Intercolony and Regional Movements of Double-crested Cormorants Breeding In Eastern Lake Ontario- Research Report for 2000 and 2001

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This report provides preliminary findings on the research activities associated with a cooperative research study between USDA's National Wildlife Research Center and the New York State Department of Environmental Conservation (Cooperative Service Agreement Number 00-7407-0399 [RA]).

Abstract: The Double-crested Cormorant (*Phalacrocorax auritus*) is the most numerous and most widely distributed of the six North American cormorants. In the Great Lakes, nesting pairs of Double-crested Cormorants (cormorants) have steadily increased from approximately 38,000 in 1991, to 115,000 pairs in the 2000 breeding season. Due to declines in fish populations and reports that cormorants have negatively impacted populations of smallmouth bass and other fishes in Lake Ontario, the New York State Department of Environmental Conservation (NYSDEC) has been conducting control activities at cormorant breeding colonies in eastern Lake Ontario. We initiated a two-year (2000-01) satellite telemetry study (n = 26 per year) in May 2000 to evaluate cormorant emigration, reproductive success, nest-site fidelity, and site-specific foraging distribution following control activities at Little Galloo Island (LGI) in western New York. Preliminary insights indicate approximately 39% of cormorants left LGI during egg oiling activities, most noticeably during the last two weeks of egg oiling. Although, cormorants may move from LGI during control activities they predominantly remained in eastern basin of Lake Ontario. Of all the cormorants that moved both during and after control activities only three (~13%) remained in the vicinity of active breeding colonies outside of the eastern basin for long enough to potentially reproduce. The mean departure date for southerly migration was ~ 6 September. Data collected thus far indicate ~ 77 % of cormorants telemetered from LGI traveled east of the Appalachian Mountains, primarily along the Atlantic and gulf coast. The remaining 23% traveled west of the Appalachian Mountains. The winter distribution of cormorants captured on LGI extends along the southern Atlantic coast to as far south as the Florida Keys and West along the Gulf of Mexico to southeastern Louisiana. The study is ongoing and further information is being collected on intercolony movements and annual site fidelity within the eastern basin to evaluate effectiveness of control efforts. If the ultimate results of this study indicate that breeding colony control efforts are effective, the distribution and abundance of breeding cormorants could be managed using colony controls (e.g., culling, nest destruction, egg oiling) at breeding colonies throughout the United States.

Background and Justification

The Double-crested Cormorant (*Phalacrocorax auritus*) is the most numerous and most widely distributed of the six North American cormorants (Hatch and Weseloh 1999). Double-crested cormorants (cormorant) have been observed to breed in nearly each state and Province east of Texas and Manitoba (Wires et al. 2001). Cormorants traditionally (late 19th and early 20th centuries) bred in the northern United States, including the Great Lakes region of the U.S. and Canada, and wintered in the Gulf Coast region (Lewis 1929; Wires 2001).

Increases in cormorant numbers have been dramatic since 1975 with numbers in large regions having doubling times of < 5 years (Hatch and Weseloh 1999). Conservative estimates of the total population

of cormorants in the United States and Canada is greater than 1 million birds, including breeding and non-breeding individuals, but is probably closer to 2 million (Hatch and Weseloh 1999, Tyson et al. 1999). While the overall rate of growth in the United States and Canadian populations slowed during the early 1990s (Tyson et al. 1999), there are still significant population increases occurring in some areas. In the Great Lakes, cormorants probably reached a low of around 200 nesting pairs sometime between 1968 and 1973 (Ludwig 1984). Nesting pairs steadily increased to approximately 38,000 in 1991 (Weseloh et al. 1995), 93,000 in 1997 (Tyson et al. 1999), and 115,000 pairs in the 2000 breeding season (D.V.C. Weseloh, unpublished data).

Increases in cormorant numbers in the Great Lakes region since 1975 have been attributed to reduction in environmental contaminants, regulatory protection of the species, and changes in fish communities (Hatch and Weseloh 1999; Glahn et al. 2000). Changes in fish communities have been affected by numerous factors including lake eutrophication, introductions of non-native fish, and commercial and recreational fishing. Declines in commercial and recreationally important fisheries since the early 1980's have been documented for many Great Lakes fisheries (MDNR 1997; Schneider et al. 1999).

A number of factors have been suggested for the decline in Great Lakes fisheries including increases in cormorant numbers, growth and population overfishing, and the recent invasion of zebra and quagga mussels which have caused a dramatic decrease in nutrient availability in the Great Lakes region (MDNR 1997; Schneider et al. 1999). All-time low abundance of some fish species was observed in Lake Ontario by 1995, causing particular concern among recreational anglers and fisheries managers in the region (Schneider et al. 1999). A series of studies conducted by New York State Department of Environmental Conservation (NYSDEC), indicated that cormorants have an impact particularly on smallmouth bass (*Micropterus dolimieu*) numbers in the eastern basin of Lake Ontario (Schneider et al. 1999).

Due to the declines in fish populations and reports that cormorants have negatively impacted populations of smallmouth bass and other fishes in Lake Ontario (Schneider et al. 1999), NYSDEC has been controlling cormorant breeding at breeding colonies in eastern Lake Ontario. Control activities have been conducted on Gull and Bass Islands, New York since 1994. The NYSDEC has also conducted control activities at Little Galloo Island from May 1999-2001. To supplement the NYSDEC efficacy assessment for these management actions, we have monitored the movements of cormorants following colony control activities at Little Galloo Island, NY (LGI) since 2 May, 2000.

The present report provides preliminary insight regarding the breeding and wintering distributions of cormorants captured at LGI. The overall objectives of the study are to; (1) evaluate the effects of the control activities on movements of cormorants from Little Galloo Island (LGI), NY, following May-July (2000 and 2001) control activities, 2) evaluate possible effects of May-July (2000 and 2001) control activities on reproductive success of cormorants from LGI, (3) evaluate annual site fidelity to LGI, (4) evaluate migratory movements of cormorants from LGI, (5) evaluate the foraging distribution of cormorants dispersed from Little Galloo Island in years following breeding control activities and it's association with physical characteristics and temporal and spatial associations with fish assemblages in the Eastern Basin of Lake Ontario.

Methods

Capture and PTT Attachment

We captured twenty-six cormorants by using modified leghold traps (King et al. 1998; 2000) on Little Galloo Island on 7 May 2001, providing a total of 52 birds telemetered for both 2000-2001. Morphometric measurements to determine sex (Glahn and McCoy 1995) were taken on all cormorants as described by Werner et al. (2001) except for central retrice width (0.1 mm precision) which was included in 2001 for gender identification as described by Bedard et al. (1995). An aluminum leg band was attached to the left tarsus, and an orange (plastic) band with a black, alpha-numeric code was attached to the right tarsus of all captured cormorants prior to release (Werner et al. 2001). A backpack harness (adapted from Dunstan 1972; King et al. 2000) was used to attach satellite

platform terminal transmitters (PTTs) on all cormorants.

In May 2001 we used a 30 g (< 2.0% bird weight) satellite in view (SiV) PTT-100 (Microwave Telemetry, Inc., Columbia, MD). These PTT's were approximately 15 g lighter than PTT's used in 2000 (Werner et al. 2001). Due to problems associated with water pressure induced fractures to the PTT's used in 2000 (Werner et al. 2001), the PTT's used in 2001 were reinforced to withstand greater diving depths. Transmitters were programmed to transmit approximately 6 hr each 48 hr from May-September 2001 and 6 hr each 10 days from October 2001 and September 2001. The PTT packages using the described programming had an expected longevity (battery life) of approximately twelve months.
Birds were located using NOAA satellites with onboard tracking equipment operated by Service Argos Inc. (Landover, Maryland). The data temporarily stored on satellites were sent to ground telemetry stations and were subsequently forwarded to us via electronic mail. Locations in latitude and longitude in decimal degrees, date time, location error, and other data were received from ARGOS within 24 h of satellite contact. Location error was reported by Service Argos as one of six location classes (LC): LC3 = <150m, LC2 = 150-350 m, LC1 = 350 –1000 m, LC0 > 1000 m LCA and LCB = no estimate of location accuracy

Data Analyses
We used PC-SAS ARGOS Filter Version 2.4 developed and described by Douglas (2000) to filter and reformat all ARGOS location data to DBASE files. The program uses two location filtering methods 1) a user defined distance to determine locational redundancy and 2) distance, rate and angle measurements designed to filter erroneous locations. The user specified information for the redundancy and rate filters include flight speed (40 km/h; rate) and daily movement of 60 km/day from Custer and Bunck (1992). Location data were analyzed, entered into databases, and plotted using ArcView PC-GIS system (Environmental Systems Research Institute Inc., Redlands, California).

We used Animal Movement Analysis ArcView Extension (Animal Movement; Hooge and Eichenlaub 1997) to determine home range centroids (the geometric center of the defined home range) for filtered data for each cormorant for which we had a suitable number of locations (Hooge and Eichenlaub 1997). Home range centroids were determined for each of these birds for a two week period prior to egg oiling (control) and for each of 4 two week periods following the initiation of egg oiling (treatment). We evaluated effects of egg oiling on resulting shifts in distance (km) of cormorant home range centroids from Little Galloo Island using a one-way ANOVA. Duncan's multiple range test was used to determine significant ($P < 0.05$) differences between group means. In addition, we used Animal Movement to develop 85% kernal home ranges (Hooge and Eichenlaub 1997) for cormorants that moved from the Eastern Basin of Lake Ontario during control activities. The 85% kernal home range is the area that contains 85% of the best location data points.

We used PC-SAS ARGOS Filter Version 2.4 to develop a subset of ARGOS locations containing the best location for each bird for each transmitting period based on previously described filtering criteria and all LC3 location classes (Douglas 2000). These data were then used to plot and qualitatively describe intercolony movements and migratory paths of cormorants for which we currently have both summer and winter locations. We qualitatively evaluated intercolony movements by whether cormorant activity moved away from LGI during egg oiling or they had $\geq$ 3 months near an active breeding colony (Wires et al 2001). Hatch and Weseloh (1999) indicate a minimum of approximately 3 months is necessary to successfully nest and raise young to independence from parental care.

Best daily location data were also used to determine mean departure date for southerly migration and site fidelity to LGI in subsequent years. Departure date for migration was defined as the mean date between the last signals in or North of Lakes Ontario, Erie, Oneida and Onondaga and the first signal date south of these lakes (Martell et al. 2001). Animal Movements was used to develop 85% kernel home ranges for cormorants that spent $\geq$ 3 months at sites outside the eastern basin of Lake Ontario subsequent to control activities in 2000-01 (1 July to 1 September).

Results

Twenty-six cormorants were transmittered in May 2001 bringing the total number of transmittered cormorants for both years to 52 individuals. The last transmittal date for birds telemetered on 2 May 2000 was 13 Oct. 2001. The mean ($\pm$ SE) number of days for which signals were received for birds telemetered in 2000 was 153 $\pm$ 35 (N=26, min = 6, max = 529). As of 30 Nov. 2001 we were receiving signals from 10 of the 26 birds telemetered in 2001. Because we are still receiving data from at least 10 birds the following analyses should be considered preliminary insights into cormorant movements on Lake Ontario.

Control activities (egg oiling) were conducted by NYSDEC on LGI from 16 May to 28 June 2000, and from 15 May to 26 June 2001. Mean distance (m) from home range centroids to Little Galloo Island differed with respect to egg oiling ($F_{4, 213}$ =2.50, P=0.044). There was a significant (Duncan's P<0.05) difference between the last two weeks of control activities and all other periods. Plots of all cormorant locations during control activities indicate that cormorants may move from LGI but the majority do not leave the Eastern Basin of Lake Ontario during control activities (Fig. 1).

We plotted and qualitatively evaluated movement data for 23 cormorants for which we had data up to the point of their southerly migration, nine (39%) of these moved away from LGI during control activities. Of the nine birds that moved during control activities and did not return, two (9%) moved out of the eastern basin. Of these two birds, one moved to Western Lake Erie, from 18 June to 30 September, 2001 (Fig 2) the other moved to the Presqu'Ile area of Lake Ontario, from 6 June to 28 July and then near Sandusky Bay, Lake Erie from 8 August to 14 September 2001 (Fig. 3).

Plots of locations of cormorants following control activities in 2000-01 (1 July- 1 September) indicate most cormorants stayed in the eastern basin (Fig 4). However, nine (39%) of 23 cormorants emigrated from the eastern basin and stayed for extended periods in other areas following control activities. Five of these cormorants moved to Lakes Oneida, Onondaga, and Erie, two moved to the St. Lawrence River near Lake Ontario, two to the St. Lawrence River near Montreal, Canada, and one to the Presqu'Ile area of Lake Ontario (Fig 4). Of all the cormorants that moved both during and after control activities three (13%) remained in the vicinity of active breeding colonies outside of the eastern basin for > 3 months, two on the St. Lawrence River near Montreal, and one on West Sister Island at the western end of Lake Erie (Fig. 2 & 5).

Mean dates of departure from breeding areas occurred over a 16 week period ranging from 12 July to 30 October. The mean departure date was 6 September (N=23, SE=35 d). Seventy-seven percent (N=22) of cormorants telemetered from LGI traveled east of the Appalachian Mountains, primarily along the Atlantic and gulf coasts (Figure 6). The remaining 23% traveled west of the Appalachian Mountains (Figure 6). The winter distribution of cormorants captured on LGI extends along the southern Atlantic coast as far south as the Florida Keys and West along the Gulf of Mexico to southeastern Louisiana (Figure 6).

Although three PTT packages transmitted data through the subsequent breeding season, only one cormorant returned to summer breeding grounds. This cormorant had almost identical 85% kernel home ranges as in the previous year (Figure 7). This bird spent the early part of the nesting season at LGI, and moved to the St Lawrence River late in the season both years. Two of the three cormorants PTT's continued to transmit from the same locations on their wintering grounds. These cormorants were presumed to have either shed their harnesses or died.

Discussion

These preliminary data suggest that control activities influence the use of Little Galloo Island (LGI) by breeding cormorants. Our data indicate that approximately 39% of breeding cormorants left LGI during egg oiling. This finding is supported by VHF telemetry data indicating that control activities on LGI cause approximately 40% of cormorants to leave LGI (Mazzocchi unpublished data). Although some cormorants moved from LGI, there was no significant shift in distance between home range centroids and LGI until the final week of egg oiling. This combined

with information on the > 95% reduction in reproductive success due to egg oiling efforts (Mazzochi unpublished, McCullough pers. comm.) suggests that cormorant movements during control activities resulted from unsuccessful nesting attempts rather than simple disturbance, or both.

Although these data indicate some cormorant home ranges may shift away from LGI in later stages of control activities, our data also indicate they do not leave the eastern basin of Lake Ontario during this time period (Fig. 1).Only three cormorants remained over 3 months at locations other than LGI. The spatial locations of these birds were widely disparate (Fig. 2 & 5). Although it is possible these birds successfully raised young, the fact that two of these three birds moved to these areas approximately mid-July would likely have reduced fledging and survival of young (Farquhar pers. comm.)

Migration of cormorants from LGI has broad temporal and spatial variation as shown in this study and as reported by (Hatch and Weseloh 1999). Departure dates of cormorants from their breeding grounds varied over a 16 week period. A similarly wide range of departure date for fall migration has also been reported in satellite telemetered Ospreys (Martell et al. 2001). However, the mean departure date (6 September) recorded from this study corresponds with the range of peak departure dates for cormorants reported by Hatch and Weseloh (1999). Although we do not have pre-control activity data specific to cormorants breeding on LGI our data indicate that cormorants from LGI were not influenced to migrate earlier due to control activities relative to that reported for cormorants in the great lakes region.

Most (77%) of the cormorants captured at Little Galloo Island in May 2000-01 migrated east of the Appalachian Mountains toward their winter range (Fig. 6). The winter distribution of cormorants captured in eastern Lake Ontario, NY in May 2001 was similar to that reported by Werner et al. (2001) for the previous year, extending from southeastern LA, along the coast of the Gulf of Mexico, and the southern portion of the Atlantic coast (Figure 6). Most of the cormorants migrated along or near the Atlantic coast. However, about 23% of the cormorants we have currently mapped migrated in the interior and some of these birds pass through or may spend a portion of the winter in areas of aquaculture production in the southeast (Figure 6).

Although we only had one bird or transmitter survive for over 12 months, this bird exhibited almost identical breeding home range patterns in 2001, as in the previous year (Fig 7). Annual site fidelity has important implications with regard to egg oiling as a non-lethal control method. If birds shift breeding activity from LGI to other colony sites a decline in numbers on LGI may not be attributable to the effectiveness of egg oiling. Current data suggest that the number of nesting pairs on LGI has been relatively stable during control activities (Weseloh unpub. data). Data collected from birds still transmitting should provide additional insights regarding annual site fidelity.

Collection of additional locational data may influence preliminary insights provided in this study. However, data presented here suggest that although cormorants may move from LGI during control activities they predominantly remained in eastern Lake Ontario. Further refinement of data filtering and analyses will be conducted to determine if these birds may have shifted to other breeding colonies within the eastern basin of Lake Ontario for a long enough duration to successfully reproduce.

Additional analyses will include an evaluation of the foraging distribution of cormorants and its association with physical characteristics and temporal and spatial associations of fish assemblages in the Eastern Basin of Lake Ontario. Additional data collected will further refine our analyses of intercolony movements and the effect of control activities on movements and reproductive success of cormorants from Little Galloo Island. When completed, the present satellite telemetry study will facilitate the development of biologically realistic alternatives for managing cormorant impacts to commercial and recreational fisheries.

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Figure Legends

(Color versions of figures available on DEC's website at www.dec.state.ny.us)

Figure 1. Satellite telemetry location data for Double-crested Cormorants (n = 50) captured on Little Galloo Island, NY (eastern Lake Ontario). Locations represent cormorant movements during control activities (2 May – 30 June, 2000-01).

Figure 2. Individual home range (85% kernel) for cormorant #28 (18 June – 30 September, 2001) near Sandusky Bay, Western Lake Erie.

Figure 3. Individual home ranges (85% kernel) for cormorant #44 (8 June - 14 September 2001).

Figure 4. Satellite telemetry location data for Double-crested Cormorants (n = 23) captured on Little Galloo Island, NY (eastern Lake Ontario). Locations represent cormorant movements following control activities (1 July-1 September, 2000-01).

Figure 5. Individual home range (85% kernel) and dates for cormorants # 4 and 21, on the St. Lawrence River near it's confluence with the borders off Ontario, Quebec, and New Brunswick, Canada.

Figure 6. Satellite telemetry location data for Double-crested Cormorants (n = 50) captured on Little Galloo Island, NY (eastern Lake Ontario). Locations represent all best of day filtered locations for cormorant movements from 2 May 2000 through 20 December 2001.

Figure 7. Individual breeding home range (85% kernel) for cormorant #15 in the Eastern Basin of Lake Ontario and the St. Lawrence River (2 May- 24 September 2000 and 24 April – 19 September 2001). Cross hatching represents areas of home range overlap between years.