Lake Erie Committee Meeting
March 29 - 30, 2000

SG-107-99

Foraging Movements of Cormorants in Western Lake Erie*

Martin Stapanian and Michael Bur
USGS, GLSC, Lake Erie Biological Station
6100 Columbus Ave., Sandusky, OH 44870

Tom Seamans and Brad Blackwell
USDA, Wildlife Services
6100 Columbus Ave., Sandusky, OH 44870

Jeff Tyson
Sandusky Fish Research Station
Ohio Department of Natural Resources
305 E. Shoreline Drive
Sandusky, Ohio 44870

Abstract

The population of Double-crested Cormorants (*Phalacrocorax auritus*), which has increased dramatically in recent years, has been a cause for concern by natural resource managers and fishers in western Lake Erie. A radiotelemetry study was conducted to describe the number and location of foraging flights in the western basin. Eighteen adult cormorants nesting on Middle Island, ON were successfully tracked from May through October 1999, using aerial and surface telemetry. Radio-tagged birds were found foraging, on average, 10.7 km from the colony on Middle Island. Approximately 73% of the 81 radio-tagged birds observed foraging were within 2 km of shore. Nearly all of the dispersal from the colony occurred between the hours of 07:00 and 15:00. In addition to radiotelemetry, the locations of 156 foraging flocks of cormorants were determined from regular census routes in the Western Basin. Flock size ranged from 1 to approximately 15,000 individuals. For flocks that did not contain radio-tagged individuals, the mean distance from nearest shore (1.87 km, sd = 1.13) was not significantly different from the mean observed for the radio tagged birds found with surface tracking. Based on available area, flocks of all sizes were found significantly more frequently than expected on water $\leq$10 m deep. The results were consistent with previous studies on foraging behavior of *P. auritus*.

* Reported to: Great Lakes Fishery Commission
Lake Erie Committee Meeting
Niagara on the Lake, Ontario
March 29 - 30, 2000

Provisional Data, not to be cited without permission

The effect of Double-crested Cormorants (*Phalacrocorax auritus*) foraging on Great Lakes fish stocks is a regional controversy. Double-crested Cormorants (DCCOs) feed almost exclusively on fish (Hobson et al. 1989; Ludwig et al. 1989, Orta 1992, Campo et al. 1993). Fishers on the Great Lakes are concerned that cormorants may have a negative impact on fish populations. In Ohio, sport anglers believe that DCCOs are depleting stocks of game fish (e.g., walleye, yellow perch, and smallmouth bass). Concern for the loss of fish in other Great Lakes has resulted in at least one incident of illegal population control that occurred on Lake Ontario in 1998. The DCCOs' rapid increase in population, coupled with their feeding habits, has the potential to affect fish stocks.

The objectives of this study were (1) to locate and quantify foraging flocks of DCCOs in a section of the western basin of Lake Erie, and (2) to estimate foraging range and temporal activity patterns of nesting cormorants. These data, coupled with available diet data, could then be used in a bioenergetics model to estimate annual consumption by cormorants and determine potential effects on prey fish stocks. Baseline data in the form of number of foraging trips and location of foraging areas could be valuable information for natural resource managers on Lake Erie and other lakes affected by cormorants. The ability to identify cormorant foraging areas may also assist in identifying temporal and spatial distribution of fish.

Methods

Between 19 April and 20 May 1999 we captured and radiotagged 20 DCCOs nesting in a colony on Middle Island, ON. The nests were all in trees on Middle Island and were typically 3-5 m above ground. All birds were captured with padded jaw leghold traps (King et al. 1998) placed at the edge of the nests. A VHF radio transmitter was attached to the back of each captured bird with an adjustable harness (Morris and Black 1980). Each transmitter was associated with a unique frequency (20 frequencies between 164.023 to 164.329 MHz). Two radio-tagged cormorants died during the study. Data from these birds were not included in the analyses.

We monitored presence/absence of the radio-tagged birds on Middle Island with a model R2100 receiver, a model DCCII data logger, and an omnidirectional antenna (Advanced Telemetry Systems, Inc., Isanti, MN). The logger was programmed to scan each frequency for 5 s during each 20-minute period. Data were downloaded at intervals ranging between 7 and 24 days. This continuous, remote monitoring was conducted between 26 April and 19 October 1999. Due to technical difficulties, data for a subset of radio-tagged birds were either missing or of questionable quality from 29 May through 4 June and from 11 June through 30 June. These data were eliminated from the analysis.

Surface observations were made from a boat at fixed coordinates along four census routes (Fig. 1) between 07:00 and 11:00 h. We completed six replicates of each census route between 15 July and 28 September 1999. All surface monitoring activity was conducted when average wave height was <1.5 m and wind speed <20 km/h. At each station we attempted to locate radio-tagged individuals with a hand-held Yagi antenna and receiver (model R2100, Advanced Telemetry Systems, Inc., Isanti, MN) using standard telemetry techniques (Mech et al. 1983). Each frequency was scanned for 8 s from the bow of the boat. When a radio-tagged bird was detected, we determined its geopositional location by moving the boat toward the signal. When there was visual confirmation of the bird, we recorded the coordinates as determined by the GPS receiver (Garmin GPS III-Plus, Garmin Corp., Olathe, KS). The activity of the bird (e.g., foraging, flying, loafing) and the size of the flock containing the radio-tagged bird were recorded. In this report, we only considered data from foraging flocks.

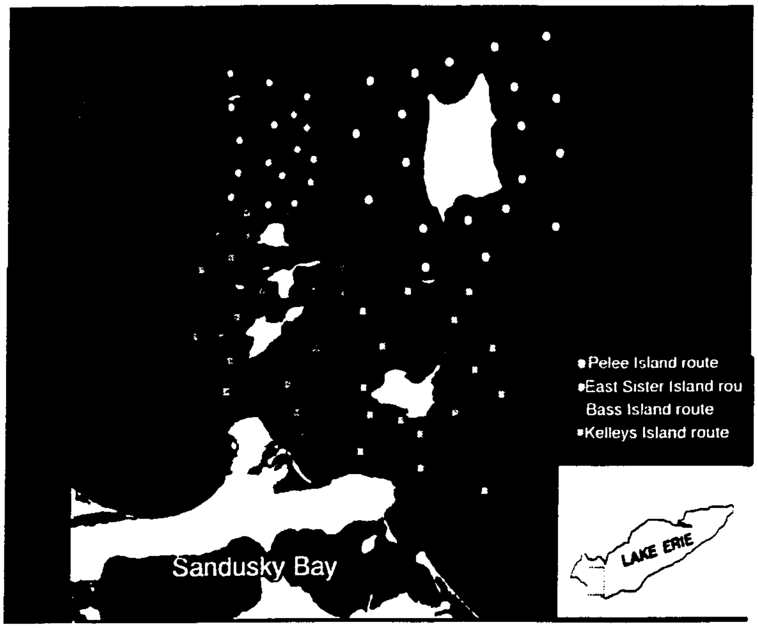

Figure 1. Location of open water radio telemetry monitoring stations at fixed coordinates along four census routes in western Lake Erie.

While tracking at each station and traveling between stations, we visually searched the area for flying DCCOs and DCCOs on the water. We made the simplifying assumption that cormorants on the water could potentially be foraging. The coordinates of each foraging flock were determined with the GPS receiver. We flew 13 aerial surveys between 1 June and 14 October 1999. On each survey we attempted to locate all of the radio-tagged birds. Tracking on each survey began over Middle Island. After we identified which radio-tagged birds were on Middle Island, tracking continued along north-south transects in the study area east of Middle Island. Each north-south transect was separated by approximately 0.8 km. We then returned to Middle Island and repeated our search on the island. Tracking resumed along north-south transects in the study area west of Middle Island.

We tested the null hypothesis that the number of flocks found in shallow and deep water was proportional to the respective areas of shallow and deep water in the study area. We defined "shallow" water in two ways: (1) less than or equal to the mean depth (rounded to 10 m) and (2) less than or equal to the median depth (8 m). We tested this hypothesis separately for four size classes of flocks (1-10, 11-100, 101-1000, and > 1000 individuals) and for all flock sizes combined. For each flock size, we performed separate analyses for the two definitions of shallow water. The expected number of flocks for a particular size class in "shallow" or "deep" water was equal to the number of flocks observed in that class multiplied by the proportion of the study area in that depth criterion. Bathymetry data were obtained from NESDIS (1999). Areas of the depth contours were calculated with Albers' equal-area projection on ArcView after overlaying the bathymetry data onto the ArcView software (ArcView 1999). We rejected the null hypothesis when the probability of the test statistic was less than 0.05.

Results

Presence/absence.

There was considerable variance among individual radio-tagged DCCOs for the proportion of time spent on Middle Island during this study. Therefore, we report data for four individuals (Fig. 2) that were representative of the variance observed. By 19 October, only two of the radio-tagged cormorants were recorded as "present" on Middle Island, and monitoring ceased. For nearly all birds, time spent on Middle Island had dropped off sharply by early September.

Similarly, there was considerable variance in the proportion of time that cormorants were recorded on Middle Island for different hours of the day (Fig.3). For convenience sake, we partitioned the data collected on Middle Island into four intervals of 40-50 days: (1) 26 April-11 June, (2) 12 June-22 July, (3) 23 July-7 September, and (4) 8 September-19 October. These intervals roughly correspond with (1) nesting, incubation, and hatchling; (2) nestling and prefledging; (3) fledging and post-fledging; and (4) premigration/migration phases, respectfully (Mendall 1936). In general, cormorants were least often recorded as "present" between the hours of 07:00 and 15:00 in all of the four time intervals. In many cases, there was a slight increase in the proportion of time on Middle Island between

11:00 and 13:00. Generally, cormorants spent a larger proportion of the time on Middle Island during intervals (2) and (3) than (1) and (4).

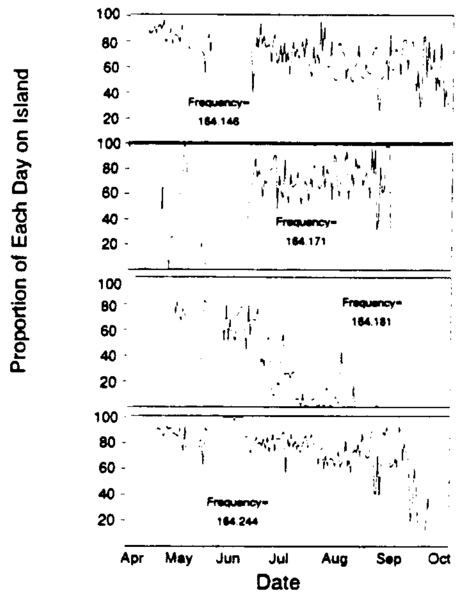

Figure 2. The proportion of time spent on Middle Island by four adult cormorants with radio transmitters between 26 April and 19 October.

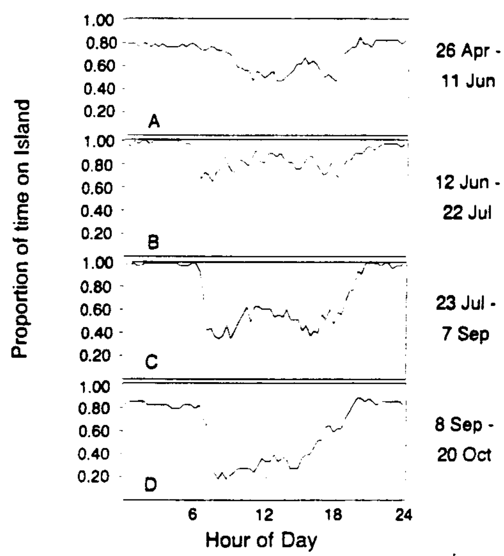

Figure 3. The proportion of time that an adult cormorant with radio transmitter was recorded on Middle Island for different hours of the day from 26 April to 20 October.

Surface and Aerial Observations.

In approximately 96 h of tracking by boat and approximately 28 h of aerial tracking, we located 42 and 39 radio-tagged birds, respectively, foraging away from Middle Island (Table 1). In all cases, the radio-tagged birds were within 5 km of shore. The mean and median ranges from Middle Island were approximately 11 km. On a typical aerial or boat survey, more than 75% of the radio tagged birds were located on or within 1 km of Middle Island.

Table 1. Distances (km) that radio-tagged DCCOs were found from the nesting colony on Middle Island, ON and from the nearest shore, using aerial (n = 39) and surface (n = 42) telemetry.

	Aerial	Surface
From Middle Island		
Mean (s)	10.65 (7.77)	10.70 (3.68)
Median	11.2	11.4
Maximum	30.3	17.1
From Nearest Shore		
Mean (s)	1.37 (0.83)	1.72 (1.27)
Median	1.1	1.3
Maximum	3.4	4.4

We located 156 flocks of DCCOs that were presumed to be foraging (Table 2, Fig. 4) during surface observations. Flock size ranged from 1 to approximately 15,000 individuals. The combined set of flock size classes were found more frequently than expected, based on available area, in water $\leq$10 m deep (Table 3). All size classes combined and flocks with more than 100 individuals were found more frequently than expected in water $\leq$8 m deep. There was a marginally significant difference in the mean depths for the four classes of flock size (Table 3: ANOVA, $F_{3,153} = 2.44$, $p = 0.067$). However, there was greater error in locating the center of flocks with >1000 individuals than for smaller flocks. Thus, the small differences in mean depth for this class may in part be due to measurement error.

Table 2. Number of flocks observed at 2-m depth intervals. Total surface water area in this study = 1196.87 km².

Observed number of flocks						
		Flock Size				
Depth Interval (m)	Area (km²)	1-10	11-100	101-1000	> 1000	Comb
0-2	27.513	1	1	0	0	2
3-4	35.793	5	4	3	1	13
4-6	94.216	3	6	2	7	18
7-8	182.769	17	9	6	2	34
9-10	372.591	31	22	9	3	65
11-12	376.545	9	11	0	0	20
13-14	103.936	1	1	1	0	3
15-16	3.499	1	0	0	0	1
Mean depth		8.54	8.63	8.00	6.69	8.34
s		2.43	2.60	2.57	1.97	2.51
Median depth (m)		9	10	8	6	9

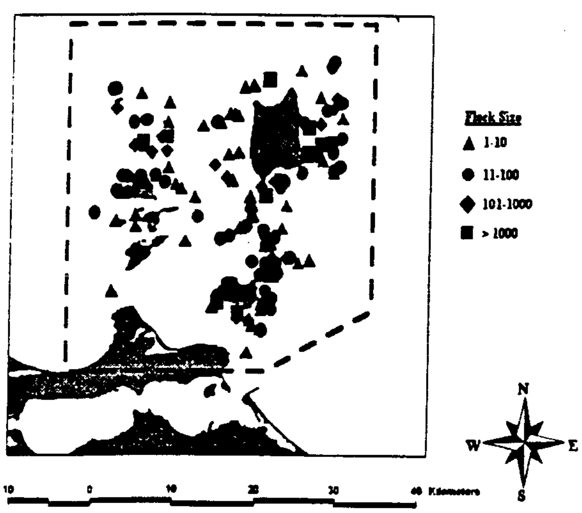

Figure 4. Location of foraging flocks, including cormorants with radio transmitters in western Lake Erie.

Table 3. Tests of the null hypothesis that foraging flocks of cormorants occur proportionately to available area, in shallow and deep water. Separate tests were performed for which "shallow" water was defined as (1) less than or equal to the median depth of 8m and (2) less than or equal to the mean depth of 10m. For the flock size class of >1000 individuals, probability was calculated with the binomial distribution. For the remaining size classes, the values of a Chi-square test with 1 degree of freedom are presented.

Flock Size	Criterion for shallow depth	
Class	≤ 8m	≤ 10m
1-10	3.21 +	16.62**
10-100	1.96 ns	7.44**
100-1000	5.92*	11.02**
> 1000	**	**
Combined	16.16**	40.65**

Symbols: + = $0.10 < p < 0.05$; * = $p < 0.05$; ** = $p < 0.01$; ns = $p > 0.10$.

Discussion

Our results for presence/absence on Middle Island were consistent with those reported in earlier studies. Mendall (1936) found that DCCOs are most active in the morning and early afternoon. Other researchers (Lewis 1929, Mendall 1936, and Dunn 1975) found that DCCOs fed young each day not before 06:00 and ended at 20:00 EDT. Average meal weights increase with age of the young in at least two species of cormorant (Dunn 1975, Wanless et al. 1992). Therefore, it was expected that cormorants spend more time at the colony during the nestling through fledgling stages than during the pre-migration and pre-hatchling stages. The differences between the curves in Fig. 3B and 3C are consistent with the observation that DCCOs require more foraging time to satisfy the metabolic demands of larger young.

Earlier studies suggest that DCCOs are highly selective in their feeding habitat. According to Mendall (1936), DCCOs generally feed in water <9 m deep. Palmer (1962) stated that cormorants feed over a wide range of depths, but typically less than 10 m. More than 80% of feeding flights observed by Custer and

Bunck (1992) were to water <9.1 m deep. Water depths ≥ 9.1 m were used significantly less than available for both colonies studied by Custer and Bunck (1992). Wanless et al. (1990) found that a related species (*Phalacrocorax aristotelis*) utilized $<11\%$ of the available habitat for foraging during chick rearing. In that study, the mean ($\pm$ s.d.) foraging range was 7.0 ± 1.9 km, with a maximum of 17 km from the colony. Therefore, the results of the present study are consistent with those reported previously.

Bur et al. (2000) found that gizzard shad, emerald shiner, and freshwater drum were the three most important prey items for cormorants on Lake Erie. Although freshwater drum is demersal, gizzard shad and emerald shiner are pelagic. Bur et al (1999) found no significant association between the locations of flocks of foraging cormorants and the historical densities of the fish species in Lake Erie. However, those results should be interpreted with caution. The spatial distributions in that study were estimated from data obtained exclusively from bottom trawls. Although bottom trawl data are useful in estimating spatial distribution of pelagic fish, the absolute densities of pelagic fish species may be underestimated.

This study was limited to near-shore (i.e., within 15 km) observations of DCCOs. Further study should include more open-water habitats and a better understanding of the population dynamics of DCCOs in the Great Lakes. A sound management plan for cormorants in Lake Erie requires more detailed studies of the associations between locations of foraging flocks of cormorants and densities of fishes.

References

ArcView. 1999.

Bur, M., J. Bales, C. Muzinic, M. Stapanian, S. Tinnirello, B. Blackwell, T. Seamans, and J. Tyson. 1999. Frequency and distance of foraging trips from a Western Lake Erie cormorant nesting colony. Proceedings of the 61st Midwest Fish and Wildlife Conference. Chicago, IL. P. 260.

Bur, M., S. Tinnirello, C. Lovell, and J. Tyson. 2000. Diet of the double-crested cormorant in western Lake Erie. U.S.D.A. Technical Publication. *In press*.

Campo, J.J., B.C. Thompson, J.C. Barron, R.C. Telfair II, P. Durocher, and S. Gutreuter. 1993. Diet of double-crested cormorants wintering in Texas. *Journal of Field Ornithology*. **64**:135-144.

Custer, T.W. and C. Bunck. 1992. Feeding flights of breeding Double-crested Cormorants at two Wisconsin colonies. *Journal of Field Ornithology* **63**:203-211.

Hobson, K.A., R.W. Knapton, and W. Lysack. 1989. Population, diet, and reproductive success of double-crested cormorants breeding on Lake Winnipegosis, Manitoba, in 1987. *Colonial Waterbirds* **12**: 191-197.

King, D.T., J.D. Paulson, D.J. Leblanc, and K. Bruce. 1998. Two capture techniques for American White Pelicans and Great Blue Herons. *Colonial Waterbirds* **21**:258-260.

Lewis, H.F. 1929. Natural history of the Double-crested Cormorant (*Phalacrocorax auritus auritus*) (Lesson). Ru-Mi-Lou Books, Ottawa.

Ludwig, J.P., C.N. Hull, M.E. Ludwig, and H.J. Auman. 1989. Food habits and feeding ecology of nesting double-crested cormorants in the upper Great Lakes, 1986-1989. *Jack Pine Warbler* **67**:117-129.

Mendall, H.L. 1936. The home-life and economic status of the Double-crested Cormorant *Phalacorax auritus auritus* (Lesson). *Maine Bulletin* **39**:1-158.

Morris, R.D. and J.E. Black. 1980. Radiotelemetry and Herring Gull foraging patterns. *Journal of Field Ornithology* **51**:111-118.

National Environmental Satellite, Data, and Information Service. 1999. Bathymetry of Lake Erie and Lake Saint Clair. Volume G1 Version 1.0. U.S. Department of Commerce, National Oceanic and Atmospheric Administration.

Orta, J. 1992. Family Phalacroncoracidae (cormorants). *In* Handbook of birds of the world. Vol. 1, *Edited* by J. del Hoyo, A. Elliot, and J. Sargatal. Lynx Edicions, Barcelona. Pp.326-353.

Palmer, R.S. 1962. Handbook of North American birds. Volume 1. Yale University Press, New Haven, Connecticut. 567 pp.

Wanless, S., M.P. Harris, and J.A. Morris. 1991. Foraging range and feeding locations of Shags (*Phalacrocorax aristotelis*) during chick rearing. Ibis **133**:30-36.