area to reduce possible negative interactions. We operated under Protocol 00-063, Animal Research Commission, Clemson University.

Radio-Telemetry

We monitored radio-implanted mink daily until they died, the signal was lost, or the transmitter ceased to function. To increase range of radio reception, a 4-element yagi antenna was suspended on a boat-mounted 5-m pole attached to a receiver (Telonics, In., Mesa, Ariz.). We obtained locations of mink by triangulation from receiving stations (sites locatable on nautical charts) using the strongest signal method (Springer 1979). To minimize error, the angle of intersection was not accepted unless it was between 60° and 120°. In most cases, exact locations were taken with a handheld GPS unit (Lowrance Electronics Inc., Ontario, Can.) when radio-implanted mink were observed during telemetry. We attempted to monitor mink 2 hours later each day to obtain location data throughout the 24-hour cycle. However, due to limited range of implanted transmitters (0.05–0.25 km), access to many mink at certain times of the 24-hour cycle was prevented because of low tide. When a transmitter signal was lost for 10–15 days a fixed wing aircraft was used in conjunction with a boat in the marsh in an attempt to locate the animal.

Data Analysis

Home range areas and dispersal distances were calculated by converting compass bearings from paired receiving stations to Universal Transverse Mercator (UTM) locations using a computer program developed by Hill and Fendley (1982) and modified by Boyle (1986). Telemetry location coordinates were input into Arcview (Environ. Systems Res. Inst., Redlands, Calif.) and merged with a Geographical Information System (GIS) land cover data set. Home range area size was determined using the minimum convex polygon method (Mohr 1947). An index to linearity and the length of the longest axis were calculated for each home range following Marchinton and Jeter (1966). Home range boundaries were plotted and percentage overlap determined using Arcview. We used split-plot analysis of variance and an LSD standardized range test to test for significant differences in dispersal distance (distance from release site to geometric center of the new home range), home range area, and index to linearity due to gender-class using SAS (SAS 1985). We calculated mortality rates for radio-implanted mink using the Kaplan-Meier product limit method (Pollock et al. 1989), which allows for the staggered entry of samples.

In addition, mink that were lost and relocated at a later time were censored when lost and added to the procedure when relocated. We based statistical significance on an alpha level of 0.05 for all tests.

Results

Capture and Handling

We captured 3 groups of mink; 2 groups in 1999 and 1 group in 2000 totaling 62 mink (31 adults, 10 sub-adults, and 21 kits). We captured mink at a rate of 1.5 man-days/mink. Three mink kits were released at the capture sites because the female parent could not be caught, and 1 mortality occurred during live trapping. The mortality appeared to be captured related and occurred for a mink captured using a live trap set on Styrofoam on a night after a flood tide. The mink was apparently in the trap overnight and access to the trap was prevented until high tide the next morning. Capture periods for groups 1 and 3 coincided with kit-rearing periods in the marsh. Under these circumstances, the family unit, a female and her young, were all released at the study area together. We implanted 19 mink with radio transmitters: 6 males and 13 females. The surgical procedure averaged 23 minutes. Following implantation, all mink were released into the CRNWR on the same day of surgery. We released 58 mink in the CRNWR, 19 radio-implanted and 30 without implants.

Radio Telemetry

We monitored radio-implanted mink from September 1999 to November 2000. Transmitter signals could be received up to 0.25 km on high tides and 0.05 km on low tides. We obtained 902 locations, 675 for females and 227 for males. We collected sufficient locations on 13 mink for home range analyses.

Only 1 known mortality occurred among radio-marked mink. This mortality occurred approximately 120 days after radio-implantation and release, and cause of death was unknown.

Contact with 3 (15.7%) of 19 implanted mink was lost shortly after release (Mean = 10 ± 3 days) and their radio signals were never relocated by air or boat. Excluding these 3 mink, the average transmitter life under field conditions was 130 days (range = 60–210 days). Thus, the Kaplan-Meier procedure was truncated at 125 days. Survival of radio-implanted mink was 0.89 with a 95% confidence interval from 0.68 to 1.09 for 125 days post-release.

Gender-specific mean dispersal distances from the release site to the geometric center of new home ranges were 3.61 ± 0.43 km for males, 4.67 ± 0.43 km for females without offspring, and 1.11 ± 0.38 km for females with offspring (Table 1). While there was no difference in dispersal distance between males and females without offspring ($F_{2,12} = 20.79$, $P = 0.11$), dispersal distances of females with offspring were less than both males ($F_{2,12} = 20.79$, $P = 0.001$) and females without offspring ($F_{2,12} = 20.79$, $P = 0.001$, Table 1). Juvenile mink of released family groups were observed with female parents on floating tide wrack during high tides.

Table 1. Gender-specific home ranges and dispersal distances for radio-implanted mink captured south of Charleston, South Carolina, and released in the Cape Romain National Wildlife Refuge, South Carolina, 1999–2000.

Sex status	*N*	Mean dispersal distance(km)	SE	LSD grouping[a]	Mean home range (km^2)	SE	LSD grouping[a]
Males	4	3.61	0.43	A	6.91	1.41	A
Females	9	2.68	0.60	C	2.28	0.89	B
Females without kits	4	4.67	0.43	A	2.08	1.26	B
Females with kits	5	1.11	0.38	B	2.44	1.41	B

a. Between gender status, means with the same letter are not significantly different.

Gender-specific mean home range sizes were 6.91 ± 1.41 km^2 for males and 2.28 ± 0.89 km^2 for females (Table 1). Although male and female home ranges were different ($F_{2,12} = 3.75$, $P = 0.03$), home ranges were not different between females without offspring and females with offspring ($F_{2,12} = 3.75$, $P = 0.85$).

Mink home ranges were consistently 2-dimensional in the salt marsh. Home range longest lengths were 4.08 km for males and 2.54 km for females. The gender-specific mean index to home range linearity was 2.10 for males and 2.03 for females, suggesting a slightly linear home range pattern for all mink.

Overlap of home ranges between genders was documented; however, there was no intra-sexual overlap documented. Home ranges of male mink were disjunct and overlap could not be determined. The home ranges of 3 females were contiguous and did not overlap. The remaining 6 female mink home ranges were disjunct and overlap could not be determined. Three male mink home ranges overlapped female home ranges, 1 male overlapped home ranges of 3 females, and 2 males overlapped the home range of 1 female each. On average. 61.4% (SE = 15.4) of female mink home ranges were overlapped by males.

Discussion

Capture and Handling

Trapping mink in the marsh was successful but labor intensive. Trapping required extensive equipment (boats, spotlights, nets) and personnel to be successful. The rate of capture per unit effort was much less (1.5 man days/mink) when compared with other studies and capture techniques. Mitchell (1961) and Stevens et al. (1997) used box traps and caught 1 mink/81.8 trap nights and 1 mink/1,518 trap nights, respectively. Capture techniques were dependent upon several variables in the marsh (water turbidity, wind speed and direction, tidal height and/or vegetation height). Dip nets provided an advantage over live traps, cast nets, and shove nets under normal circumstances. Dip nets allowed the operator multiple attempts to capture a mink.

During May through July, young captured with a dip net or by hand were placed in a closed live trap adjacent to a second live trap set to catch the female. Capture using this technique was 100% successful. This technique became more difficult as young aged and became more mobile. Surgery for transmitter implantation could be completed in approximately 23 minutes. Eagle et al. (1984) reported a similar time frame for the implant procedure (20 minutes).

Radio Telemetry

Literature on radio-telemetry in mink reported 2 types of monitoring: single daily locations and periodic continuous radio locating. Stevens et al. (1997) reported locations of mink collected similar to our study. They reported 97 locations, which were daily diurnal radio-locations, on 3 mink. We also collected a single daily radio location. Although we attempted to collect more than 1 daily location, low tide periods prevented access to the mink. Gerell (1969, 1970) and Niemimaa (1995) reported periodic data on several mink tracked continuously over a period of time.

Surgical techniques were the major factor in the survival of mink implanted with radio-transmitters in a study conducted at the University of Minnesota, which reported an 89% survival of radio-implanted mink (Eagle et al. 1984). We also documented an 89% survival of radio-implanted mink in our study; however, we feel implant surgery did not contribute to mortality because only 1 implanted mink was known to have died after surgery and the death occurred 120 days after surgery and release. No other study in the literature reported mortality and this lack of reported mortality may have been because of their overall short tracking periods (Gerell 1969, 1970) or transmitter failures (Stevens et al. 1997).

Dispersal distances of male mink were less than females without offspring. This is unusual since home range estimates between gender were less for females and may be due to a small sample size (4) for males. Female mink dispersal distances were especially reduced in females released with offspring. This is assumed to be because females with offspring could not move their kits great distances after release.

Previous radio-telemetry studies of mink use areas have reported 2 home range shapes depending on the type of wetland environment they occupy (Gerell 1970, Whitman 1981). In some habitat types home ranges may be measured in 2 ways (Niemimaa 1995). In riverine, lacustrine, and reservoir environments, mink home ranges were linear (1 dimensional) and have been presented at linear distance along a stream or lake shoreline. In general, lengths of CRNWR mink home ranges were greater than linear lengths reported for mink home ranges along streams, canals, and lakeshores in England (Birks and Linn 1982, Dunstone and Birks 1983), Finland (Niemimaa 1995), Montana (Mitchell 1961), and Sweden (Gerell 1970). However, CRNWR mink home range lengths were less than those reported for mink along streams in Tennessee (Stevens et al. 1997). Index to linearity values (>2) indicated progressively linear home range patterns, which are comparable to mink home ranges along rivers in Montana (Mitchell 1961) and Tennessee (Stevens et al. 1997).

Two-dimensional mink home ranges have been reported for mink in the Prairie Pot Hole Region of Canada (7.7 km^2) by Arnold and Fritzell (1987), and in the Finnish outer archipelagos (0.28 km^2) by Niemimaa (1995). CRNWR mink home ranges (6.91 km^2 for males and 2.28 km^2 for females) were also two-dimensional and larger than most in the literature (Birks and Linn 1982, Dunstone and Birks 1983, Niemimaa 1995) but smaller than those reported by Arnold and Fritzell (1987). The large home ranges of CRNWR mink could be because of greater-than-normal movements after release into a new environment. In addition, home ranges of male mink in our study may have been larger than normal because of low population density. Adult male bobcats on the Savannah River Plant increased their movement and home range size, particularly during the breeding season, after feline panleukopenia was suspected to have severely reduced population density (Fendley and Griffith 1982).

Although not significant, home ranges of female mink with offspring were slightly larger than females without offspring. It is highly probable with sufficient telemetry data during the kit-rearing periods that we may have observed significant differences in home range size between the 2 female groups. Home range overlap was documented between genders but not within genders. Dunstone and Birks (1983) also reported a high inter-sexual but low intra-sexual overlap of home ranges in marine environments. Although Dunstone and Birks (1983) related the overlap to high mink densities in coastal marshes, mink re-introduced to this marsh study area expressed similar behavior at minimal densities.

Although based on a small sample, our findings indicate male home ranges and movements increased during the breeding season and were assumed to be due to movements in search of females. Males also were much more difficult to locate during this period. Gerell (1970), Eagle and Sargeant (1985), and Arnold and Fritzell (1987) reported increased movements or extensions of home range during breeding periods. Female mink maintained smaller home ranges than males in the CRNWR. This appears to be the case in most situations with wild mink (Gerell 1970, Dunstone and Birks 1983). Although we temporarily lost contact with both male and female mink during the study, male mink were generally the most difficult to monitor. This may be because male mink are known to travel great distances in a 24-hour period (Birks and Linn 1982). Although mink moved <4.3 km in Tennessee (Stevens et al. 1997) in one night, they moved as much as 12 km overnight in Canada (Arnold and Fritzell 1987).

Because some areas were too shallow to conduct telemetry at low tides, precise activity patterns of mink could not be obtained. Although minimal data was available for analysis, our observations suggest there could be an activity pattern associated with the availability of prey in the marsh. We observed mink feeding on red jointed fiddler crabs *(Uca minax)* on exposed mud flats. This is supported by food habit studies conducted by the SCDNR that indicate mink feed heavily on red fiddler crabs in the marsh (SCDNR unpubl. data). Such behavior could correspond to high availability of fiddler crabs and other prey species on mud flats at low tide. Mink also were observed during this study preying upon marsh hens *(Rallus sp.)* occupying mats of marsh tide wrack and floating debris during flood tides. After observation of mink chasing blue crabs on tide wrack in the marsh, Baker (1998) speculated that this behavior was possible evidence of a hunting strategy. Gerell (1970) and Dunstone and Birks (1983) indicated primarily nocturnal activity among mink and reported mink activities coincided with peaks in certain prey activity.

Management Implications

We developed techniques to allow efficient capture of mink in marsh environments. The most effective capture techniques were dip netting single individuals and box trapping family groups during extreme high tides. Tide levels required to allow flooding of the mink habitat to facilitate capture may vary by location. Mink reintroduction attempts may be more efficient during May through July when females have small offspring. Within gender overlap of home range indicated intra-sexual territoriality and suggested that animals of the same gender should be released at different sites across the area to be restocked to reduce intra-sexual aggression. We determined a distance of 500 m between release sites be sufficient. Survival (0.89) of radio-implanted mink was high indicating that surgery was not a factor contributing to mortality of implanted animals and repatriation is feasible using the techniques developed during this study.

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