USE OF WESTERN LAKE ERIE BY MIGRATORY AND WINTERING WATERFOWL

Thesis for the Degree of M. S.

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LANNY WARNER REED

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ABSTRACT

USE OF WESTERN LAKE ERIE BY MIGRATORY
AND WINTERING WATERFOWL

By

Lanny Warner Reed

Waterfowl distribution, abundance, and activity along the western shore of Lake Erie was studied as a preoperational evaluation of the environment to be affected by a large steam electric station that is being constructed. The study was executed in two portions: (1) an analysis of waterfowl habits during the fall and spring migrations along a ten mile stretch of shore near the steam electric station, and (2) a description of the seasonal and daily activity of wintering mallards (Anas platyrhynchos) and black ducks (Anas rubripes) on the ice-free areas of a spring near the lake and on the plume of a small electric station that operates 10 miles south of the power plant being constructed.

During the fall and spring migration the birds were counted by four techniques: (1) a fixed point observation, (2) a 23 mile boat transect, (3) a 23 mile aerial transect, and (4) a 6 point shore count. The winter waterfowl activity was monitored from land vantage points. Of the four census methods, the boat transect provided the best representation of species and numbers when weather was favorable. However, the data from the aerial transect also displayed a reasonable representation of waterfowl numbers and was not as limited by unfavorable weather.

Seven species commonly used the area during the fall and spring migrations: common merganser (Mergus merganser), lesser scaup (Aythya affinis), common goldeneye (Bucephala clangula), black duck, American

widgeon (Anas Americana), ruddy duck (Oxyura jamicensis), and mallard. The migratory birds used the area from late September to freeze-up in mid-December and from ice break-up in early March to early May. Diurnally, most of the birds used the lake during the early morning, but the mallards and blacks concentrated their use during the midday period. The distribution of the waterfowl on the area appeared to be influenced by hunting and, with the fish eating waterfowl, food availability. Dabbling ducks appeared to concentrate near marshes.

During the winter months, 6,000 to 8,000 mallards and black ducks used the ice-free water present at the power plant (minimum, 8 acres) and the spring (minimum, 2.4 acres). Mallards comprised 85 to 90 percent of the wintering birds using these areas. The birds spent the night on either the spring or the plume, but all birds spent the morning on the spring, and the late morning and afternoon feeding in corn fields. Weather influenced bird behavior, and during colder periods, the birds were more likely to spend the night on the spring and rest on the ice during the day. When warmer temperatures occurred, social display increased and more time was spent away from the spring during the afternoon.

USE OF WESTERN LAKE ERIE BY MIGRATORY AND WINTERING WATERFOWL

By

Lanny Warner Reed

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INTRODUCTION

Western Lake Erie is used by a diverse group of waterfowl. Use on the Detroit River and western Lake Erie is concentrated during the spring, fall, and winter with the average concentrations of 50,850; 114,950; and 42,280 waterfowl, respectively, over the period of 1947 to 1966 (Mikula, 1966). Waterfowl have spent the winter in the area since the advent of open water throughout the winter in the early 1930's (Hunt, 1957). Hunt (1953,1957, 1960, 1961, and 1963) studied the factors that influence the mortality of waterfowl wintering on the lower Detroit River. Winter losses varied from 100 to 10,000 ducks, or from less than 1 percent to 27 percent of the population. Lead poisoning, aspergillosis, coccidiosis, helminthic infestations, phosphorus poisoning, pneumonia, injuries, proventriculitis, and neoplasms together accounted for 30 to 50 percent of the duck losses. Oil pollution caused 9 to 33 percent of the deaths. Starvation occurred when 70 to 90 percent of the food beds become covered with ice and resulted in 37 to 56 percent of the mortality. However, there is a dearth of information on distribution and daily pattern of habitat use by migratory and wintering waterfowl on western Lake Erie.

The purpose of this study is to determine the distribution, abundance, and activity of waterfowl during the spring, fall, and winter on Lake Erie in the vicinity of Monroe, Michigan. The winter portion of the study concentrates on describing the daily and seasonal activity of the mallards and black ducks that winter on an inland sulfur spring and a heated effluent along the Lake Erie shore. The data from the study also provides a baseline of waterfowl use prior to the introduction of a heated effluent from a fossil fuel power plant at Monroe by the Detroit Edison Power Company.

PART ONE

Utilization of Western Lake Erie by Migratory and Wintering Waterfowl in the Vicinity of Monroe, Michigan

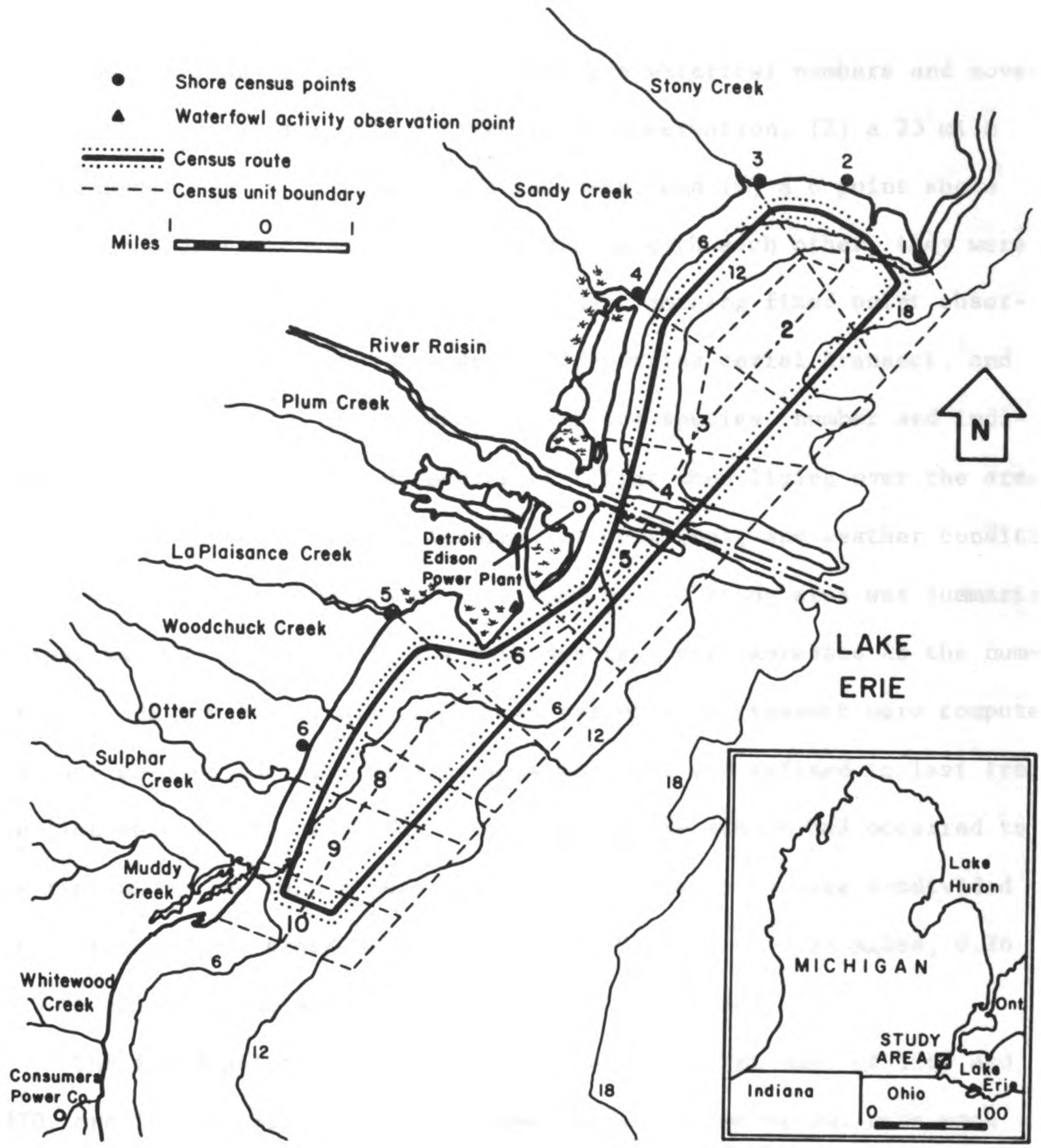
STUDY AREA

The study area is located along the western shore of Lake Erie at Monroe, Michigan (Figure 1). The area is a zone along the shore that extends 6 miles north and 4.5 miles south of the Detroit Edison Power Plant effluent channel and 1.5 to 2.75 miles from shore about 23 square miles. The study area is divided into 10 units with a shallow portion and a deep portion that are serially numbered from NE to SW. The boundaries are based on compass bearings of easily identifiable landmarks, such as creeks and land points, to facilitate the location of waterfowl on the area.

The study area is shallow with maximum depths of 19 feet in portions of units 1 and 2. The 6, 12, and 18 foot depth contours are shown in Figure 1; 33 percent of the area is less than 6 feet deep, 36 percent of the area is 6 to 12 feet deep, and 31 percent is greater than 12 feet deep (U.S. Lake Survey, 1968). The inshore areas and the large shallow portions of units 5 and 6 have a sand and gravel bottom. The remainder of the bottom is a silt-clay sludge (FWPCA, 1968). Summer Secchi disc visabilities average 18 to 36 inches. The water levels are subject to large short-period seiches. Water currents are influenced primarily by the Detroit River inflow and the prevailing winds. The prevailing winds in the spring and fall are generally south to southwest with some strong storms out of the north and northeast. The main tributary in the study area is the River Raisin which carries municipal and industrial wastes (FWPCA, 1968). Macrophytes are rare on the study area; approximately 50 percent of the shallow portion of unit 6 contains scattered sago pondweed

(Potamogeton pectinatus) beds, and 10 percent of the shallow portion of unit 1 contains soft-stem bulrush (Scirpus validus). There are no marshes contiguous with the lake, but there are diked marshes both north and south of the River Raisin. North of the river is approximately 200 acres of marsh adjacent to unit 4, south there is 600 acres of marsh adjacent to units 5 and 6.

Figure 1. The study area, western Lake Erie, in vicinity of Monroe, Michigan.


Shore census points
Waterfowl activity observation point
Census route
Census unit boundary
Miles
Stony Creek
Sandy Creek
River Raisin
Plum Creek
LaPlaisance Creek
Woodchuck Creek
Otter Creek
Sulphar Creek
Muddy Creek
Whitewood Creek
Consumers Power Co
Detroit Edison Power Plant
LAKE ERIE
N
MICHIGAN
Lake Huron
Ont
STUDY AREA
Lake Erie
Indiana
Ohio

METHODS

Four methods were employed to evaluate waterfowl numbers and movement on the study area: (1) a fixed point observation, (2) a 23 mile boat transect, (3) a 23 mile aerial transect, and (4) a 6 point shore count. To keep the counts from interferring with each other, they were completed in the following order; first day, morning fixed point observations, early morning boat transect, mid-morning aerial transect, and midday boat transect. During each census the species, number and individuals, location by unit, direction of flight when flying over the area, activity when known (resting, feeding, or courting), and weather conditions were recorded. Distribution of waterfowl on the study area was summarized by seasonal use of each unit for each species, and expressed as the number of birds per linear mile. Numbers per mile of transect were computed for each species during a migratory period that was defined to last from the time when 2 percent of the total use for the season had occurred to the time when less than 2 percent remained. The units were subdivided into three groups, based on distance from shore: 0 to 0.25 miles, 0.26 to 0.50 miles, and greater than 0.50 miles from shore.

The fixed point observation was used during the fall of 1969 and 1970, and in the spring of 1970. Observations of waterfowl were made during the first half-hour after sunrise from the mouth of the power company's discharge channel at the juncture of units 5 and 6 (Figure 1). This was done twice each week on consecutive days, in the fall of 1969 and spring 1970, and once each week in the fall of 1970. The primary objectives of the technique were to quantify waterfowl activity and measure waterfowl movement per unit time over the study area. In the fall of 1969, counts were also made during the hour prior to sunset.

The second method employed a 23 mile boat transect on the lake. The waterfowl species were identified and counted on each side of the boat as a prescribed census route was followed (Figure 1). Birds that flushed and did not leave the study area were noted and not recounted. The route was always completed in the same counterclockwise direction at an average speed of 10 miles per hour. It required 2 to 3 hours to complete, depending on weather conditions. During the fall of 1969 and the spring of 1970, the boat transect was completed twice a week on two consecutive days during the first 3 hours after sunrise; a second during midday in a period 5 to 8 hours after sunrise; and a third in the evening during the last 3 hours before sunset.

The third technique was an aerial count conducted once per week during the fall of 1970 over the same route as the boat (Figure 1). Waterfowl were counted out one side of a Cessna 150 airplane flying 65 miles per hour at an altitude of 300 feet. Including circling to identify birds, the census required 30 to 40 minutes to complete. The census was completed during the mid-morning, starting 2 to 3 hours after sunrise.

The fourth technique was a shore count completed once weekly during the winter of 1969-70, fall 1970, and winter 1970-71. Waterfowl were counted at six on-shore observation points (Figure 1) which covered approximately 4.7 square miles or 22 percent of the area. Approximately 0.5 mile radius from each point was counted by scanning twice with a twenty power spotting scope.

RESULTS

Census Technique Evaluation

Although the data are limited in terms of comparing the techniques of evaluating waterfowl numbers on the study area, the counts tended to be related and reflected comparable trends with respect to relative numbers and species composition (Figure 2). The number of birds observed on the early morning fixed point observations was not related to the morning boat census in either of the fall seasons, but was significantly correlated ($P<.05$) in the spring of 1970 (Figure 2). Waterfowl hunting on the area during the fall could have disturbed the birds along shore and caused the low correlation index at that time.

The number of birds observed on two consecutive early morning boat censuses made during the fall of 1969 were related to each other, which suggested that one count per week was adequate. Although the boat censuses completed in the fall of 1970, during the morning, midday and evening, appeared to reflect similar waterfowl numbers, extreme weather conditions interferred with the completion of many of the counts and resulted in a low sample size.

The total birds observed on the mid-morning aerial census was significantly correlated to the numbers observed on the midday boat census. A low sample size and drastic weather changes between days on two occasions, appeared to contribute to a non-significant correlation between the early morning boat census and the mid-morning aerial census.

Figure 2. The relationship between the techniques used for the enumeration of waterfowl on the Monroe study area.

FALL 1969

Early Morning Fixed Point Observations ← r = .33, df = 12 → Early Morning Boat Transect

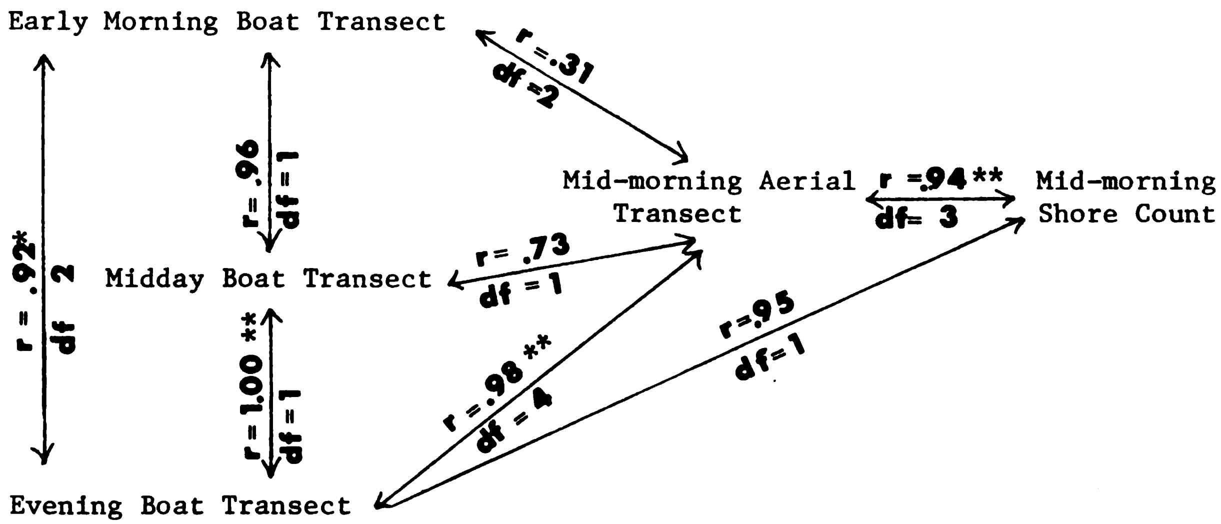
Early Morning Boat Transect Day 1 ← r = .98 **, df = 4 → Early Morning Boat Transect Day 2

SPRING 1970

Early Morning Fixed Point Observations ← r = .74*, df = 5 → Early Morning Boat Transect

FALL 1970

Early Morning Fixed Point Observations ← r = .30, df = 3 → Early Morning Boat Transect



* Significant at α = .10
** Significant at α = .05

The number of birds observed during the mid-morning shore census were correlated with the mid-morning aerial census. The shore census was dependent on the distance of the birds from shore and was most satisfactory for enumerating common goldeneye (Bucephala clangula) and the common merganser (Mergus merganser) during the fall. These birds tended to feed where they could be observed from shore and also were commonly in large flocks.

Species Utilizing the Study Area

The study area was used by six major species during the fall: black duck (Anas rubripes), mallard (Anas platyrhynchos), lesser scaup (Aythya affinis), ruddy duck (Oxyura jamaicensis), common goldeneye, and common merganser (Figure 3). An average number of each species present per day during each week was computed and multiplied by 7 to get the number of waterfowl use days for the season (Table 1). During a 49 day period from mid-October through November there were 15,134 waterfowl use days in 1969 and 14,588 waterfowl use days in 1970. Although the total use remained similar, the species composition did vary; there was a decrease in use from 1969 to 1970 by lesser scaup and American widgeon (Anas Americana), and an increase in use by the mallard, common merganser, and common goldeneye. In the fall of 1969 counts could not be made from the boat during December due to ice conditions, but in 1970 aerial counts were continued during freeze-over. These additional aerial counts were responsible for the increase in use by common mergansers and common goldeneyes.

The total number of waterfowl on the study area and the species composition changed significantly with the time of day. The largest numbers of lesser scaup, ruddy duck, common merganser, and total waterfowl

Figure 3. Composition of waterfowl utilizing the Lake Erie study area.

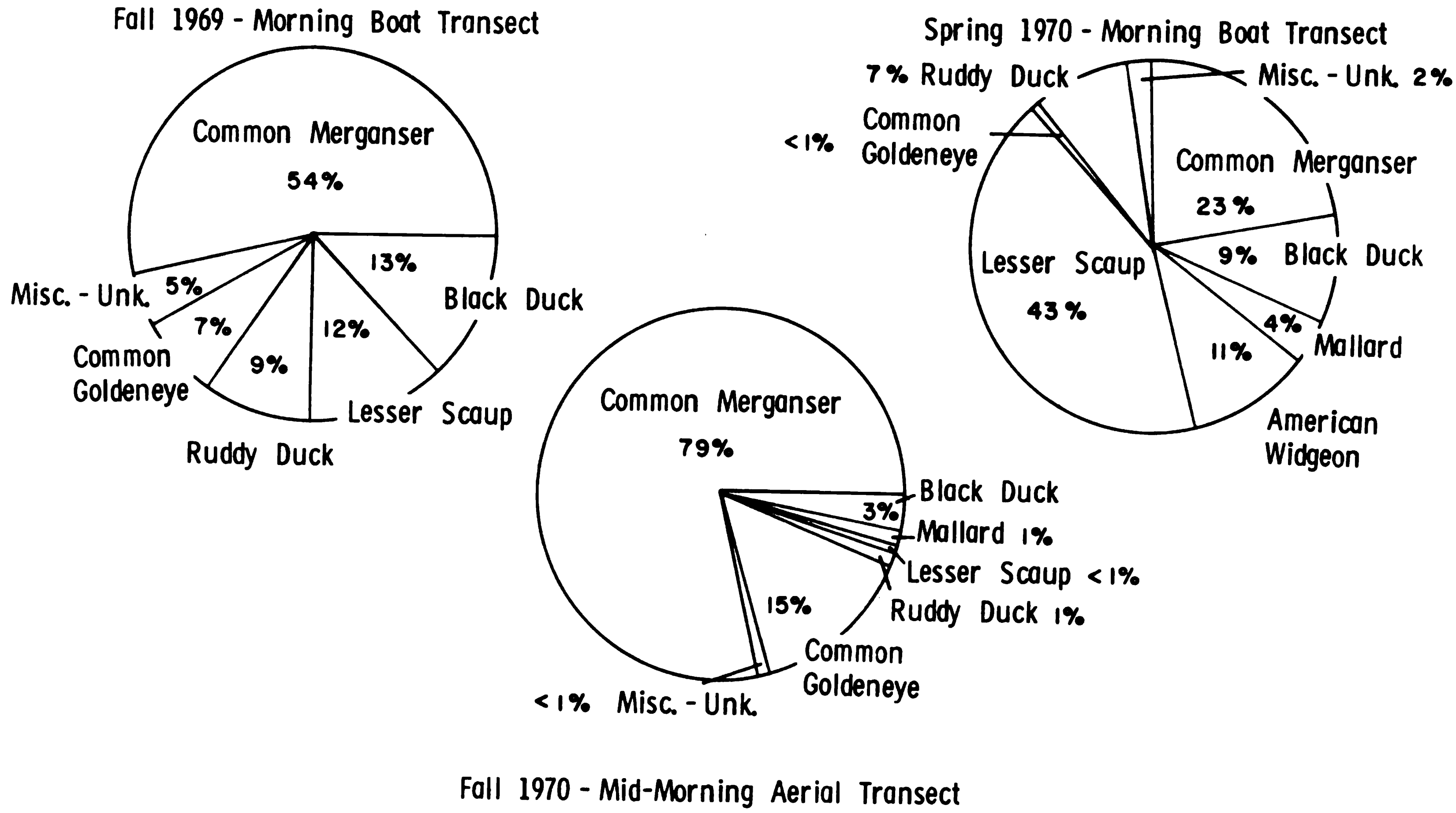

Fall 1969 - Morning Boat Transect
Common Merganser
54%
13%
Black Duck
12%
Lesser Scaup
9%
Ruddy Duck
7%
Common Goldeneye
5%
Misc. - Unk.
Spring 1970 - Morning Boat Transect
7% Ruddy Duck
Misc. - Unk. 2%
<1% Common Goldeneye
Common Merganser
23%
9% Black Duck
4%
Mallard
11%
American Widgeon
Lesser Scaup
43%
Fall 1970 - Mid-Morning Aerial Transect
Common Merganser
79%
Black Duck
3%
Mallard 1%
Lesser Scaup <1%
Ruddy Duck 1%
15%
Common Goldeneye
<1% Misc. - Unk.

Table 1. Number of waterfowl use days on the Lake Erie study area.

			Number of Waterfowl Days								
Census Method	Date	Number Days	Black Duck	Mallard	American Widgeon	Lesser Scaup	Ruddy Duck	Common Goldeneye	Common Merganser	Unknown	Total Waterfowl
Fall 1969 Early morning Boat	10/17-12/5	49	1,870	0	196	1,855	1,449	1,092	8,141	511	15,134
Fall 1970 Mid-morning Aerial	10/15-12/3	49	1,505	504	0	294	896	0	10,878	511	14,588
Mid-morning* Aerial	10/6-12/17	72	2,191	728	0	301	896	10,276	54,733	511	69,636
Spring 1970 Early morning Boat	4/5 5/3	35	2,254	987	2,807	10,710	1,680	91	5,698	553	24,780

*Includes entire fall survey

occurred during the early morning (Table 2). The mid-morning was lower in total count with a decrease in lesser scaup and ruddy duck. The largest numbers of black duck and mallard were present during the mid-morning and the midday periods. The midday and evening periods were lowest in total numbers of waterfowl. Late in the fall the common merganser and goldeneye were abundant during the mid-morning period (Table 3).

Flight activity over the area was greatest in the early morning. In fall 1969 the early morning fixed point observations averaged 39.5 birds flying per 0.5 hours, and the early morning boat census averaged 17.5 flying waterfowl per 0.5 hours. In the fall of 1970 the early morning fixed point observations, the early morning boat transect, the midday boat census, and the evening census averaged 14.0, 2.3, 8.4 and 5.3 birds flying per 0.5 hours, respectively.

The species composition during both spring and fall was similar. The more common species present during the spring were lesser scaup, common mergansers, American widgeon, black duck, ruddy duck, mallard, and common goldeneye (Figure 3). The importance of the common goldeneye is not accurately reflected by these data due to their tendency to utilize the area just after break-up, a period when ice conditions interferred with the early morning boat transect. There was a total of 24,780 waterfowl use days in the spring of 1970 (Table 1). Both dabbling ducks and lesser scaup increased in importance over the fall.

Spring flight activity over the study area averaged 55.6 flying waterfowl per 0.5 hours for the early morning fixed point observations and 15.5 flying waterfowl per 0.5 hours on the early morning boat census.

Table 2. Use of the study area by each species during four periods of the day from October 6 to November 12, 1970.

		Species (No.)							
Census Method	Period	Black Duck	Mallard	Lesser Scaup	Ruddy Duck	Common Goldeneye	Common Merganser	Misc./ Unknown	Total All Species
Boat transect	Early Morning	55	1	70	462	7	46	29	670
Aerial transect	Mid-Morning	72	62	42	128	0	0	70	374
Boat transect	Midday	61	75	26	79	0	3	12	256
Boat transect	Evening	18	0	33	148	0	0	5	204

Table 3. Use of the study area by each species during the mid-morning from November 18 to December 10, 1970

		Species (No.)							
Census Method	Period	Black Duck	Mallard	Lesser Scaup	Ruddy Duck	Common Goldeneye	Common Merganser	Misc./ Unknown	Total All Species
Aerial transect	Mid-Morning	241	42	1	0	1,468	7,819	3	9,571
Shore transect	Mid-Morning	0	0	35	1	442	3,853	2	4,333

Flock Size

The average flock size for all species was less than 20 birds for 80 percent of the flocks during the fall and the spring (Table 4). The common merganser was the only exception with 49 percent of the flocks composed of less than 20 birds during the fall. The mergansers and golden-eye were highly variable in flock size in the fall, as were the dabbling ducks in the spring.

Chronology of Use

Waterfowl were on the study area for 10 weeks during the fall from late September to freeze-over of the lake in mid-December. The majority of lesser scaup move through the area first, followed by the ruddy duck, dabbling ducks, common goldeneye and common merganser (Figure 4). The pattern of use for lesser scaup was similar both years. The ruddy was present in low numbers throughout a 9 week period in 1969 but utilized the area in 1970 for a shorter period. Although mallards were not observed on the area during the fall of 1969, they were present on the study area in 1970 from early October until the lake froze. Black ducks were on the area from late September until freeze-over of the lake both years. They were present in the largest numbers during the last two weeks of November and the first week of December. Common goldeneye and common merganser were present from late October until freeze-up. The weekly numbers for both species were greatest in 1969 during the last 2 weeks of November, and in 1970 during the first 2 weeks of December.

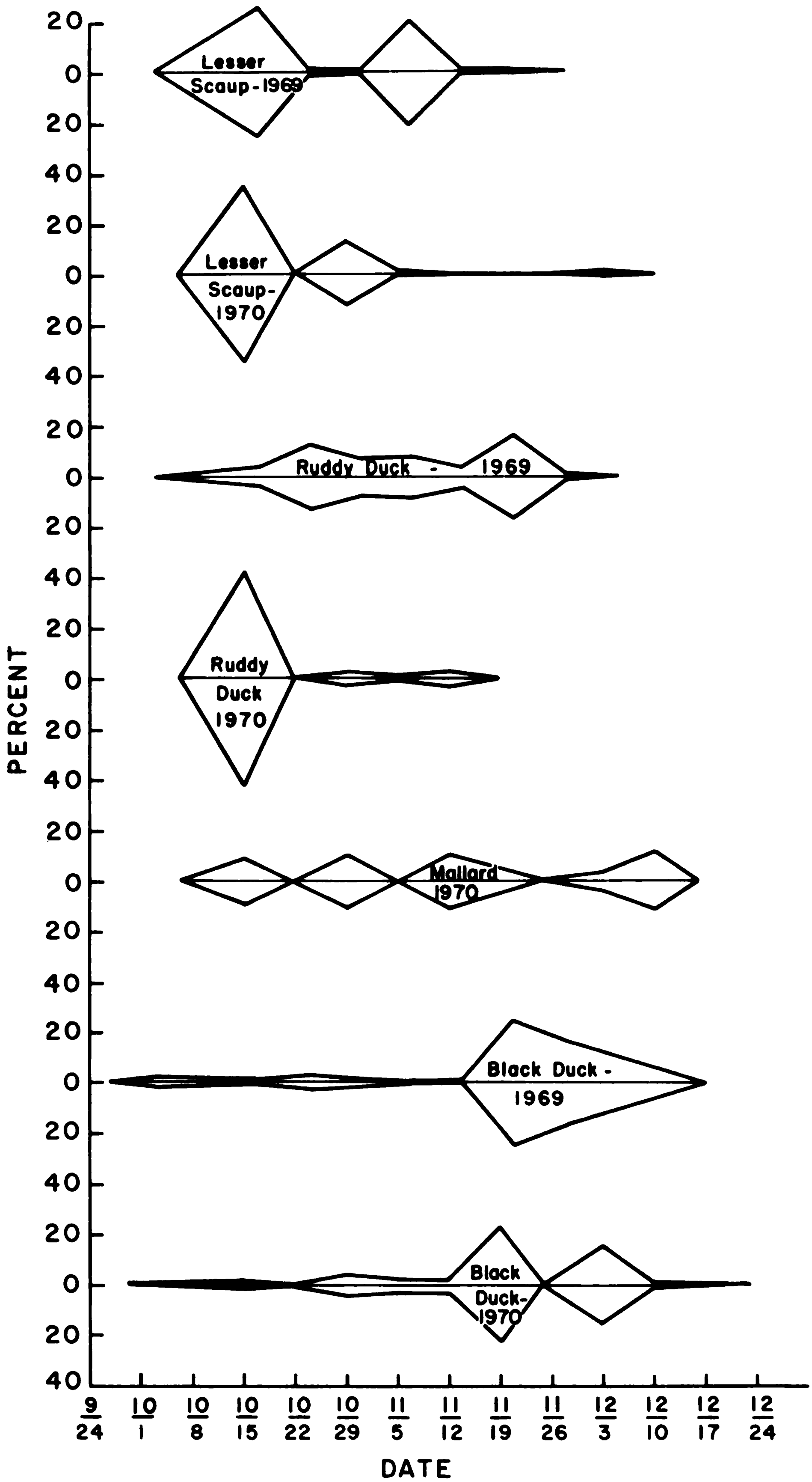
Waterfowl used the study area for 6 weeks during the spring from break-up of ice on the lake in early March until early May. The common goldeneye was the first species to move through the area followed by

Table 4. Flock sizes of waterfowl on study area.

	N	$\bar{X}$	SD	Flock Size Frequency							Range
				1	2	3-9	10-19	20-49	50-99	100	
Dabblers Fall	112	9	17.3	22	14	46	20	7	2	1	1-160
Spring	32	29	100.5	1	16	10	2	0	1	2	1-540
Lesser Scaup											
Fall	55	12	29.3	12	8	21	8	2	3	1	1-200
Spring	107	15	23.0	7	13	41	25	14	5	2	1-150
Ruddy Duck											
Fall	95	10	12.7	17	12	37	15	12	2	0	1-80
Spring	36	9	11.1	8	3	15	3	7	0	0	1-48
Common Goldeneye											
Fall	78	22	52.0	21	10	26	5	4	6	6	1-300
Spring	-*	-	-	-	-	-	-	-	-	-	- -
Common Merganser											
Fall	79	124	220.1	12	7	17	3	9	7	24	1-1250
Spring	60	14	32.0	12	13	23	3	4	2	3	1-200

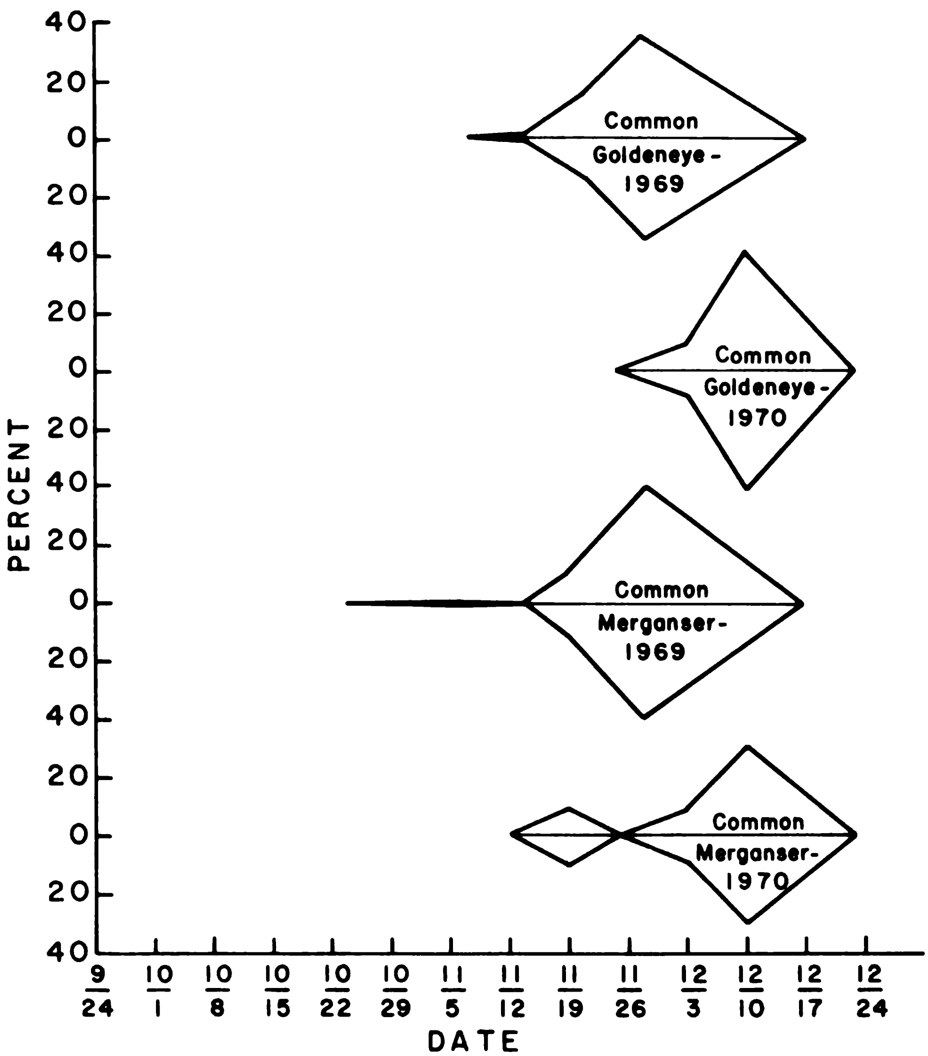
* No data.

Figure 4. Chronology of waterfowl use on the Lake Erie study area, during the falls of 1969 and 1970.



PERCENT
20
0
20
40
Lesser
Scaup-1969
Lesser
Scaup-
1970
Ruddy Duck - 1969
Ruddy
Duck
1970
Mallard
1970
Black Duck -
1969
Black
Duck-
1970
9/24
10/1
10/8
10/15
10/22
10/29
11/5
11/12
11/19
11/26
12/3
12/10
12/17
12/24
DATE

Figure 4. (continued)


PERCENT
40
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0
20
40
Common
Goldeneye -
1969
Common
Goldeneye -
1970
Common
Merganser -
1969
Common
Merganser-
1970
9/24
10/1
10/8
10/15
10/22
10/29
11/5
11/12
11/19
11/26
12/3
12/10
12/17
12/24
DATE

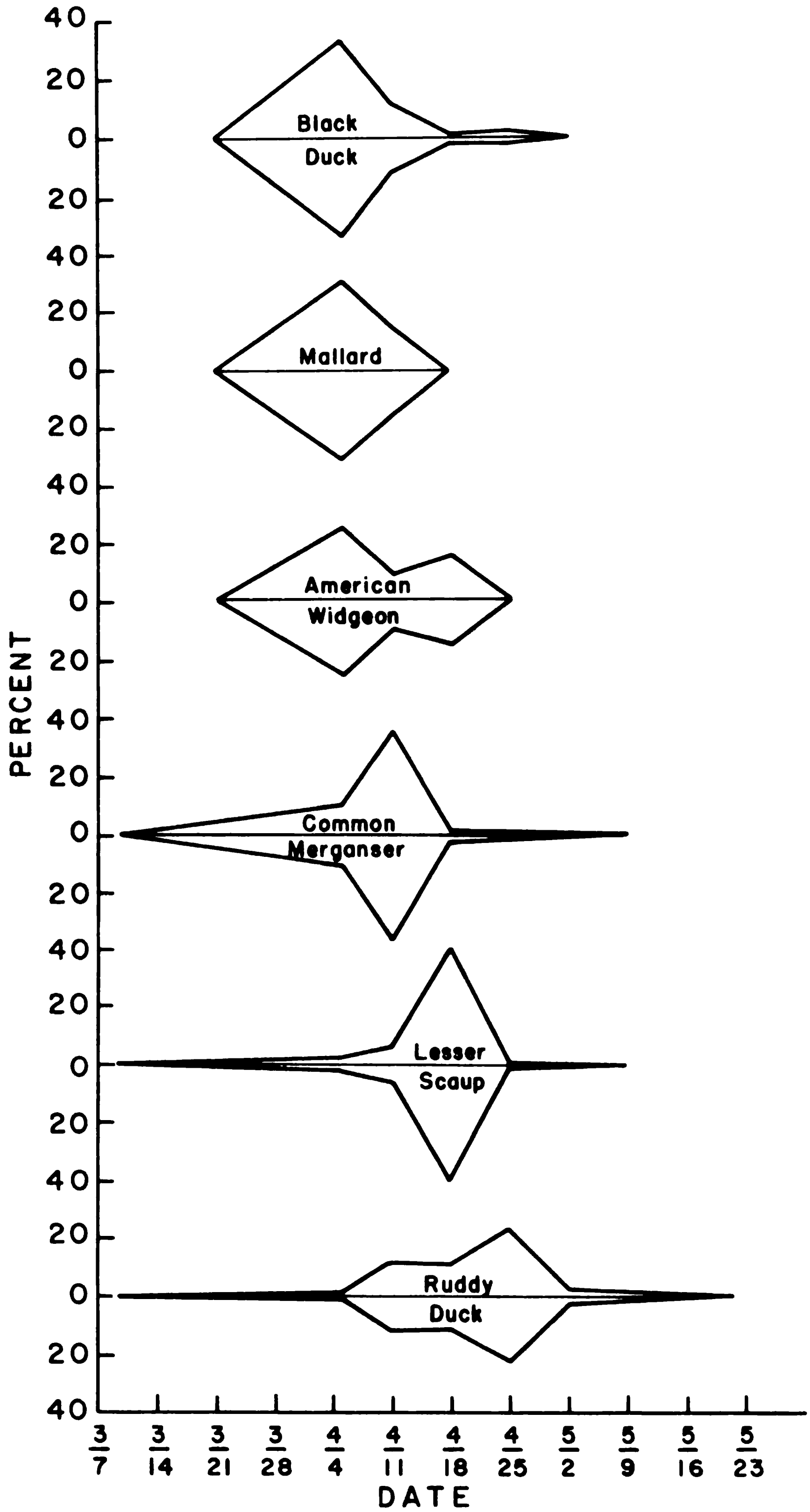
the dabbling ducks, common merganser, lesser scaup and ruddy duck (Figure 5). The goldeneyes arrived on the study area at break-up in early March and remained until the first week of April. Ice conditions restricted the boat transect and an accurate representation of their chronology cannot be made. The greatest use by the black duck, mallard, American widgeon, and pintail was during a 3 week period from late March through early April. The common merganser and lesser scaup were present from break-up through the first week of May, and their numbers were greatest during mid-April. Ruddy ducks were present from break-up until mid-May with the largest numbers present during the month of April.

Distribution of Waterfowl

The distribution of waterfowl on the study area was dependent on the season of the year. During the fall hunting season, less than 30 percent of any species was within 0.25 miles of shore (Table 5). There was a significant ($P<.05$) shift in the distribution toward shore after the hunting season. The distribution during the spring was significantly different from the fall periods with the greatest number of birds occurring in the 0-0.25 mile zone. These shifts in distribution are apparent in Figure 6, where it can be seen that not all units were equally preferred by waterfowl in the fall or spring.

The distribution of dabbling ducks (black duck, mallard and American widgeon) was similar for both fall periods [Spearman Rank (r_s)= .21; $P<.05$]. Their densities were low, averaging less than 10 birds per mile of transect (Figure 7). The distribution during the spring shifted toward inshore areas, and the shallow portion of units 1, 5 and 6 were preferred. Although the number of lesser scaup was greater in 1969 than

Figure 5. Chronology of waterfowl use on the Lake Erie study area during Spring, 1970.



PERCENT
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0
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40
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20
40
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20
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20
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20
40
20
0
20
40
Black
Duck
Mallard
American
Widgeon
Common
Merganser
Lesser
Scaup
Ruddy
Duck
3/7
3/14
3/21
3/28
4/4
4/11
4/18
4/25
5/2
5/9
5/16
5/23
DATE

Table 5. Relative distribution of waterfowl in relation to distance from shore when counted during the falls of 1969 and 1970, and the spring of 1970 by boat transects.

Species	Distance from Shore (Miles) Fall						Spring		
	Hunting Season			Post-hunting Season					
	0-.25	.26-.50	.51>	0-.25	.26-.50	.51>	0-.25	.26-.50	.51>
Dabblers	23	30	47	74	0	26	94	3	3
Lesser Scaup	2	17	81	0*	100	0	82	12	6
Ruddy Duck	24	35	41	2	28	70	43	33	24
Common Goldeneye	30*	40	30	8	38	54	-**	-**	-**
Common Merganser	1<	35	64	32	34	34	61	26	13

* Sample size less than 10 birds
** No data

Figure 6. The relative density by census unit during the migration period for all species on the study area.

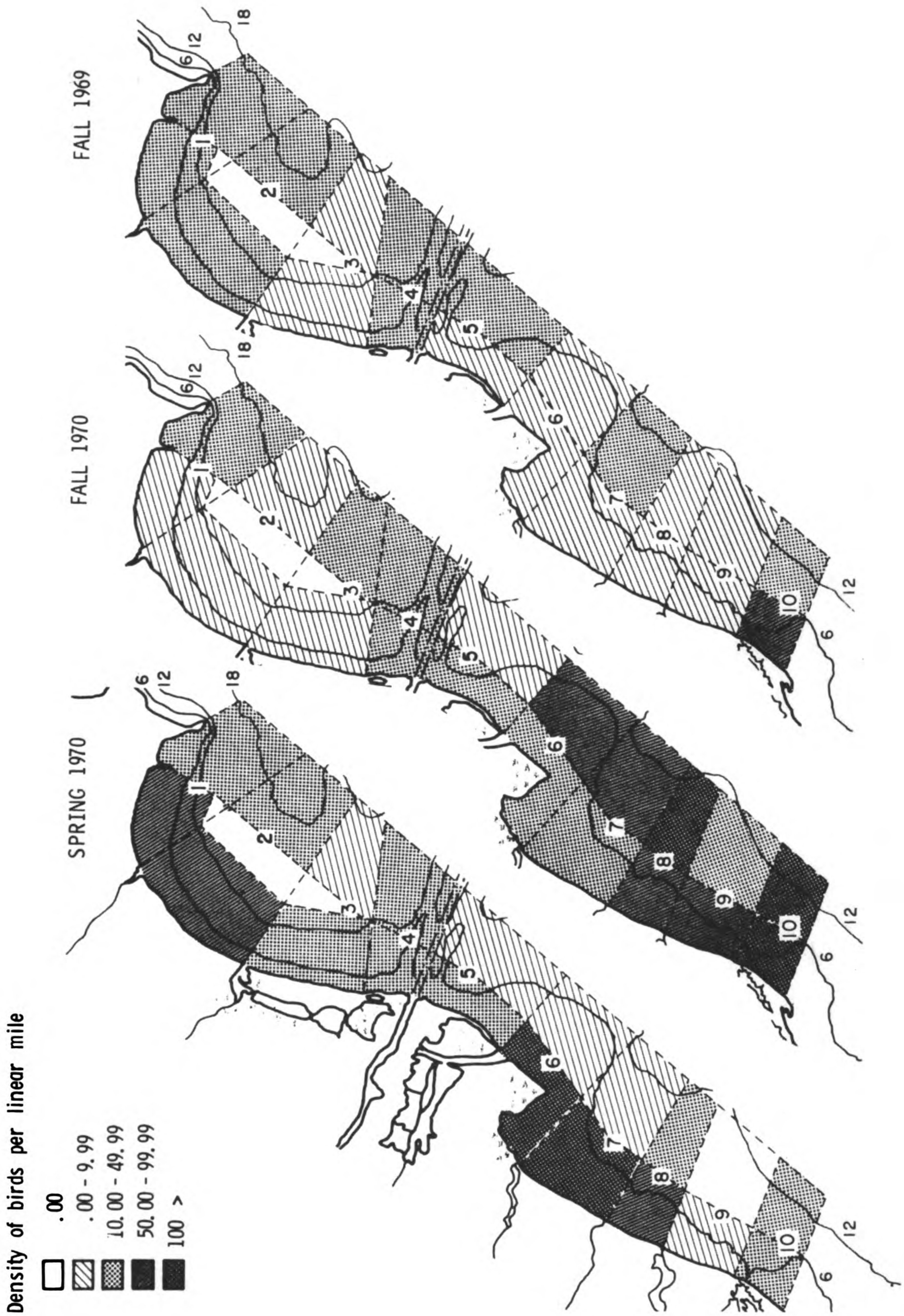
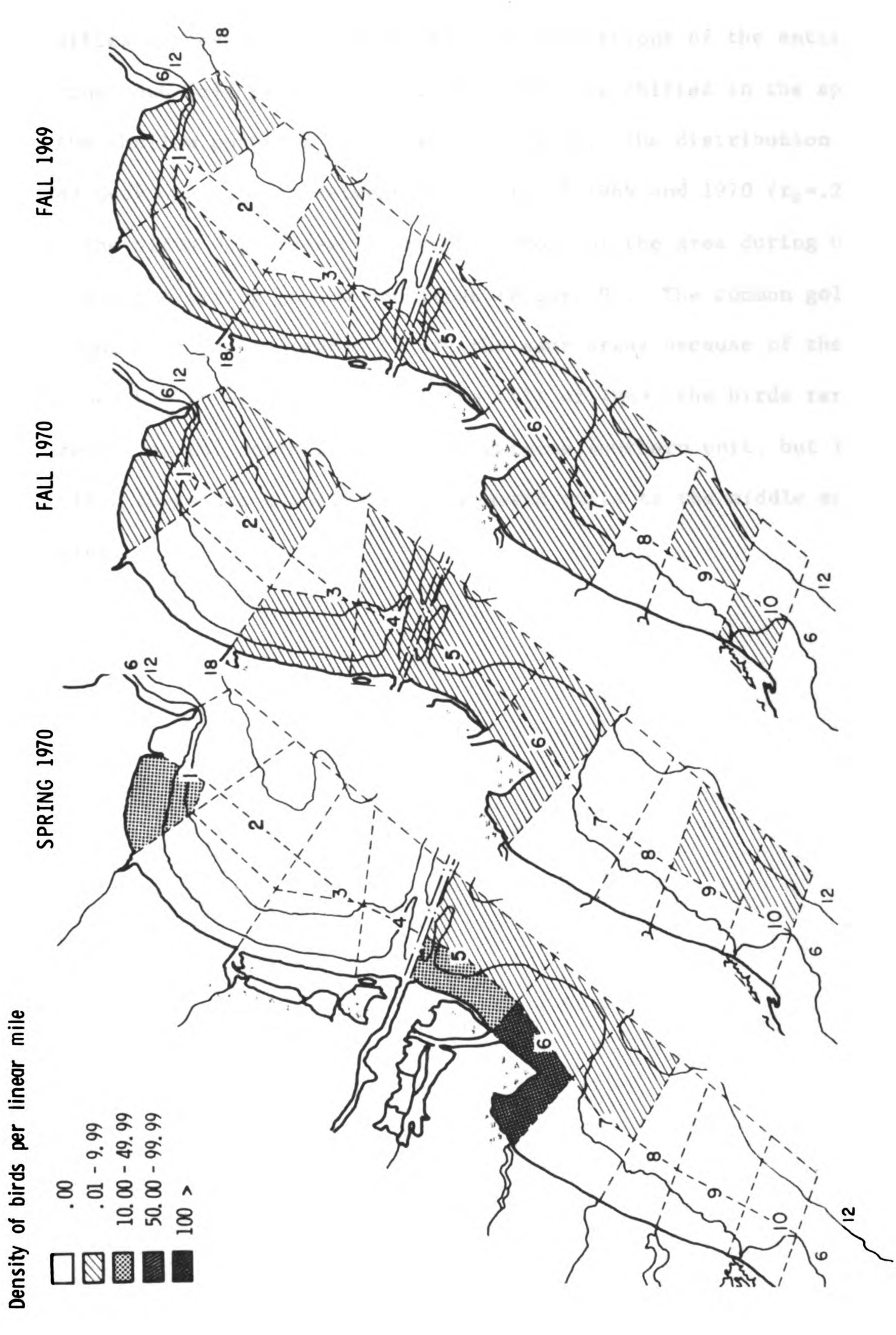

Density of birds per linear mile
.00
.00 - 9.99
10.00 - 49.99
50.00 - 99.99
100 >
SPRING 1970
FALL 1970
FALL 1969

Figure 7. The relative density by census units during the migration period for dabbling ducks on the study area.


Density of birds per linear mile
.00
.01 - 9.99
10.00 - 49.99
50.00 - 99.99
100 >
SPRING 1970
FALL 1970
FALL 1969

1970, the pattern of use between years was similar (r_s= .11; P<.05). Low densities of lesser scaup were observed on portions of the entire area during both fall periods (Figure 8). The use shifted in the spring toward the shallow portions of units 1 through 8. The distribution of the ruddy duck was similar between the falls of 1969 and 1970 (r_s=.22; P<.05). The birds were present throughout most of the area during both the fall and the spring in low densities (Figure 9). The common golden-eye and common merganser tended to use the same areas because of their similar food habits (Figure 10). In the fall of 1969, the birds tended to be present on the northern units and extreme southern unit, but in the fall of 1970 there was a shift from the north units to the middle and south units.

Figure 8. The relative density by census units during the migration period for the lesser scaup on the study area.

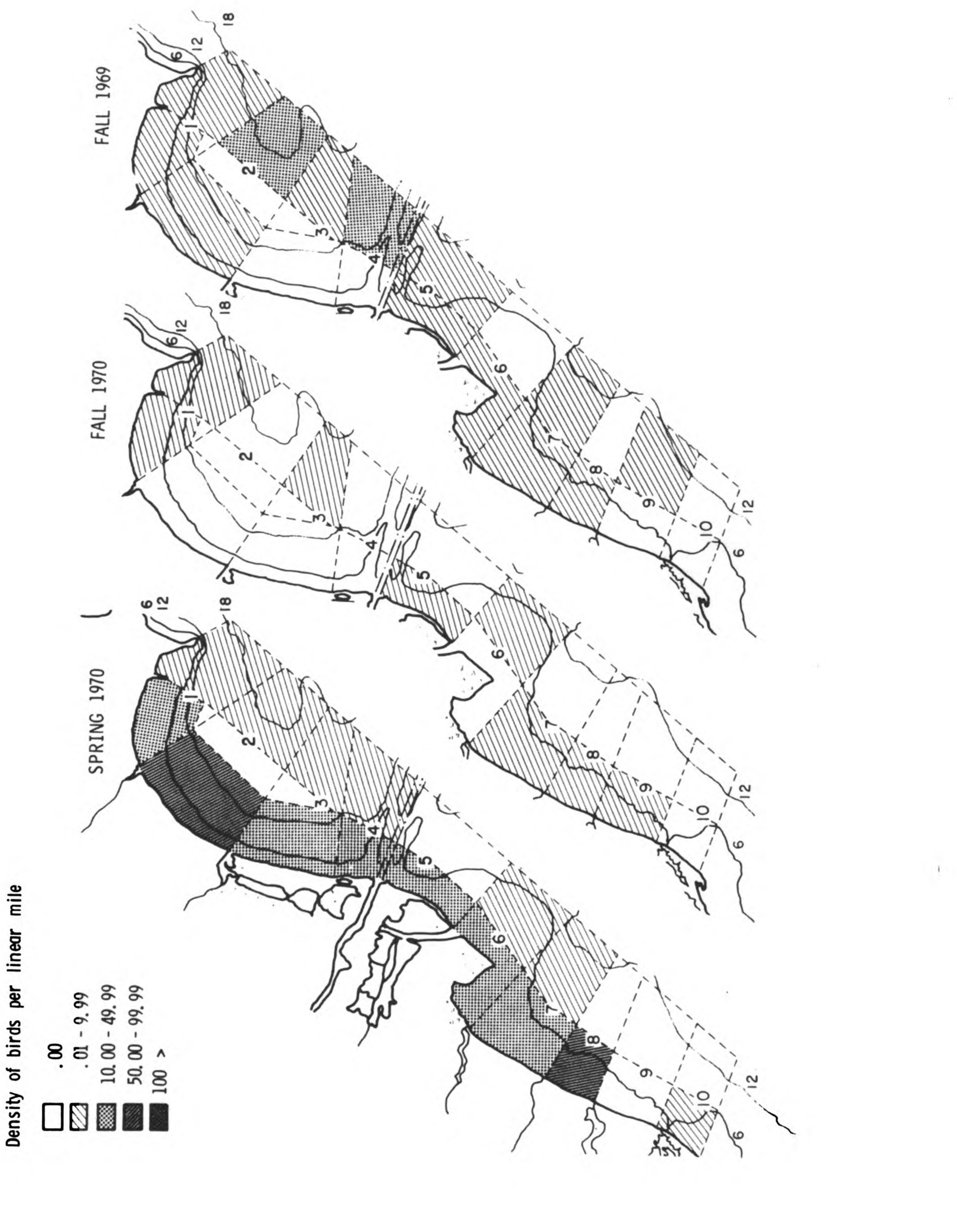

Density of birds per linear mile
.00
.01 - 9.99
10.00 - 49.99
50.00 - 99.99
100 >
SPRING 1970
FALL 1970
FALL 1969

Figure 9. The relative density by census units during the migration period for the ruddy duck on the study area.

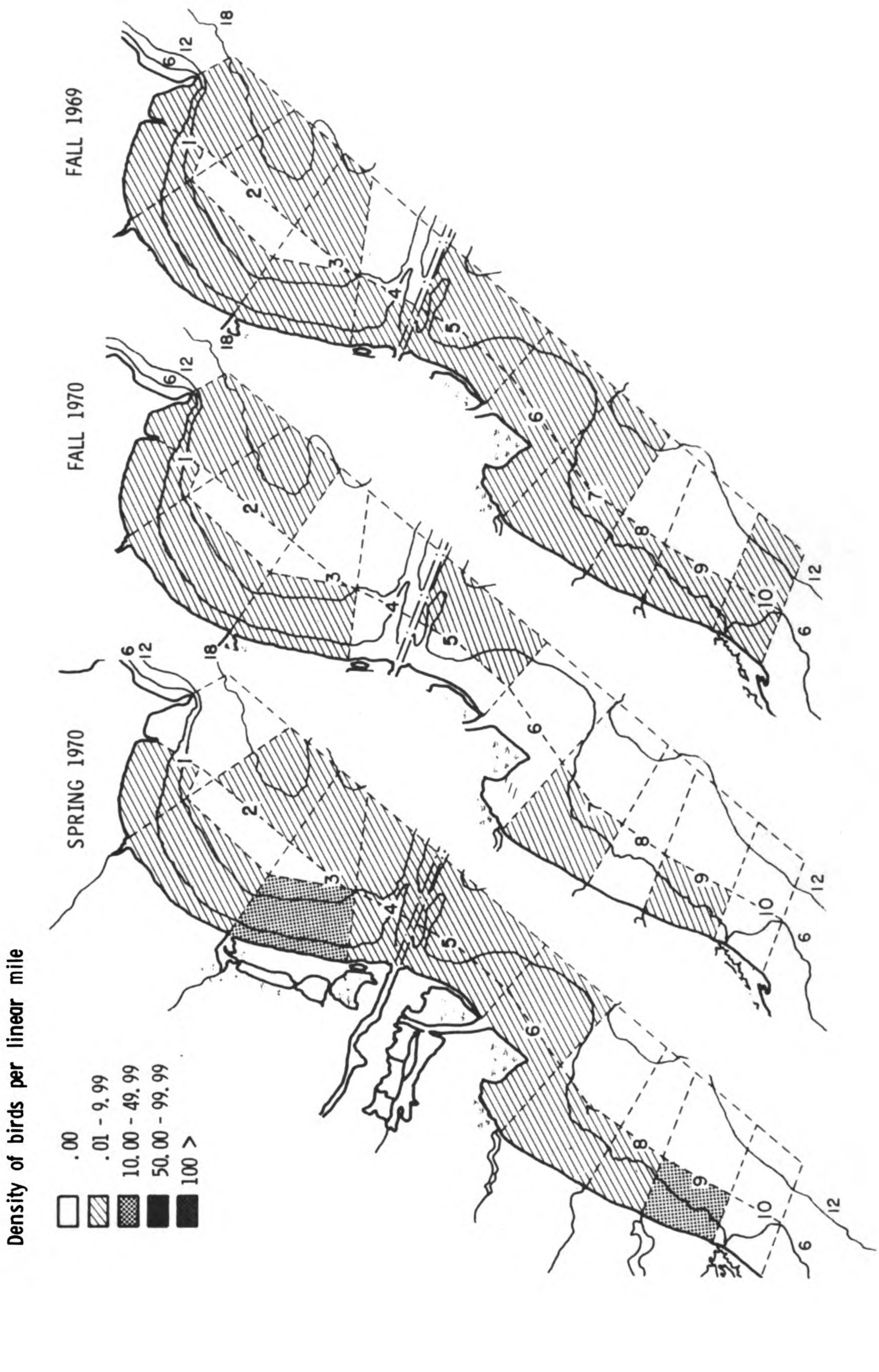
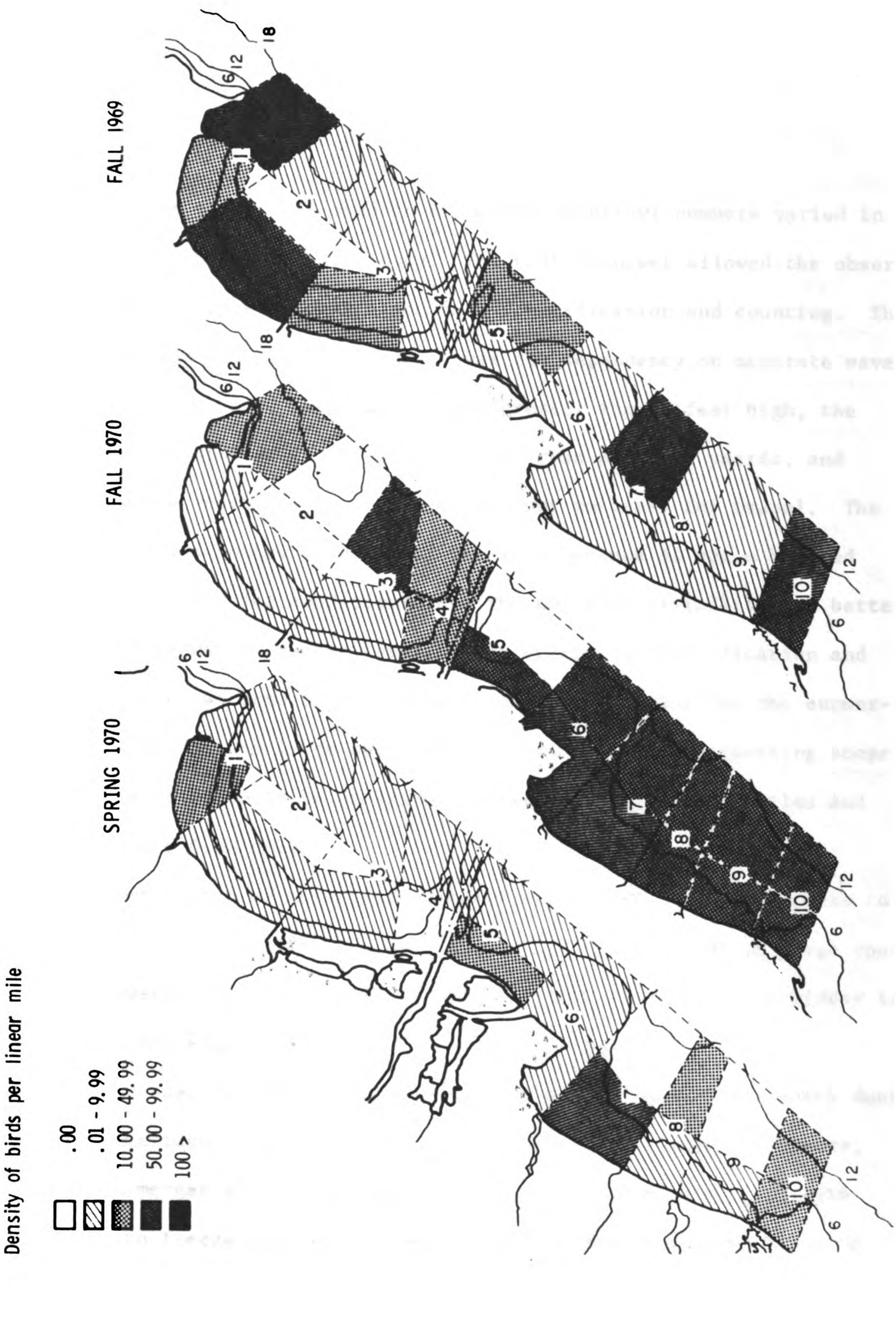

Density of birds per linear mile
.00
.01 - 9.99
10.00 - 49.99
50.00 - 99.99
100 >
SPRING 1970
FALL 1970
FALL 1969

Figure 10. The relative density by census units during the migration period for the common merganser and common goldeneye on the study area.


Density of birds per linear mile
.00
.01 - 9.99
10.00 - 49.99
50.00 - 99.99
100 >
SPRING 1970
FALL 1970
FALL 1969

DISCUSSION

The four techniques used to enumerate waterfowl numbers varied in their effectiveness and efficiency. The boat transect allowed the observer to cover a large area with accurate identification and counting. The main limitation of the boat transect was its dependency on moderate wave conditions and no ice. When waves were greater than 3 feet high, the visibility was limited to 500 yards rather than 800 plus yeards, and when the waves reached 4 to 5 feet it was not suitable for travel. The airplane allowed better coverage of the lake because it could be used under all wind and ice conditions, and the angle of visibility was better. However, there was a greater tendency for errors in identification and counting. The two land techniques were of limited value for the enumeration of waterfowl on large open bodies of water. When a spotting scope was used, species could be accurately identified within 0.25 miles and counted within 0.50 miles.

A combination of an aerial transect and a boat transect appears to be suitable for identification and enumeration of waterfowl on large open bodies of water. Counts should be made at least at sunrise and midday to get a good representation of both numbers and species.

Seven species of waterfowl commonly used the study area; black duck, mallard, American widgeon, lesser scaup, ruddy duck, common goldeneye, and common merganser. Birds were present on the study area from late September to freeze-over of the lake in mid-December and from break-up of the lake in early March to mid-May. The greatest numbers were present from mid-October through early December and from late March through April. No use occurred during the winter, when ice was present, and during the summer. Total waterfowl use averaged 66,140 waterfowl use days per year. Waterfowl were present on the area throughout the day, but the highest numbers occurred during the early morning and the lowest numbers in the evening.

The study area appeared to serve as a refuge and feeding ground for some of the species. Hunting influenced the distribution of waterfowl on the study area with all species except the ruddy duck, tending to move from greater than 0.50 miles from shore to less than 0.25 miles from shore after the hunting season ends in the spring.

The availability of food may influence the distribution of some species on the study area. There are few macrophytes and only a limited amount of invertebrates to serve as a food source (Cole, 1971). The benthos never exceeded 7.2 g/m^2 on the study area during the fall or spring. The family Tubificidae composed 49 to 93 percent of the benthos by weight; the Chironomidae larvae made up 2 to 50 percent of the benthos by weight; and the Sphaeridae, fingernail clams, composed 0 to 34 percent of the benthos by weight. Units 5 and 6 had the greatest concentrations of sphearids; during the spring of 1970 the wet weight was 1.4 g/m^2, and during the fall of 1970 was 0.4 g/m^2. The largest amount of chironomids was 1.0 g/m^2 in unit 4 during the spring of 1970 and 1.6 g/m^2 in unit 7 during the fall of 1970. Coulter (1955) and Mendall (1949) report pelecypods as a common dietary item for the black duck, but the concentrations on the study area appear to be insignificant in relation to the daily food requirements. The black duck, mallard and American widgeon distributions appear to be influenced by the marsh areas such as those adjacent to units 4, 5, and 6. The lesser scaup commonly eats chironomid larvae, and sphearids (Bartonek and Murdy, 1970; Cottam, 1939; Dirschl, 1969; Rogers and Korschgen, 1966; and Thompson, 1969). The concentrations of sphearids in the areas where feeding waterfowl were concentrating during the fall and winter on the lower Detroit River were 5.8 g/m^2 on 50 percent of the area, 3.0 g/m^2 on 36 percent, and 1.2 g/m^2 on 19 percent (Hunt, 1957). The Keokuk Pool on the Mississippi River also contains large concentrations of migratory scaup, and the average sphearid concentrations were 126.9 g/m^2 (Thompson, 1969). The fall food requirements of lesser scaup eating natural food in captivity ranges in wet weight from 200 to 331 grams per day (Longcore and Cornwell, 1964). Thus, it appears unlikely that birds on the Monroe study area could get enough invertebrates to satisfy their daily requirements. However, if fish were consumed in addition to invertebrates, the area could be of value as a feeding grounds.

There are eight main fish species in the study area, these are: yellow perch (Perca flavescens), white bass (Roccus chrysops), gold fish (Cerassius auratus), carp (Cyprinus carpio), alewives (Alosa pseudoharengus), gizzard shad (Dorosoma cepedianum), spottail shiner (Notropis hudsonius), and emerald shiner (Notropis atherinoides) (Parkhurst, 1971). Forage fish (alewives, gizzard shad, spottail shiner, and emerald shiner) are potential foods for waterfowl, and they composed at least 81 percent of the fish numbers in units 5 through 10 in both the fall and the spring of 1970 (Table 6). Units 3 and 4 during the fall and spring of 1970 contained a large number of yellow perch, white bass, and some forage fish. At both the north and central units, carp and goldfish often dominate the catch in biomass, but are too large to serve as food. Ninety-nine percent of the forage fishes and white bass in the spring and fall of 1970 were less than 15 cm, and 99 percent of the yellow perch were less than 25 cm

Table 6. Relative abundance and weight of fish captured in five-minute otter trawls on the study area.*

Species	Spring Units						Fall Units					
	3 and 4		5 and 6		9 and 10		3 and 4		5 and 6		9 and 10	
	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Perca flavescens	87	-	0	0	3	-	10	3	3	27	4	10
Roccus chrysops	2	-	6	4	1<	-	7	1	2	1	1	1<
Carassius auratus and *Cyprinus carpio*	6	-	13	82	1	-	39	93	0	0	2	53
Alosa pseudoharengus	4	-	7	6	0	-	0	0	6	8	3	2
Dorosoma cepedianum	0	-	0	0	0	-	18	2	7	15	29	22
Notropis hudsonius	0	-	21	3	93	-	9	1<	3	2	7	2
Notropis atherinoides	0	-	53	5	2	-	11	1<	78	46	52	7
Miscellaneous	1	-	0	0	0	-	6	1<	1	1	2	3
TOTAL	100	-	100	100	100	-	100	100	100	100	100	100
TOTAL NUMBER	169	-	47	-	464	-	66.5	-	81	-	94	-
TOTAL WEIGHT (kg)	-	-	-	3.27	-	-	-	17.77	-	.83	-	2.40

*Benjamin Parkhurst. 1971. Unpublished data. Michigan State University in the spring and fall (Parkhurst, 1971). Lesser scaup along the Louisiana Coast during the late fall and winter eat 41.8 percent fish by volume (Rogers and Korschgen, 1966). Cottam (1939) and Hunt (1957) also found some consumption of fish by lesser scaup. Although the goldeneye has been reported to eat fish in numbers, fish represented only 3 percent of the diet (Cottam, 1930; and Olney and Mills, 1963). However, Dementiev and Gladkov (1952) reported that during early spring in certain areas of Russia, the goldeneye ate 60 percent small fish. The major food item of the common merganser is fish. In the northcentral United States during the fall, winter and spring, the common merganser ate 37 percent gizzard shad, 26 percent freshwater drum (Aplodinotus grunniens), 11 percent white bass and 24 percent of other fish species (Timken and Anderson, 1969). In the Great Lakes wintering, common mergansers ate 20.4 percent yellow perch, 22.7 percent forage fishes of which the emerald shiner was the most important, 2.9 percent lake herring (Corregonus sp.), 20.3 percent unidentified fishes, 3.5 percent crayfish and 1.6 percent insects (Salyer and Lagler, 1940). All the important fishes for mergansers found in the two studies were present on the Monroe study area. There are no data on size classes of fish preferred by lesser scaup and goldeneye; but the common merganser will eat fish as large as a 38 cm brown trout (Salyer and Lagler, 1940), however, they prefer fish in small size classes from 10 to 25 cm which are small in girth (Latta and Sharkey, 1966). In both the spring and fall of 1970, the common merganser and goldeneye were most abundant in units 5 through 10 which contained the most schooling forage fish, and to a lesser extent units 3 and 4 where yellow perch and white bass were more abundant. The lesser scaup distribution did not appear to be influenced as strongly by the distribution of fish. Through the relationship of food and observations of mergansers and goldeneyes feeding, it may be concluded that these two species probably used the study area as a feeding area and they were distributed on the lake where the fish, used for food, were most abundant.

PART TWO

The Daily and Seasonal Activity of a Wintering Mallard and Black Population in Southeastern Michigan

STUDY AREA

The study area was located in southwestern Michigan along the shore of Lake Erie near the city of Erie, and included the plume of heated effluent from the Consumers Power Plant and a sulfur spring located on the property of the Erie Shooting Club. The spring is .9 miles from the lake and 1.7 miles southwest of the fossil fuel electric power plant. The water remained ice free throughout the winter in both the outflow of the spring and the heated effluent.

The spring is surrounded by a dike and is located near the center of a managed waterfowl marsh. The ice free area of the diked portion and the outflow from the spring ranged from 2.4 to 4.0 acres in size and averaged 3.0 acres. The water temperature at the margins of the diked area averaged 46° F throughout the winter. Cattails (*Typha latifolia*) border the edge of the spring and the outflow. The bottom of the spring is composed of marl, that through cementation has formed strata of tufa rock which consists of approximately 95 percent calcite (Pirnie and Foster, 1964). The bottom of the outflow area is mainly silt and dentritus and the water over it is less than 2 feet deep. The dominant species of submergent vegetation is muskgrass (*Chara* sp.).

The open water area at the power plant is created by the discharge of cooling water into Lake Erie. The effluent flows through a 15 X 100 yard channel into the lake. The average temperature of the water entering the lake during January and February was 53° F and the minimum size of the plume was 8 acres. The water depth in the area of the plume is a maximum of 4 feet except immediately outside the discharge where it is 8 feet. The sand and gravel bottom is free of aquatic plants. The shoreline is sandy with a band of trees separating the lake from inland marshes. The heated effluent apparently attracts fish that are eaten by common mergansers, common goldeneyes, herring gulls (Larus argentatus) and ring-billed gulls (Larus delawarenis).

METHODS

The mallards and black ducks were counted at the spring and the power plant plume during the winters of 1969-70 and 1970-71 from early December through early March. The ducks were counted once a week during the winter of 1969-70 in the following order; one-half hour before sunrise a lake count was made, then a count of the spring during the next hour, and lastly a late morning count of the lake. Attempts were made during the afternoon period to follow feeding flights to grain fields.

During the winter of 1970-71 two consecutive days per week were spent on the study area. On the first day the entire time was spent at the spring from 1 hour before sunrise to 1 hour after sunset. The total number of birds present was estimated at 5 minute intervals and the behavioral activity of the birds was quantified. Six imaginary transect lines were chosen to systematically represent the open water area of the spring and outflow. Observations were made along each of these lines in a random order for a 2.5 minute period for every 15 minute period from sunrise to sunset, and the behavior of the birds was classified into the following categories; resting on the ice or shore, resting on the water, actively swimming, feeding comfort movements, and sexual display. Sexual display included those activity patterns described by Lorenz (1941) and Weidmann (1956), and comfort movements as described by McKinney (1965). Sexual display and comfort movements were very low in occurrence during this period of the year and they are combined into one category designated as social display. On the second day, counts were made by 5 minute intervals on the spring from 1 hour before sunrise until 1 hour after sunset with approximately a 1 hour break during the mid-morning period when the number of waterfowl present on the plume at the lake was counted.

RESULTS AND DISCUSSION

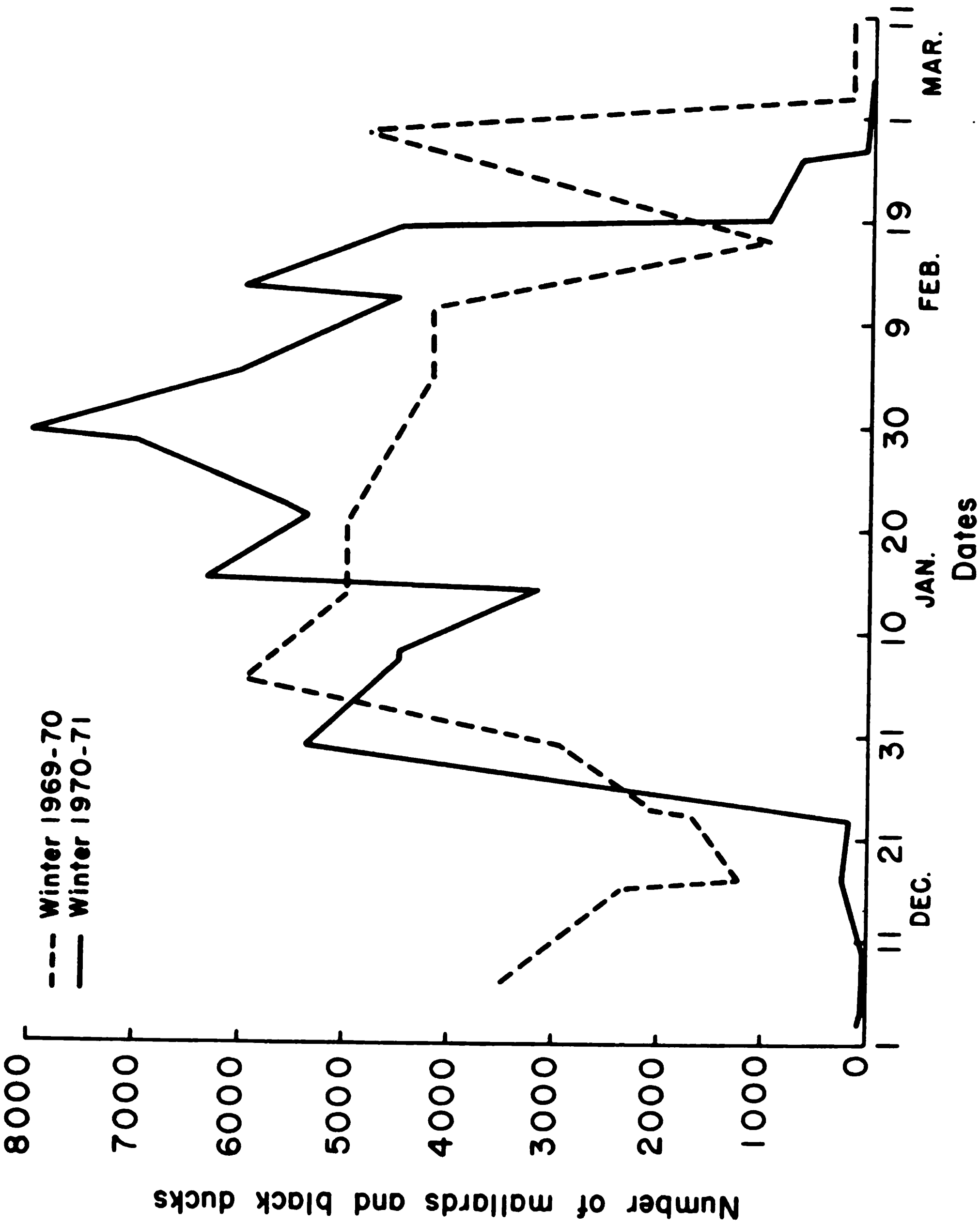
Seasonal Use

Although small numbers of wintering mallards and black ducks started using the spring and heated effluent areas in late November and early December, the peak use occurred both years from late December to late February when ice free water was limited. The birds left these areas as soon as the break-up of the ice occurred in late February. During the winter of 1969-70 the period of peak use was 24 December to 24 February, 62 days; and during the winter of 1970-71 the period was 30 December to 18 February, 50 days (Figure 11). The largest number of mallards and black ducks using the spring and effluent in the winter of 1969-70 was 6,000 birds on 4 January 1970; and during the second winter it was 8,000 birds on 29 January 1971 (Figure 11). The species composition was 10 percent black ducks and 90 percent mallards in 1969-70 and 15 percent black ducks and 85 percent mallards in 1970-71. The sex ratio for mallard both years varied during the winter period from 67 to 75 percent males.

Daily Use

The mallards and black ducks used the spring, the heated effluent and the grain fields each day during the period of peak use. During the 2 year period, 58 percent of the birds spent the night at the spring (Table 7). The spring was preferred during the morning with an average

Figure 11. Total number of mallards and black ducks utilizing the spring and the power plant effluent.


Winter 1969-70
Winter 1970-71
Number of mallards and black ducks
8000
7000
6000
5000
4000
3000
2000
1000
0
1
11
21
31
10
20
30
9
19
1
11
DEC.
JAN.
FEB.
MAR.
Dates

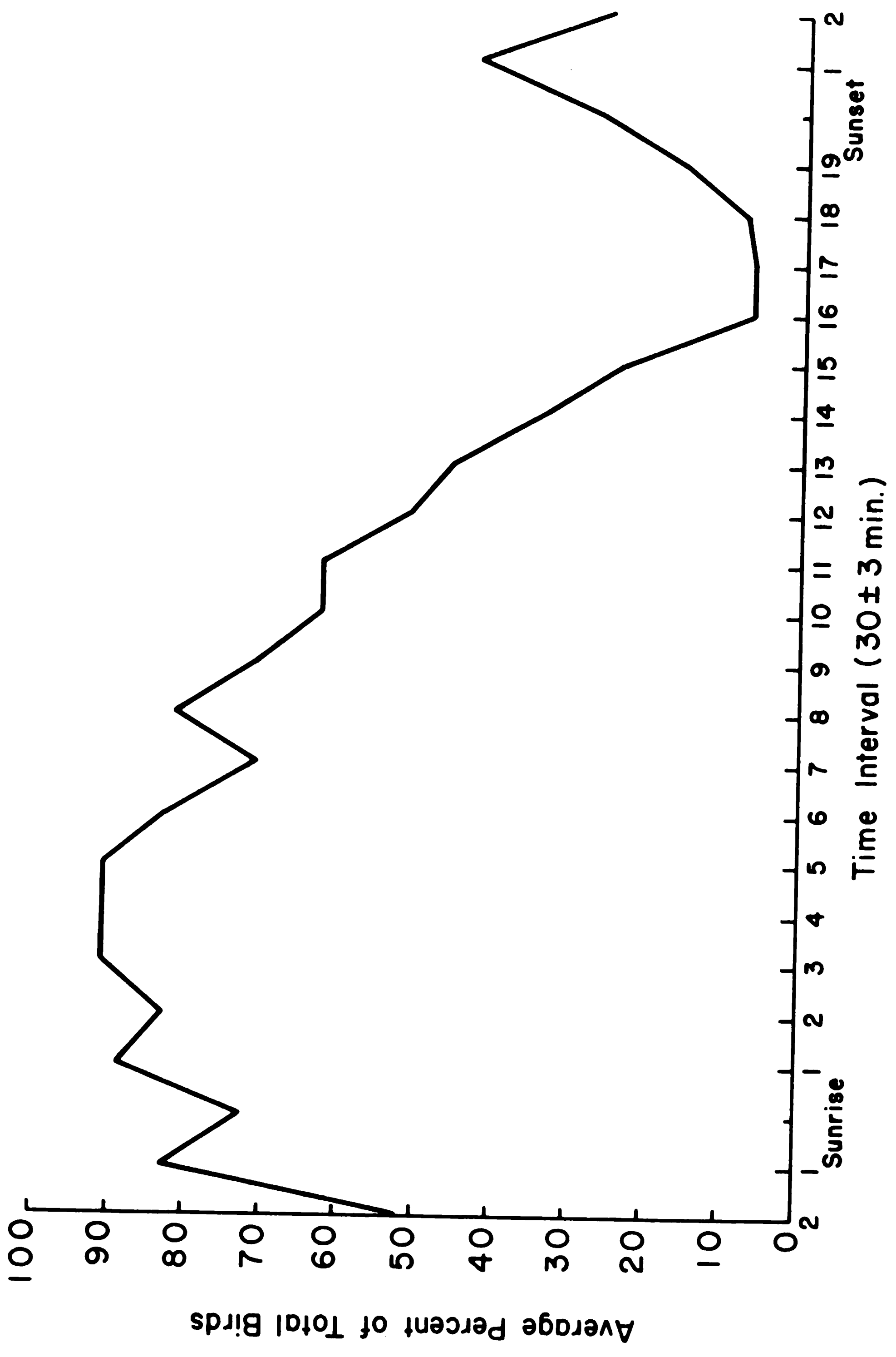
of 84 percent of the birds present. All the birds left the water area to feed during the late morning or early afternoon. The birds returned either to the spring or heated effluent in the late afternoon after feeding.

Table 7. The relative number of the total mallards and black ducks estimated to be on the study area present at the spring or the heated effluent during the night, morning, and afternoon.

			Location (Percent)	
Activity	Year	n	Spring	Heated Effluent
Spent night	1969-70	8	76	24
	1970-71	13	47	53
	Total	21	58	42
Spent morning	1969-70	8	87	13
	1970-71	13	81	19
	Total	21	84	16
Return after feeding	1970-71	8	53	47

The period from sunrise to sunset was divided into twenty equal segments to depict an average day. The proportion of the population present out of the total population from 7 January to 12 February 1971, was averaged for each of the 20 time intervals and also for the 2 time intervals before sunrise and after sunset (Figure 12). During this period the time intervals ranged between 27 and 32 minutes. A variable number of birds spent the night on the spring but averaged 50 percent of the population present at the 2nd time interval before sunrise (Figure 12). The proportion of the mallard and black duck population on the spring increased at sunrise when there was an influx of birds from the lake. The composition of the incoming birds varied between 11 and 76 percent black

Figure 12. Average daily use of the spring by time intervals for the maximum number of birds estimated to be on the study area during 7 January through 12 February 1971.


Average Percent of Total Birds
0
10
20
30
40
50
60
70
80
90
100
Time Interval (30 ± 3 min.)
2
Sunrise
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
Sunset
1
2

ducks and averaged 49 percent black ducks. This suggests the black ducks tended to use the heated effluent to a greater extent at night than the mallards did. After sunrise the proportion of the population on the spring remained between 70 and 91 percent for the next 9 time intervals or about 4.5 hours (Figure 12). Starting about midday there was a steady decline in numbers on the spring until the 16th time interval or about 8 hours past sunrise when the value was 7 percent (Figure 12). The proportion began to increase once more during the 18th time interval or about 1 hour prior to sunset, and during the hour past sunset, increased to 25 to 45 percent of the population present on the spring (Figure 12).

The mean time for morning flights to the spring began about 0.2 hours after sunrise and peak movement (at least 10 birds per 5 minute period for two consecutive periods) occurred between 0.7 hours and 1.8 hours after sunrise (Table 8). All movement to the spring was completed 2.3 hours after sunrise. Light intensities during the morning period of movement was monitored indirectly by a pyrheliometer but the intensities were below the capabilities of the recorder as they also were at the time of evening return. Winner (1959) used a light meter and found a similar problem. During the morning hours, from daylight to the departure of feeding flights, the waterfowl preferred to utilize the spring area both years and under all weather conditions.

The behavior of the waterfowl at the spring was quantified for the morning period in the winter of 1970-71. At sunrise, approximately 55 percent of the birds were resting on the ice, 34 percent resting on the water, 2 percent actively swimming, and 9 percent engaged in social display (Figure 13). During the first hour after sunrise, the number of birds in the water increased to 66 percent and social display increased to 10 percent. This period coincided with the coldest time of the day

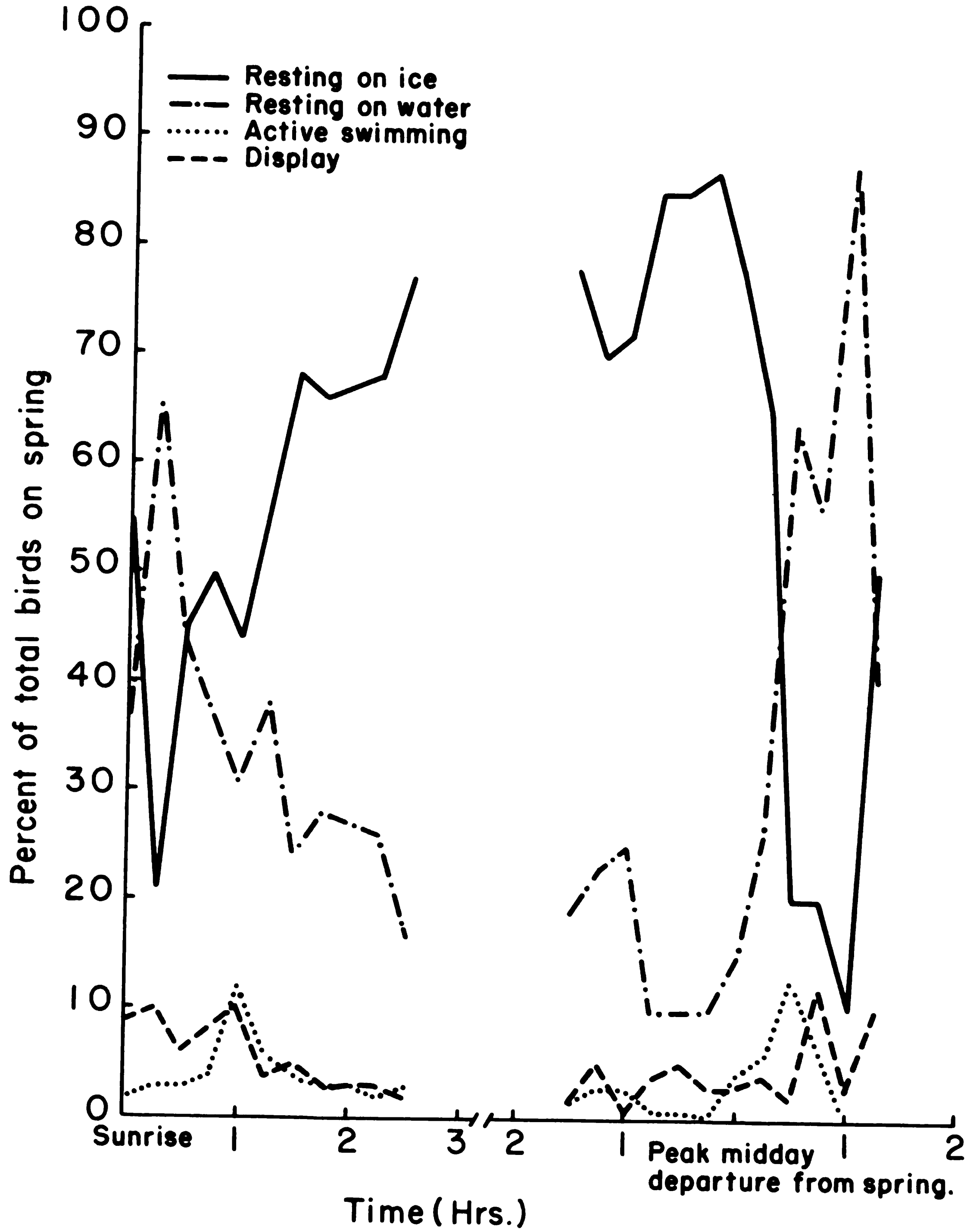
Table 8. Time of movements to and from the spring by mallards and black ducks during the peak winter concentration period from January 7 through February 18, 1971.

Movements	N	Time of Movement (Hrs.) Mean±S.D.	Range Min.	Range Max.
Hours after sunrise				
Start of flights from lake to spring	9	0.2 ± 1.3	+0.7*	3.1
Start of peak flights from lake to spring	9	0.7 ± 0.2	+0.7	3.1
End of peak flights from lake to spring	9	1.8 ± 1.7	0.0	4.0
End of flights from lake to spring	9	2.3 ± 1.8	0.0	4.0
Hours before sunset				
Start of feeding flights from spring	10	5.9 ± 1.8	3.0	8.4
Start of peak feeding flights from spring	9	4.8 ± 1.7	2.8	7.3
End of peak feeding flights from spring	7	3.4 ± 1.9	1.8	6.4
End of feeding flights from spring	7	2.5 ± 1.5	1.3	4.8
Start of return to spring from feeding	9	3.3 ± 2.2	1.0	7.0
Start of peak return to spring from feeding	9	1.3 ± 1.5	-0.1**	5.0
End of peak return to spring from feeding	9	0.2 ± 1.7	-1.0	4.5
End of return to spring from feeding	9	-0.3 ± 0.5	-1.0	0.5

* plus signifies hours before sunrise

** minus signifies hours after sunset

Figure 13. Activity of mallards and black ducks on the spring in the morning after sunrise and prior to feeding flights.


100
90
80
70
60
50
40
30
20
10
0
Percent of total birds on spring
Resting on ice
Resting on water
Active swimming
Display
Sunrise
1
2
3
2
1
Peak midday departure from spring.
1
2
Time (Hrs.)

and also with the arrival of birds from the lake. During the period of the behavioral observations the temperature during the first hour ranged from 6° to 40° F and the chill factor (the resultant of the temperature and wind speed) ranged from -24° to 24° F. No relationship was observed between the temperature on that morning with the relative number of birds engaged in social display, resting on water, or resting on ice (Table 9). However, the rate of increase in temperature between 0700 and 1000 hours seemed to be directly related with an increase of birds resting on the ice (Table 9). At least two possible explanations are; the temperature change may disturb the birds sufficiently to cause the activity change, or the temperature change may be a stimulus that causes the birds to expand beyond the confines of the spring and the intraspecific pressures exerted there. There was also significant correlations between the proportion of birds participating in social display on the spring during the first hour after sunrise with environmental factors averaged over the 3 previous days. The proportion of birds engaged in social display increased with the average minimum and maximum temperatures on the previous 3 days (Table 9). Raitasuo (1964) also found the increase in display to be related to the increase in temperature and decrease in wind on preceeding days. The relative proportion of birds resting on the ice or water was not related significantly to any of the preceeding 3-day temperature or wind averages (Table 9). Although the relationship of social display, resting on the water, resting on the ice, and other behavioral activities with environmental factors is very complex and probably influenced by many factors, temperature, wind, and the resultant of temperature and wind (chill factor) do appear to be related with the amount and type of activity observed during the first hour after sunrise.

Table 9. Simple correlations of behavioral activity by mallard and black ducks with environmental factors.

				Percent of Birds			
				At spring during 1st hour after sunrise			
		Min. time on spring in the morning	Min. time on spring in the afternoon	Participating in social display	Resting on water	Resting on ice	Spending night at lake 1970 & 71
Temperature - 0700 hours	r	-.43	.30	.26	-.21	.00	--
	n	8	8	6	6	6	
Chill factor - 0700 hours	r	-.11	.35	.28	-.21	.00	--
	n	8	8	6	6	6	
Ave. temp. during 1st. hr. after sunrise	r	--	--	.38	-.07	-.15	--
	n			6	6	6	
Ave. chill during 1st. hr. after sunrise	r	--	--	.37	-.08	-.15	--
	n			6	6	6	
Change in temp. from 0700-1000 hours	r	-.41	.25	-.53	-.59	.77*	--
	n	8	8	6	6	6	
Change in chill from 0700-1000 hours	r	-.26	-.13	.33	-.52	.20	--
	n	8	8	6	6	6	
Temperature - 1300 hours	r	-.09	.10	--	--	--	.44
	n	8	8				21
Chill - 1300 hours	r	-.25	.38	--	--	--	.29
	n	8	8				21
Temperature - 1600 hours	r	--	--	--	--	--	.50*
	n						21
Chill - 1600 hours	r	--	--	--	--	--	.42*
	n						21
Temperature - 1900 hours	r	--	--	--	--	--	.62*
	n						21
Chill - 1900 hours	r	--	--	--	--	--	.48*
	n						21
Day's average temperature	r	-.39	.25	--	--	--	.61**
	n	8	8				21
Day's average chill	r	-.28	.27	--	--	--	.36
	n	8	8				21
Preceeding day's average temperature	r	-.30	.72*	.69	.25	-.52	--
	n	8	8	6	6	6	
Preceeding day's average chill	r	-.41	.70*	.62	.25	-.52	--
	n	8	8	6	6	6	
3 preceeding day's average maximum temp.	r	-.25	.75*	.77*	.27	-.56	.17
	n	8	8	6	6	6	21
3 preceeding day's average chill based	r	-.26	.85**	.68	.28	-.54	.15
on maximum temp. and resultant wind	n	8	8	6	6	6	21
3 preceeding day's average minimum temp.	r	-.18	.61	.81*	.36	-.59	.09
	n	8	8	6	6	6	21
3 preceeding day's average chill based	r	-.35	.69*	.74*	.15	-.45	.06
on minimum temp. and resultant wind	n	8	8	6	6	6	21
3 preceeding day's average wind speed	r	.29	-.64*	-.44	-.25	.43	-.07
	n	8	8	6	6	6	21
No. of days of limited open water	r	-.41	-.07	.33	-.36	.16	-.08
	n	8	8	6	6	6	21
Minimum time away from spring in the	r	-.74*	--	--	--	--	--
the afternoon	n	8					

* p < .10
** p < .05

The proportion of birds resting on the ice increased to 87 percent and social display dropped to 2 percent during the mid-morning (Figure 13). As the time for midday departure from the spring approached the birds moved into the water and social display increased to 12 percent. The majority of the birds departed from the water rather than the ice.

Poor visibility generally prevailed at the lake during the early morning and behavioral activity could not be accurately described. During this post sunrise period the majority of the waterfowl appeared to be on the water. Later in the morning when visibility improved it was found that most of the waterfowl were resting on the ice. Social display seemed to be more frequent among the birds on the spring when compared to the lake. Raitasuo (1964) found the peak social display in the warmer brighter times of day such as midday and early afternoon. In this study the increase in display was observed at the spring during both early morning and in the midday before leaving to feed. Raitasuo (1964) also found greater social display on greater expanses of open water. Although the area of open water at the lake was larger by at least 6 acres, display was not as frequent; and factors other than the size of the area apparently influenced the number of birds that displayed.

The mean start of feeding flights was 5.9 hours before sunset, peak movement away from the spring occurred between 4.8 hours and 3.4 hours before sunset, and feed flights ended by 2.5 hours before sunset (Table 8). Although there was no apparent relationship between absolute light intensity and departure from the spring, the birds did tend to leave at the brightest time of the day. There was an inverse relationship between the amount of time spent on the spring in the morning and the length of time away in the afternoon (Table 9). The length of time on the spring in the morning did not appear to be related to a decrease in temperature and an increase in the chill factor on that day or preceeding days. The time away from the spring in the afternoon also was not related to the temperature or chill factor on that day when the flight occurred, but there were significant correlations between the increase in the length of time away from the spring and increases in the previous day average temperature or chill factor, the preceeding 3-day average maximum temperature, the 3-day average chill based on maximum temperature, 3-day average chill based on minimum temperature and 3-day average wind speed (Table 9).

Food was not available at the spring since most of the chara beds surrounding the spring were covered with ice and only when there was a thaw over a portion of these beds was any feeding observed. Corn, sugarbeets, and soybeans were the main agricultural crops on the surrounding farmland. The birds tended to feed in large groups on inland corn fields; based on my observations and reports from area residents. Both unharvested corn fields and corn fields with waste grain from mechanical pickers were utilized by the birds. Occassionally small numbers of birds were observed in soybean fields. Snow did not appear to interfere with feeding. The maximum depth on the ground during January and February was 8 inches and 3 inches respectively in 1970, and 2 inches and 3 inches respectively in 1971 (U.S. Dept. of Commerce, 1970 and 1971). The mean monthly snow fall from 1930-1959 in January was 6.8 inches, and 6.2 inches in February (U. S. Dept. of Commerce, 1960). The closest the birds were found to feed was in an unharvested corn field 2.5 miles north of the spring. This field was believed to be used for at least 7 days by 5,000 mallards and black ducks. The farthest away the birds were observed feeding was 11 miles north of the springs. Bossenmair and Marshall (1958) report mallards flying up to 12 miles to feed but averaged 3 to 4 miles.

The wintering flock made one flight to the grain fields per day. Bellrose (1944), Bossenmair and Marshall (1958), and Hochbaum (1955) report fall feeding flights to upland areas tend to be in two daily periods, once in the morning and once in the afternoon. Winner (1959) also reports feeding flights in south central Ohio were concentrated in the same two periods during the months of November, December, and January. The cold weather may be influencing the birds on this study area to make only one feeding flight per day. Bossenmair and Marshall (1958) and Hochbaum (1955) do indicate that during colder weather there were early afternoon feeding flights, and Bellrose (1944) reported that in below freezing weather the birds made only one flight during the midday.

Return to the spring from the midday feeding flights started at a mean time of 3.3 hours before sunset, peaked between 1.3 and 0.2 hours before sunset, and ended at 0.3 hours after sunset (Table 8). Birds spent the night on both the lake and the spring. The number of birds using each area appeared to be related to the temperature on that day. As the temperature decreased the percent of the birds on the lake decreased and increased at the spring (Table 9). The correlation coefficient increased from 1300 to 1900 hours suggesting that the temperature between 1600 and 1900 may be influencing their selection.

CONCLUSIONS

The spring and heated effluent are important habitat components for the wintering mallards and black ducks during the period of open-water limitation. The birds spent the night on either the spring or the lake. Temperatures on that day appeared to influence the decision with a higher proportion of the birds at the spring during cold weather. On all mornings the spring was used by a majority of the birds regardless of temperature and wind on that day or preceeding days. The relative number of birds engaged in social display during the early morning period on the spring increased when the temperature was warmer on preceeding days, but an increase in resting on the ice occurred under opposite conditions. The length of time away on the midday feeding flight also decreased during a series of cold days. It appears, during periods of cold weather, the birds conserve energy by less activity. There also appears to be a summation effect influencing behavioral activity and length of time away from the spring since temperature on the day of observations had a low correlation, but the average temperature over the preceeding days gave significant correlations.

The waterfowl in this study were wintering along the northern limits of suitable winter habitat. They were dependent on ice free water and an ample food supply. With the increase of thermal effluents, more areas will be ice free throughout the winter period. Hunt (1957) studied the mortality factors of wintering waterfowl on the Detroit River. During severe weather ice formed over food beds causing starvation. Parasites, disease, injuries, and contamination by municiple and industrial discharges caused death when in combination with the added stress of starvation and exposure due to severe weather. Many of the hazards to the birds are not lethal but may hinder other life processes such as reproduction.

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