Prey fish consumption by Double-crested Cormorants in western Lake Erie near West Sister Island, Ohio

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Abstract

The objectives for this study were to: 1) determine the diet of Double-crested Cormorants (*Phalacrocorax auritus*, hereafter: cormorants) in western Lake Erie; 2) to determine if yellow perch (*Perca flavescens*) or walleye (*Sander vitreus*) were a noteworthy prey item; and 3) to determine if the invasive round goby (*Neogobius melanostomus*) are consumed. Diet of cormorants was determined from stomach contents of 228 birds collected in western Lake Erie. Cormorants consumed 16 different fish species and one benthic invertebrate, *Dreissena spp*. Although white perch (*Morone americana)* composed the largest percent of the biomass consumed by cormorants during April - June, gizzard shad (*Dorosoma cepedianum*) dominated from July - September and, by weight, was the fish consumed most over the entire study period. Emerald shiner (*Notropis atherinoides*) was the most frequently consumed prey but the species accounted for a very small percent of the total diet biomass. Round goby, white perch, white bass (*M. chrysops*), and yellow perch were consumed most frequently by cormorants in May. Mean individual prey fish weights for major species were generally greatest during April and May. The frequency of empty stomachs was extremely high from the end of July through early September.

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Introduction

In the Great Lakes, the population of the Double-crested Cormorant (*Phalacrocorax auritus*, hereafter: cormorant) increased at an average annual rate of 29% from 1970 to 1991 (Weseloh *et al*. 1995) and 23% from 1990 to 1994 (Tyson *et al*. 1999). The first documented colony of cormorants in Lake Erie was established in 1939 (Langlois 1950), however cormorants were not regular nesters until the early 1990's. Cormorants first nested on West Sister Island in Lake Erie in 1992, and by 2006 there were approximately 3,800 nesting pairs on the island (M. Shieldcastle, Ohio Division of Wildlife, unpublished data). In 2006, nearby nesting colonies on East Sister and Middle Islands each supported approximately 6,000 nesting pairs (D.V. Weseloh, Canadian Wildlife Service, personal communication).

Studies on cormorant diets generally indicate that cormorants are opportunistic piscivores (e.g., Hobson *et al.* 1989, Ludwig *et al.* 1989, Campo *et al.* 1993, Bur *et al*. 1999a). In the Great Lakes, clupeids (*e.g.,* alewife [*Alosa pseudoharengus*] and gizzard shad [*Dorosoma cepedianum*]) and minnows (Cyprinidae) are predominant in cormorant diets (Craven and Lev 1987, Ludwig *et al*. 1989).

Sport anglers and commercial fishers in the Lake Erie area are concerned that cormorants are negatively affecting populations of important fish species (*e.g*., walleye [*Sander vitreus*], yellow perch [*Perca flavescens*] and smallmouth bass [*Micropterus dolomieui*]). The magnitude of cormorant piscivory in western Lake Erie has been estimated from a bioenergetics model (Madenjian and Gabrey 1995). The model estimated that the proportion of fish biomass consumed by cormorants was relatively small (equilivant to < 2% of the fish biomass eaten by walleye in western Lake Erie). Information on the seasonal diets of cormorants will lead to a greater understanding of the predator-prey dynamics associated with cormorants and their prey. Moreover, the round goby (*Neogobius melanostomus*), which was first collected in western Lake Erie in 1996 (Bur *et al.* 1997), may have recently become important in cormorant diets. By 1999, round gobies were the second most abundant species in trawl catches near East Harbor, Ohio (Bur *et al.* 2000a).

In addition to the concerns of anglers and commercial fishers, there are mounting concerns by conservation biologists that the increasingly large cormorant colonies will displace other, co-nesting waterbird (*e.g.,* herons and egrets [Ciconiiformes]) colonies via nest-site competition and/or habitat degradation. In the 1990s, two islands in western Lake Erie (East Sister and Middle islands) experienced large-scale loss of all trees and shrubs due to the highly acidic excrement of cormorants (Moore *et al*. 1995). Thus, there is also concern that the Carolinean vegetation endemic to Lake Erie islands may be destroyed by cormorant colonies.

Our objectives were to: 1) determine the diet of Double-crested Cormorants in western Lake Erie; 2) determine if the invasive round goby are consumed; and 3) determine if yellow perch or walleye were a noteworthy prey item. .

Methods

Diet of cormorants was determined by analyzing stomach contents of adults and juveniles collected in waters adjacent to West Sister Island (Figure 1). Approximately 20 cormorants were collected every two weeks from 24 April through 26 September. Cormorants were shot with a 12-gauge shotgun (with non-toxic steel shot) as they returned to their nest or roost sites from foraging in the lake. Immediately after collection, 70% ethanol was injected into each bird's stomach, and the carcasses were stored on ice in a cooler to reduce digestion. The birds were then returned to the laboratory for further analysis. The esophagus and stomach of each bird were removed and the food items in them were identified.

All food items were identified to species or genus. Fish in cormorant stomachs were identified from whole specimens or diagnostic bones, such as cleithra and otoliths. Whole fish were measured to the nearest millimeter and weighed to the nearest g. When possible, standard and backbone lengths were measured from partially digested fish. Regression equations (Knight *et al.* 1984; K. Kayle, Ohio Department of Natural Resources, unpublished data) were used to convert standard and backbone lengths to total lengths. Wet weight of fishes at the time of ingestion was estimated using total length-wet weight regressions (Hartman 1989; Ohio Department of Natural Resources unpublished data). For each prey taxon we reported number of individuals consumed, percentage of stomachs in which it occurred, and percentage of the total wet weight of all prey in the diet.

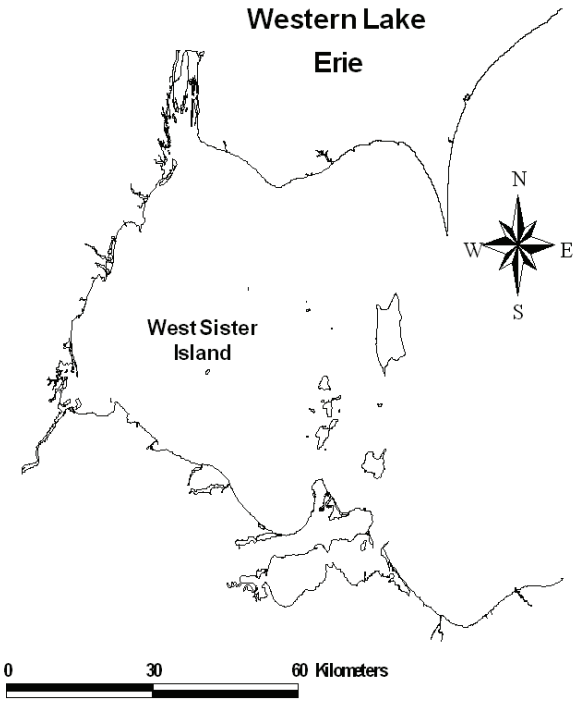

Figure 1. Sampling area for Double-crested Cormorants, near West Sister Island in western Lake Erie.

Results and Discussion

We collected 228 cormorants from 24 April to 26 September 2006, of which 178 (78%) contained food items. The average number of prey items per stomach was 9.7 (SE = 1.6), and the average weight of stomach contents in each cormorant was 241 g (SE = 14.2). We identified 16 species of fish and one invertebrate in the cormorant stomachs (Table 1). Emerald shiner (*Notropis atherinoides*) was the most abundant prey species consumed, composing more than 31% of all prey ingested, although it ranked only fifth for frequency of occurrence of stomachs in which it occurred. White perch (*Morone americana*) was recorded in more stomachs than any other species and accounted for the second largest percentage by weight. Gizzard shad ranked first in percentage by weight, third in number of stomachs in which it occurred, and third in proportion of prey eaten. Round goby was the second most numerous species found in cormorant stomachs and ranked fifth in percentage by weight. Freshwater drum (*Aplodinotus grunniens*) ranked third in percentage weight and fourth in number of stomachs in which it occurred. White bass (*Morone chrysops*) was another important prey species, both in terms of percentage by weight and frequency of stomachs in which it occurred.

Emerald shiner was the most frequently occurring food item in cormorant stomachs during April, whereas white perch became the most frequent diet item in May (Figure 2). Gizzard shad increased in frequency from April through September, and by September, shad was the most frequently consumed prey.

Table 1. Prey species found in stomachs of Double-crested Cormorants collected from western Lake Erie during April - September, 2006. Symbols: - = unable to determin**e.**

Species	N	% Number	% Frequency	% Weight
Gizzard shad *Dorosoma cepedianum*	391	23.4	28.3	26.7
Brown bullhead *Ameiurus nebulosus*	1	<0.1	0.6	< 0.1
Channel catfish *Ictalurus punctatus*	2	0.1	1.1	2.0
Trout-perch *Percopsis omiscomaycus*	1	<0.1	0.6	< 0.1
Goldfish *Carassius auratus*	6	0.4	0.6	0.5
Silver chub *Macrhybopsis storeriana*	1	<0.1	0.6	0.1
Emerald shiner *Notropis atherinoides*	527	31.6	21.8	3.1
Mimic shiner *Notropis volucellus*	3	0.2	0.6	< 0.1
Unidentified minnow (Cyprinidae)	3	0.2	1.1	< 0.1
White sucker *Catostomus commersoni*	1	<0.1	0.6	1.6
Shorthead redhorse *Moxostoma macrolepidotum*	1	<0.1	0.6	0.1
White perch *Morone americana*	94	5.6	35.6	20.7
White bass *Morone chrysops*	34	2.0	16.7	14.0
Morone spp.	1	<0.1	0.6	< 0.1
Freshwater drum *Aplodinotus grunniens*	46	2.8	23.0	18.3
Bluegill *Lepomis macrochirus*	2	0.1	0.6	0.2
Smallmouth bass *Micropterus dolomieui*	7	0.4	2.9	0.2
Yellow perch *Perca flavescens*	30	1.8	11.5	5.2
Round goby *Neogobius melanostomus*	479	28.7	32.2	6.8
Dreissena spp.	-	-	0.6	< 0.1
Unidentified fish	40	2.4	-	< 0.1
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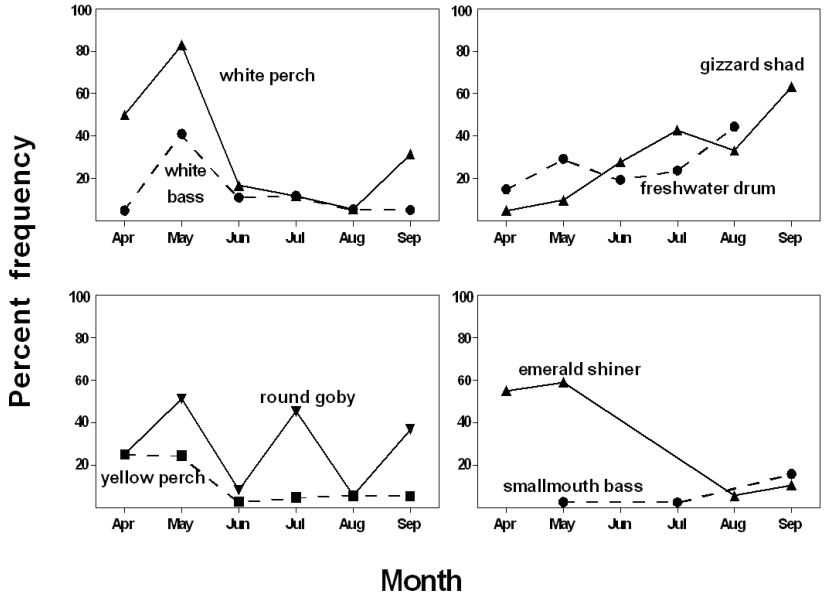

Figure 2. Frequency of occurrence by month for major prey fish consumed by Double-crested Cormorants in western Lake Erie near West Sister Island.

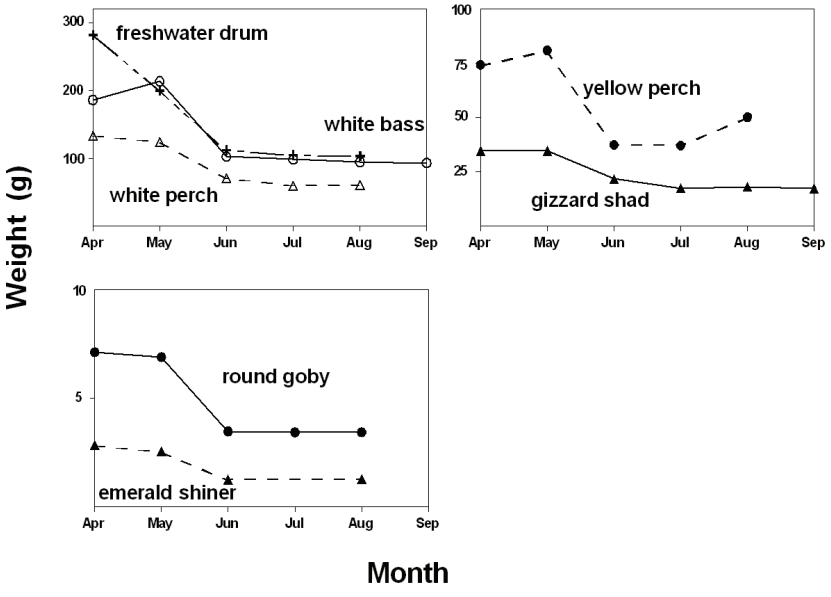

Figure 3. Mean weights by month for major prey fish consumed by Double-crested Cormorants in western Lake Erie near West Sister Island.

Mean weights of prey were generally greatest in April and May (Figure 3). After May, mean weights of most species were similar throughout the remaining sampling periods. By June cormorants shifted to eating smaller prey, indicating that they fed on younger fish. By August, however, larger yellow perch were consumed than in June or July.

Cormorants consumed varying proportions of each species, in terms of total biomass, during the study period (Figure 4). In April and May, large prey species, such as white perch, freshwater drum, and white bass, composed the largest percentage of the biomass consumed. Although white perch accounted for the greatest percentage of diet biomass during April - June, gizzard shad (most of which were age-0) dominated diet biomass during July - September (range 42% - 91%). For all months except September, freshwater drum contributed a minimum of 18% (range 18% - 38%) of the monthly diet biomass. White bass, yellow perch, and round goby were also important contributors to the diet of cormorants.

The data strongly support the notion that cormorants are opportunistic piscivores and not major predators of important recreational or commercial fishes. White perch, white bass, freshwater drum, and yellow perch were consumed in largest numbers around the time of spring spawning, whereas gizzard shad was a common diet item when they became available as age-0 fish later in the year.

The number of empty cormorant stomachs rose from 9% to 77% from the middle to the end of July, and the percent of empty stomachs remained relatively high through early September (Figure 5). The combined effects of presence of young cormorant fledglings and very warm air and water temperatures during this period may be related to the high number of empty stomachs. When young cormorants are first learning to feed they are not efficient predators and often miss their prey during dives (Mendall 1936). The period in which young cormorants were learning to feed coincided with late July through mid-August samples. Extremely warm air and water temperatures (National Data Buoy Center web site: http://www.ndbc.noaa.gov) and low dissolved oxygen (Bur, *et al*. 2007), which occurred during late July into August (Figure 5), may have reduced fish populations near the colony and inhibited foraging activity by cormorants.

Although round goby was absent from Lake Erie cormorant diets in 1997 (Bur *et al.* 1999a), the species accounted for 29% of the prey items eaten and occurred in nearly one-third (32%) of all cormorant stomachs. Since its rapid population increase in western Lake Erie, the round goby has become a relatively important food item for many piscivorous fish (Deller *et al.* 2003) and birds such as Red-breasted Merganser (*Mergus serrator*) (Bur *et al.* 1999b, Bur *et al.* 2000b). Walleye were absent from the diet, whereas yellow perch were consumed in low numbers and were nearly absent after May. Cormorants have the ability to consume large quantities of fish, based upon their daily ingestion rate, 550 g/day (Weseloh and Casselman 1992), and population size, 16,871 in western Lake Erie (D.V. Weseloh, Canadian Wildlife Service, personal communication). Ascertaining the magnitude of annual fish consumption by western Lake Erie cormorants poses an important future research question.

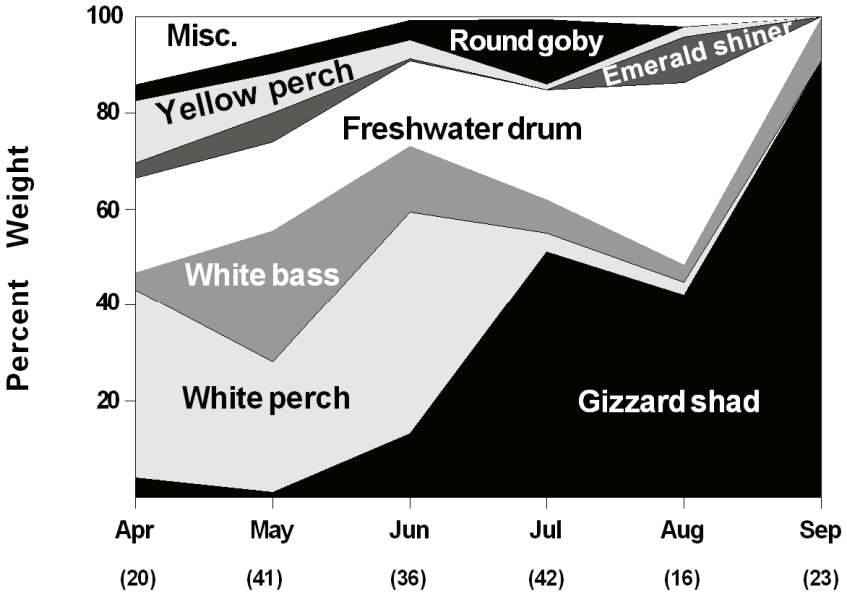

Figure 4. Percent biomass for prey items identified in Double-crested Cormorant stomachs by month, April-September, in western Lake Erie near West Sister Island. Abbreviation: Misc. = 9 fish species, unidentified fishes, and dreissenid mussels. Numbers in parentheses are sample sizes.

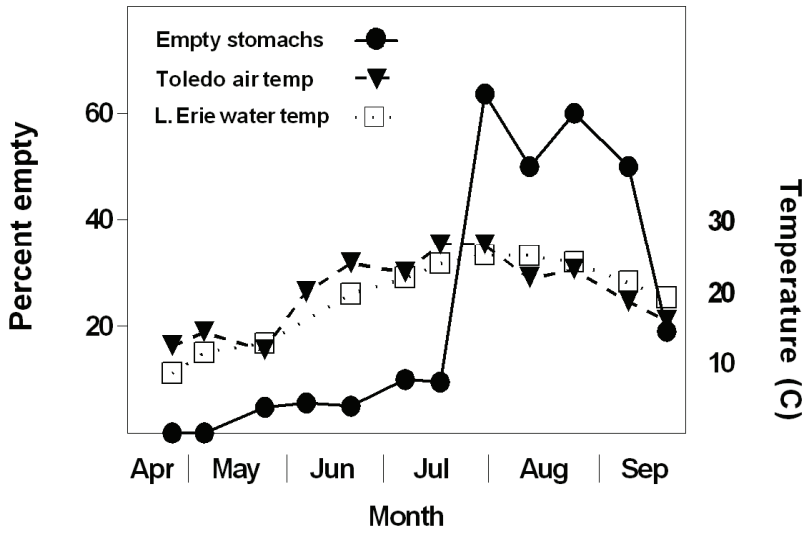

Figure 5. Percent of Double-crested Cormorant stomachs that did not contain food items and mean air and water temperatures from the Toledo, Ohio area, which is near West Sister Island. Air and water temperature data were obtained from http://www.ndbc.noaa.gov/view_text_file.php?filename=thro172006.txt.gz&dir=data/stdmet/

References

Bur, M., S. Tinnirello, and B. Ickes. 1997. Surveillance and status of fish stocks in Lake Erie, 1996. Great Lakes Fishery Commission, Lake Erie Committee Meeting, 1997.

Bur, M., S. Tinnirello, C. Lovell,, and J. Tyson. 1999a. Diet of the Double-crested Cormorant in western Lake Erie. *In* M. E. Tobin (Tech. Coord.), Symposium on Double-crested Cormorants: Population, status and management issues in the Midwest. U. S. Department of Agriculture, Animal and Plant Health Inspection Service Technical Bulletin 1879:73-85.

Bur, M., R. Dolbeer, and J. Tyson. 1999b. The diet of Red-breasted Mergansers in western Lake Erie and Sandusky Bay. Great Lakes Fishery Commission, Lake Erie Committee Meeting, 1998.

Bur, M., S. Tinnirello, C. Muzinic, and J. Bales. 2000a. Surveillance and status of fish stocks in Lake Erie, 1999. Great Lakes Fishery Commission, Lake Erie Committee Meeting, 2000.

Bur, M. and G. Bernhardt. 2000b. The diet of Red-breasted Mergansers in Western Lake Erie. Great Lakes Fishery Commission, Lake Erie Committee Meeting, 2000.

Bur, M. T., M. A. Stapanian, P. M. Kocovsky, W. H. Edwards and M. J. Porta. Surveillance and status of fish stocks in Lake Erie, 2006. Great Lakes Fishery Commission, Lake Erie Committee Meeting, 2007.

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.

Craven, S.R., and E. Lev. 1987. Double-crested Cormorant in the Apostle Islands, Wisconsin, USA: population trends, food habits, and fishery depredation. Colonial Waterbirds 10:64-71.

Deller, J., E. Trometer, M. Bur, D. Einhouse, R. Haas, T. Johnson, J. Markham, C. Murray, L. Rudstam, M. Thomas, J. Tyson, and L. Witzel. 2003. Report of the Forage Task Group to the Standing Technical Committee of the Lake Erie Committee, Great Lakes Fishery Commission. 38 pp.

Hartman, K.J. 1989. Western Lake Erie walleye: predation, prey utilization and the relationship with somatic growth. Ph.D. Dissertation, The Ohio State University, Columbus.

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.

Knight, R.L., F.J. Margraf, and R.F. Carline. 1984. Piscivory by walleyes and yellow perch in western Lake Erie. Transactions of the American Fisheries Society 113:677-693.

Langlois, T.H. 1950. Crow ducks on Little Chicken Island. Ohio Conservation Bulletin 13:6-7.

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.

Madenjian, C.P., and S.W. Gabrey. 1995. Waterbird predation on fish in western Lake Erie: a bioenergetics model application. Condor 97:141-153.

Mendall, H.L. 1936. The home-life and economic status of the Double-crested Cormorant (*Phalacrocorax auritus L.*). The Maine Bulletin 39:1-159.

Moore, D.J., H. Blokpoel, K.P. Lampman, and D.V. Weseloh. 1995. Status, ecology and management of colonial waterbirds nesting in Hamilton Harbour, Lake Ontario, 1988-1994. Technical Report Series No. 213. Canadian Wildlife Service, Ontario region. 38 pp.

National Data Buoy Center, National Oceanic and Atmospheric Administration, web site http://www.ndbc.noaa.gov.

Tyson, L.A., J. Belant, F. Cuthbert, and D.V. Weseloh. 1999. Nesting populations of Double-crested Cormorants in the United States and Canada. *In* M. E. Tobin (Tech. Coord.) Symposium on Double-crested Cormorants: Population, status and management issues in the Midwest. U. S. Department of Agriculture, Animal and Plant Health Inspection Service Technical Bulletin 1879:17-26.

Weseloh, D.V. and J. Casselman. 1992. Calculated fish consumption by double-crested cormorants in eastern Lake Ontario. Colonial Waterbird Society Bulletin 16(2):63-64.

Weseloh, D.V., P.J. Ewins, J. Struger, P. Mineau, C.A. Bishop, S. Postupalsky, and J.P. Ludwig. 1995. Double-crested Cormorants of the Great Lakes: changes in population size, breeding distribution, and reproductive output between 1913 and 1991. Colonial Waterbirds 18 (Special Publication 1):48-59