ABSTRACT

HERRING, GARTH. Assessing nutrient reserves and local population dynamics of wintering lesser scaup in east-central Florida. (Under the direction of Dr. Jaime Collazo)

The current decline of the continental population of scaup coincides with a decline in body condition of birds arriving on the breeding grounds. The Spring Condition Hypothesis is one of the leading explanations for the current decline, and states that lesser scaup are arriving in poor body condition on the breeding grounds, which has the potential to impair their reproductive capabilities. However, it is not known if this decline in body condition is related to habitat on the wintering or staging areas along the flyways, or a combination of both. I examined changes in body condition (fresh body mass, corrected body mass, lipids, protein, mineral reserves) between mid and late winter on the most significant wintering grounds for scaup on the Atlantic Flyway; the Indian River Lagoon System during the winters of 2002 - 2003. If acquiring elevated levels of reserves prior to migration were critical to scaup, a significant change could be detected between mid and late winter (energy maximization strategy). Additionally, I examined changes in time spent foraging during mid and late winter to understand how scaup behavior might be related to their body condition. Diurnal foraging was similar between mid and late winter ($P = 0.06$). Nocturnal foraging increased by 70% ($P = 0.03$) in females and 263% ($P = <0.0001$) in males from mid to late winter. When time spent feeding was examined throughout the diel cycle, female scaup increased foraging by only 5%, or from 4.62 to 4.83 hr/day, while males increased foraging by 28%, or from 4.69 to 6.02 h. There was no change between mid and late winter for corrected body mass (female $P = 0.09$, male $P = 0.65$), lipids (female $P = 0.09$, male $P =$

0.96), mineral reserves (female $P = 0.74$, male $P = 0.11$) and protein (2002 female $P = 0.74$; 2002 male $P = 0.12$; 2003 male $P = 0.12$). Protein levels in females dropped seasonally by 4%. It is not known if this change is important physiologically.

My results lend support to recent research findings that contend that nutrient reserve acquisition prior to arriving at the breeding grounds is most likely constrained by changes in habitat conditions (e.g., prey availability, wetland degradation) on the northern staging areas, not conditions on the southern wintering grounds. Although it does not seem that nutrient reserves increased dramatically, it is noteworthy that recorded fat levels in this study were 70-80% of levels recorded on scaup just prior to the onset of reproduction. Therefore, wintering grounds remain as an integral habitat of the annual and season cycle of scaups to meet basic energetic requirements. Consequently, preventing habitat degradation should remain a critical component of scaup management efforts. Use of a wide variety of habitats (estuarine and impounded wetlands) by wintering scaup increases the likelihood of continued habitat availability on the wintering grounds.

Period specific survival estimates are necessary to understand the ecological basis of this decline, but such data are not available for scaup. I report winter survival of scaup in central Florida, where 62% of the Atlantic Flyway population overwinters. Estimates of survival were not confounded by hunting mortality as data were collected posthunting in 2002. The Kaplan-Meier survival estimate for females was 0.95 ± 0.04 (SE), and for males was 0.90 ± 0.09 (SE) for the period of 11 January – 14 March. These estimates were not different ($P = 0.64$). Pooled survival was 0.93 ± 0.04 (SE). Temporary emigration was exhibited by 24% of the birds, but their absence was short (24-hr intervals) and had little effect on precision of survival estimates as censored birds were added back into the model.

These results were consistent with the dietary freshwater hypothesis, which states that scaup most likely flew inland to acquire freshwater after foraging in saline systems. These findings also suggested that posthunting season winter survival was high. Hence, sources of mortality, other than hunting, likely occur during other stages of their annual cycle. Estimating survival during other stages of their annual cycle is necessary to identify the underlying reasons for continental population declines.

Florida is the most important wintering site for lesser scaup in the Atlantic Flyway, yet understanding how habitats are used by wintering scaup and why in Florida is inadequate. Continental population declines suggest that addressing this information void is important to evaluate habitat conditions and how habitat conditions may relate to the health and fitness of scaup. I used radio telemetry to test habitat use within the constraints of the Functional Unit System theory (FUS). The FUS theory suggests that wintering waterfowl will use separate units or regions for comfort and feeding activities. I further tested for differences in movements and home range between males and females to determine if they used different habitats. Lastly, I used data on movements and home range to coarsely evaluate habitat quality and potential effects of human disturbance. I found that sexes traveled similar distances in mid and late winter between diurnal and nocturnal sites ($P >$ 0.05). Scaup increased distance between diurnal and nocturnal sites by 5% in late winter ($P = 0.03$) from 2.4 km to 2.6 km. Male and female fixed kernel home ranges ($P > 0.05$) and core use areas ($P > 0.05$) did not differ. Mean pooled fixed kernel 95% home range and 50% core use areas were 15.1 ± 4.2 km^2 and 2.7 ± 1.1 km^2, representing 3% and 0.5% of available habitats. Results suggested that scaup did use different habitats for comfort and feeding activities. Sexes appeared to use habitats similarly and short distances traveled between

diurnal and nocturnal sites suggested that habitat conditions were similar across the impounded wetlands and shallow portions of the Indian and Banana Rivers, and that disturbance was likely negligible. Scaup appeared to locate suitable habitats early in the winter period (January) and remain there throughout much of the season. Accordingly, I believe that the IRL system provides adequate winter habitat, at least around Merritt Island National Wildlife Refuge.

ASSESSING NUTRIENT RESERVES AND LOCAL POPULATION DYNAMICS OF WINTERING LESSER SCAUP IN EAST-CENTRAL FLORIDA

by

GARTH HERRING

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BIOGRAPHY

Garth Herring was born in 1971 in Cambridge, Ontario; he moved to Prince Edward Island in 1972. Growing up on the east coast of Canada, with wildlife in his backyard, Garth developed a love for wetlands and waterfowl. Garth's interest in waterfowl was further developed during his teenage years, working for a private waterfowl hunting club.

Garth graduated from Sir Sandford Fleming College in 1992 as a Fisheries and Wildlife Technician. During the next six years he refined his interest in waterfowl ecology and conservation, while working for the Canadian Wildlife Service, Ducks Unlimited Canada, and Long Point Waterfowl and Wetlands Research Fund. In 1997 he entered the University of Lethbridge, graduating in 1999 with a Bachelor of Science (Environmental Science). Continuing with his interest in waterfowl, he worked on projects in Florida, Illinois, Ontario, Saskatchewan, and South Carolina for the North Carolina Cooperative Fish and Wildlife Research Unit, Max McGraw Wildlife Foundation, and the Institute for Wetlands and Waterfowl Research.

Garth's long-term interest in diving ducks landed him at North Carolina State University, studying Lesser Scaup under Dr. Jaime Collazo, becoming a Master of Science student in 2002. Garth intends to continue research on wintering waterfowl, while applying newly developed, sound, scientific based management strategies to waterfowl conservation initiatives.

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ASSESSING NUTRIENT RESERVES AND DIEL TIME ACTIVITY BUDGETS IN WINTERING LESSER SCAUP IN EAST-CENTRAL FLORIDA

ABSTRACT

The current decline of the continental population of scaup coincides with a decline in body condition of birds arriving on the breeding grounds. The Spring Condition Hypothesis is one of the leading explanations for the current decline, and states that lesser scaup are arriving in poor body condition on the breeding grounds, which has the potential to impair their reproductive capabilities. However, it is not known if this decline in body condition is related to habitat on the wintering or staging areas along the flyways, or a combination of both. I examined changes in body condition (fresh body mass, corrected body mass, lipids, protein, mineral reserves) between mid and late winter on the most significant wintering grounds for scaup on the Atlantic Flyway; the Indian River Lagoon System during the winters of 2002 - 2003. If acquiring elevated levels of reserves prior to migration were critical to scaup, a significant change could be detected between mid and late winter (energy maximization strategy). Additionally, I examined changes in time spent foraging during mid and late winter to understand how scaup behavior might be related to their body condition. Diurnal foraging was similar between mid and late winter ($P = 0.06$). Nocturnal foraging increased by 70% ($P = 0.03$) in females and 263% ($P = <0.0001$) in males from mid to late winter. When time spent feeding was examined throughout the diel cycle, female scaup increased foraging by only 5%, or from 4.62 to 4.83 hr/day, while males increased foraging by 28%, or from 4.69 to 6.02 h. No change between mid and late winter corrected body mass (female $P = 0.09$, male $P = 0.65$), lipids (female $P = 0.09$, male $P = 0.96$), mineral reserves (female $P = 0.74$, male $P = 0.11$) and protein (2002 female $P = 0.74$; 2002 male $P = 0.12$; 2003 male $P = 0.12$) was detected. Protein levels in females dropped seasonally by 4% in 2003 ($P = 0.01$). It is not known if this change is important physiologically.

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My results lend support to recent research findings that contend that nutrient reserve acquisition prior to arriving at the breeding grounds is most likely constrained by changes in habitat conditions (e.g., prey availability, wetland degradation) on the northern staging areas, not conditions on the southern wintering grounds. Although it does not seem that nutrient reserves increased dramatically, it is noteworthy that recorded fat levels in this study were 70-80% of levels recorded on scaup just prior to the onset of reproduction. Therefore, wintering grounds remain as an integral habitat of the annual and season cycle of scaups to meet basic energetic requirements. Consequently, preventing habitat degradation should remain a critical component of scaup management efforts. Use of a wide variety of habitats (estuarine and impounded wetlands) by wintering scaup increases the likelihood of continued habitat availability on the wintering grounds.

INTRODUCTION

Scaup (greater [*Aythya marilla*] and lesser [*A. affinis*] combined) populations have declined progressively since the mid 1980's, considerably below goals of the North American Waterfowl Management Plan (NAWMP; U.S. Fish and Wildlife Service 1986, 1988). Lesser scaup comprise an estimated 89% of the continental scaup population (Bellrose 1980, Austin et al. 1998), with recent analysis suggesting that only the lesser scaup population is in decline (Allen et al. U.S. Fish and Wildlife Service, unpublished report).

Merritt Island National Wildlife Refuge (Merritt Island) and its adjacent estuarine areas (Banana and Indian River, Mosquito Lagoon) provide the most valuable wintering habitat for scaup on the Atlantic Flyway (Bellrose 1980), harboring up to 62% of Atlantic Flyway scaups (Bellrose 1980). Several key findings strengthen the need to investigate scaup use of habitats in this area. For example, an estimate of the total numbers of waterfowl (scaup) use days was 1,402,231 at MINWR during the winter of 2001 (Herring and Collazo 2001). This figure supports the contention that the area is important for wintering scaups. However, the USFWS midwinter waterfowl survey of 16 January 2001 yielded 83,173 scaups (Marc Epstein, Merritt Island, personal communication). This value was 26.6% below the 30-year mean for the region. In the winter of 2000-2001, I documented that mean body mass (male and female), as defined by Chabreck (1964), Joanen (1964), Bellrose (1980) and Austin et al. (1998), was at the bottom of the standard range for wintering birds (Herring and Collazo 2001). When compared to birds collected in Louisiana in 2001 (Anteau 2002), fresh body mass of males (700 g) and females (678 g) were approximately 140 g and 72 g lower. Low or depleted nutrient reserves on wintering grounds may result from low quality habitat (e.g., food availability), or reflect that energetic

maintenance in a benign environment (e.g., Florida) does not require higher levels of nutrient reserves. If the former possibility is true, then it could lead to increases in time spent foraging on the wintering grounds as well as on staging areas along flyways.

High quality wintering habitat is essential to maintain and accumulate body fat and nutrient reserves prior to northbound migration and the breeding grounds in an assorted number of species of waterfowl (Takekawa 1987, Heitmeyer 1988, Serie and Sharp 1989, Hohman and Weller 1994). Overwintering environmental conditions (e.g., food availability) can exert an important regulatory function on waterfowl, influencing their productivity (Fretwell 1972, Ankney and MacInnes 1978, Raveling 1979) and seasonal and annual survival rates (Hepp et al. 1986, Haramis et al. 1986, Baldassarre and Bolen 1988). Thus, current scaup population declines might be symptomatic of poor habitat on wintering or staging grounds (Afton 1984, Austin et al. 1999, Austin et al. 2000, Afton and Anderson 2001).

The Spring Condition Hypothesis (SCH; Austin et al. 2000, Afton and Anderson 2001) states that reproductive success of scaup has declined in recent years because females arrive at the breeding grounds with low levels of nutrients as compared to historical data. The problem may be due to reduced food resources on the wintering grounds or on the staging areas that prevent females from acquiring sufficient nutrient reserves (Afton and Anderson 2001). Hypothetically, females that arrived with depleted or low nutrient reserves would have to spend a greater amount of time foraging prior to initiating a nest due to their dependence on reserves for egg development and incubation (Afton and Ankney 1991, Afton and Paulus 1992, Esler et al. 2001). Moreover, nest initiation date is frequently negatively correlated with both nest success and duckling survival among waterfowl (Rohwer 1992,

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Flint and Grand 1996, Grand and Flint 1996, Dzus and Clark 1998, Guyn and Clark 1999), and clutch size of scaup declines seasonally (Afton 1984, Esler et al. 2001, Brook 2002). Consequently, females that arrived on the breeding grounds with low nutrient reserves would likely nest later (Reynolds 1972, Esler et al. 2001) and produce less ducklings.

Examining the positive relationship between time spent foraging and nutrient reserves (Austin 1987) while on the wintering grounds, particularly prior to spring migration, is essential to understand scaup winter ecology, and ultimately, test SCH. Therefore, I documented nutrient reserve levels and foraging patterns of wintering scaup in Merritt Island in 2002 and 2003. I hypothesized that females and males would not significantly alter their activity patterns throughout winter, with females foraging at comparable levels and containing similar nutrient reserves, particularly lipids, due to its implications on reproduction. In an effort to place my findings in a broader geographic context, I also compared Florida nutrient reserve values with those from Louisiana (Anteau 2002) and body mass to those of Anteau (2002) and Vest (2002).

Interest in lipid reserves is based on a positive relationship between body weight (mass) and both fat (Owen and Cook 1977, Bailey 1979) and total nutrient (lipid and protein combined) reserves (Wisehart 1979). If I documented a significant seasonal increase in foraging it would lend support to the contention that scaup were attempting to increase nutrient reserves prior to migration. Such a finding would be in concert with predictions by SCH. Conversely, if no change in foraging and nutrient levels were noted, then nutrient acquisition on wintering grounds was not as important for reproduction. This outcome would support recent research that suggests northern staging areas are more critical for nutrient reserve acquisition (Anteau 2002). Establishing the extent to which scaup fed on a

diel basis was important because nocturnal feeding may be symptomatic of lower nutrient reserves, even in a temperature "benign" environment. For example, if lipid reserve estimates validated my preliminary body mass findings (i.e., low) despite substantial diel foraging, forage quality becomes a plausible factor accounting for body condition patterns. Conversely, if I documented low diel foraging levels, "good" body condition could be explained by "good" forage quality, locally or at adjacent foraging areas. Clearly, foraging outside the study area (or at night) can obscure interpretation of findings. To elucidate such possibilities, I also monitored nocturnal activities of radio tagged scaups. Establishing the extent to which scaup forage at night was critical because this behavior might be critical in scaup maintaining or increasing nutrient reserves during winter while diurnal feeding could suggest otherwise.

STUDY AREA

Merritt Island National Wildlife Refuge is located 1 km east of Titusville, Florida (28 40'N, 80 46'W) and envelops the J. F. Kennedy Space Center (KSC) on Merritt Island, covering 55,039 ha of the National Aeronautics and Space Administration's (NASA) 57,000 hectares in Brevard and Volusia counties. The study area is part of the Indian River Lagoon (IRL) complex, including the waters of the Indian and Banana Rivers and the southern half of the Mosquito Lagoon (Figure 1). Merritt Island is a barrier island complex separated from the mainland by the Indian River and from Cape Canaveral by the northern Banana River, occurring within a biogeographical transition zone, with fauna and flora assemblages from both temperate Carolinian and subtropical Caribbean provinces (Ehrhart 1976, Gilmore et al. 1981, Provencha et al. 1986). The island is composed of sandy beaches, dune systems, hammocks, longitudinal lagoons, and 72 salt marsh impoundments, and is jointly managed by the Brevard Mosquito Control District, National Park Service, NASA, and U. S. Fish and Wildlife Service. Waters tend to be shallow, aeolian lagoons with depths averaging 1.5 m and maximums of 9 m (dredged regions); typical salinities vary from 10 to 42 ppt (Provencha and Sheidt 1998). Snelson (1976) and Down (1978) provided comprehensive descriptions of the area.

METHODS

NUTRIENT RESERVES

I collected scaup at Merritt Island with a shotgun (North Carolina State University, Institutional Animal Care and Use Committee Protocol # 01-144-0; U. S. Fish and Wildlife Service, Collection Permit # 773137; and State of Florida Fish and Wildlife Conservation Commission, Scientific Collecting Permit # WXO1671). I used a combination of jump and pass shooting to avoid collecting birds in a biased method (e.g., using decoys; Pace and Afton 1999).

I collected scaup during 2 winter periods, mid and late winter. These 2 periods were defined on the basis of aerial survey data from winter 2000-2001 (Herring and Collazo 2001) and migration chronology (Bellrose 1980). Mid-winter was defined as mid-December through early February; late-winter was defined as mid-February until mid-March when the majority of scaup had migrated. For purposes of analyses, midwinter ended on 10 February and late winter on 20 March. In winter 2002, dates of collection were 18 - 21 January (midwinter) and 27 February – 1 March (late-winter); during winter 2003 dates of collection during midwinter were 27 - 29 January, and 26 - 28 February (late winter).

I recorded fresh body mass (FBM) within one hour of collecting (± 1 g). Birds were classified as male or female via a combination of wing plumage (Carney 1992) and cloacal examination (Hochbaum 1942). Age class was not assigned to collected birds because the precision of ageing techniques has not been verified for late winter (Hochbaum 1942, Carney 1992). Birds were labeled, sealed in double bags, frozen and later transported to the laboratory at North Carolina State University.

All nutrient reserve assessment work was conducted in the Department of Poultry Science's Nutritional Laboratory at North Carolina State University. In the laboratory, I recorded the following morphological measurements: culmen length, head, rectrix, tarsus, total length, and wing chord. Afterwards, carcasses were plucked, their esophageal, proventricular, gizzard, and gastro intestinal tract contents removed and reweighed ($\pm$ 1 g) to estimate corrected body weight (CBM). I obtained a carcass homogenate by continually passing samples through a Hobart meat Grinder (Troy, Ohio 45374), using first a 10-mm grinding plate followed by a 3-mm plate. Samples were then mixed and a 200-g subsample removed, weighed, and dried at 80 ° C, and reweighed (subsample minus dry mass = water content). The dry subsample was then reground using an industrial grade blender (Waring model 36BL23, Torrington, CT 06790) until all the subsample passed through a 2 mm sieve (Anteau 2002). Finally, I took 2 samples of 10 g from each bird homogenate and extracted lipids using a Goldfisch apparatus for 8 hr using petroleum ether (Dobush et al. 1985). Ash content was determined by burning lean samples in a muffle furnace at 600 ° C for 12 hr, removing organics, and leaving mineral ash. Protein was assumed to be ash-free lean mass. The techniques used for lipid extraction were similar to those used by Afton et al. (1989), Afton and Ankney (1991), and Anteau (2002).

DIEL TIME ACTIVITY BUDGETS

I collected time activity budget data were using scan sampling (diurnal) and radio telemetry (nocturnal). I used 2 different sampling techniques, unlike Custer et al. (1996), who examined diel winter foraging of scaup in Illinois. First, Custer et al.'s study site was

approximately 50 m wide by 10 km long, with few areas of limited access or visibility. Open water habitat at MINWR covers an area of approximately 400 km^2; over 3 distinct lagoon systems and 72 impounded wetlands, and is 50 km across on a diagonal. Prior telemetry research in such a large area suggested that finding birds "on demand" could be both time consuming and data limiting if the entire study rested on a single technique. Second, when imposed, security measures at the KSC limited access to portions of the study site throughout the 24 hr period (e.g., prevented consistent telemetry data collection in some areas). Finally, collecting data on time activity budgets using telemetry is limited to feeding activities (yes or no); visual methods (scans) allowed me to collect more data, further quantify behavioral activities, and therefore more accurately describe diurnal time budgets. To compare nocturnal (telemetry) and diurnal (scan) feeding activity, I expressed results as percent time spent feeding.

I conducted scan sampling following protocols described by Altman (1974), Baldassarre et al. (1988), and Bergman et al. (1989). Behavioral "activities" used in this study were defined by Paulus (1984) and include (1) feeding- ingestion of food obtained by surface or subsurface feeding or grazing (includes drinking); (2) resting - sleeping or loafing; (3) locomotion- swimming, walking, and flying; (4) alert (attentive to nearby conspecifics or disturbances); (5) preening- activities involved with maintenance or bathing; (6) social display- displays associated with pair formation, maintenance activities and copulation; and (7) agonistic- threat displays.

Locations, flocks, and time of day for diurnal sampling were chosen randomly. I arbitrarily divided the diurnal period into 2 approximately even blocks of time: sunrise until 1200 h and 1200 h until sunset, and conducted near equal numbers of scans in each period. I

randomly selected the time and location where surveys started on each day. I scanned all flocks at each sites either with a 60 X spotting scope or with 10 X 40 binoculars, recording the behavior. I alternated flock scans from right to left and left to right. In addition, I recorded time of observation, location, percent cloud cover, wind speed, and precipitation. Sex was not recorded because preliminary results from winter 2001 indicated that diurnal female and male scaup behaved similarly (Wilcoxon tests: feed $P = 0.95$; rest $P = 0.80$; locomotion $P = 0.74$; preen $P = 0.98$, df = 320). I assumed that diurnal female and male behavior was also similar during the winter of 2002.

To monitor nocturnal feeding activity, I used radiotagged scaup. Scaup were captured using quick-catch corral traps over baited locations (Joanen 1964, Haramis et al. 1986). I used 9 separate trap locations within MINWR to minimize group-dependent behaviors among radioed birds. Birds were classified as male or female using a combination of wing plumage (Carney 1992) and cloacal examination (Hochbaum 1942). I did not age scaup, because the precision of aging techniques has not been verified for late winter (Hochbaum 1942, Carney 1992).

I trapped 60 scaup between 4 and 7 January 2002, of which 34 were females and 26 males. A radio transmitter was surgically implanted in each bird (Korschgen et al.1984, Olsen et al.1992). I used intra-abdominal transmitters with an external whip antenna, rather than traditional back-mounted units, because I was concerned that scaup might alter their behavior (Woakes and Butler 1975, Perry 1981, Olsen et al. 1992, Brook and Clark 2002). Transmitters were in the 152.000-153.999 MHz range, implantable model A2310 (Advanced Telemetry Systems, Isanti, MN 55040). Mean mass of transmitters was 18 g, which was $\leq$ 2.91% of our lightest bird. Isoflurane was used as the anesthetic (Aerane, Ananquest,

Madison, WI 53713), delivered into the bird via an Isotec 3 vaporizer (Ohmeda, Madison, WI 53707). All other surgical procedures followed that of Olsen et al. (1992).

Prior to release, all birds were given fluids and monitored for > 1 hr after surgery. In addition, all birds were banded with a U. S. Fish and Wildlife Service aluminum band and released at the same site where they were captured. Research techniques were approved by the North Carolina State University, Institutional Animal Care and Use Committee (Protocol # 01-144-0), and conducted under U. S. Fish and Wildlife Service Research Permit # 773137, and State of Florida Fish and Wildlife Conservation Commission, Scientific Collecting Permit # WXO1671.

Prior to establishing data collection procedures, I monitored the activity patterns of 8 implanted birds for > 6 hr. Implanted scaup behaved in the same manner as nonimplanted birds, feeding in regular rhythmic patterns and performing other activities (e.g., resting, preening). Additionally, I confirmed that I was able to use attenuation of radio signal strength to discern feeding activity (i.e., signal strength either weak or non existent) or nonfeeding (i.e., signal strength normal). Distinct attenuation occurred in waters > 55 cm deep. Data from sites < 55 cm deep were not included in the analyses to avoid underestimating nocturnal foraging.

I used a 30-min sampling bout after determining that time between foraging bouts averaged 21.88 min ± 2.41 min ($n = 13$ implanted birds). The 30-min period increased the likelihood of detecting foraging activity during sampling. I randomly selected the time and location where surveys started on each day. I then determined if radioed scaup were present at sites and selected 2 radioed scaup to monitor if they could be located from 2 distinct locations to determine that birds were not in < 55 cm deep waters and have sufficient signal

strength for tracking before they were deemed suitable for data collection. I only recorded

the behavior of 2 radioed scaup at each site to allow sufficient time to travel to other areas

within Merritt Island. I assumed that birds at each site were feeding similarly.

Birds were located from 2 separate points and a compass bearing was taken to allow

triangulation [handheld GPS coordinates at each site using a Garmin, model 12CX GPS

(Garmin, Olathe, KS 66062)]. I attempted to take both bearings no more than 30 min apart,

minimizing movement and subsequent error in the birds' location and depth of position.

Program Locate II (Pacer, Truro, NS, Canada, B2N 5E5) was used to calculate positions of

radioed scaup. Once this was established, I set up a micro cassette recorder and collected 30

minutes of audio data from the radio telemetry receiver. Additionally, I recorded the

frequency of the bird, date, time and location of data collection.

The nocturnal period was divided into 2 approximately equal periods: sunset to 2400

hr, and 2400 to sunrise. I attempted to collect equal amounts of data within both periods

during mid and late-winter. Data were collected 2 - 3 nights per week, from 14 January to

19 March. Data were summarized as percent time spent feeding per 30-minute period and

then extended as an estimate of proportion of time spent feeding per night.

STATISTICAL ANALYSES

NUTRIENT RESERVES

I used a principal component analysis (PCA) to index body size from the 6

morphometric measurements. I used the standardized scores of the first principal component

(PC1) as the index of body size (Ankney and Afton 1988, Afton and Ankney 1991,

Alisauskas and Ankney 1994). Analysis of covariance (ANCOVA) was then used to test for differences between seasons, with lipids, protein, and corrected (CBM) body mass as the response variables for each size-adjusted sex, collection year as a class variable, and PC1 scores as a covariate (after testing for seasonal or year interactions in the slopes of my response variables). All tests were considered significant at $P \leq 0.05$. Data met assumptions of equal variances (Levene's test, JMP 2001).

All analyses presented herein on changes in body condition between mid and late-winter were based on corrected body mass. Comparisons of this study's body mass with results from scaup at wintering grounds in Louisiana (Anteau 2002, Vest 2002) were made using FBM because it was the only expression of body mass that permitted comparisons across studies. Nutrient reserves compared between this study and Louisiana (Anteau 2002) were made using CBM estimates.

DIEL TIME ACTIVITY BUDGETS

Diurnal TAB data were expressed as percent time spent per activity. Because some data did not meet normality assumptions (Levene's test: JMP 2001), I used Wilcoxon non-parametric tests for all analyses comparing differences between seasons for time spent feeding, resting, locomoting, preening, and habitat use. Nocturnal data by season and sex (percent time spent feeding/night) were also tested using Wilcoxon's tests.

RESULTS

NUTRIENT RESERVES

I collected 73 scaup in 2002 and 85 in 2003. The breakdown by sex and period of winter was as follows. In 2002, 16 females and 23 males were collected in mid-winter. Subsequently, 19 females and 15 males were collected in late winter. In 2003, 9 females and 7 males were collected in mid-winter. In late winter, I collected 39 females and 30 males. Levels for each nutrient are reported by sex in Table 1. Principle component 1 explained 42% of the overall variation among morphometric measurements, all factor loadings were positive and ranged from 0.11-0.54. Principle component 1 was described by the following eigenvector loadings of my morphometric measurements: head, 0.54; wing chord, 0.49; culmen, 0.43; tarsus, 0.39; rectrix, 0.31; and total length, 0.11.

Male mid-winter protein levels ($F = 3.17$, $P = 0.05$, df = 1, 28) varied with year. Protein levels were 19.05 g lower in 2003 than 2002 [means = 151.32 g $\pm$ 4.51 SE (2002), and 132.27 g $\pm$ 7.09 SE (2003)]. All other values (CBM, lipids, mineral reserves) did not vary with year and season, and data were pooled to test for seasonal effects. There were no differences between mid and late winter male CBM, lipid, or mineral reserves (Table 2; Figure 2).

Female late winter protein levels varied by season and year ($F = 4.44$, $P = 0.01$, df = 1, 56). Protein levels were 9.59 g lower in 2003 than 2002 [means = 134.17 g $\pm$ 3.62 SE (2002), and 124.58 g $\pm$ 2.26 SE (2003)] (Figure 3). All other data were similar ($P > 0.05$) and were pooled across years. No differences were detected between mid and late winter for female FBM, CBM, lipids, or mineral reserves (Table 2; Figure 4).

DIEL TIME ACTIVITY BUDGETS

I made 1,587 scans between 28 December 2001 and 20 March 2002 on 69,427 scaup at > 50 locations within Merritt Island. Mean flock size of scanned scaup was 44 ± 3. Of all activities, only time spent resting ($Z = 2.14$, $P = 0.03$, df = 1,585) and in locomotion ($Z = 20.20$, $P = < 0.001$, df = 1,585) changed between winter periods (Figure 5). The amount of time spent resting increased in late winter by 7%. Conversely, time-spent in locomotion decreased by 33%.

Female and male scaup spent 28% of the diurnal time feeding in midwinter and 26% in late winter. These differences were not significant ($Z = -1.82$, $P = 0.07$, df = 1,585). Scaup spent 17% more time foraging in impounded wetlands than estuarine habitat ($Z = 2.04$, $P = 0.04$, df = 1,585). Scaup spent 103% more time resting in open estuarine habitats than impounded wetlands ($Z = -3.87$, $P = 0.0001$, df = 1,585). Correspondingly, scaup engaged in locomotion 53% more often in impounded wetlands than estuarine habitats ($Z = 4.41$, $P = <0.0001$, df = 1,585).

I sampled nocturnal feeding activities over 98 hours between 14 January and 19 March 2002. I collected activity data on 43 of 60 telemetry-implanted scaup for a mean number of 4.55 ± 1.29 budgets per radioed scaup. Total sampling bouts were 85 for males (44 mid and 41 late winter) and 111 for females (47 mid and 64 late winter). Female scaup increased nocturnal foraging from mid to late winter by 71% ($Z = -2.06$, $P = 0.003$, df = 110; Figure 6). Male scaup increased nocturnal foraging in late winter by 263% ($Z = 3.49$, $P = 0.0005$, df = 83; Figure 6). When I combined estimates of diurnal and nocturnal time spent foraging for mid and late winter, the seasonal differences were markedly smaller. Female

scaup increased foraging by only 5%, or from 4.62 to 4.83 hr/day, where as males increased

foraging by 28%, or from 4.69 to 6.02 hr/day (Figure 7).

DISCUSSION

My findings suggested that most nutrients (e.g., lipids) and body mass did not increase seasonally. Changes were only detected for protein levels. Thus, my findings support Anteau's (2002) conclusion that body condition build-ups are not occurring on southern wintering grounds of scaups, and that the build-up is most likely influenced by habitat conditions (e.g., prey availability, wetland degradation) on the northern staging areas. It is noteworthy, however, that recorded lipid levels in this study were at least 70-80% of historical levels recorded on scaup just prior to the onset of reproduction (e.g., approximately 95 g, Anteau 2002). Therefore, wintering grounds remain as an integral habitat of the annual and season cycle of scaups to meet basic energetic requirements. Interannual variability in selected nutrient levels of waterfowl (e.g., protein in this study) has been noted in other studies as well (see Chappell 1982, Thompson and Baldassarre 1990). I cannot provide an explanation for the decrease in protein levels in females in 2003. Although statistically significant, it remains to be determined if a ~4% decrease from mid to late winter is physiologically important.

Male and female scaup exhibited similar diurnal feeding activity patterns throughout the winter. Moreover, there was no seasonal increase in feeding activity. However, nocturnal observations revealed a different scenario, as both male and female scaup increased time spent foraging in late winter. However, if females were building up or maximizing prebreeding nutrient reserves, then a change in body condition would have been in concert with increased foraging activity, and it was not. Overall (i.e., diel cycle), females only increased their seasonal foraging activities by only 5%, which appears within the realm of maintenance (Austin et al. 1998) and concurs with no observed change in body mass or

nutrient reserves. Males increased their seasonal foraging activity levels at night, but as with

females, this increase did not translate to detectable change in body mass or nutrient

reserves. As in this study, Bergman et al. (1989) reported differences between males and

females in total time spent feeding during the day on the wintering grounds in South

Carolina. In their study, females invested a greater amount of time feeding. The authors

contended that the smaller-bodied females are at a metabolic disadvantage relative to males,

and could explain the elevated feeding (see also Calder 1974). In such a case, I would have

expected that females in Florida would have exhibited a higher level of nocturnal feeding

activity than males, the period of lowest ambient temperatures. My data do not support the

said contention, nor the results reported by Tamisier (1976), Turnball and Baldassarre

(1987), Paulus (1988) and Custer et al. (1996). Possibly in a temperature benign wintering

habitat higher feeding rates by females are not necessary, and thus, not detectable.

Nutrient levels for scaup in Florida were considerably lower than those reported by

Anteau (2002) in Louisiana. Apparent differences in body mass between scaup in Florida

and Louisiana (Anteau 2002) are difficult to interpret, in part, because comparisons may

depend on indices that are subject to substantial error and confounded by year. For example,

FBM is influenced by the amount of food content of the bird at the time of capture.

However, lipids and mineral reserves in Florida were markedly lower for both sexes, and

measures of body condition were based on standardized techniques. Differences between

wintering sites may reflect local conditions or proximate factors such as ambient temperature

and food availability. However, scaup might be well within their maintenance energetic and

nutritional budgets. Support for this contention comes from high estimates of survival in

Florida, which suggests lower body mass and nutrient reserves were not detrimental to scaup

(Chapter 2). Scaup body masses in Florida were similar to those reported by Vest (2002) from another locale in Louisiana, underscoring the variation in body condition among wintering sites.

Two hypotheses about migration strategies on shorebirds provide a theoretical framework to speculate about how and when scaup build up their energetic reserves (see Alerstam and Lindström 1990). The energy-selected hypothesis purports that birds migrate to the next stopover site as soon as their fat reserves allow them to cover the distance safely, regardless of the quality of the next site. The time-selected hypothesis purports that birds seek to minimize the time spent on migration, bypassing lower quality sites in favor of sites where potential energy gains are greater. Scaup do not appear to conform to the time-limited hypothesis because they exhibit a protracted migration pattern, spending high amounts of time at staging areas (Bellrose 1980, Austin et al. 1998). Judging from the lack of seasonal changes in body condition, scaup do not appear to conform with the energy maximization hypothesis either.

I believe that lack of significant increase in body condition might be due to constraints imposed by the relative small body size and high wing-loading of scaups, coupled with adaptations for diving (Hendenstrom and Alerstam 1992, Lovvorn and Jones 1994). Although recent experimental work in wind tunnels suggest that carrying large fuel loads during long distance flights is not as energetically demanding as previously believed (Kvist et al. 2001), Red Knots (*Calidris canutus*) are probably not the best biological model for waterfowl. Moreover, Red Knots often migrate nonstop for distances of 4,000 km (Piersma and Baker 2000, Harrington, 2001), which requires substantial energy reserves. These distances are in sharp contrast to scaup that cover significantly shorter distances per

flight (Bellrose 1980, Austin et al. 1998). Diving ducks have relatively higher wing loading

(Lovvorn and Jones 1994), in relation to shorebirds (Charadriiformes) (Rayner 1988), so

their ability to efficiently carry large fuel loads long distances is likely impaired.

Maximizing energetic loads appears to be occurring just before arriving on the

breeding grounds as reported by Anteau (2002). In this sense, scaup and migrant shorebirds

follow a similar pattern of energy reserve build up (Anteau 2002, Farmer and Wiens 1999,

Gudmundur et al. 1991, Lyons and Haig 1995). This pattern underscores the value of

protecting stopover habitat for waterfowl near their breeding grounds. While maximizing

nutrient reserves on the wintering grounds does not appear to be a critical requirement for

scaup beyond basic maintenance, these areas are an integral part of their yearly cycle

balancing the costs of spring migration (Hohman and Weller 1994). Furthermore, scaup left

the winter grounds in Florida carrying reserve levels similar to those at the onset of breeding

(Afton and Ankney 1991, Esler et al. 2001). Consequently, preventing habitat degradation

should remain a critical component of scaup management efforts. Use of impounded

wetlands at MINWR complements available estuarine systems and increases the likelihood

of continued habitat availability on the wintering grounds.

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Table 1. Mean nutrient reserves and body mass ± standard error of female and male lesser scaup collected at Merritt Island National Wildlife Refuge from 18 January 2002 to 28 February 2003.

| | 2002 | | | | 2003 | | | |
| | Mid | | Late | | Mid | | Late | |
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Female								
Fresh Body Mass	673.0	17.8	708.7	19.7	683.5	27.6	711.5	12.3
Corrected Body Mass	637.7	19.1	671.7	17.5	648.6	27.7	669.4	12.3
Lipid	69.3	8.7	84.6	12.7	69.5	13.5	95.3	8.0
Protein	131.0	3.9	134.1	3.6	130.0	6.18	124.5	2.2
Mineral	20.2	1.0	21.47	1.3	20.5	1.6	20.0	0.8
Male								
Fresh Body Mass	776.0	14.0	768.5	17.29	699.6	22.14	768.4	11.0
Corrected Body Mass	749.4	16.6	731.1	18.74	669.0	23.9	722.3	10.8
Lipid	108.6	11.8	105.2	12.66	63.6	18.6	97.3	8.5
Protein	151.3	4.51	140.8	2.87	132.2	7.0	136.9	1.95
Mineral	23.0	1.6	25.4	1.09	20.1	2.6	23.7	0.74

Table 2. Analysis of covariance results for size-adjusted female and male lesser scaup collected during mid and late winter at Merritt Island National Wildlife Refuge, in 2002 – 2003. Response variables were fresh body mass, corrected body mass, lipid, and mineral, year was used as a class variable, and PC1 as a covariate.

Parameter	df	F	P
Female FBM	2, 78	2.69	0.07
Female CBM	2, 78	2.46	0.09
Female Lipid	2, 78	2.47	0.09
Female Mineral	2, 78	0.28	0.74
Male CBM	2, 73	0.42	0.65
Male Lipid	2, 73	0.03	0.96
Male Mineral	2, 73	2.27	0.11
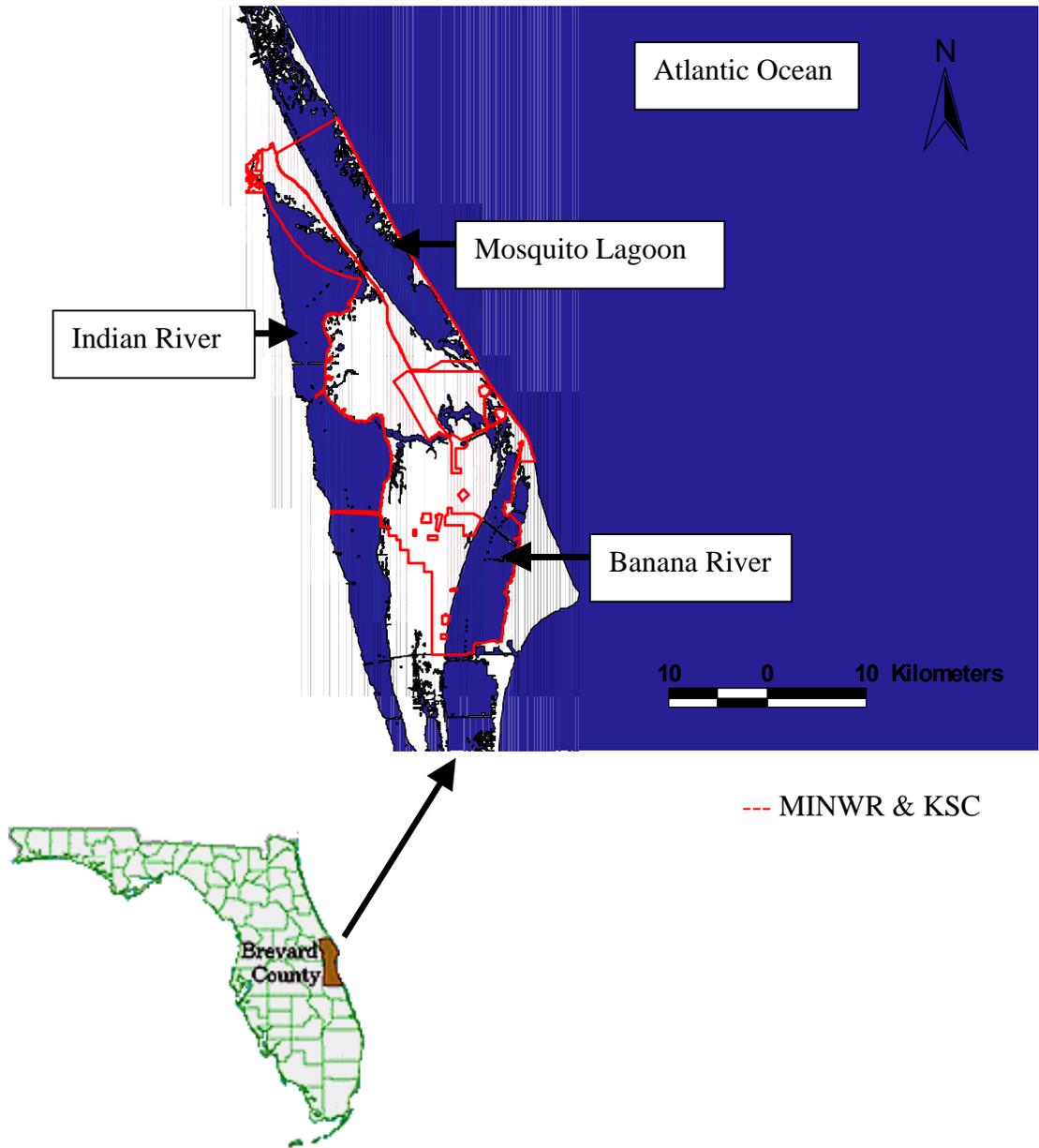
Figure 1. Study site – Merritt Island National Wildlife Refuge and the Kennedy Space

Center, Brevard and Volusia Counties, Florida.
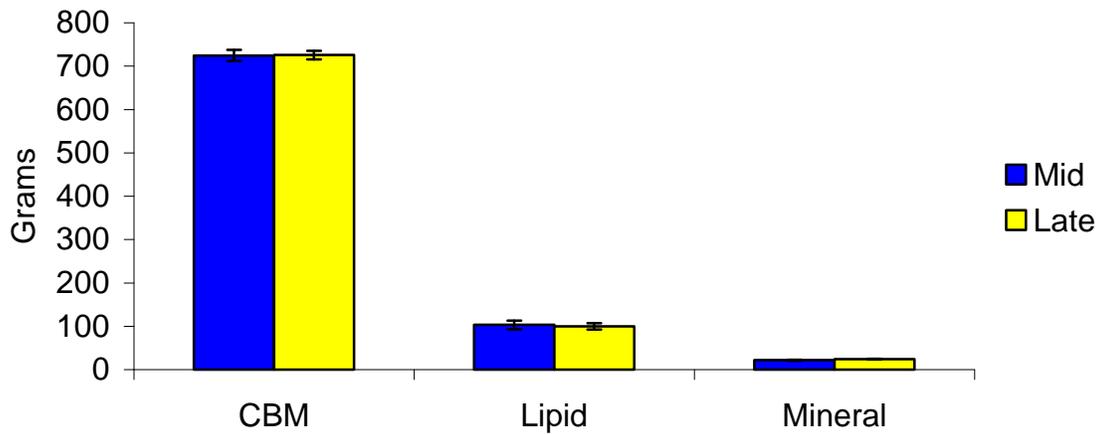
Figure 2. Least-square means (g ± SE) of corrected body mass, lipids, and mineral reserves for males collected in mid and late winter 2002 and 2003 at Merritt Island National Wildlife Refuge (FL). Significant differences were determined by ANCOVA and denoted by an * (P < 0.05), df = 2, 73.
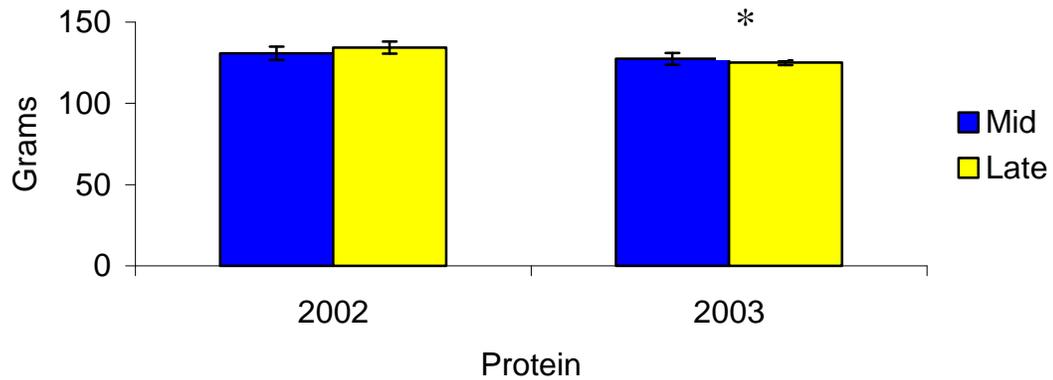
Figure 3. Least-square means (g ± SE) of protein for females collected in mid and late winter 2002 and 2003 at Merritt Island National Wildlife Refuge (FL). Significant differences were determined by ANCOVA and are denoted by an * (P < 0.05), df = 1, 33 and 1, 46.
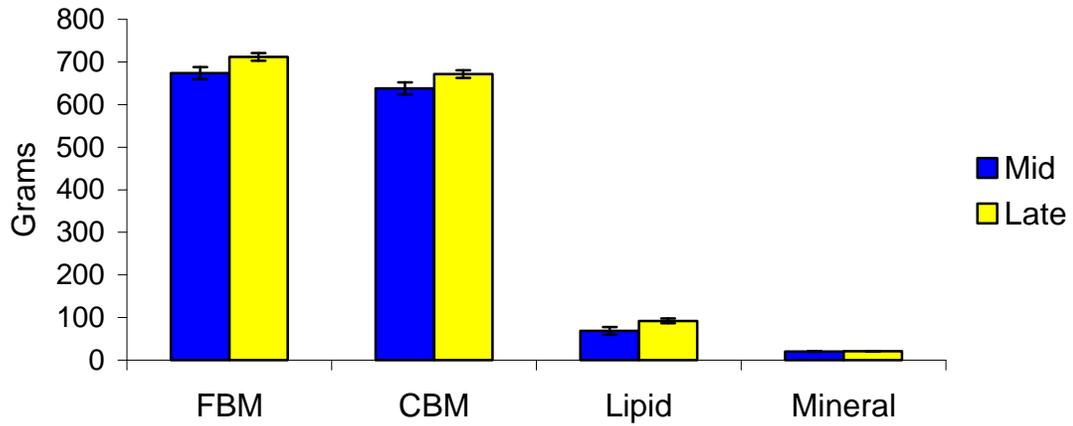
Figure 4. Least-square means (g ± SE) of fresh body mass, corrected body mass, lipids, and mineral reserves for females collected in mid and late winter 2002 and 2003 at Merritt Island National Wildlife Refuge (FL). Significant differences were determined by ANCOVA and are denoted by an * (P < 0.05), df = 2, 78.
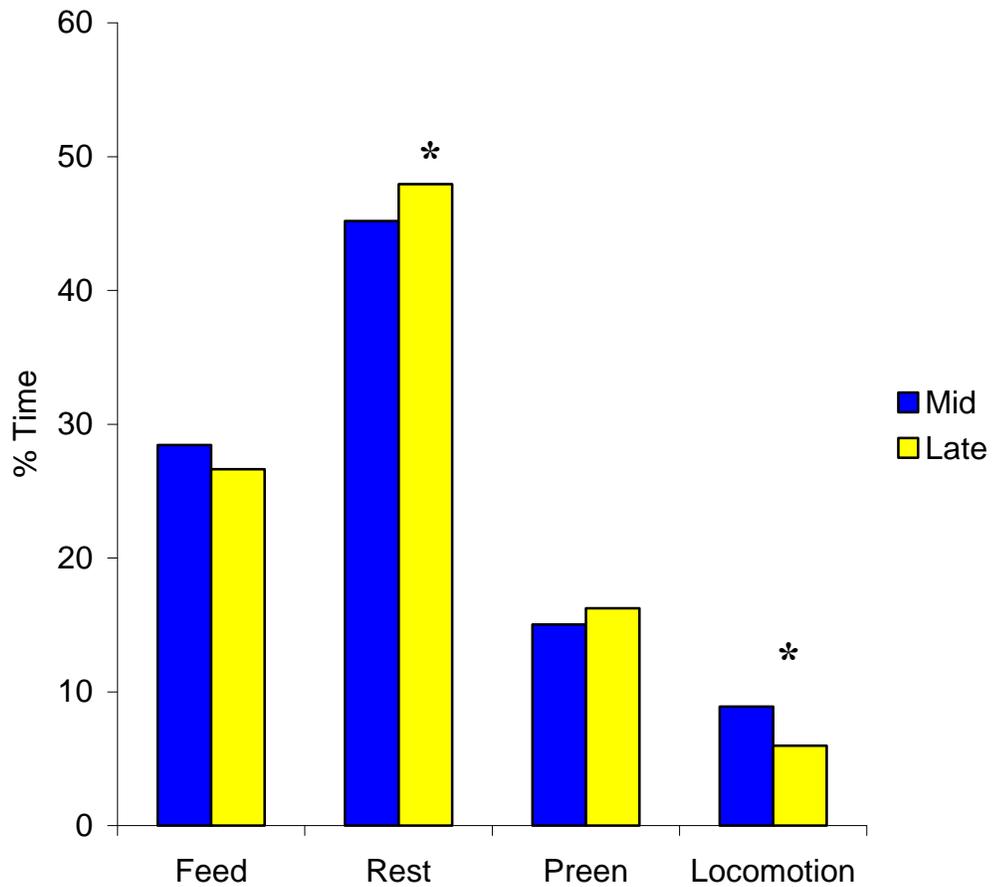
Figure 5. Seasonal diurnal activity patterns of lesser scaup at Merritt Island National Wildlife Refuge, winter of 2001-2002, as determined by scan sampling (*n*=1,587). Significant differences between mid and late winter for diurnal periods were determined by Wilcoxon nonparametric tests and denoted by an * (P <0.05), df = 1,585. All other activities accounted for <1% of time (alert, display, threat).
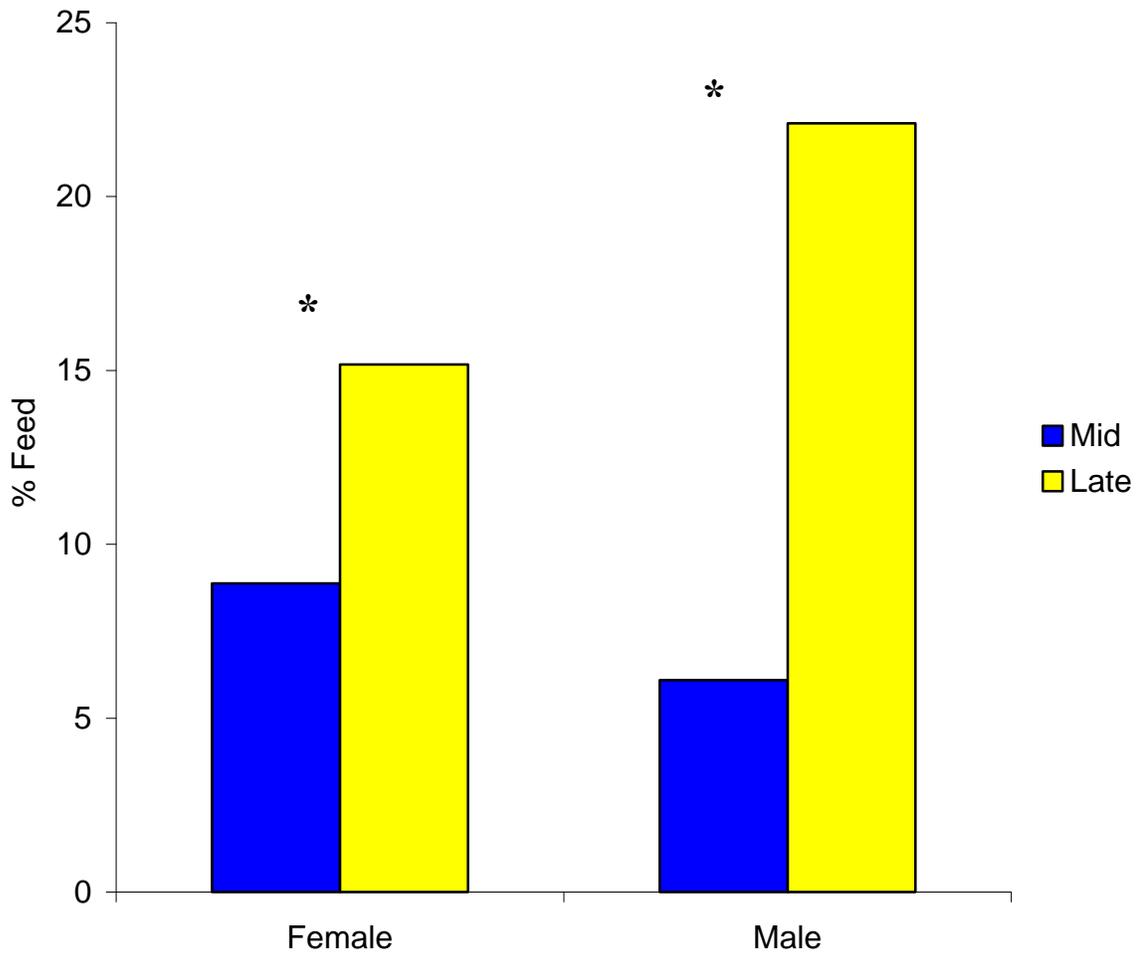
Figure 6. Seasonal nocturnal foraging patterns of Lesser Scaup at Merritt Island National Wildlife Refuge as determined by radio telemetry sampling during the winter of 2001-2002 (n = 196). Significant differences between mid and late winter for diurnal and nocturnal periods were determined by Wilcoxon nonparametric tests and denoted by an * (P <0.05), df = 109 and 83.
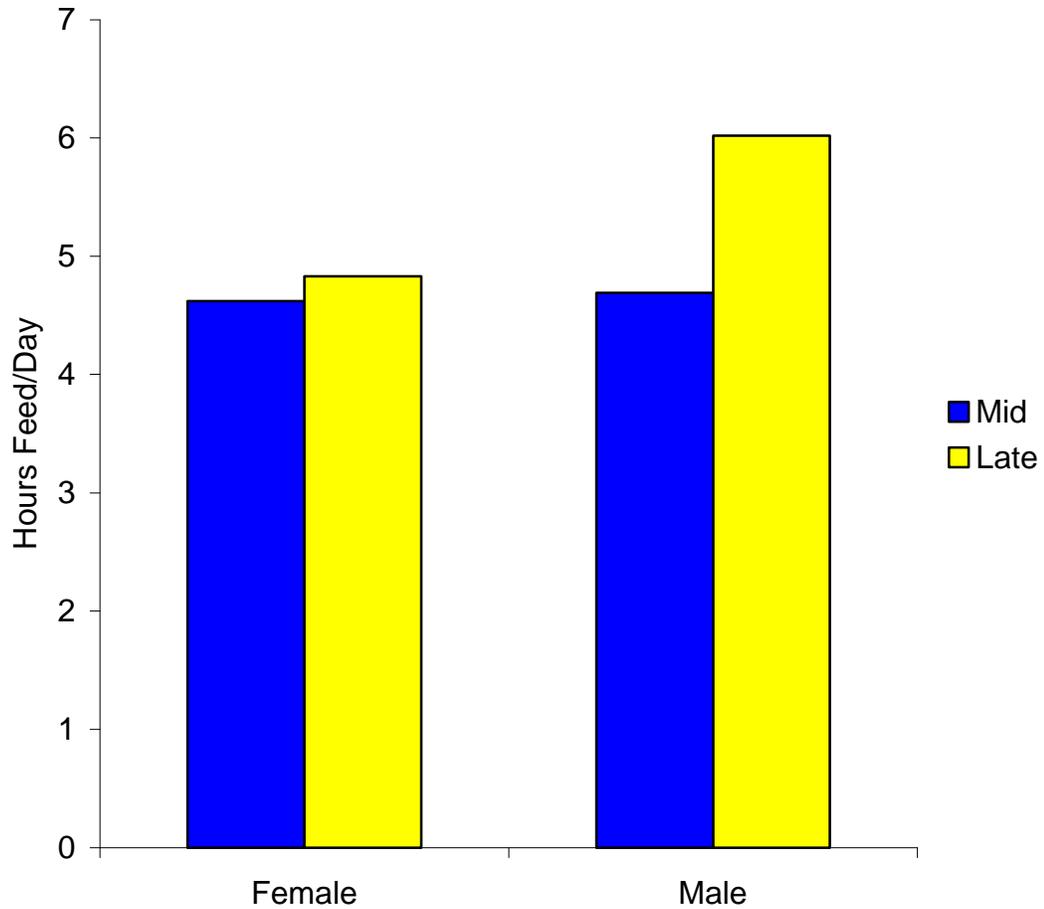
Figure 7. Comparison of mean diel time spent foraging between mid and later winter for female and male lesser scaup at Merritt Island National Wildlife Refuge, as determined by radio telemetry and scan sampling during the winter of 2001/2002 (196 nocturnal telemetry observations and 1,587 scans).

CHAPTER 2

ESTIMATING WINTER SURVIVAL AND TEMPORARY EMIGRATION OF LESSER SCAUP IN FLORIDA

ABSTRACT

The continental population of lesser scaup (*Aythya affinis*) has been declining since the mid-1980s. Period-specific survival estimates are necessary to understand the ecological basis of this decline, but such data are not available for scaup. I report winter survival of scaup in central Florida, where 62% of the Atlantic Flyway population overwinters. Estimates of survival were not confounded by hunting mortality as data were collected posthunting in 2002. The Kaplan-Meier survival estimate for females was 0.95 ± 0.04 (SE), and for males was 0.90 ± 0.09 (SE) for the period of 11 January – 14 March. These estimates were not different ($P = 0.64$). Pooled survival was 0.93 ± 0.04 (SE). Temporary emigration was exhibited by 24% of the birds, but their absence was short (24-hr intervals) and had little effect on precision of survival estimates as censored birds were added back into the model. These results were consistent with the dietary freshwater hypothesis, which states that scaup most likely flew inland to acquire freshwater after foraging in saline systems. These findings also suggested that posthunting season winter survival was high. Hence, sources of mortality, other than hunting, likely occur during other stages of their annual cycle. Estimating survival during other stages of their annual cycle is necessary to identify the underlying reasons for continental population declines.

INTRODUCTION

Lesser scaup populations have declined progressively since the mid-1980s, considerably below goals of the North American Waterfowl Management Plan (NAWMP; U.S. Fish and Wildlife Service 1986, 1988). However, before managers can develop strategies to curb the decline of the species, they must fully understand the basis of the decline. An essential step in that direction is obtaining estimates of survival on both breeding and wintering grounds, with particular emphasis in identifying sources of mortality. The best understanding of winter survival and sources of mortality come from harvest trends through the annual U. S. Fish and Wildlife Service's parts collection surveys and band returns (Afton and Anderson 2001). Annual survival estimates between 1954 and 1969 ranged from 0.44 to 0.87. These estimates were based on band returns, however since 1969, banding data have been insufficient to estimate survival rates (Austin et al. 2000). Furthermore, review of the scientific literature yielded no estimates of survival for wintering scaup outside of the hunting season.

Merritt Island and its adjacent estuarine areas (Banana and Indian River, Mosquito Lagoon) provide the most valuable wintering habitat for scaup on the Atlantic Flyway (Bellrose 1980). This area harbors up to 62% of all Atlantic Flyway wintering scaup, which constitutes almost 20% of the entire continental population (Bellrose 1980, Austin et al. 1998). Here I report winter survival estimates for scaup in central Florida from 11 January to 14 March 2002. Estimates were posthunting; hence, I believe estimates are indicative of "natural" winter survival rates. Of particular interest were survival estimates for females, because some studies suggest females have lower annual survival than males (Austin et al. 2000, Afton and Anderson 2001). I also evaluated temporary emigration for 2 reasons: (1)

understanding the extent of movements outside of the study area provides insights on habitat requirements, or differential survival if it exists (i.e., differential vulnerability to death); and (2) temporary emigration could lead to elevated variance and low precision of survival estimates (Seber 1982, Pollock et al. 1990, Kendall 1995, 1997).

METHODS

I used radio telemetry techniques to monitor survival and temporary emigration of wintering scaup. Capture and radio transmitter methods are outlined in methods for time activity budgets (Chapter 1). The large size of the study area and intermittent security restrictions associated with the KSC operations prevented all radio-tagged scaup from being located every day. Instead, I located radio-tagged scaup every 6 - 7 days.

Additionally, a boat-mounted telemetry setup was used to survey the entire area concurrent with the truck survey on 2 separate days (30 January and 26 February) to ensure no birds were being missed throughout winter. Lastly, I flew 1 aerial survey in a Cessna 172, using strut mounted telemetry antennas to search for missing scaup and verify ground survey results (14 February). Coverage of the aerial survey was from the north end of the Indian River (northern extent of the study site) south 100 km, by 15 km east west (1,500 km^2).

I started estimates of winter survival on 11 January, at that time; all radio-tagged scaup had had at least 4 days to acclimate to their transmitters. Additionally, prior to establishing data collection procedures, I monitored the activity patterns of 8 implanted birds for >6 h. Implanted scaup were observed to behave in the exact same manner as adjacent birds, feeding in regular rhythmic patterns without disruptions of performing other activities (e.g. resting, preening), with no detectable social detriment.

Wintering period was defined as 15 December to 15 March, based on preliminary migration chronology fieldwork conducted in 2001 (Herring and Collazo 2001), and from literature (Bellrose 1980). Mortality was suspected when radio-tagged scaup were located in the same area on consecutive days (all birds were triangulated to an exact location as part of

a concurrent study). These sites were then visited to determine fate of the suspect bird. Observation and scrutiny of the bird's condition was required to separate natural mortality from implant surgery mortality.

STATISTICAL ANALYSES

A Kaplan-Meier survival model was used to estimate winter survival (ϕ) for female and male scaup, and a pooled estimate for sexes combined (Pollock 1984, Pollock et al. 1989*a*, *b*). Scaup were right censored during weekly survival estimates if they temporarily emigrated out of the region; if they returned to the study site, they were included as new at-risk birds. Before data were pooled on sexes, I used a log-rank test to determine if male and female survival curves were different (Pollock et al. 1989*a*). I also used a *z*-test to examine sex-specific survival at the end of winter. I used Student's *t*-test to compare empirical weekly temporary emigration of female and male birds absent from weekly surveys. I explored the possibility of testing for the effects of temporary emigration on survival estimates assuming that departures were completely random or Markovian. However, emigration occurred at a finer temporal scale (24 hr) than my sampling temporal scale (weekly intervals), precluding such tests.

Model assumptions were as follows: (1) birds were randomly selected for sex; (2) birds have independent survival times [i.e., the fate of one bird is not related to another (e.g. paired birds)]; (3) the marking method does not effect survival (radio transmitter implant surgery and carrying the transmitters throughout the winter period); (4) death times are known exactly; (5) censoring is random and independent of survival; and a well defined time

origin for the study (Pollock et al. 1989*a, b*). These assumptions are validated in the following manner:

Birds were randomly selected for sex.   Trapping and subsequent capture of female and male scaup occurred over 4 days at 9 locations. By capturing birds from a large number of sites in a short period, I assume birds had less time to develop any bait response. Additionally, in the course of capturing >150 birds, there was only 1 recapture event, suggesting that new birds were continually caught daily.

Random selection of birds again was based on the large number of trapping sites, and capturing in excess of the number of birds that was required to meet the goal of 60 implanted scaup.

Independent survival times. Lesser scaup do not begin to form pair bonds until late winter (Bellrose 1980, Austin et al. 1998); accordingly, I assumed the fate of 1 bird would not be related to another.

Marking method does not effect survival. Woakes and Butler (1975), Perry (1981), Olsen et al. (1992), and Brook and Clark (2002) all showed that implanted radio transmitters resulted in no adverse effect on the behavior or survival of canvasbacks (*A. valisineria*) and lesser scaup. Additionally, in a recent study on mallards (*Anas platyrhynchus*), >2300 transmitters were implanted over 5 years with no adverse effect on survival or impairment of reproductive capacity (Devries et al. 2003).

Death times are known exactly. The assessment of time of death for individual birds was considered accurate, because as part of a concurrent project, telemetry locations of scaup were being collected between weekly data collection periods. Consequently, this fact ensured that time of death was accurately determined.

Censoring is random and independent of survival. Statistical tests showed that temporary emigration occurred at similar rates for both sexes (see results). In addition, censoring was found to be independent of survival as all birds that were censored (temporarily emigrated) were later observed on the study site, during the 10-week winter period.

Well-defined time origin for the study. The period for which survival was to be determined for was assigned prior to initiation of the study. Previous research in this area (Herring and Collazo 2001), and literature values (Bellrose 1980) were the primary sources from which the length of the winter period was assigned.

RESULTS

Radiotagged survival data were collected for 54 of the 60 implanted scaup, 30 female, 24 male. Five of the 6 idle implanted scaup were never detected in a 1,500-km^2 aerial search area; hence, I assumed the transmitters failed or the birds left the region entirely. Regardless all birds were searched for throughout the entire study, even if they were assumed to have left the study site permanently. A hunter shot the last of the idle radiotagged scaup within 2 days of it being implanted (there was 1 day left in the waterfowl hunting season when tagged birds were released). Additionally, 1 radioed scaup mortality could not be assigned a cause of death, accordingly I did not include it an estimates of survival.

Cumulative survival estimates for females were 0.95 ± 0.04 (SE) (Table 1) (Figure 1), and for males was 0.90 ± 0.09 (SE) (Table 2) (Figure 1). Estimates were not different ($z = -0.52$, $P = 0.3$, 1df), nor were their survival curves ($\div^2 = 0.11$, $P = 0.64$, 1df). Pooled survival was 0.93 ± 0.04 (SE) (Table 3). Of 3 deaths recorded during the study, 2 were likely caused by avian predation and did not occur until the week of 8-14 March (Figure 2). I could not determine the cause of the third death.

No significant differences in weekly empirical temporary emigration rates were detected between female and male birds ($t = -1.77$, $P = 0.11$, 18df). Mean weekly apparent temporary emigration of pooled sexes was $24.92 \pm 3.79\%$ (Figure 3).

DISCUSSION

Although these estimates of survival do not cover the first 3 weeks of winter, they cover the period in which numbers of scaup on the wintering grounds are highest (Bellrose 1980, Herring and Collazo 2001). The pooled winter period survival estimate in this study was 0.93 ± 0.04, which was within the range of other species of ducks under similar circumstances (i.e., no hunting pressure). For example, winter period survival of canvasbacks in Chesapeake Bay was 0.89 (Haramis et al. 1993), whereas winter survival for mallards in Arkansas ranged from 0.96 - 0.99 (Dugger et al. 1994). Differences in survival between male and females were not significantly different. Notwithstanding low precision, our findings suggest that sex-specific differences in annual survival (Austin et al. 2000, Afton and Anderson 2001) might be stemming from differential survival elsewhere (e.g., nesting females; Koons 2001).

Temporary emigration did not affect these estimates, as the absence of scaup from the study area was brief, lasting less than 24 hr. Scaup may have flown inland to freshwater systems, where I did not radio track. Although data were insufficient to test whether this behavior affected precision of survival, we believe that its influence was likely small. These estimates of cumulative survival were based on 10 "recapture" occasions every 6-7 days, a temporal scale much broader than the daily activity schedule exhibited by scaup. Zehfuss et al. (1999) illustrated that model estimates were generally unbiased if animals had a high probability of returning to the study site after temporary emigration. When the probability of being absent is constant, then temporary emigration simply reduces capture probabilities so that estimates are less precise (Zehfuss et al. 1999). I surmised that my sampling scheme provided multiple opportunities to detect birds if they were in the area. In telemetry studies,

detection probability is almost always 100% when animals remain in the study area (White and Garrot 1990, Williams et al. 2002). Moreover, our coverage of the area was extensive and included ground, boat, and aerial surveys. Therefore, I feel that temporary emigration had a negligible effect on precision.

Temporary movements can be explained by birds using different areas for foraging, loafing, and obtaining access to a source of fresh water. Of these possibilities, I believe the latter was most likely. Adair et al. (1996) showed that scaup wintering in coastal Texas traveled inland primarily to obtain fresh water, critical for birds spending substantial time in saline systems as purported by the dietary freshwater hypothesis (Kiel 1957, Mitchell et al. 1992, Woodin 1994). Scaup wintering in east-central Florida experience similar conditions, and exhibited temporary emigration patterns similar to Adair (1996). Furthermore, my radio tracking efforts focused on the estuarine regions around Merritt Island, had scaup flown inland to fresh water ponds they would not be detected during surveys.

The available 0.57-0.71 annual survival estimates for scaup (Austin et al. 2000) seem of little value in ascertaining the underlying reasons of the recent decline of this species, because they precede the onset of the decline (1954-69) and are based on band recovery data, which are often plagued by low recovery rates and low precision. Period specific survival analyses need to be undertaken throughout the annual cycle of the species to gain a better handle on when the species is most vulnerable, and if management can be prescribed to enhance survival. This work was the first critical evaluation of winter survival for scaup, and is further strengthened because estimates of survival were obtained in the absence of hunting. These findings suggest that natural mortality at Merritt Island and surrounding estuarine areas was not unusually high during the time of my study. My data also hint at the

possibility that habitat quality in the area is sufficient to meet wintering requirements required for high survival (e.g., foraging opportunities, and subsequent nutrient reserves, Chapter 1).

Temporary emigration (behavior) underscored the importance of multiple habitats for scaup. Scaup need access to habitats that provide freshwater after foraging in saline systems. A comprehensive evaluation of overwinter survival of scaup at Merritt Island and adjacent estuaries should include the effects of hunting mortality. In a spatial context, temporary emigration may contribute to lower period survival due to increased exposure to hunting.

Apparent high survival at Merritt Island reflects the importance of high quality wintering habitats for scaup. Maintaining these areas may be an essential requirement to curtail the decline of the species, from the perspective of minimizing winter mortality and preventing it from becoming an ancillary factor in current declines. Comparisons of wintering sites among species of diving ducks show that survival rates and mortality sources are often heterogeneous, which emphasizes the need to examine scaup survival at other wintering sites.

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Table 1. Female weekly and cumulative survival estimates for lesser scaup exposed to natural mortality factors at Merritt Island National Wildlife Refuge, Florida. Determined by radio telemetry sampling during the winter of 2001-2002, modified to allow temporary emigrants to re-enter the model. Exact dates are from 11 January to 14 March 2002.

Week	Date	No. risk	No. deaths	No. censored	New added	Cumulative survival	95% CI
1	7 Jan-11 Jan	30	0	0	0	1.00	1.00-1.00
2	12 Jan-17 Jan	30	1[1]	5	0	1.00	1.00-1.00
3	18 Jan-26 Jan	24	0	5	5	1.00	1.00-1.00
4	27 Jan-1 Feb	24	0	10	5	1.00	1.00-1.00
5	2 Feb-7 Feb	19	0	6	10	1.00	1.00-1.00
6	8 Feb-14 Feb	23	0	4	6	1.00	1.00-1.00
7	15 Feb-21 Feb	25	0	7	4	1.00	1.00-1.00
8	22 Feb-1 Mar	22	0	6	7	1.00	1.00-1.00
9	2 Mar-7 Mar	23	0	8	6	1.00	1.00-1.00
10	8 Mar-14 Mar	21	1	9	8	0.95	1.00-0.86

[1] Mortality of unknown nature, not included in survival estimates.

Table 2. Male weekly and cumulative survival estimates for lesser scaup exposed to natural mortality factors at Merritt Island National Wildlife Refuge, Florida. Determined by radio telemetry sampling during the winter of 2001-2002, modified to allow temporary emigrants to re-enter the model. Exact dates are from 11 January to 14 March 2002.

Week	Date	No. risk	No. deaths	No. censored	New added	Cumulative survival	95% CI
1	7 Jan-11 Jan	24	0	0	0	1.00	1.00-1.00
2	12 Jan-17 Jan	24	0	4	0	1.00	1.00-1.00
3	18 Jan-26 Jan	20	0	1	4	1.00	1.00-1.00
4	27 Jan-1 Feb	23	0	6	1	1.00	1.00-1.00
5	2 Feb-7 Feb	18	0	6	6	1.00	1.00-1.00
6	8 Feb-14 Feb	18	0	5	6	1.00	1.00-1.00
7	15 Feb-21 Feb	19	0	10	5	1.00	1.00-1.00
8	22 Feb-1 Mar	14	0	10	10	1.00	1.00-1.00
9	2 Mar-7 Mar	14	0	14	10	1.00	1.00-1.00
10	8 Mar-14 Mar	10	1	14	14	0.90	1.00-0.72

Table 3. Pooled sex survival estimates for lesser scaup exposed to natural mortality factors at Merritt Island National Wildlife Refuge, Florida. Determined by radio telemetry sampling during the winter of 2001-2002, modified to allow temporary emigrants to re-enter the model. Exact dates are from 11 January to 14 March 2002.

Week	Date	No. risk	No. deaths	No. censored	New added	Cumulative survival	95% CI
1	7 Jan - 11 Jan	54	0	13	0	1.00	1.00-1.00
2	12 Jan - 17 Jan	41	1[1]	5	13	1.00	1.00-1.00
3	18 Jan - 26 Jan	48	0	17	5	1.00	1.00-1.00
4	27 Jan - 1 Feb	36	0	14	17	1.00	1.00-1.00
5	2 Feb - 7 Feb	39	0	10	14	1.00	1.00-1.00
6	8 Feb - 14 Feb	43	0	19	10	1.00	1.00-1.00
7	15 Feb- 21 Feb	34	0	18	19	1.00	1.00-1.00
8	22 Feb - 1 Mar	35	0	24	18	1.00	1.00-1.00
9	2 Mar - 7 Mar	29	0	21	24	1.00	1.00-1.00
10	8 Mar - 14 Mar	32	2	33	21	0.93	1.00-0.85

[1] Mortality of unknown nature, not included in survival estimates.
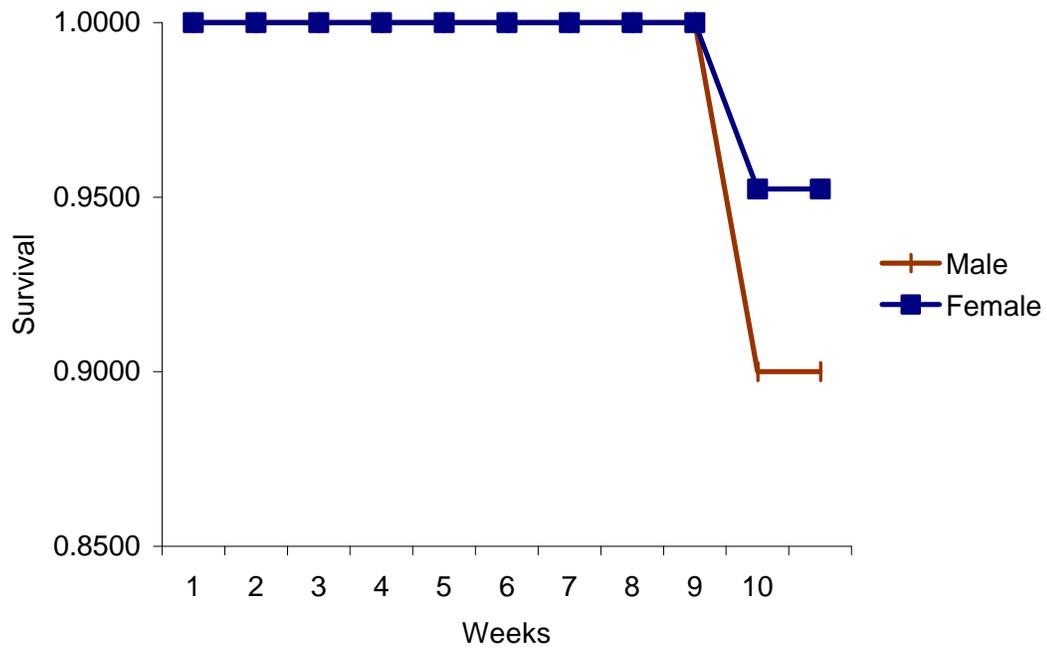
Figure 1. Survival probabilities of wintering lesser scaup (29 female, 24 male) exposed to natural mortality factors at Merritt Island National Wildlife Refuge, Florida. Determined by radio telemetry sampling during the winter of 2001-2002, modified to allow temporary emigrants to re-enter the model. Exact dates are from 11 January to 14 March 2002.
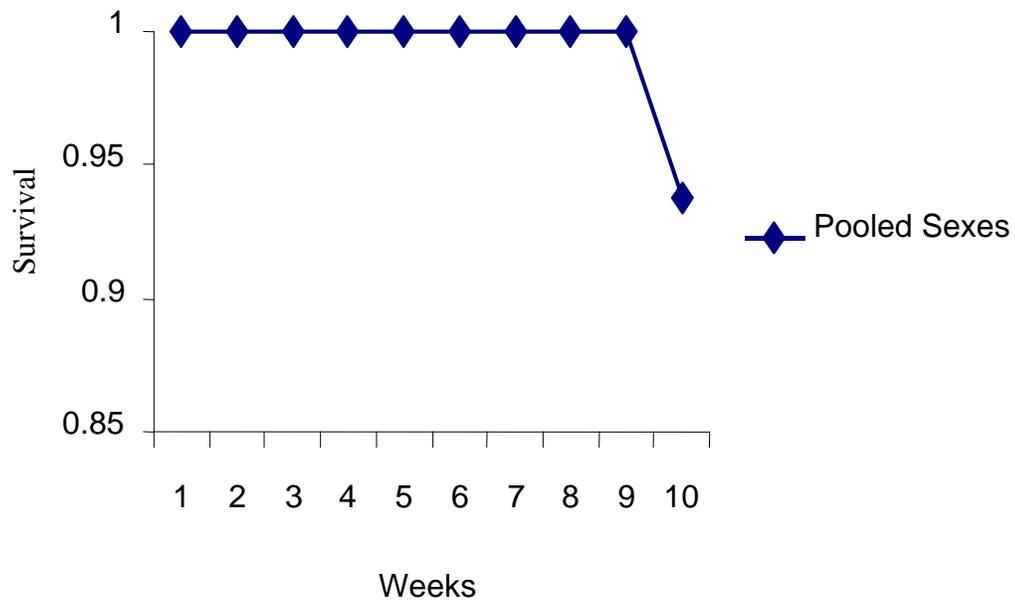
Figure 2. Pooled Survival probabilities of wintering lesser scaup (29 female, 24 male) exposed to natural mortality factors at Merritt Island National Wildlife Refuge, Florida. Determined by radio telemetry sampling during the winter of 2001-2002, modified to allow temporary emigrants to re-enter the model. Exact dates are from 11 January to 14 March 2002.
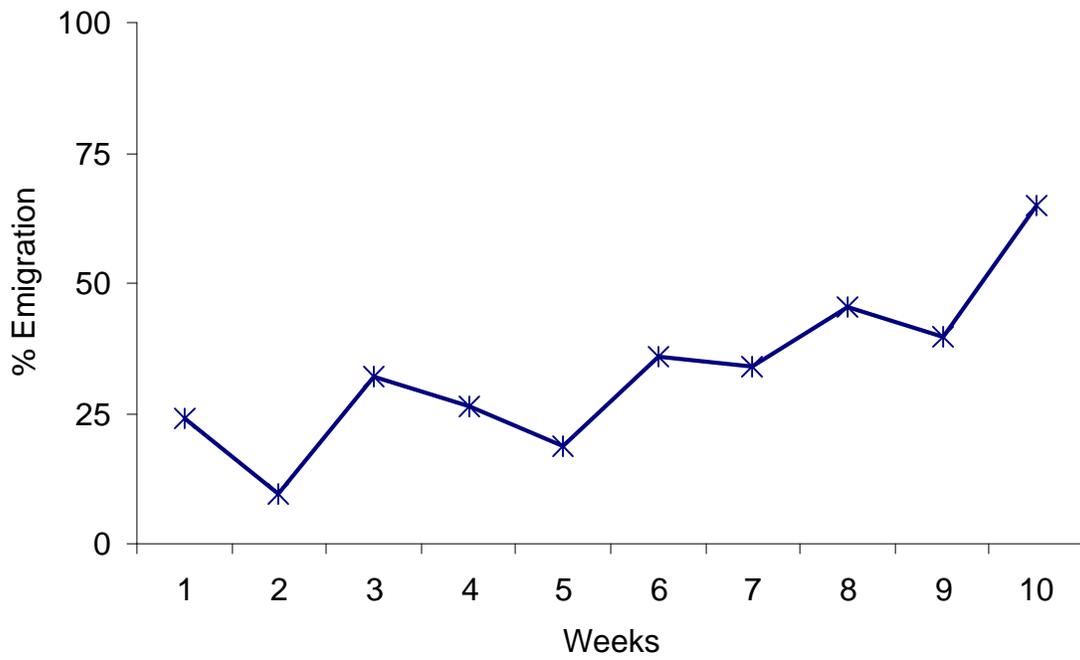
Figure 3. Mean weekly empirical temporary emigration of pooled sexes wintering lesser scaup (29 female, 24 male) at Merritt Island National Wildlife Refuge Florida, as determined by radio telemetry sampling during the winter of 2001-2002. Exact dates are from 11 January to 14 March 2002.

CHAPTER 3

ESTIMATING MOVEMENTS AND HOME RANGE OF WINTERING LESSER SCAUP IN EAST-CENTRAL FLORIDA

ABSTRACT

Florida is the most important wintering site for lesser scaup in the Atlantic Flyway, yet understanding how habitats are used by wintering scaup and why in Florida is inadequate. Continental population declines suggest that addressing this information void is important to evaluate habitat conditions and how habitat conditions may relate to the health and fitness of scaup. I used radio telemetry to test habitat use within the constraints of the Functional Unit System theory (FUS). The FUS theory suggests that wintering waterfowl will use separate units or regions for comfort and feeding activities. I further tested for differences in movements and home range between males and females to determine if they used different habitats. Lastly, I used data on movements and home range to coarsely evaluate habitat quality and potential effects of human disturbance. I found that sexes traveled similar distances in mid and late winter between diurnal and nocturnal sites (P > 0.05). Scaup increased distance between diurnal and nocturnal sites by 5% in late winter (P = 0.03) from 2.4 km to 2.6 km. Male and female fixed kernel home ranges (P > 0.05) and core use areas (P > 0.05) did not differ. Mean pooled fixed kernel 95% home range and 50% core use areas were 15.1 ± 4.2 km^2 and 2.7 ± 1.1 km^2, representing 3% and 0.5% of available habitats. Results suggested that scaup did use different habitats for comfort and feeding activities. Sexes appeared to use habitats similarly and short distances traveled between diurnal and nocturnal sites suggested that habitat conditions were similar across the impounded wetlands and shallow portions of the Indian and Banana Rivers, and that disturbance was likely negligible. Scaup appeared to locate suitable habitats early in the winter period (January) and remain there throughout much of the season. Accordingly, I believe that the IRL system provides adequate winter habitat, at least around MINWR.

INTRODUCTION

Current knowledge of habitats used by wintering scaup and why they are used in Florida is inadequate considering the region is the most significant wintering site for scaup along the Atlantic Flyway (Bellrose 1980, Austin et al. 1998). Continental population declines suggest that addressing this information void is important to evaluate habitat conditions and how this relates to the health and fitness of scaup.

Few studies have examined habitat use by scaup on the winter grounds. Bergman and Smith (1989) reported where scaup occurred but not within the context of an estimated winter home range. Their focus was differential habitat use as a function of water depth. Adair et al. (1996) also studied habitat use but focused on one-way movements, that is, movements to low salinity areas to purge their salt gland (fresh water hypothesis). Therefore, a study aimed at estimating home range throughout winter could yield valuable information for management and protection of wintering scaup habitats.

I used radio telemetry to estimate home range and movements of wintering scaup to gain a basic understanding of how scaup behaved through time and space at Merritt Island. I was interested in determining if scaup had a "functional unit system," that is, if scaup used separate types of habitat, or areas for different aspects of their daily maintenance requirements. Tamaisier (1976, 1979, 1985) reported that green-winged teal (*Anas crecca*) carried out comfort activities at one site and feeding at night in another locale. This behavior has also been observed in diving ducks (Nilsson 1970, Pedroli 1982). Another question of interest was determining whether males and females used different habitats as suggested by Bergman and Smith (1989) and Afton and Anderson (2001). Finally, I used data on

movements and home range to coarsely evaluate habitat quality and potential effects of

human disturbance.

METHODS

I used radio telemetry to monitor and quantify movements and estimate home range of wintering scaup. I captured and instrumented 60 scaup, albeit only 54 were available for tracking. Five scaup were never located (within an area of 1500 km^2 area). Presumably, these birds moved entirely out of the study area or transmitters failed. A hunter killed one bird during the first 2 days of this study (there was 1 day left in the waterfowl hunting season when tagged birds were released). Capture and radio transmitter methods were outlined in the methods for time activity budgets (Chapter 1). I evaluated radio-location angle errors by taking 13 triangulated readings (26 bearings) from different locations from a distance of 1 km (arbitrary distance) prior to initiating tracking. Triangulated locations were compared to the known position as determined by GPS [Garmin, model 12CX GPS (Garmin Corp, Olathe, KS 66062)]. The mean angle error was 2º ± 0.09 SE. Mean distance error between triangulated locations and actual locations was 53m ± 3 SE. The mean error polygon for all subsequent scaup locations was 231 m ± 5.57 SE.

Radio-tagged scaup were relocated every 2 - 3 days. Monitoring more frequently was not possible because the study area was large and there were intermittent security restrictions associated with operations of the Kennedy Space Center. Triangulations were based on bearings taken from 2 locations (GPS coordinates were also taken at each site). I endeavored to take both bearings and GPS coordinates no more than 30 min apart in an effort to minimize bird movement. Program Locate II (Pacer, Truro, NS, Canada B2N 5E5) was used to calculate positions of triangulated birds.

Location data were plotted on a map of Merritt Island and adjacent estuarine habitat using a geographic information system (Arcview v. 3.3, ESRI, Redlands CA). Home range

for scaup was defined following Wortons's (1995); minimum area in which an animal has a specified probability of being located. Core area was defined as an area within the home range that surrounded the maximum number of locations and exceeded a uniform bivariate distribution (Samuel and Green 1988).

I tested for site fidelity using the Movement Analysis Extension of Arcview (v.2.04, Hooge and Eichenlaub 1997) to determine if assumptions of a home range were met (Spencer et al. 1990, White and Garrott 1990, Hooge 1995). Home range analyses were then conducted using fixed kernel methods and least squares cross validation for scaup with ≥ 20 observations (Worton 1989, Seaman and Powell 1996, Seaman et al. 1999). Previous studies have suggested that a minimum of 30 relocations per individual should be used to estimates home range using fixed kernel methods (Worton 1989, Seaman and Powell 1996, Seaman et al. 1999). I relaxed this assumption, using all scuap with ≥ 20 locations, if they met the assumptions of site fidelity (Spencer et al. 1990, White and Garrott 1990, Hooge 1995).

In this study only 18 scaup met that sample size criteria, with 8 having ≥ 30 locations. I used a Wilcoxon test to examine differences in home range and core use area between scaup with < 30 and ≥ 30 observations, to determine if scaup with < 30 locations would bias my estimates. Fixed kernel estimates of 50% (core areas) and 95% were calculated using the Movement Analysis Extension to Arcview (v.2.04, Hooge and Eichenlaub 1997).

Home range size has been shown to stabilize at or near 20 locations (Anderson 1982, Jaremovic and Croft 1987), and bootstrapping my estimates of home range also resulted in estimates leveling off around 20 locations. Accordingly, I believe that fixed kernel estimates of home range and core use areas were an accurate reflection of home ranges for scaup.

I subtracted the amount of nonuseable habitat (e.g., forested uplands) located within home ranges or core areas to more accurately reflect the amount of usable habitat. I used Arcview (v. 3.3, ESRI, Redlands CA) to calculate distance from capture site to the center of female and male 50% kernel (core) and proportion of 50% core and 95% home range within the boundary of MINWR. I calculated distances between each diurnal location of radioed scaup and following nocturnal location using Arcview (v. 3.3, ESRI, Redlands CA). Paired diurnal and nocturnal distances are based on relocation events >12 hr apart (White and Garrott 1990). I assume that these estimates of mobility reflect the actual distances traveled daily by scaup at Merritt Island.

STATISTICAL ANALYSES

I used Student's t-tests to compare differences in male and female fixed kernel 50% core and 95% home ranges using. Differences in the distance traveled between males and females from the capture site to the center of 50% fixed kernel (core) were compared using Student's t-test. The same tests, but using pooled data for sexes, were conducted when differences between sexes were not significant. I used a Wilcoxon test to compare distances traveled between males and females from diurnal to nocturnal sites between mid and late winter. Significance of all statistical tests were set at an alpha of 0.10 due to low sample sizes, to minimize the probability of making a Type I error (Anonymous 1995, Zar 1996).

RESULTS

I collected 274 paired diurnal/nocturnal locations on 48 of the 54-instrumented birds available for tracking. The mean number of observations per bird was 5.73 ± 1.33. Mean distance traveled for all radioed birds was 2.51 ± 0.45 km with a range of $0.67 – 36.08$ km. There was no difference between sexes for daily movements for mid or late winter (Mid-winter $Z = -0.31$, $P = 0.74$, df = 106; Late Winter $Z = -1.04$, $P = 0.29$, df = 164). After pooling data for both sexes, late winter radioed scaup traveled 5% farther between diurnal and nocturnal sites in late winter ($Z = 2.08$, $P = 0.03$, df = 272).

Fixed kernel estimates of home range ($t = -0.83$, $P = 0.41$, df = 22) and cores use area were similar ($t = -0.98$, $P = 0.33$, df = 22) between scaup with ≥ 20 and ≥ 30 locations. Subsequent results and discussion are restricted to fixed kernel estimates for scaup with ≥ 20 observations. The 18 scaup used for fixed kernel analysis yielded 583 observations (mean observations/individual = 32 ± 3.22 SE). Male and female fixed kernel home ranges ($t = 1.05$, $P = 0.30$, df = 16) and core use areas ($t = 0.77$, $P = 0.45$, df = 16) did not differ. Fixed kernel core areas were on average $12.76\% \pm 2.22$ SE of their home ranges (Figure 1). Mean pooled 95% and 50% fixed kernel home ranges were 15.1 ± 4.2 km^2 and 2.7 ± 1.1 km^2, representing 3% and 0.5% of available habitat (Table 1). Mean proportions of 95% home range and 50% core use areas within MINWR were $56.18\% \pm 5.2$ SE and $67.88\% \pm 7.45$ SE, respectively. Mean distance from the capture site to the center of the scaups 50% core use area was 3.52 ± 1.83 km, and did not differ by sex ($t = 0.38$, $P = 0.70$, df = 16).

DISCUSSION

Home range and core area estimates suggested that scaup had strong site fidelity throughout the winter. This finding is consistent with reports of scaups in other locales (Custer et al. 1996, Poulton et al. 2002, Takekawa et al. 2002). Scaup appeared to select locations in early winter that allowed them to forage and rest throughout the winter. A plausible explanation for this pattern is predictable and abundant resources (Skagen and Knopf 1993, Drake et al. 2001).

Scaup home ranges and core use areas were consistently near or associated with the boundary of Merritt Island. Core use areas were generally associated with the shallow (<1 m) waters located near the lagoon edge, and within impounded wetlands. The 95% home range areas covered a broader array of habitats, from the shallow edge and impoundment habitats to the large open expanses of the center of the lagoon system, where depth was often >3 m. Significant differences in scaup behavior were detected between impounded wetlands and estuarine habitats (Chapter 1), such that scaup spent more time foraging and locomoting in impoundments, resting more in open estuarine habitats. Shallower, calmer waters in impoundments may have facilitated foraging, allowing scaup to forage in uncharacteristic habitats. Scaup were frequently observed tip feeding in shallow waters in and adjacent to impounded wetlands. Differential habitat use suggests scaup might be using different areas for foraging and resting as purported by the Functional Unit Theory (Tamisier 1979, 1985).

Similarities between male and female scaup home ranges and movements suggest that they do not use different habitats as suggested by Bergman and Smith (1989) and Afton and Anderson (2001), at least at Merritt Island and in the adjacent estuaries. The scale used in this study possibly may not be appropriate to detect such differences. Certainly, detecting

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differences in habitat use between sexes may be confounded by ratios of male to female scaup. Furthermore, Marsden and Sullivan (2000) showed that females were able to occupy the most suitable habitats in a male-dominated wintering pochard (*A. ferina*) population. However, habitat preferences often occurred at very small scales, suggesting differences in wintering scaup habitat use could occur but may be undetectable at the home range and core use area scale.

Home range and core use areas did not reflect the occurrence of temporary emigration outside of my study site as observed during the estimation of survival (Chapter 2). Temporary emigration results suggests that some scaup may have left the study site on sallies inland to acquire fresh water as purported by the dietary freshwater hypothesis (Kiel 1957, Mitchell et al. 1992, Woodin 1994, Adair et al. 1996). While these events are statistically confounding, they remain biologically significant, and understanding the extent to which wintering scaup rely on freshwater sources or if this is an opportunistic occurrence is not clear.

Disturbance of rafting diving ducks has been shown to be common on important staging and wintering areas (Korschgen et al. 1985, Kahl 1991, Havera et al. 1992, Knapton et al. 2000, Mori et al. 2001, Evans and Day 2002). While this study did not directly measure the effects of human disturbance on scaup, I summarize observations, suggesting that disturbance impacts are different in the systems surrounding Merritt island. For example, the relatively small core use areas and short distances traveled between diurnal and nocturnal sites in the Indian River Lagoon suggested that radioed scaup were not disturbed often. As suggested before, scaup probably locate suitable habitat soon after they reach the area and remain fairly sedentary during the remainder of the season. The impact of

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disturbance, however, might be different in early to mid winter (November – January), during the hunting season, a period not covered during this study.

Scaup failed to use available habitat in the Mosquito Lagoon in both years of this study. Only a few (<10) of the radioed birds were periodically located in the Mosquito Lagoon. Consequently, no portions of the radioed scaup home ranges or core use areas were located within the Mosquito Lagoon. Additionally, during aerial surveys in 2001, less than 200 scaup in total were counted in 5 successive flights in 4 months (Herring and Collazo 2001). Forage availability was assessed among estuaries in 2001 at MINWR (Herring and Collazo 2001); results suggested that conditions were similar between estuaries (Mosquito Lagoon, Indian and Banana Rivers). Disproportionate use of this lagoon by commercial crab fishers, pleasure boaters, and sport anglers might contribute to the lack of scaup in this habitat.

Previous estimates of daily distances flown by waterfowl on wintering grounds range from 0.6 km – 48.8 km, averaging around 15 km per flight (Lebret 1959, Costanzo et al. 1983, Jorde et al. 1983, Davis et al. 1989, Morton et al. 1989, Adair 1990, Howerter 1990, Cox and Afton 1996). However, only Adair (1990) and Howerter (1990) examined movement patterns of wintering diving ducks, with movements ranging from 3.3 km – 10.7 km for lesser scaup and 23.4 km for canvasbacks (*A. valisineria*). Therefore, I consider this study's estimates of 50% core and 95% home range to be small. Scaup appear to be able to meet their requirements (e.g., nutritional) without having to travel long distances (see also Chapter 1). Similarly, distances traveled between diurnal and nocturnal sites were short. Accordingly, I believe that the IRL system provides adequate winter habitat, at least in the regions around Merritt Island. Conditions elsewhere (e.g., southern IRL portions) were

unknown, but the high numbers of wintering scaup consistently observed in the area suggests that conditions may be comparable throughout IRL. Use of impounded wetlands at Merritt Island complements available estuarine systems and increases the likelihood of continued habitat availability on the wintering grounds.

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Table 1. Home range and core use areas of lesser scaup based on 95% and 50% fixed kernel estimates for radioed scaup with ≥20 observations. Overall means, standard errors, and sample sizes are reported for observations and fixed kernel home ranges and core use areas.

Bird	Sex	Observations	95% Home Range (km^2)	50% Core (km^2)
2.043	M	20	21.75	4.36
2.133	F	22	11.20	2.45
2.222	F	25	12.19	0.83
2.253	F	45	8.01	1.21
2.315	M	20	0.94	0.17
2.375	M	24	6.32	1.47
2.674	F	33	37.50	10.89
2.853	M	20	21.79	4.84
2.884	F	45	23.85	2.94
2.973	F	20	31.26	5.94
3.109	M	55	13.25	2.13
3.123	M	42	16.57	1.40
3.170	F	53	15.96	2.90
3.191	F	20	14.43	1.79
3.214	F	43	6.52	1.17
3.509	F	20	10.63	0.96
3.561	M	54	5.01	1.21
3.601	F	22	15.26	4.00
Mean		33	15.11	2.81
SE		3.22	2.01	0.53
N		583	18	18

N

Atlantic Ocean

Mosquito Lagoon

90%

50%

Banana River

Indian River

| 10 | 0 | 10 | 20 | Kilometers |
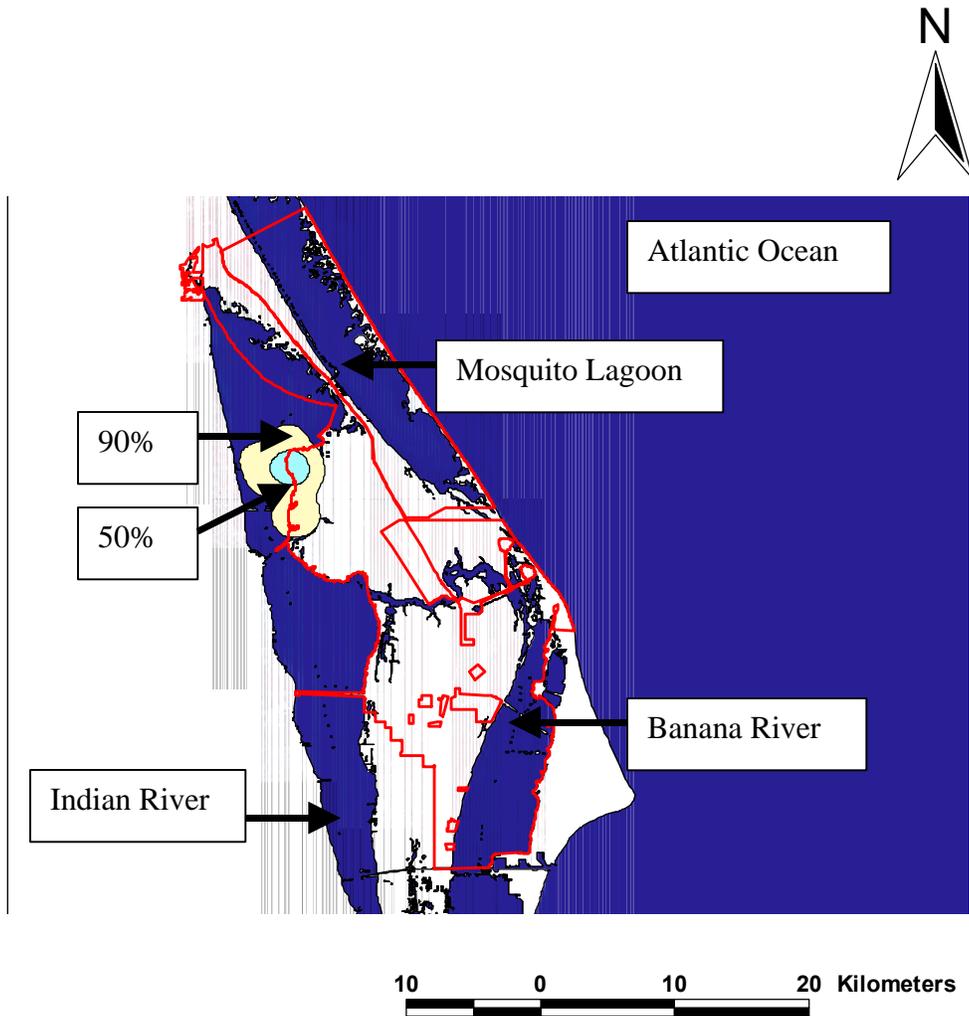
Figure 1. Example of 95% home range and 50% core use area for lesser scaup (152.133) from 11 January – 14 March at Merritt Island National Wildlife Refuge, calculated using fixed kernel analysis.