Habitat Use by Juvenile Female Canvasbacks Wintering on the Upper Chesapeake Bay

by

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(ABSTRACT)

During the winter 1988-89, diurnal and nocturnal habitat use by juvenile female canvasbacks wintering on the upper Chesapeake Bay was determined. Radio-implanted canvasbacks used shallow water (0-2 m) areas near artificial feeding sites during the day, and deeper water (2-6 m) that had an adundant (> 200/m^2) population of small (< 25 mm) *Macoma balthica* at night. Because of poorer *Macoma* populations on the east side of the Bay, canvasbacks there may feed more during the day and are in lower *Macoma* densities at night than west shore canvasbacks. Management of Chesapeake Bay canvasback populations should focus on providing natural foods and rest areas.

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This study involved many organizations and people who shared an intense interest of canvasbacks on the Chesapeake Bay. I would like to express my sincere appreciation to the following:

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INTRODUCTION

The Chesapeake Bay traditionally has been a major wintering area for canvasbacks (*Aythya valisineria*) in the United States (Stewart 1962, Bellrose 1980, Perry et al. 1981). Munro and Perry (1981) reported that more than half of the Atlantic Flyway population of canvasbacks wintered on the upper Chesapeake Bay from 1956-1971. However, the number of canvasbacks wintering on the Chesapeake Bay has declined from about 230,000 in the early 1950's to the recent estimate of 38,500 in the 1980's (U.S. Fish and Wildlife Service Midwinter Waterfowl Inventories 1953-88). Conversely, populations of canvasbacks elsewhere in the United States and the Atlantic Flyway exhibited an increase during the 1970's. These nationwide increases were thought to be the result of more restrictive hunting regulations (Perry et al. 1981). Geis and Crissey (1969) determined from nationwide band returns that restrictive hunting can lead to increased numbers of canvasbacks. Anderson and Burnham (1976) later pointed out underlying statistical problems in the analysis performed by Geis and Crissey (1969). Although Nichols and Haramis (1980) reported lower survival rates for Delaware-Maryland-Virginia canvasbacks during liberal hunting seasons, they neither supported nor rejected the hypothesis that restrictive hunting leads to higher populations.

Serie et al. (1983) hypothesized that the distribution patterns of wintering canvasbacks "may result from the predictability of natural foods and the ability of canvasbacks to exploit these food resources." Perry et al. (1981) and Lovvorn (1989) believed that habitat alteration on the wintering grounds, especially with regard to food resources, probably was responsible for the lack of increase in Chesapeake Bay canvasback populations during the increase in the Atlantic Flyway population. A number of studies (Stewart 1962, Rawls 1978, Perry 1982, Perry and Uhler 1988) have been done on canvasback food habits in the Chesapeake Bay; however, they give no ecological relationship to the habitat in which the bird was collected.

Recently, attention has been directed towards the dynamics of waterfowl populations on their wintering grounds (e.g., Wintering Waterfowl Symposium 1985). Fretwell (1972) argued that environmental factors outside the breeding season were crucial in regulating populations of migrating waterfowl species, and various studies (Ankney and MacInnes 1978, Krapu 1981) have indicated that the condition of waterfowl leaving the wintering grounds exerts a great influence on reproductive efforts during the subsequent spring. The Chesapeake Bay Living Resources Task Force (1987) reported that the critical life stage for canvasbacks is "wintering." Yet, of 1,748 waterfowl studies reviewed by Reinecke (1981), only 8% pertained to wintering waterfowl. Clearly, additional research is needed to determine the role of winter habitat quality in waterfowl survival and reproduction.

Given the dynamic nature of habitat availability, food resources, and population numbers of canvasbacks wintering in the Chesapeake Bay, identifying the habitats actually being used by canvasbacks is essential. The Patuxent Wildlife Research Center, U.S. Fish and Wildlife Service, currently is undertaking a study of the habitat use and survival of juvenile female canvasbacks wintering in the Chesapeake Bay. Objectives of the Patuxent study were as follows:

1. To develop a successful telemetry system for use with wintering canvasbacks.

2. To estimate daily survival rates and identify causes of mortality for a sample of hatching year (HY) female canvasbacks wintering in upper Chesapeake Bay.

3. To evaluate habitat use of canvasbacks wintering in upper Chesapeake Bay and North Carolina.

The research to be reported here is being conducted in cooperation with the Patuxent Wildlife Research Center and deals with accomplishing objective 3 above. The objective of this study was as follows:

1. To determine and explain diurnal and nocturnal habitat use by juvenile female canvasbacks wintering in the upper Chesapeake Bay.

Funding for this study was provided by the U.S. Fish and Wildlife Service and the Department of Fisheries and Wildlife Sciences at Virginia Polytechnic Institute and State University.

STUDY AREA

The study area was located in the upper Chesapeake Bay, the largest estuary in North America. The 3500 km^2 study area encompassed the area within 24.1 km north on both shores and 46.4 km south on the western shore and 40.3 km south on the eastern shore of the Wm. Preston Lane, Jr. Memorial Bridge (U.S. Route 50/301)(Figure 1). The area was characterized by numerous creeks and rivers that were generally shallow. The western and eastern shores of the Bay represented a contrast in habitat. The western shore was characterized by a generally urban setting. Waterfowl received little or no hunting pressure, and artificial feeding by private citizens was common. The eastern shore was largely rural and waterfowl hunting was widespread. During winter 1988-89, 35,651 canvasbacks or $\simeq$38% of the Atlantic Flyway population wintered in

Maryland (Serie 1989). At least 78% of the 1988-89 Maryland population wintered in the study area (data from this study).

The mean annual and winter (December-February) temperatures at Baltimore-Washington International (BWI) Airport, located south of Baltimore, MD in the northern end of the study area, were 13° C and 2° C, respectively. The mean annual precipitation for BWI was 107 cm with annual snowfall averaging 38.1 cm.

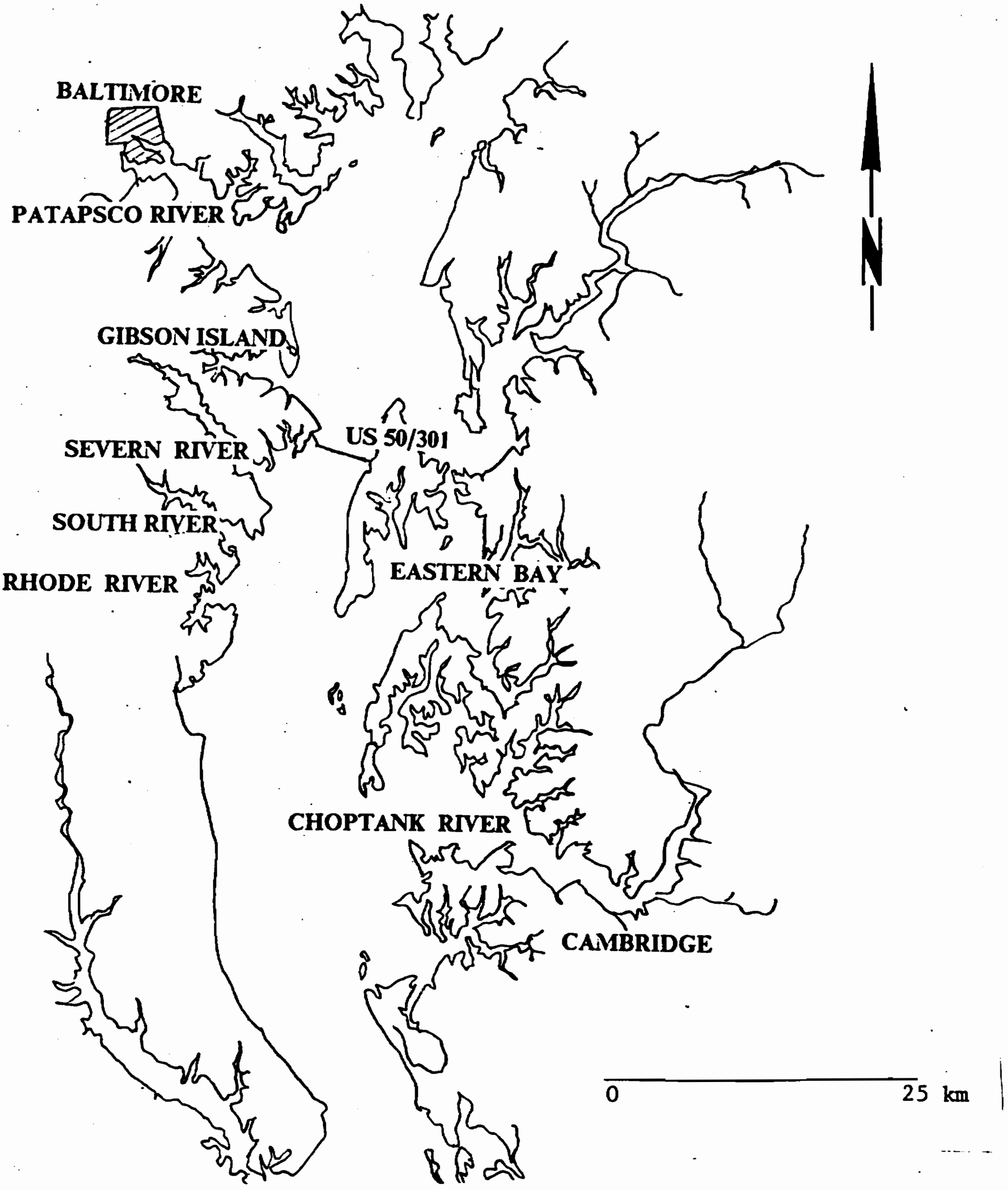

Figure 1. Study area in Chesapeake Bay, Maryland, 1988-89.

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CHAPTER 1: DAYTIME HABITAT USE

METHODS

Trapping

During the 2nd week of December 1988, canvasbacks were captured in corral traps (Haramis et al. 1987) and banded in cooperation with Patuxent Wildlife Research Center personnel. Traps located on both the western and eastern shores of the Bay (Figure 2) were prebaited with corn for ≃ one week prior to capture. Captured ducks were held for 1-3 hours to allow plumage to dry and bait to pass. Each was aged (Haramis et al. 1982) and weighed to the nearest 10 g. Wing length (nearest 1 mm) also was recorded. Adult male and female and juvenile male canvasbacks then were released and juvenile female canvasbacks were transported in wooden poultry crates to Patuxent Wildlife Research Center to receive radio transmitters. Under antiseptic conditions, veterinarians surgically implanted canvasbacks with encapsulated radio transmitters (Telonics Inc., Mesa, AZ).

Implantation required ≃ 10 minutes. Following the operation, canvasbacks were given a 50 cc. subcutaneous injection of a glucose-electrolyte mixture to prevent dehydration and held overnight. Canvasbacks were released the next day where they were captured.

Telemetry System

The transmitter implants operated at 164-165 megahertz, had a body temperature mortality switch and weighed approximately 20 g (≃ 2% of body weight). Each had an estimated ground range of ≃1 mile. Transmitters were of visceral implant design with a coiled antenna.

Radio tagged canvasbacks were monitored from 28 December 1988 through 29 March 1989. Daytime locations (sunrise to sunset) were obtained using scanning receivers and a vehicle roof-mounted null peak system (Telonics, Inc., Mesa, AZ). Canvasbacks radio tagged during the 1988-89 field season were monitored along 2 routes, 1 each on the eastern and western shores (Figure 3). This allowed me to evaluate the hypothesis that discrete populations of canvasbacks existed within the Bay. Each route was run from a randomly selected starting point during daylight hours and required 1-2 days to complete, depending on traffic and weather. Routes were designed to maximize the number of radioed canvasbacks encountered (Appendix I). Therefore, routes changed slightly (ie.stops were added or deleted) as the distribution of canvasbacks changed. When a raft of canvasbacks was observed in a new area, a stop was added to survey that location for radioed birds. A stop was deleted if no canvasbacks (radioed or non-radioed) were located at that point during 2 consecutive surveys.

The center of a flock that contained ≥ 1 radioed canvasback was visually plotted in the field on 1:24,000 composite USGS topographic-National Wetlands Inventory maps. Date, time, wind speed and direction, flock size, approximate number of canvasbacks, flock behavior, and whether

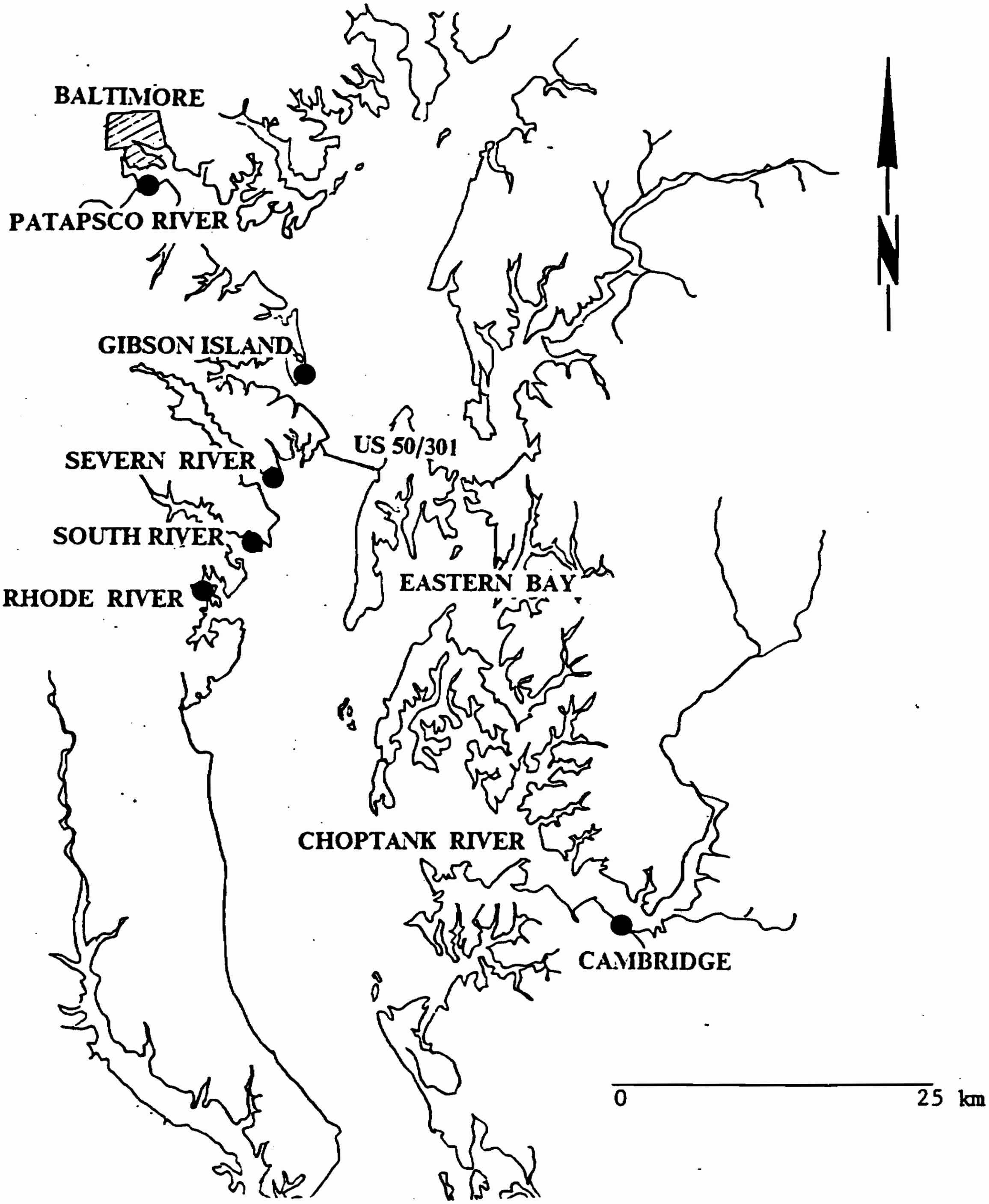


Figure 2. Canvasback trapping sites in Chesapeake Bay, Maryland, 1988-89.

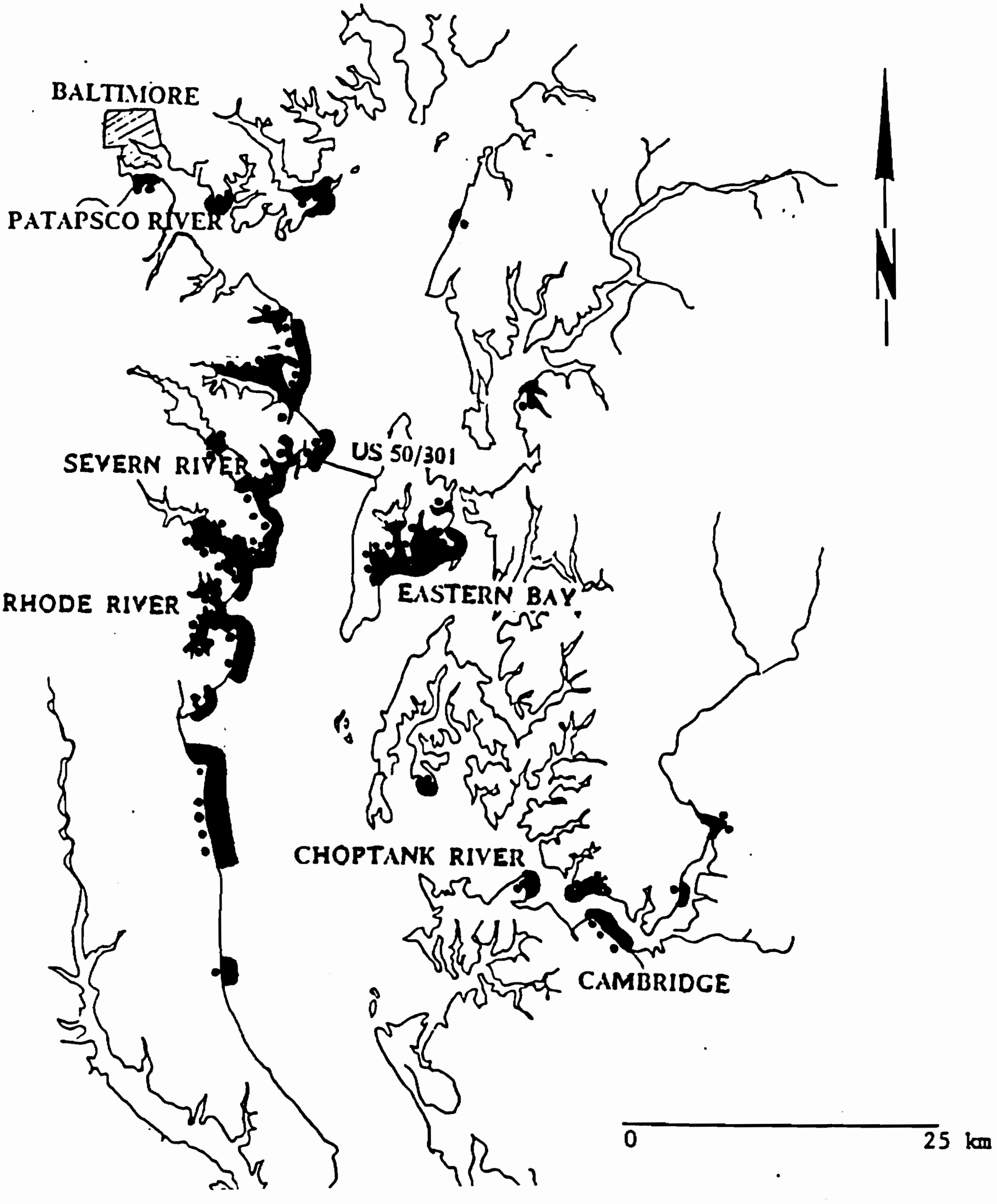


Figure 3. Location of stops and diurnal habitat availability of each route, Chesapeake Bay, Maryland, 1988-89.

or not artificial feeding took place at the location were recorded. Diurnal locations were once a day and 1-6 times per week. Because the null peak system was used only to determine the presence of radioed canvasbacks in a flock, accuracy of the system was not calculated.

Habitat Classification

Habitat classification could not be based on the National Wetland Inventory (NWI) scheme developed by Cowardin et al. (1979) because water is classified only as "open water" (E1OWL). Therefore, it became apparent in the beginning of the study that a habitat classification design would have to be developed.

Biological and physical features of the shoreline and open water were inventoried to describe habitats used by canvasbacks wintering in the upper Chesapeake Bay. Features selected for the macrohabitat scheme were salinity, shoreline land use, substrate, density of baltic clams (*Macoma balthica*), density of dwarf surf clams (*Mulinia lateralis*), water depth, artificial feeding locations, and hunting blind locations (Table 1). Submerged aquatic vegetation was not chosen because food habit studies (Stewart 1962, Rawls 1978, and Perry and Uhler 1988), for the portion of the Bay in this study, reported little to no use by canvasbacks.

Salinity regimes were mapped according to Stewart (1962) (Appendix C). Land use of the shoreline was obtained from 1985 land use maps (Maryland Office of State Planning) and ≃ 70% was field checked. Substrate types were obtained from maps compiled by the Maryland Geological Survey (Appendix D). Abundance intervals of *Macoma* and *Mulinia* were based on density frequencies for each species (Appendices E & F). Data for each clam species was obtained and mapped in cooperation with Dr. A. Fred Holland and Anna T. Shaughnessy of Versar, Inc., Columbia, MD (Shaughnessy et al. 1990). Water depth was obtained from nautical navigation

Table 1. Habitat classification features for canvasback winter habitat, Chesapeake Bay, Maryland, 1988-89.

Salinity	Slightly Brackish Estuarine Bays (4-8 ppt) Brackish Estuarine Bays (9-14 ppt) Salt Estuarine Bays (> 15 ppt) Impoundments (0-3 ppt)
Shoreline Land Use	Low Density Residential (.08-.81 dwelling unit/ha) Medium Density Residential (> .81-3.2 dwelling unit/ha) High Density Residential (> 3.2 dwelling unit/ha) Open Urban Land Industrial Forest Agriculture Wetlands
Substrate	Sand-Silt-Clay Sands Clays Silts
Macoma balthica (Baltic clam)	0-49 / sq m 50-200 / sq m > 200 / sq m
Mulinia lateralis (Dwarf surf clam)	0-49 / sq m 50-200 / sq m > 200 / sq m
Water Depth	0-2 m 2-4 m 4-6 m > 6 m
Artificial Feeding Sites	Point Locations
Hunting Blind Locations	Point Locations

charts of the study area. Artificial feeding locations were identified by general observation and inquiry (Appendix G). Hunting blind locations were recorded during the summer of 1988 and ground-truthed during the winter of 1988-89 (Appendix H).

Data Processing

Canvasback locations, habitat classification features, and random points were digitized using Arc-Info Mapping Software (Environmental Systems Research Institute, Inc., Redlands CA.). At each stop along the 2 routes where radioed canvasbacks were located a single point defining the center of all daytime locations for that stop was assigned a unique Universal Transverse Mercator (UTM) coordinate (rounded to the nearest 50) used in determining habitat use. All daytime locations recorded at each stop were assigned the unique UTM coordinate of that stop unless a radio-marked canvasback was located in an adjacent creek or around a point of land, in which case it was assigned a separate location. Since habitat categories were broadly defined, using the technique of assigning a single location (the center of a raft that may have spanned 400 m) to describe habitat used, likely did not bias the results.

Habitat availability was defined as water habitat within 1 mile (telemetry ground range) of all stops along the 2 routes (Figure 3). In addition, habitat composition of all water areas of the study area was determined for comparison. Habitat characteristics were determined for canvasback locations and random points using Arc-Info. Random points were used to estimate availability of habitat features (Marcum and Loftsgarden 1980). Random points were determined using a FORTRAN random number generator program.

This study was designed as a spatial rather than a behavioral investigation. Therefore, I chose the term *habitat use* rather than *habitat selection* because the term *habitat use* indicates "the actual distribution of individuals," whereas *habitat selection* implies that organisms "consciously choose among alternative habitats" (Hutto 1985). This distinction does not, however, eliminate the possibility that mechanisms that govern habitat selection might be responsible for differences between habitat use and availability.

Daytime and geographical habitat use versus availability was examined. Daytime was defined as all locations recorded in the study area between sunrise and sunset. All available habitat of each stop defined daytime habitat availability. A line was drawn down the center portion of the main Bay. Daytime locations to the west of the line were defined as western shore locations and locations to the east of the line were eastern shore locations. Available habitat of stops to the west of the line defined western shore habitat availability and available habitat of stops to the east of the line defined eastern shore habitat availability.

Chi-square tests were used to determine if differences ($P < 0.05$) occurred between use and availability of habitats and whether use of habitats by juvenile female canvasbacks differed geographically. A nonmapping technique described by Marcum and Loftsgarden (1980) was used to test for disproportionate use of habitat types. Use versus availability was not examined for shoreline land use because land use associated with each random point could not be estimated accurately.

RESULTS

Eighty percent (70 of 87) of the implanted canvasbacks were located 1919 times inside the study area in 1988-89. The remaining canvasbacks either died (ie. predation, shot), had radio failure, or left the study area. An average of 86% (range 80-95) of the radioed canvasbacks known to be in the study area each week were located with the route survey method (Appendix I).

Daytime Habitat Use

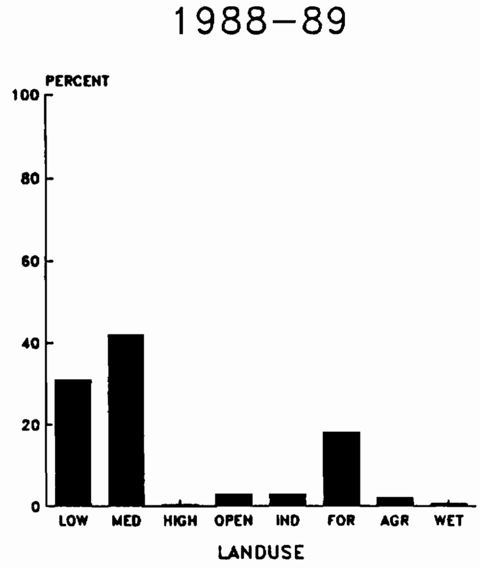
Canvasbacks used the 0-2 m water depth, 0-49 *Macoma*/m^2, 0-49 *Mulinia*/m^2, slightly brackish estuarine bays, impoundments, and sand substrate more ($P < 0.05$) than expected and used all other *Macoma* densities and water depths, sand-silt-clay and clay substrates, salt estuarine bays, and > 200 *Mulinia*/m^2 less ($P < 0.05$) than expected (Table 2). All other habitats were used in proportion to availability.

Canvasbacks were associated most often (43% of locations) with medium residential development and low residential development (34% of locations)(Figure 4).

Table 2. Daily habitat use by juvenile female canvasbacks and availability in the Chesapeake Bay, MD, 1988-89.

Habitat	Level	1988-89 % use[a]			%avail(1)[b]	% avail(2)[c]
Macoma (#/m^2)	0-49	95	+[d]	+[e]	73	79
	50-200	2	-	-	19	12
	> 200	3	-	-	8	9
Mulinia (#/m^2)	0-49	26	+	+	4	6
	50-200	0		-	0	3
	> 200	74	-	-	96	91
Water Depth (m)	0-2	87	+	+	49	21
	2-4	9	-	-	27	17
	4-6	4	-	-	16	19
	> 6	0	-	-	8	43
Salinity	SEB[f]	5	-	-	20	29
	BEB[f]	70		+	72	55
	SBEB[f]	12	+	-	7	16
	IMP[f]	13	+	+	1	0
Sediment	S-S-C[g]	0	-	-	8	4
	Sand	96	+	+	73	35
	Clay	3	-	-	18	54
	Silt	1		-	1	7

[a] Based on 1919 radio locations of 70 birds.
[b] Availability within 1 mile of all stops on route.
[c] Availability within the entire the study area.
[d] A "+" indicates more ($P < 0.05$) use and a "-" indicates less ($P < 0.05$) use than expected based on availability 1.
[e] A "+" indicates more ($P < 0.05$) use and a "-" indicates less ($P < 0.05$) use than expected based on availability 2.
[f] Salt Estuarine Bays, Brackish Estuarine Bays, Slightly Brackish Estuarine Bays, Impoundments
[g] Sand-Silt-Clay



Low Density Residential (.08-.81 dwelling unit/ha)
Medium Density Residential (> .81-3.2 dwelling unit/ha)
High Density Residential (> 3.2 dwelling unit/ha)
Open Urban Land
Industrial
Forest
Agriculture
Wetlands

Figure 4. Land-use use associated with juvenile female canvasback locations, Chesapeake Bay, MD, 1988-89.

Geographic Habitat Use

Juvenile female canvasbacks on both shores used the 0-2 m water depth, 0-49 *Macoma*/m^2, and sand substrates more ($P < 0.05$) than expected and used 50-200 *Macoma*/m^2, all other water depths, and sand-silt-clay and clay substrates less ($P < 0.05$) than expected (Tables 3 & 4). In addition, canvasbacks on the eastern shore used slightly brackish estuarine bays more ($P < 0.05$) than expected and brackish estuarine bays less ($P < 0.05$) than expected. Western shore canvasbacks used 0-49 *Mulinia*/m^2, brackish estuarine bays, and impoundments more ($P < 0.05$) than expected and the > 200/m^2 *Macoma* and *Mulinia* density intervals and salt estuarine bays less ($P < 0.05$) than expected. All other habitats were used in proportion to availability.

Daytime use of water depths, salinity type, *Macoma* and *Mulinia* densities, and substrate types differed between shores ($X^2 = 28.83$, df$=2$, $P < 0.001$; $X^2 = 150.39$, df$=3$, $P < 0.001$; $X^2 = 66.09$, df$=2$, $P < 0.001$; $X^2 = 229.07$, df$=1$, $P < 0.001$; $X^2 = 91.84$, df$=2$, $P < 0.001$, respectively; Figure 5). Although canvasbacks on both sides of the bay used 0-2 m of water $> 80\%$ of the time, those on the east shore used 2-4 m of water more and 0-2 m and 4-6 m water depths less than those on the west shore. Brackish estuarine bays were used $> 65\%$ of the time by canvasbacks on both sides of the bay; however, canvasbacks on the west shore used all other salinity types, whereas, slightly brackish estuarine bays were the other salinity type used by canvasbacks on the east shore. Canvasbacks on both shores used the 0-49 *Macoma*/m^2 density interval over 90% of the time; however, canvasbacks on the east shore also used the 50-200 *Macoma*/m^2 density interval, whereas, > 200 *Macoma*/m^2 was the other density interval used by west shore birds. Canvasbacks on the east shore used the > 200 *Mulinia*/m^2 density interval almost exclusively, whereas canvasbacks on the west shore used the 0-49 and > 200 *Mulinia*/m^2 density intervals. Canvasbacks on the east shore used the sand, clay, and silt substrates, while canvasbacks on the west shore used the sand substrate almost exclusively.

Canvasbacks on the east shore used low residential development and to a lesser extent medium residential development, whereas canvasbacks on the west shore used medium residential

Table 3. East shore habitat use by juvenile female canvasbacks and availability in the Chesapeake Bay, MD, 1988-89.

Habitat	Level	% use[a]			% avail(1)[b]	% avail(2)[c]
Macoma (#/m²)	0-49	94	+[d]	+[e]	68	89
	50-200	6	-		32	9
	> 200	0		-	0	2
Mulinia (#/m²)	0-49	1		-	1	2
	50-200	0		-	0	6
	> 200	99		+	99	92
Water Depth (m)	0-2	85	+	+	53	25
	2-4	13	-	-	28	19
	4-6	2	-	-	13	16
	> 6	0	-	-	6	40
Salinity	SEB[f]	0		-	0	22
	BEB[f]	80	-	+	95	70
	SBEB[f]	19	+	+	4	8
	IMP[f]	1			1	0
Sediment	S-S-C[g]	0	-	-	3	2
	Sand	72	+	+	52	47
	Clay	18	-	-	40	38
	Silt	10			5	13

[a] Based on 503 radio locations of 27 birds.
[b] Availability within 1 mile of all stops on route on the eastern half of the study area.
[c] Availability within the entire eastern half of the study area.
[d] A "+" indicates more ($P < 0.05$) use and a "-" indicates less ($P < 0.05$) use than expected based on availability 1.
[e] A "+" indicated more ($P < 0.05$) use and a "-" indicates less ($P < 0.05$) sue than expected based on availability 2.
[f] Salt Estuarine Bays, Brackish Estuarine Bays, Slightly Brackish Estuarine Bays, Impoundments
[g] Sand-Silt-Clay

Table 4. West shore habitat use by juvenile female canvasbacks and availability in the Chesapeake Bay, MD, 1988-89.

Habitat	Level	% use [a]	% avail(1) [b]	% avail(2) [c]
Macoma ($\#/m^2$)	0-49	95 + [d] + [e]	74	64
	50-200	1 - -	14	17
	> 200	4 - -	12	19
Mulinia ($\#/m^2$)	0-49	35 + +	6	11
	50-200	0	0	0
	> 200	65 - -	94	89
Water Depth (m)	0-2	88 + +	48	17
	2-4	7 - -	26	12
	4-6	5 - -	17	23
	> 6	0 - -	9	48
Salinity	SEB [f]	6 - -	29	41
	BEB [f]	67 + +	62	31
	SBEB [f]	10 -	8	27
	IMP [f]	17 + +	1	0
Sediment	S-S-C [g]	0 - -	9	7
	Sand	98 + +	71	21
	Clay	2 - -	19	72
	Silt	0	1	1

[a] Based on 1416 radio locations of 59 birds.

[b] Availability within 1 mile of all stops on route in the western half on the study area.

[c] Availability within the entire western half of the study area.

[d] A "+" indicates more ($P < 0.05$) use and a "-" indicates less ($P < 0.05$) use than expected based on availability 1.

[e] A "+" indicates more ($P < 0.05$) use and a "-" indicates less ($P < 0.05$) use than expected based on availability 2.

[f] Salt Estuarine Bays, Brackish Estuarine Bays, Slightly Brackish Estuarine Bays, Impoundments

[g] Sand-Silt-Clay

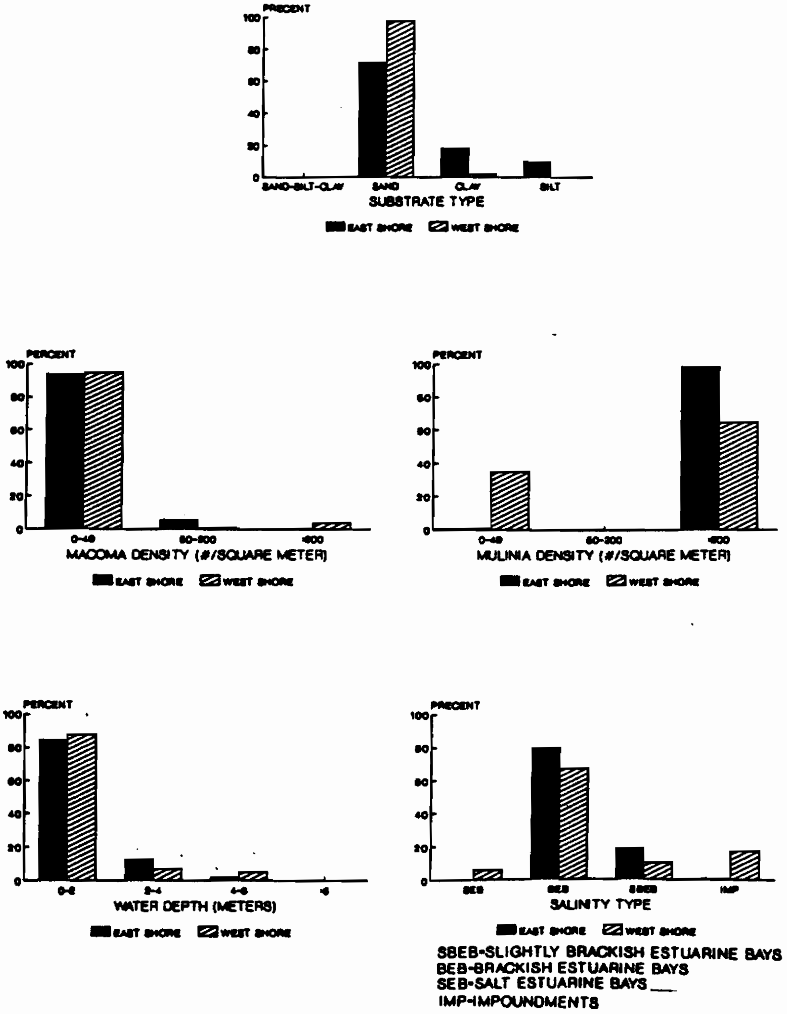


Figure 5. Comparison between east and west shore daytime habitat use of juvenile female canvasbacks, Chesapeake Bay, MD, 1988-89: based on 27 birds (n = 503) for east shore and 59 birds (n = 1416) for west shore.

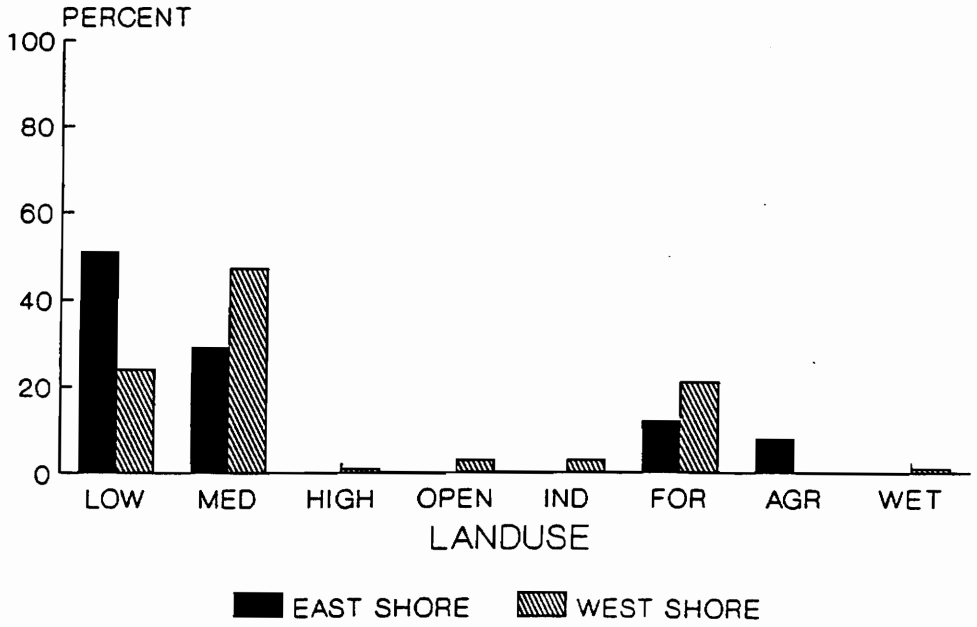
development more and low residential development less ($X^2 = 294.82$, df = 7, $P < 0.001$)(Figure 6). This may merely be a function of the amount of development on each shore of the Bay.

DISCUSSION

Daytime Habitat Use

During daylight hours, canvasbacks usually were found in shallow water, close to shore, and in lightly disturbed areas. Canvasbacks were found near residential areas *only* where artificial feeding was common. Where artificial feeding was not common, canvasbacks used habitats that provided a resting area. These areas had forested shorelines and little, if any, boat traffic. Areas where artificial feeding was common were essentially refuges; low in disturbance with minimal or no hunting. Some impoundments also provided suitable daytime habitats. However, canvasbacks sometimes rested near busy places in the Bay as long as they were not disturbed on the water.

Canvasbacks wintering on the Chesapeake Bay abandoned areas where disturbance was common and appeared to prefer habitats that were free of disturbance. Jahn and Hunt (1964) stated that the best habitats are seldom used by waterfowl if disturbance is excessive, and Nilsson (1972) reported that wintering waterfowl in Sweden occurred in habitats that lacked excessive disturbance. Tuite et al. (1983) concluded that recreational boating limited the carrying capacity of a reservoir



Low Density Residential (.08-.81 dwelling unit/ha)
Medium Density Residential (> .81-3.2 dwelling unit/ha)
High Density Residential (> 3.2 dwelling unit/ha)
Open Urban Land
Industrial
Forest
Agriculture
Wetlands

Figure 6. **Geographic land-use association for juvenile female canvasback locations, Chesapeake Bay, MD, 1988-89.**

in South Wales for wintering waterfowl. Reichholf (1976) and Henry (1980) documented similar effects in Germany and California, respectivley.

Brackish estuarine bays were the principal salinity type used by wintering canvasbacks. During the study, 70% of the canvasback locations occurred in this salinity type. Stewart (1962) found that 69% of the canvasbacks wintering on the Chesapeake Bay from 1955-58 occurred on brackish estuarine bays. Thus, after 30 years this pattern of habitat use is still evident in the Bay. The presence of *Macoma*, the canvasback's primary food (Stewart 1962, Rawls 1978, Perry and Uhler 1988), in this area (Holland et al. 1988) in part accounts for the distribution of canvasbacks observed.

Although used proportionately less than their availability, salt estuarine bays and their associated *Mulinia* populations were an important wintering habitat for canvasbacks on the Chesapeake Bay. Cold weather during the winter months of 1987-88 resulted in ice cover in the upper bay. Canvasbacks shifted southward in the Bay to the salt estuarine areas where open water was present. Although these areas are low in *Macoma* abundance, *Mulinia* populations are high. Earlier, Stewart (1962) reported that during the severe winter of 1958-59 canvasbacks in the Chesapeake Bay occurred in greater proportions on salt estuarine bays. In addition, food habits reported by Stewart (1962) also showed a decreased use of *Macoma* in these areas. Likewise, Olney (1968) reported that pochards (*Aythya ferina*) in Great Britain were not often found on brackish or salt-water areas except when temporarily displaced by freezing weather or disturbance.

One apparent difference in canvasback distributions between the 1950's and 1980's is the discontinued use of fresh estuarine bays of the upper Chesapeake. Stewart (1962) reported that 92% of the canvasbacks on the Chesapeake Bay in November 1958 were on the fresh estuarine sections of the Bay but in the current study, no canvasbacks were found on the fresh estuarine sections of the Bay. The decline of wild celery (*Vallisneria americana*) in these areas is probably responsible for the lack of canvasbacks in this habitat.

The proportionately high use of the sand substrate is likely related to artificial feeding. Sand substrates generally are found in shallow water areas near shore (data from this study).

Canvasbacks may use these areas to take advantage of artificial feeding by humans and/or lack of disturbance and not necessarily because the bottom is sand.

Geographic Habitat Use

Canvasbacks on the Chesapeake Bay moved from one side of the Bay to the other; however, habitat use was generally the same on both sides. Canvasbacks on both shores primarily slept during the day (Howerter 1990) in shallow water, close to shore, and near artificial feeding sites. Where artificial feeding was not common, canvasbacks on both shores occurred in habitats that were free of disturbance; these included wetlands, coves with forested shorelines, and industrial areas. Waterfowl use industrial areas as long as they are not disturbed (Nilsson 1972).

Canvasbacks affiliated with the Chesapeake Bay appeared to be one wintering population, but differences in hunting pressure, density of humans, and food resources between the east and west shores may have resulted in some dissimilar use of habitats. Hunting was widespread on the east side of the Bay (Appendix H) where waterfowl concentrations were high, residential development low, and artificial feeding was uncommon. In addition, *Macoma* populations were lower on the east side of the Bay (Holland, unpubl. data). In apparent response to these conditions, canvasbacks on the east side of the Bay used brackish estuarine bays with high densities of *Macoma* for daytime feeding. Nichols and Haramis (1980b) noted that canvasbacks trapped on the east side of the Bay during the late 1970's weighed less than birds trapped on the west shore of the Bay. If these conditions still hold true, canvasbacks associated with the east side of the Bay may feed more during the day than west shore birds to maintain body weight. Although some interchange between the shores was recorded during this study, different body weights between the two shores would suggest separate populations exist within the Bay.

Because food appears more abundant on the west side of the Bay (high *Macoma* populations and corn provided by local residents), canvasbacks may not feed much on *Macoma* during the day and therefore are not associated with brackish estuarine bays, but rather all salinity types. Salt estuarine bays, slightly brackish estuarine bays, and impoundments used by west shore canvasbacks provided an artificial food source and rest areas. These areas usually were close to high *Macoma* populations of brackish estuarine bays that canvasbacks utilized at night. Because canvasbacks left impoundments at night apparently for the security of open water and to feed on *Macoma* located in the main Bay, impoundments within $\simeq$ 1 mile of the main Bay were most frequently used.

Human access to impoundments on the upper eastern shore was difficult and inefficient, thus our sampling may have failed to detect use of this habitat. However, when waterfowl season closed, landowners began to feed corn to Canada geese to "hold" them on their ponds (Dierker, landowner, pers. commun.). Canvasbacks apparently responded to this new food source and disturbance-free habitat by using these impoundments.

Canvasbacks on both shores occurred most often near residential development. This was most likely due to the food and sanctuary that these areas provided. This does not necessarily support the hypothesis that artificial feeding and development are beneficial to canvasbacks; it only emphasizes the need for sanctuaries and natural foods.

Although the entire study area could not be monitored for radioed canvasbacks from the ground, it was still considered available for comparison to availability within the area sampled (Tables 2, 3 & 4). I believed this was valid because a high proportion ($\bar{x} = 86\%$, Appendix I) of the canvasbacks known to be on the study area each week (from Patuxent Wildlife Research Center aerial tracking) were located in the limited ground monitoring area. In addition, flight data from this study and other agencies (MDFPWS and USFWS) have failed to report canvasbacks during the day in most areas I could not sample. The habitat use in relation to availability results were basically the same whether the sampled area or the entire bay was considered available; however, some differences were noted. These differences were the result of a failure to record as available habitats > 1 mile from shore and a bias of estimating available habitats only where I detected birds. I believe that the canvasbacks that I detected from the ground are likely representative of the population. Therefore, the results reported using the entire study area as available may accurately represent habitat use.

CHAPTER 2: NIGHTTIME HABITAT USE

METHODS

Trapping procedures and habitat classification were as described in Chapter 1.

Telemetry System

The transmitter implants (Telonics Inc., Mesa, AZ) operated at 164-165 megahertz, had a body temperature mortality switch and weighed approximately 20 g (≃ 2% of body weight). Each had an estimated aerial range of 3-7 miles from aircraft at 1,000 ft. Transmitters were of visceral implant design with a coiled antenna.

Radio tagged canvasbacks were monitored from 30 December 1988 through 28 March 1989. Nocturnal locations were obtained using scanning receivers and fixed-winged aircraft (Cessna 172) with directional H antennas mounted under each wing. Flights were once each week and commenced ≃ one hour after sunset. Flights were started at a random point along a shoreline flight pattern that surveyed the entire study area. Two observers attempted to locate a maximum of 50 birds each flight. Temperature and wind speed and direction were recorded prior to takeoff. Locations were determined by homing in (Mech 1983) and plotted on 1:24,000 composite USGS topographic-National Wetlands Inventory maps. Nocturnal feeding activity was assumed if periodic loss of the signal from diving behavior occurred. Accuracy of the aerial system was tested by having a person place radios at different locations and a separate person locate them from the plane. Error was expressed as the average linear difference (m) between the calculated and known coordinates of the radio transmitters (Lee et al. 1985). Error was between 50 m and 600 m ($n = 3$, $\bar{x} = 300$ m).

Data Processing

Canvasback locations, habitat classification features, and random points were digitized using Arc-Info Mapping Software (Environmental Systems Research Institute, Inc., Redlands CA.). Habitat characteristics were determined for canvasback locations and random points using Arc-Info. Random points were used to estimate availability of habitat features (Marcum and Loftsgarden 1980). Random points were determined using a FORTRAN random number generator program. All water habitats in the study area were monitored and considered available.

All locations recorded from nocturnal aerial surveys were used to examine nighttime habitat use versus availability. To determine geographical habitat use versus availability, the study area was divided into east and west sides by a line drawn down the center portion of the main Bay.

All nocturnal locations and habitats considered available were examined for each side of the study area.

Chi-square tests were used to determine if differences ($P < 0.05$) occurred between use and availability of habitats and whether use of habitats by juvenile female canvasbacks differed geographically. A nonmapping technique described by Marcum and Loftsgarden (1980) was used to test for disproportionate use of habitat types.

RESULTS

Seventy-seven percent (67 of 87) of the implanted canvasbacks were located 392 times at night inside the study area in 1988-89. The remaining canvasbacks either died (ie. predation, shot), had radio failure, or left the study area. Canvasbacks outside the study area were not followed. An average of 36 birds/flight (range 12-48) were located during 11 flights.

Nightly Habitat Use

Canvasbacks used the 2-4 m and 4-6m water depths, brackish estuarine bays, 50-200 and >200 *Macoma*/m^2 density intervals, $>$ 200 *Mulinia*/m^2, and sand substrates more ($P < 0.05$) than expected (Figure 7). All other *Macoma* and *Mulinia* densities, salt estuarine and slightly brackish estuarine bays, >6 m water depth, and sand-silt-clay and silt substrates were used less ($P < 0.05$) than expected. The remaining habitats were used in proportion to availability.

Geographic Habitat Use

Juvenile female canvasbacks on both shores used the 2-4 m water depth, brackish estuarine bays, 50-200 *Macoma*/m^2, and >200 *Mulinia*/m^2 more ($P < 0.05$) than expected (Figures 8 & 9). In addition, canvasbacks on the western shore used 4-6 m of water, >200 *Macoma*/m^2, and sand substrates more ($P < 0.05$) than expected. The >6 m water depth, salt estuarine bays, and 0-49 *Macoma*/m^2 were used less ($P < 0.05$) than expected on both shores. On the west shore, slightly brackish estuarine bays, 0-49 *Mulinia*/m^2, and sand-silt-clay substrates were used less ($P < 0.05$) than expected, while 50-200 *Mulinia*/m^2 were used less ($P < 0.05$) than expected on the east shore. All other water depths, salinity types, *Mulinia* densities, and substrates were used as expected ($P > 0.05$).

Nighttime use of water depths, salinity types, *Macoma* densities and substrate types differed between shores ($X^2 = 55.85$, $df = 3$, $P < 0.001$; $X^2 = 14.30$, $df = 2$, $P < 0.001$; $X^2 = 117.65$, $df = 2$, $P < 0.001$; $X^2 = 13.14$, $df = 3$, $P = 0.004$, respectively; Figure 10). Use of *Mulinia* did not differ between shores ($X^2 = 1.71$, $df = 1$, $P = 0.191$). Canvasbacks on the east shore were in 0-4 m of water > 70% of the time, whereas, canvasbacks on the west shore were in 2-6 m of water > 75% of the time. Brackish estuarine bays were used over 80% of the time on both shores; however, east shore birds also used slightly brackish estuarine bays while west shore birds used salt estuarine bays. Canvasbacks on the east shore used 0-49 and 50-200/m^2 densities of *Macoma* 100% of the time, whereas west shore birds mostly used 50-200 and >200/m^2 densities of *Macoma*. Canvasbacks on the east shore mainly used the sand, clay, and silt substrates while birds on the west shore used sand

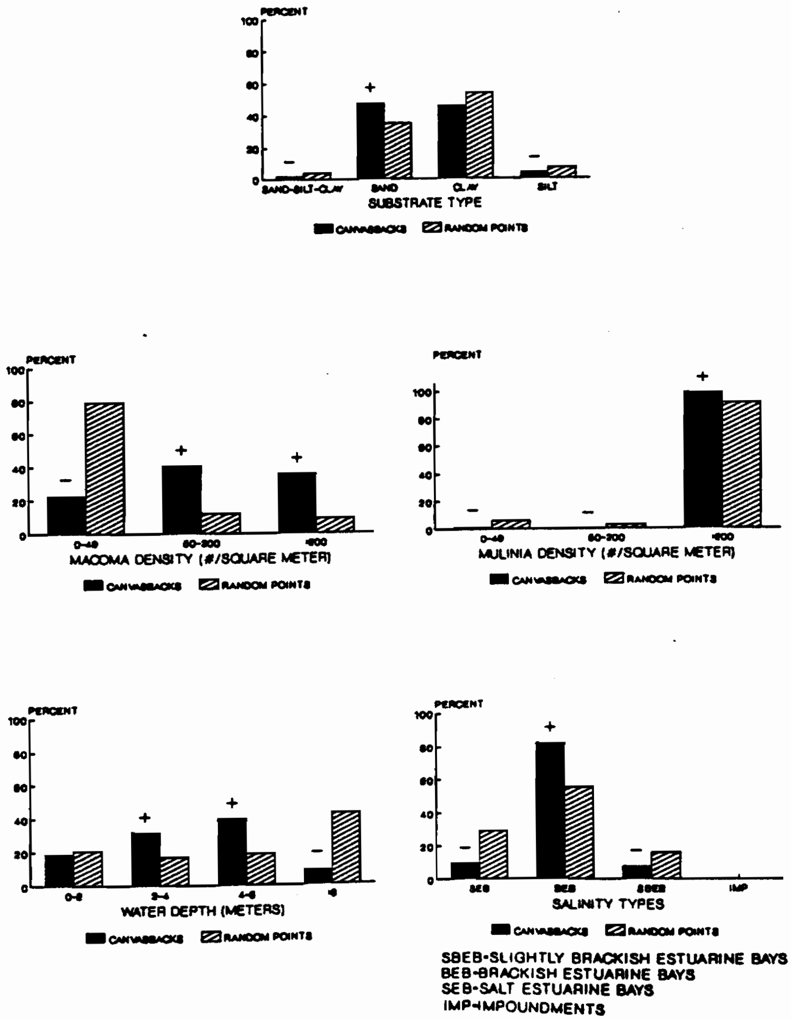


Figure 7. Night habitat use by juvenile female canvasbacks and availability in the Chesapeake Bay, Md, 1988-89: a "+" indicates more ($P < 0.05$) use than expected and a "-" indicates less ($p < 0.05$) use than expected; 67 birds ($n = 392$).

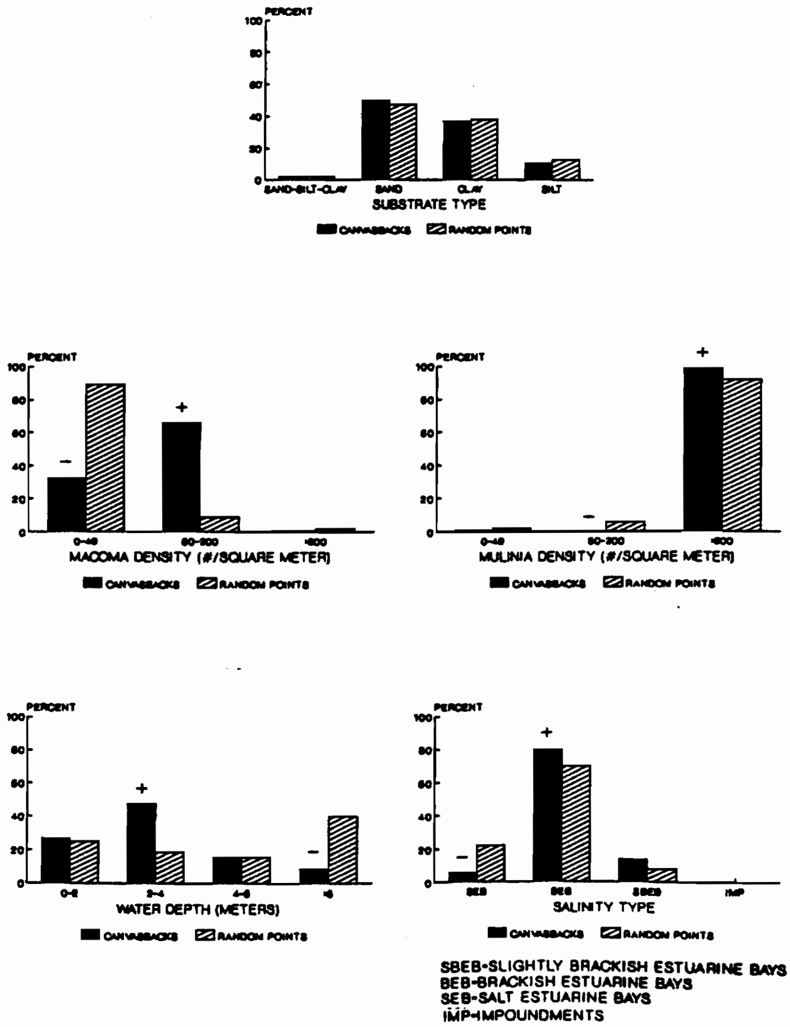


Figure 8. East shore nocturnal habitat use by juvenile female canvasbacks and availability in the Chesapeake Bay, MD, 1988-89: a "+" indicates more ($p < 0.05$) use than expected and a "-" indicates less ($p < 0.05$) use than expected; 30 birds ($n = 145$).

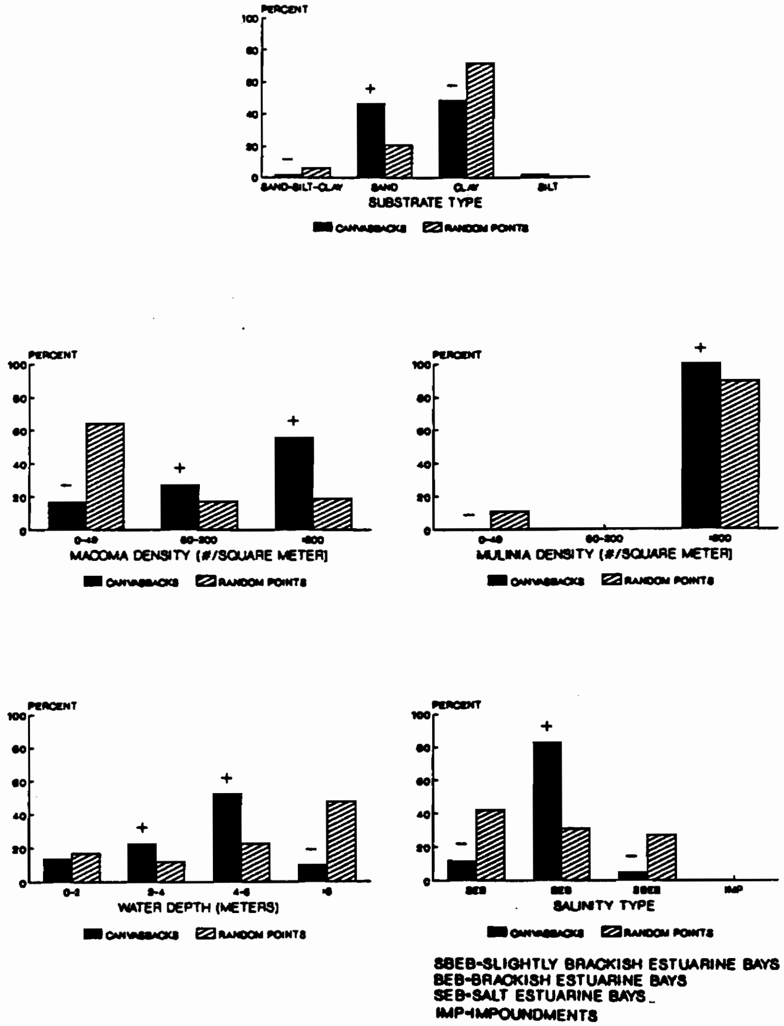


Figure 9. West shore nocturnal habitat use by juvenile female canvasbacks and avialability in the Cheapeake Bay, MD, 1988-89: a "+" indicates more ($p < 0.05$) use than expected and a "-" indicates less ($p < 0.05$) use than expected; 49 birds ($n = 247$).

and clay substrates over 90% of the time. Canvasbacks on both shores used the > 200 *Mulinia*/m^2 $> 98\%$ of the time.

DISCUSSION

Nightly Habitat Use

At night, juvenile female canvasbacks in this study preferred water depths from 2-6 meters, depths that support the highest *Macoma* populations (Holland, unpubl. data), sand substrates, and brackish estuarine bays. *Macoma* has high fidelity for sandy-mud (Clay substrates, particles < 0.002 mm, are sometimes referred to as "mud" (Brady 1984).) and muddy substrates and brackish water (Tenore 1972, Chambers and Milne 1975, Holland et al. 1977, Nilsson 1980, Holland 1985, Holland et al. 1987); however, in the Chesapeake Bay summer anoxia tends to limit *Macoma* to the sandy-mud substrates and not deep water mud substrates (Holland 1985). Therefore, it seems as though nocturnal distributions of canvasbacks were related to the overall distribution of *Macoma*. Thornburg (1973) also reported that distributions of diving ducks on the Mississippi River were associated with the greatest abundance of benthic organisms used for food.

During the winter of 1988-89, night use of clay and sand substrates was similar. As previously noted, sand substrates are associated with high *Macoma* populations. Because *Macoma* usually is

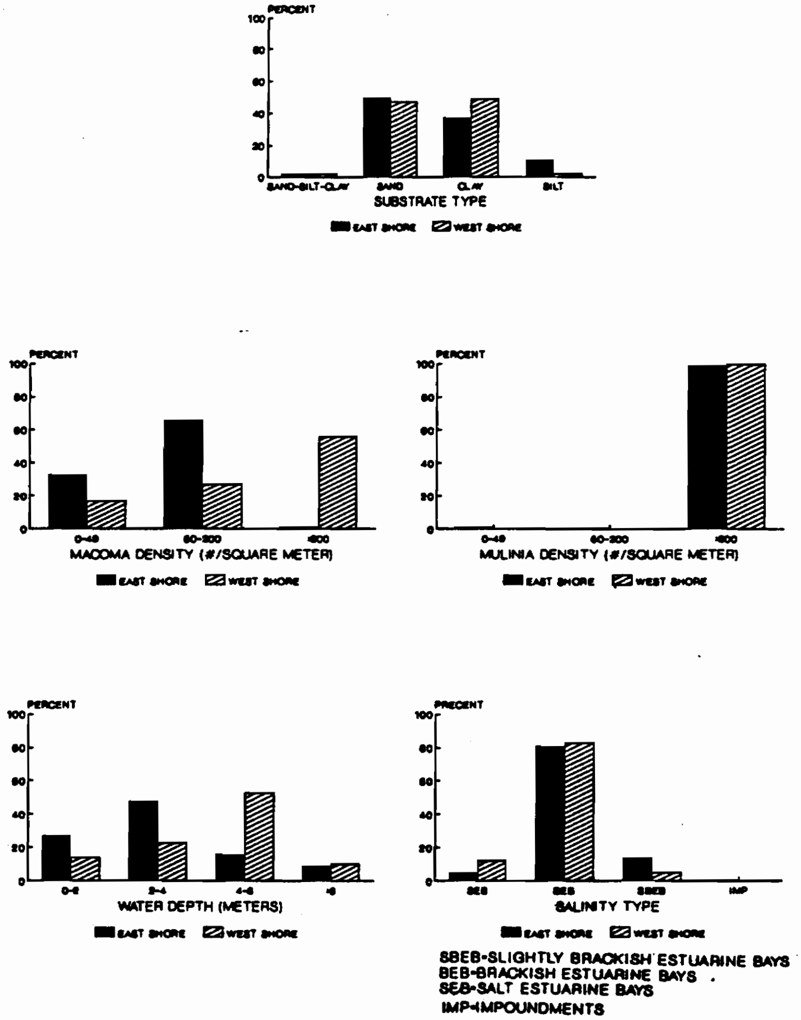


Figure 10. East and west shore nighttime habitat use by juvenile female canvasbacks, Chesapeake Bay, MD, 1988-89: based on 30 birds (n = 145) for east shore and 49 bird (n = 247) for west shore.

not found in clay substrates in the Chesapeake Bay, canvasbacks using this substrate likely are not feeding. Takekawa (1987) reported that canvasbacks on Lake Onalaska in Wisconsin rested, swam, and fed more at night. Nilsson (1970) speculated that tufted ducks (*Aythya fuligula*) did not need the whole night for food-seeking. Therefore, canvasbacks on the Chesapeake Bay associated with the clay substrates likely were resting or involved in some other nonfeeding activity. Clay substrates are the furthest from shore in areas that offered security of the open water and minimal disturbance. In addition, clay substrates usually were situated next to the sandy-mud substrates where *Macoma* is found (Holland 1985).

The high use of >200 *Mulinia*/m^2 may result from the clam's distribution. *Mulinia* is a opportunistic species that occupies almost all substrates, begins appearing in 3 m of water, and is abundant (>200/m^2) at 6 m and beyond (Holland 1985). Because canvasbacks apparently occur in these same water depths to feed on *Macoma* populations and *Mulinia* is common throughout the Bay, the high use of >200 *Mulinia*/m^2 was not unusual. Since *Macoma* abundance is low in salt estuarine bays, *Mulinia* may be an important food source to canvasbacks forced to occupy this habitat during icy weather.

Geographic Habitat Use

Geographic nocturnal habitat use by juvenile female canvasbacks apparently was related to *Macoma* density and distribution. Canvasbacks on both shores often were found in brackish estuarine bays with sand and clay substrates. These are areas that usually produce abundant populations of *Macoma.*

Macoma populations are lower in abundance on the east shore of the Bay than on the west shore (Holland, unpubl. data). Thus, canvasbacks on the east shore most often occurred in the 50-200/m^2 density interval, whereas canvasbacks on the west shore were found most often in the

$>200/m^2$ density interval. Apparently, at night canvasbacks utilized the highest abundance of *Macoma* available to them on their wintering grounds. If this is true, then the factor(s) that limit *Macoma* production in the Bay and further limit it on the eastern shore could influence the size of the wintering population of canvasbacks.

Because *Macoma* populations are not abundant on the east side of the Bay, high use of the >200 *Mulinia*/m^2 density interval suggests that *Mulinia* may be an important food item for canvasbacks there. Stewart (1962) earlier reported that *Mulinia* composed 17% of the total diet for canvasbacks on the eastern shore of the Bay. Conversely, because *Macoma* is abundant on the west side of the Bay, *Mulinia* probably is not an important food item to canvasbacks there. Perry and Uhler (1988) found very little use of *Mulinia* by canvasbacks on the western shore of the Bay. *Mulinia* became significant when canvasbacks were forced by ice cover to feed in salt estuarine bays where *Macoma* was not abundant.

Day versus Night Habitat Use

Perry (1975) reported that at dusk canvasbacks resting on the Chesapeake Bay leave protected coves where food is available (but no feeding observed) and fly to areas in the Bay farther from shore. He believed that the coves did not offer the security of the open water. Haramis (pers. commun.) speculated that canvasbacks fly to open water at dusk to feed. Both of these opinions may be supported by our results.

During the day canvasbacks were found close (< 100 m) to shore in coves and creeks located up rivers away from the main Bay or in impoundments located within $\simeq$ 1 mile of the main Bay. These birds were resting and ate *mainly* when fed by humans (Howerter 1990). During our nighttime aerial telemetry surveys, at least 40% of the telemetered ducks located were feeding (Howerter 1990). Canvasbacks returned to daytime resting areas at dawn. Nilsson (1969, 1970,

1972) reported that pochards, tufted ducks, and scaups (*Aythya marila*) in Sweden all made regular feeding flights to sea from inland waters and ponds and returned to daytime locations at dawn. Draulans (1985) reported pochards in Belgium left daytime roosting ponds, which have a rich freshwater mussel supply, to forage on nearby channels at night.

Daytime use areas on the Chesapeake Bay may be energetically beneficial because they provide some food (i.e. artificial feeding) and shelter, are free of disturbance, and are situated close to nocturnal feeding locations. Nilsson (1972) reported that because pochards, tufted ducks, and scaup rested during the day, they selected areas providing shelter from the weather. Bain (1980) hypothesized that canvasbacks at Long Point, Lake Erie used inland waters because they may be less demanding from an energetics viewpoint than the open water habitat.

The size and abundance of *Macoma* appears to determine nocturnal habitats used by canvasbacks wintering on the Chesapeake Bay. Perry and Uhler (1988) concluded that the maximum size of brackish water clams (*Rangia cuneata*) eaten by canvasbacks was 25 mm. Draulans (1987) reported that pochards and tufted ducks selected mussels between 0-15 mm and 7.5-27.5 mm, respectively. The maximum length of *Mytilus* used by long-tailed ducks (*Clangula hyemalis*) and tufted ducks was 20 mm and 25 mm, respectively (Madsen 1954). However, *Macoma* size ranged from 28-33 mm at a primary daytime location for canvasbacks wintering on the Chesapeake Bay (Cory and Redding 1977) and therefore may be too large for canvasbacks to digest.

Several studies (McErlean 1964, Chambers and Milne 1975, Holland et al. 1987) have indicated that shell sizes of *Macoma* decrease in the down-river direction. Canvasbacks may fly to the main Bay and mouths of rivers to utilize the smaller *Macoma* found there. In addition, larger *Macoma* tend to bury deeper into the substrate (Chambers and Milne 1975, Reading and McGorty 1978) and thus are not as available to canvasbacks as smaller size *Macoma* at the same water depth.

Nystrom and Pehrsson (1987) believed that diving ducks feeding on mussels would tend to select small mussels due to their low salt content. They believed that the high salt content in large mussels was selected against because of the energy needed to excrete excess salts.

Draulans (1987) stated that pochards could discriminate between mussels of less than 2.5 mm difference in length and that they increased selectivity, always selecting the smallest size class, with increasing prey density. In the Chesapeake Bay, as *Macoma* abundance increased in deeper water, size decreased (Holland et al. 1988). Holland et al. (1988) noted that smaller *Macoma* are especially abundant in 4-8 m of water due to high recruitment following summer anoxia. Canvasbacks apparently use these water depths due to the high populations of the appropiate size *Macoma* found there. Buxton (1981) determined that the distribution of shelducks (*Tadorna tadorna*) in Aberdeenshire was related to the overall distribution of the main prey *Hydrobia* and that areas with the most dense prey were the favored sites.

CHAPTER 3: MANAGEMENT IMPLICATIONS

The North American Waterfowl Management Plan (NAWMP) calls for protection of 50,000 additional acres of wetlands on the east coast of the United States. A problem with this plan and other plans of the past is that they are aimed at protecting areas, such as wetlands and bottomlands, that rarely are used by diving duck species. While these areas do need protection, large-scale management plans should go one step further to protect and restore habitats that are critical to the declining diving duck populations.

On the Chesapeake Bay, canvasbacks are affiliated with open water and the associated benthic resources. Historically, canvasbacks of the Chesapeake Bay fed on lush submerged aquatic vegetation (SAV), particularity wild celery. As winter progressed, they shifted to *Macoma* populations (Lovvorn 1989). However, the lush beds of SAV are no longer widespread in the Bay (Orth and Moore 1984). Therefore, canvasbacks now subsist primarily on *Macoma* and corn that landowners provide (Perry and Uhler 1988).

Water quality in the Chesapeake Bay has declined severely (Officer et al. 1984). As a result, the SAV has declined (MDFPWS SAV Surveys 1971-1989, unpubl. data) and *Macoma* populations also are showing a decline (Holland unpubl. data). Waterfowl management plans for the

Chesapeake Bay region should address water quality in addition to wetlands protection. As water quality is improved, species of SAV and other benthic organisms favorable to canvasbacks and other waterfowl likely will respond in a positive manner.

Although canvasbacks presently are not harvested legally in the Bay, my study indicated that canvasbacks may alter the habitats used in response to hunting. Refuges that provide rest areas and appropriate food resources need to be developed. Currently, areas where people feed canvasbacks and undisturbed locations are the only habitats that serve as refuges. A refuge for canvasbacks should be in the brackish estuarine section of the Bay and be made up of protected shallow water areas for resting and deeper waters that have abundant populations of *Macoma* < 25 mm for feeding. In addition, an area in the salt estuarine portion of the Bay with abundant *Mulinia* populations should be protected for icy periods. Both of these areas should restrict boating and hunting to minimize disturbance. The areas that canvasbacks currently are using during the day could be protected for resting locations, and better water quality in the Bay would improve *Macoma* populations that could be utilized at night for feeding. Providing natural food resources and adequate resting areas for canvasbacks on the Chesapeake Bay will help insure their use of the Bay.

CHAPTER 4: SUMMARY AND CONCLUSIONS

Daytime habitat use by juvenile female canvasbacks was in areas that are free of disturbance, close to shore, away from hunting activity, and have an abundant *Macoma* population nearby. Nighttime habitats were generally away from shore and in water 2-6 m deep that had abundant populations of small (< 25 mm) *Macoma.* At dusk, canvasbacks made flights to nocturnal habitats to feed and returned to diurnal resting habitats at dawn. Salt estuarine bays and their associated *Mulinia* populations may be important diurnal and nocturnal habitat to canvasbacks during icy periods.

Juvenile female canvsbacks on both sides of the Bay used habitats during the day that permit resting. Canvasbacks on both shores moved offshore at night apparently to feed on *Macoma* and for the security of open water. Because *Macoma* populations are poorer on the east side of the Bay, canvasbacks affiliated with the east side of the Bay may have fed more during the day and were in lower *Macoma* densities at night than west shore canvasbacks.

Further research is needed to determine the effects of artificial feeding and disturbance on canvasback populations of the Chesapeake Bay. Management of Chesapeake Bay canvasback populations must focus on increasing natural foods and protection of resting areas.

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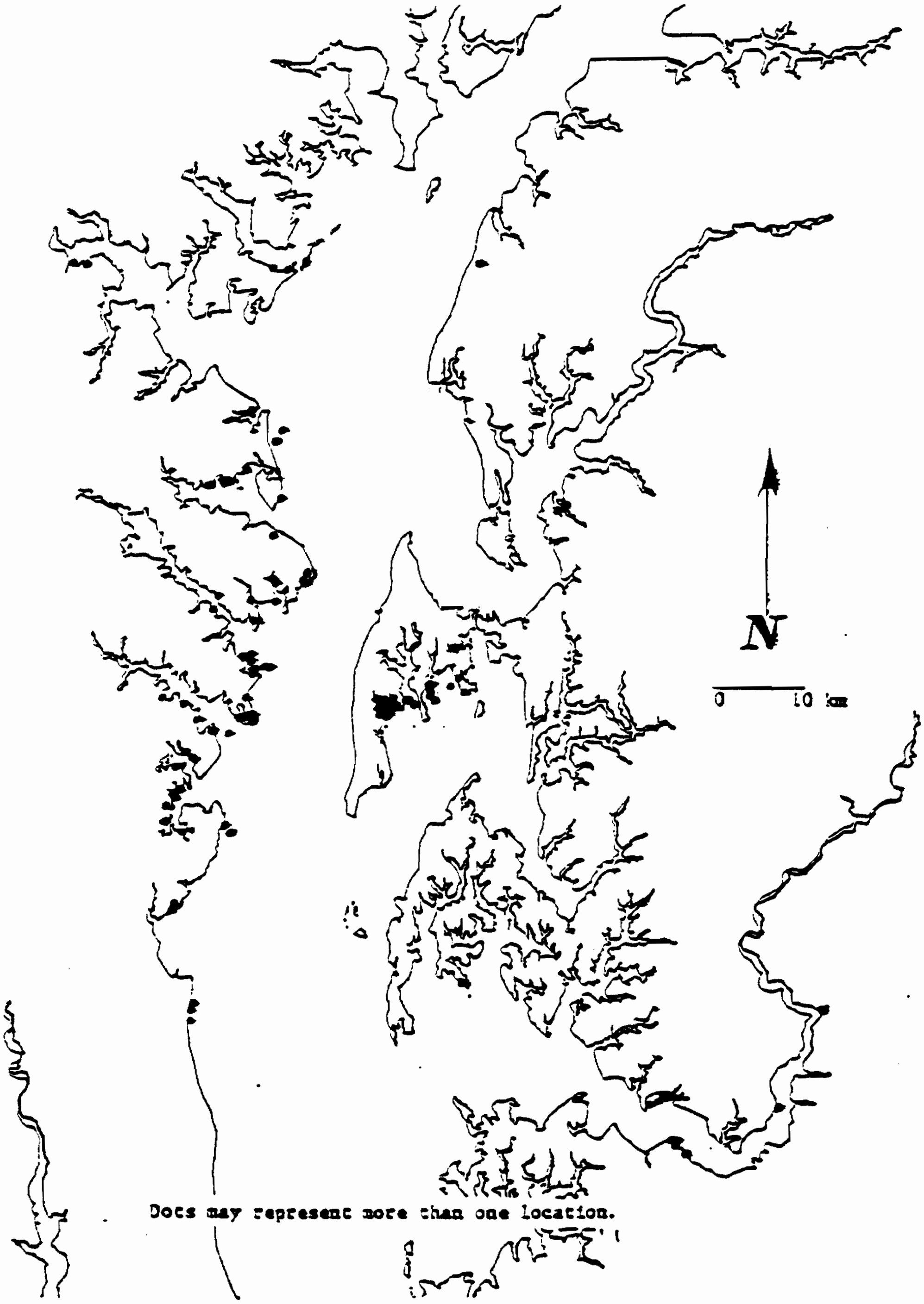
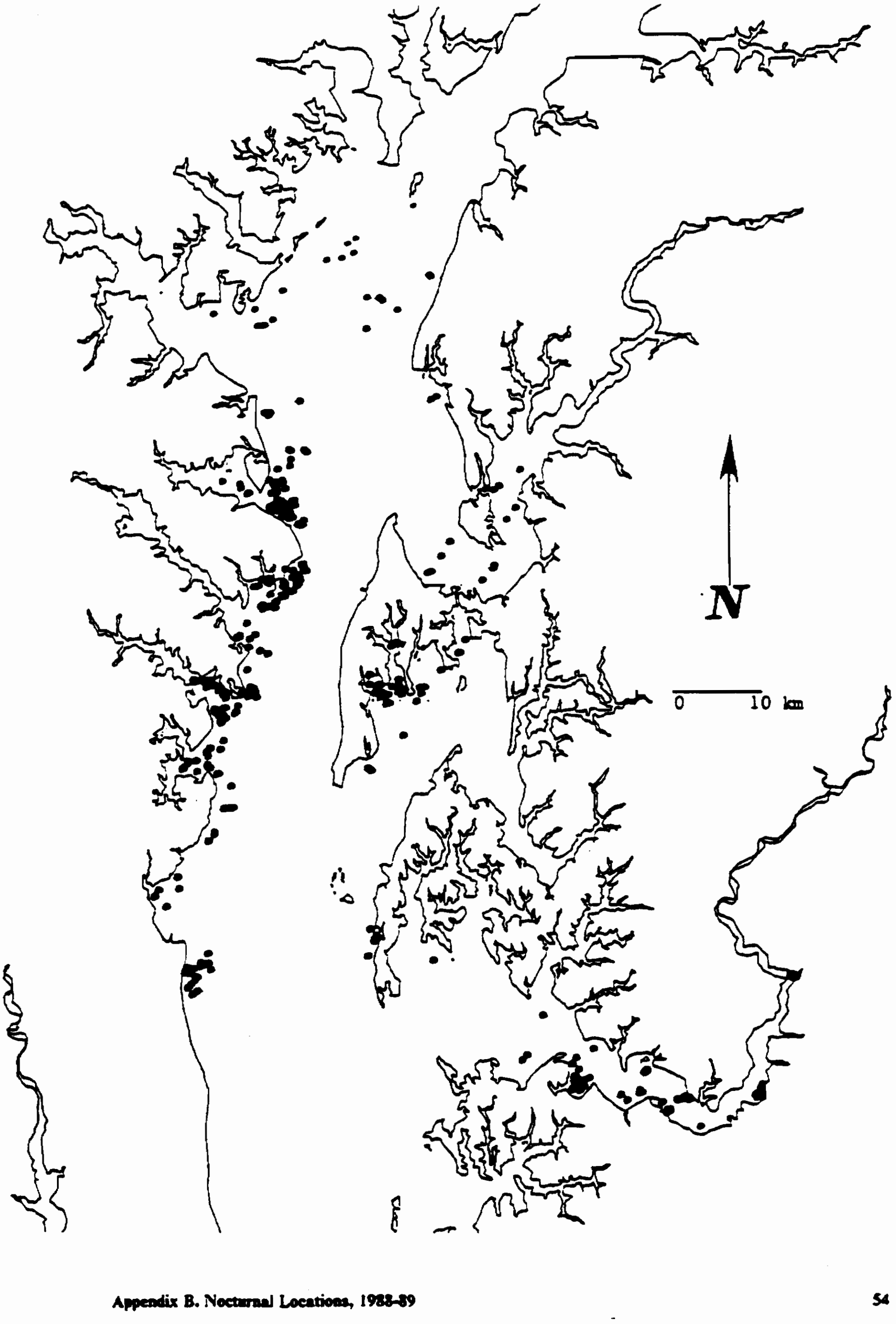
Appendix A. Diurnal Locations, 1988-89



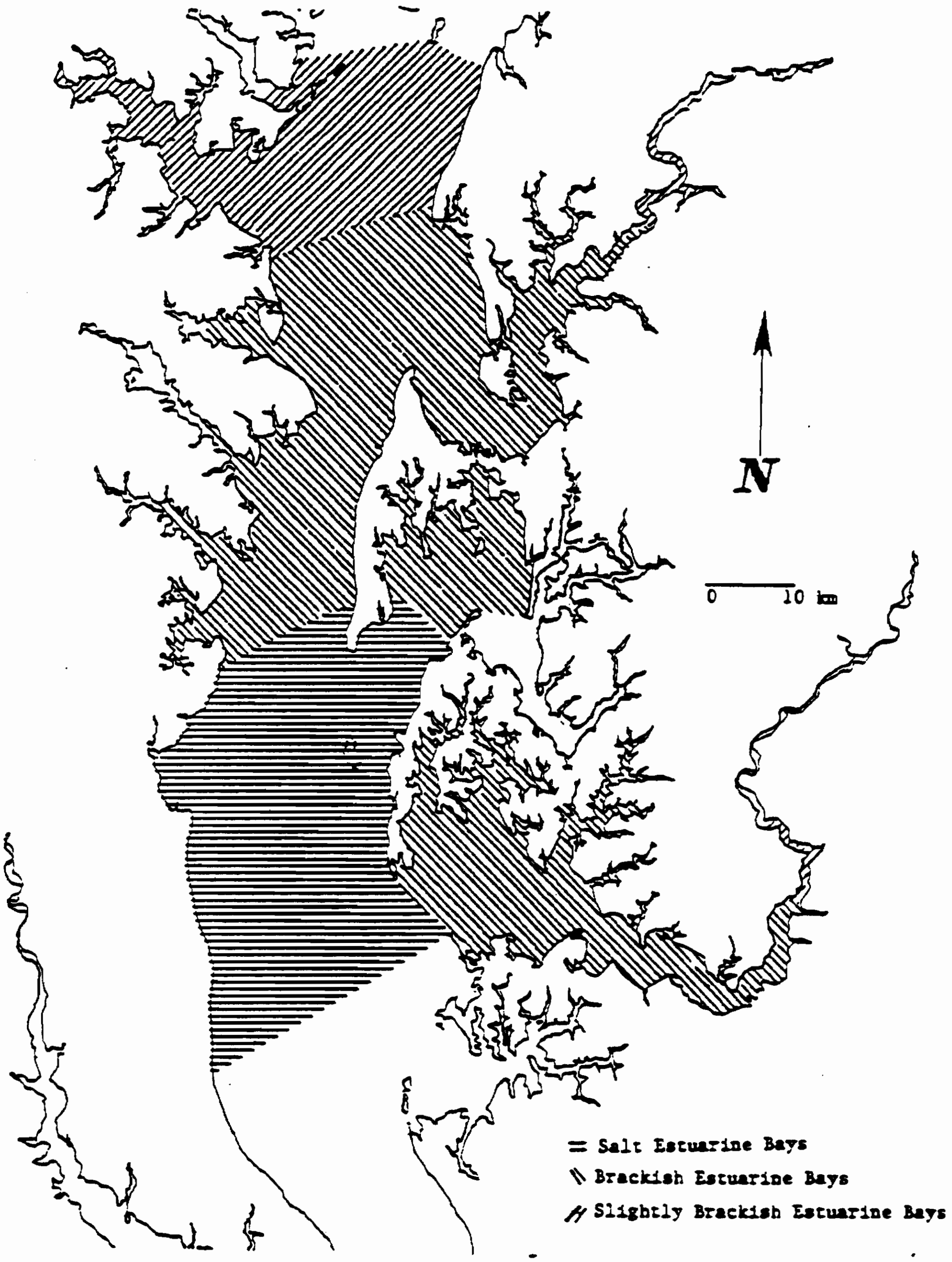
Dots may represent more than one location.

Appendix B. Nocturnal Locations, 1988-89

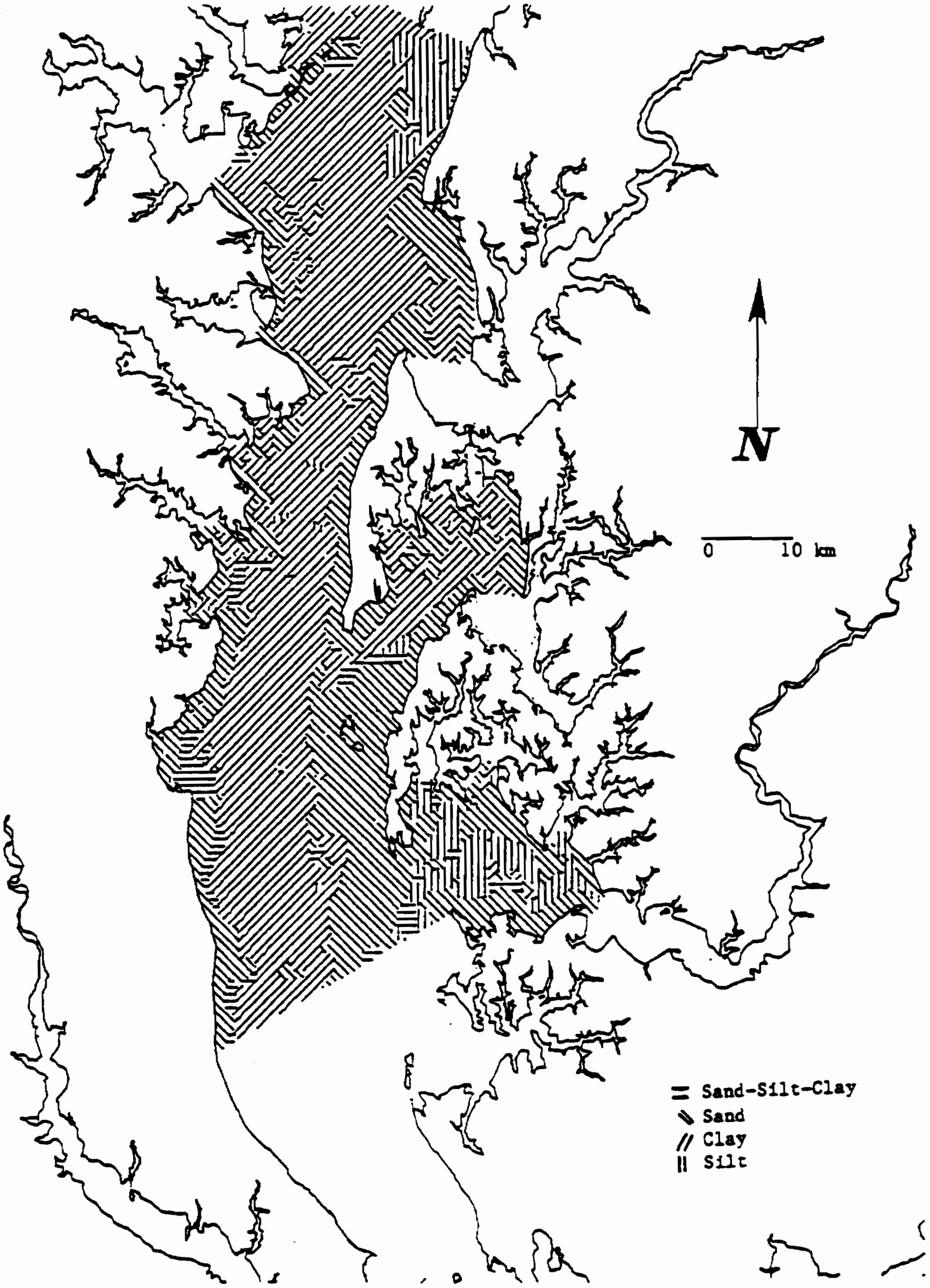


Appendix B. Nocturnal Locations, 1988-89

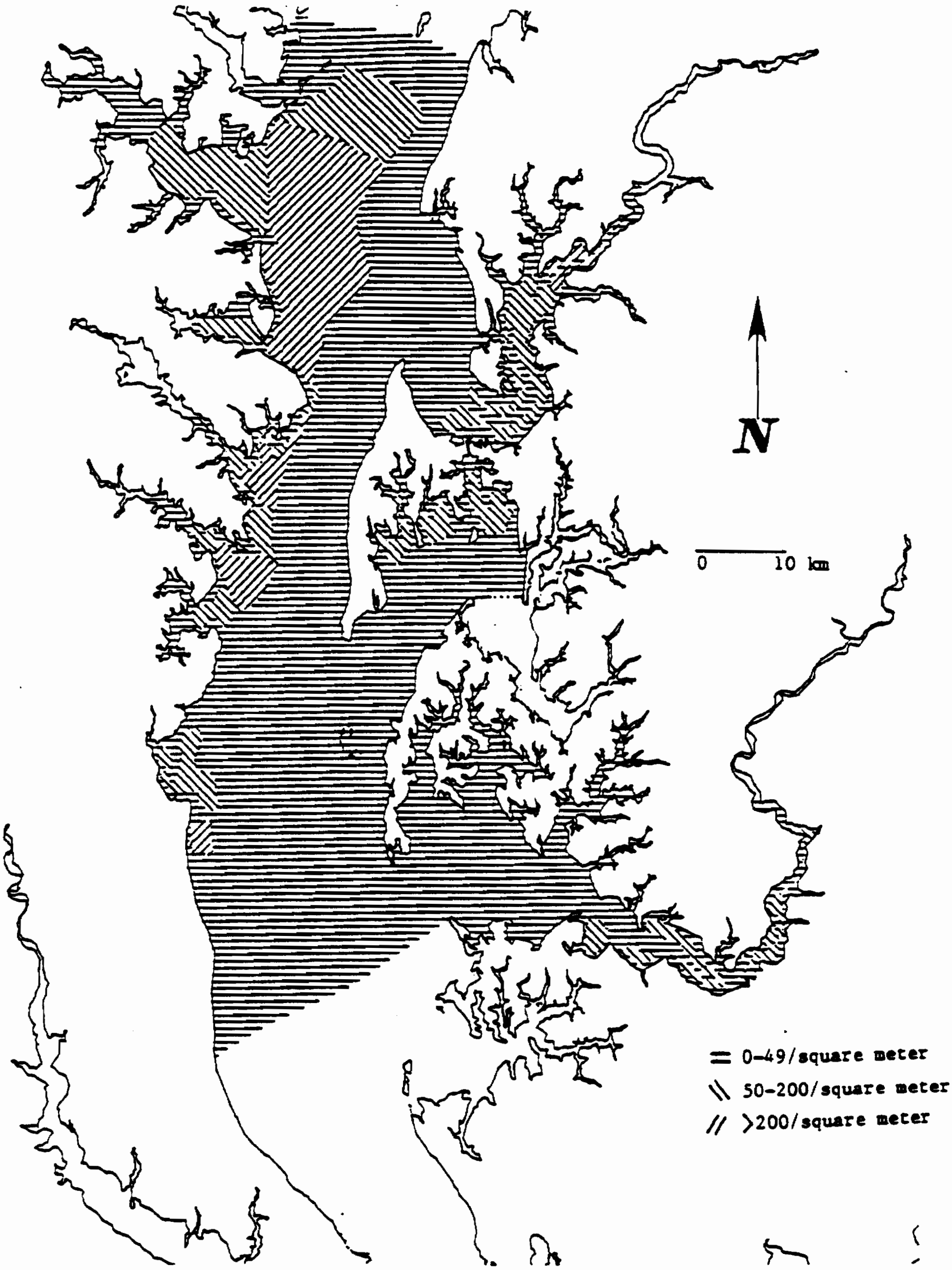
Appendix C. Salinity Distribution


N
0 10 km
= Salt Estuarine Bays
\\ Brackish Estuarine Bays
// Slightly Brackish Estuarine Bays

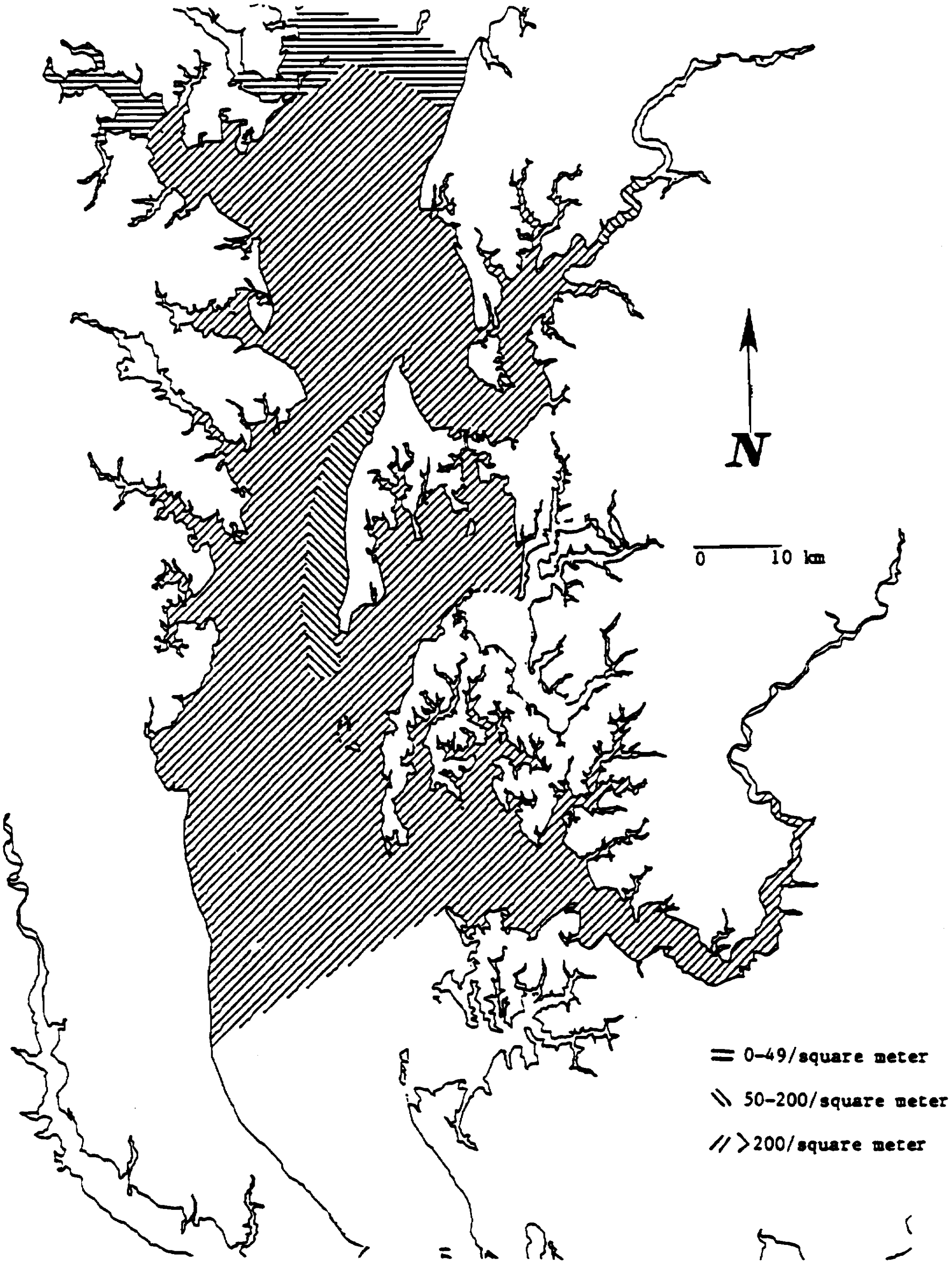
Appendix D. Sediment Distribution


N
0 10 km
= Sand-Silt-Clay
\ Sand
// Clay
|| Silt

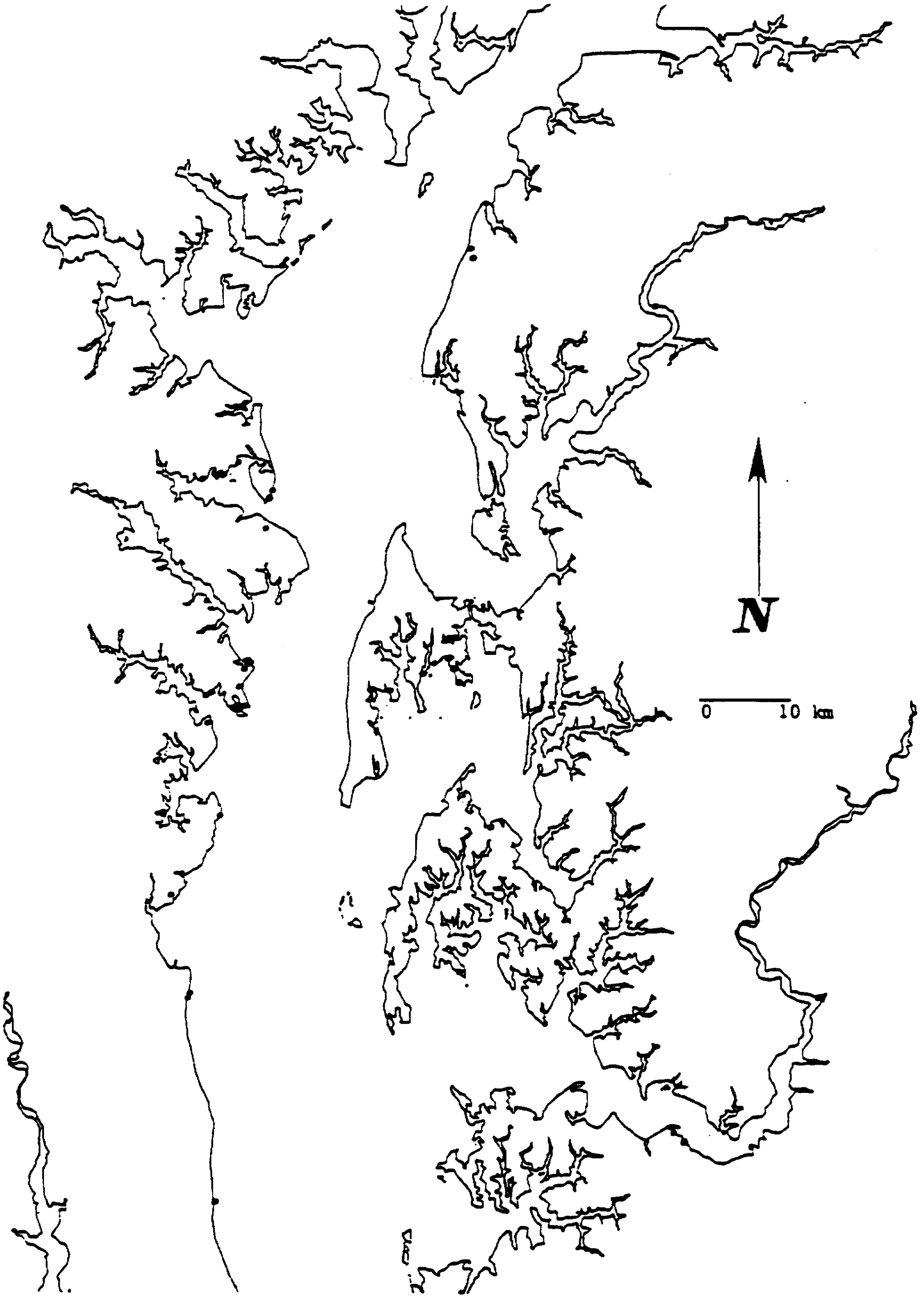
Appendix E. Macoma balthica Distribution


N
0 10 km
= 0–49/square meter
\\ 50–200/square meter
// >200/square meter

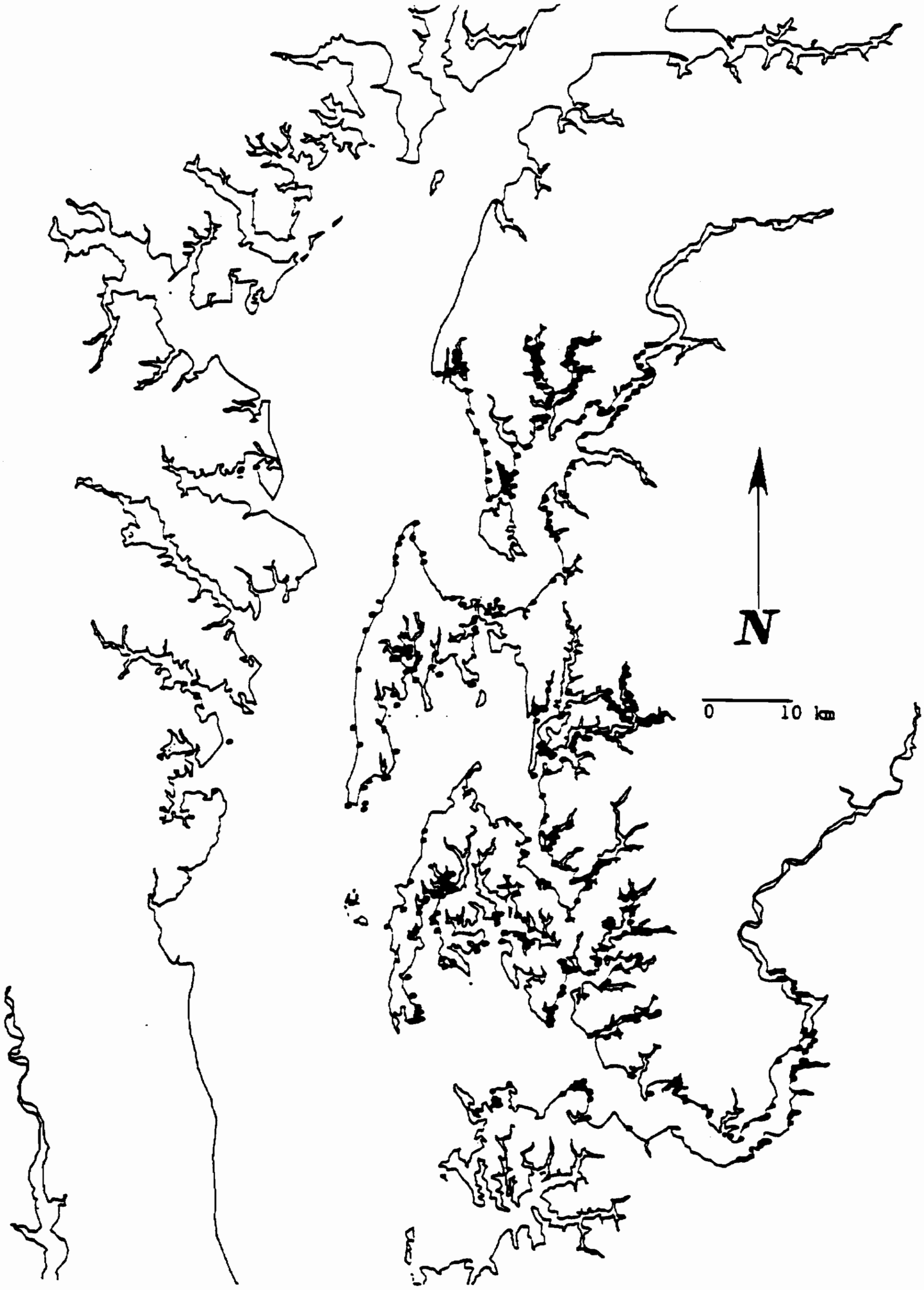
Appendix F. Mulinia lateralis Distribution


N
0 10 km
= 0-49/square meter
\\ 50-200/square meter
// >200/square meter

Appendix G. Artificial Feeding Sites


N
0
10 km

Appendix H. Hunting Blind Locations



Appendix H. Hunting Blind Locations

Appendix I. Number of Canvasbacks Located/Week

Appendix I Number of canvasbacks located each week, Chesapeake Bay, Maryland, 1988-89.

Week	No. Located	No. in Study Area[a]	% Located
1	59	68	87
2	54	65	83
3	58	66	88
4	55	67	82
5	55	64	86
6	60	65	92
7	56	63	89
8	53	63	84
9	56	63	89
10	51	64	80
11	49	61	80
12	40	42	95
Mean	54	63	86

[a] Data from Patuxent Wildlife Research Center aerial tracking.

VITA

Walter E. Rhodes III was born on January 22, 1965 in Baltimore, Maryland. Walt grew up on the Eastern Shore of Maryland in the town of Chester. During his youth, he could be found catching Chesapeake Bay crabs, running a trapline for muskrats, or hunting Canada geese. It was these years of growing up on the Chesapeake Bay that stimulated Walt to pursue a career in wildlife. He graduated from Queen Annes County High School, located in Centreville, MD, in 1983. After one year of school at Anne Arundel County Community College, Walt transferred to Virginia Tech and received his Bachelors Degree in Forestry and Wildlife Sciences in 1987. In the Fall of 1987, Walt became a candidate for a Masters Degree in the School of Forestry and Wildlife Resources at Virginia Tech. Walt's studied habitat use by juvenile female canvasbacks wintering on the upper Chesapeake Bay.

During the summers from 1984 through 1988, Walt worked as a summmer technician in the Waterfowl Program for the Maryland Forest, Park and Wildlife Service. His primary duty was to conduct surveys monitoring the populations of submerged aquatic vegetation (SAV) in the Chesapeake Bay. In addition, he worked on other projects such as examining the relationships between waterfowl and SAV in the Chesapeake Bay, studying the migration and wintering distribution of Canada geese banded in Maryland, and analyzing the effects of hunting pressure on

Canada geese. Walt is currently employed as Alligator Project Supervisor for the South Carolina Wildlife and Marine Resources Department.