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WATERBIRD USE OF A HYDROLOGICALLY ALTERED RIVER SYSTEM

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Abstract.—Waterbirds were surveyed monthly from July 1996 to June 1998 in remnant river channels within three sections of the channelized Kissimmee River. These data will provide a baseline for future comparisons with post-restoration data in evaluating the success of Kissimmee River restoration. Mean number of birds per survey was 10.8 in 96/97 and 11.9 in 97/98. Waterbird abundance was greatest during winter and spring. Twenty-six species representing six orders were recorded. Species from Ciconiiformes and Gruiformes were the most abundant during both sample years. Common Moorhens (*Gallinula chloropus*) were the most commonly observed species. Mean species richness per survey was very low (2.9 in 96/97 and 3.2 in 97/98) and did not differ significantly among seasons. No historic data exist for waterbird abundance; however, species richness was lower in the channelized system than in the historic system or another similar river system in southwest Florida.

The Kissimmee River, located in central Florida, is the site of the largest river restoration project ever attempted. The project will restore 104 km^2 of river-floodplain ecosystem, including 70 km of river channel and 11,000 ha of wetland habitat. The Kissimmee Basin consists of a lower basin, comprising 1963 km^2 of river channel and floodplain, and the headwaters, which include Lake Kissimmee and 18 other smaller lakes ranging from a few hectares to 144 km^2 in size (Koebel 1995). The Kissimmee River flows into Lake Okeechobee, and was historically connected hydrologically to the Everglades system. This area is characterized by low topographical diversity and well-defined wet and dry seasons.

The Kissimmee River is unique among North American rivers because, prior to channelization, large portions of its low gradient floodplain were inundated for extended periods (>200 days) each year (Toth et al. 1998). The river channel itself was highly braided with numerous meanders, abandoned channels, and backwater sloughs (Toth 1996) that supported abundant fish and wildlife resources (Perrin et al. 1982). The bird community was diverse, including a variety of wading birds, waterfowl, and other waterbirds that were common in littoral habitats (National Audubon Society 1947-55). Large predatory fishes such as largemouth bass (*Micropterus salmoides*) and sunfish (*Lepomis* spp.) were abundant in the river channel, while smaller omnivorous and herbivorous fish thrived in littoral and floodplain wetlands (Florida Game and Freshwater Fish Commission 1957, Perrin et al. 1982).

Between 1962 and 1971, the Kissimmee River was channelized through the construction of a 90-km long, 9-m deep, 100-m wide box-shaped canal (C-38) which stretches from the southern outlet of Lake Kissimmee to the northwest shore of Lake Okeechobee. The channelized system consists of a series of linear flood storage reservoirs, referred to as “pools”, as well as 109 km of remnant sections of intact river channel. The boundaries of each pool include large water-control structures at the upstream and downstream ends, and the natural edges of the floodplain on the east and west (Fig. 1), delineated by a slight increase in elevation (~1m). Remnants of the original river channel exist on either side of the man-made canal. However, these sections of river channel are no longer connected to each other and exhibit no measurable flow under most hydrologic conditions. Although many of the remnant river sections are connected to the C-38 canal at both ends, the immense carrying capacity of the canal precludes the flow of water through any of the river channel remnants. Throughout this paper, the term “canal” refers to the man-made box canal, while “river channel” refers only to the remnants of the original river channel that still exist within the system.

Elimination of seasonally variable flow through the river channel remnants contributed to dramatic changes in habitat structure and quality, resulting in an estimated 40% decline in fish and wildlife habitat value since channelization (U.S. Fish and Wildlife Service 1991). Physical and chemical changes to the original river channel include deposition of organic matter (10-30 cm) from decaying vegetation, elimination of natural hydrogeomorphic processes such as sand bar formation, and severely reduced dissolved oxygen levels (Toth 1993, 1996). Biological changes to river channels include an increase in floating and emergent vegetation, a shift by benthic invertebrates from lotic species to those indicative of reservoirs (Toth 1993), decreased abundance of large predatory fish, and a decline in smaller omnivorous and herbivorous fish populations (Perrin et al. 1982, Miller 1990). Fish species that can tolerate low oxygen conditions, including gar (*Lepisosteus* spp.) and bowfin (*Amia calva*), have increased in abundance since channelization (Florida Game and Freshwater Fish Commission 1996).

Changes to the waterbird community with channelization of the river were not well documented. However, altered habitat and food web structure likely contributed to decreased use of river channels by shorebirds and wading birds, along with an increase in Cattle Egret (*Bubulcus ibis*) abundance, similar to what has been reported for floodplain wetlands in the channelized system (Perrin et al. 1982, Toland 1990). Cattle Egrets were not documented in the Kissimmee Basin prior to 1954 (National Audubon Society 1947-55), however, the conversion of floodplain wetlands to cattle pastures following channelization greatly increased the availability of habitat for this exotic species and it is now abundant on the floodplain.

Quantitative historical data describing the waterbird community of the Kissimmee River are not available, however, some anecdotal reports and reference data from other low gradient subtropical systems may be potentially useful for providing insight into species composition in the natural Kissimmee system. The Myakka River, a less-impacted river in southwest Florida, is surveyed monthly by the Florida Department of Environmental Protection (DEP unpubl. data). Hayes (1996) documented waterbird use of the Paraguay River in South America, a naturally flowing river that is relatively unimpacted by human activities and the Usumacinta-Grijalva delta in Mexico was surveyed from 1971-1979 primarily to determine the population of nesting wading birds (Ogden et al. 1988). Because of its proximity, the Myakka River has the most potential value as a reference site for waterbird use of the Kissimmee River.

Because waterbirds use such a diversity of resources, they can provide good information about how the restoration project affects other components of the ecosystem. Therefore, waterbirds have been identified as an important group for evaluating wildlife response to the Kissimmee River restoration project (Karr et al. 1992, Weller 1995). The objective of this study was to quantify waterbird use of remnant river sections in the channelized Kissimmee River as a baseline for evaluating avifaunal response to the restoration of river channel habitat.

METHODS

This study was designed to satisfy two objectives: (1) determine abundance and diversity of waterbirds using the Kissimmee River in its current, channelized state, and (2) conduct a repeatable baseline study so that comparable data can be collected from the same area after restoration. Although this portion of the research is not truly experimental, when the second portion of data collection has been completed, a Before-After-Control-Impact (Stewart-Oaten and Murdock 1986) method of analysis can be applied to determine the effect of restoration on waterbird abundance and species richness.

Three sections of remnant river channel were chosen for study from each of three pools in the channelized system (Fig. 1). Selection criteria included length (longest stretches of remnant channel in each pool) and connection at both ends to the C-38

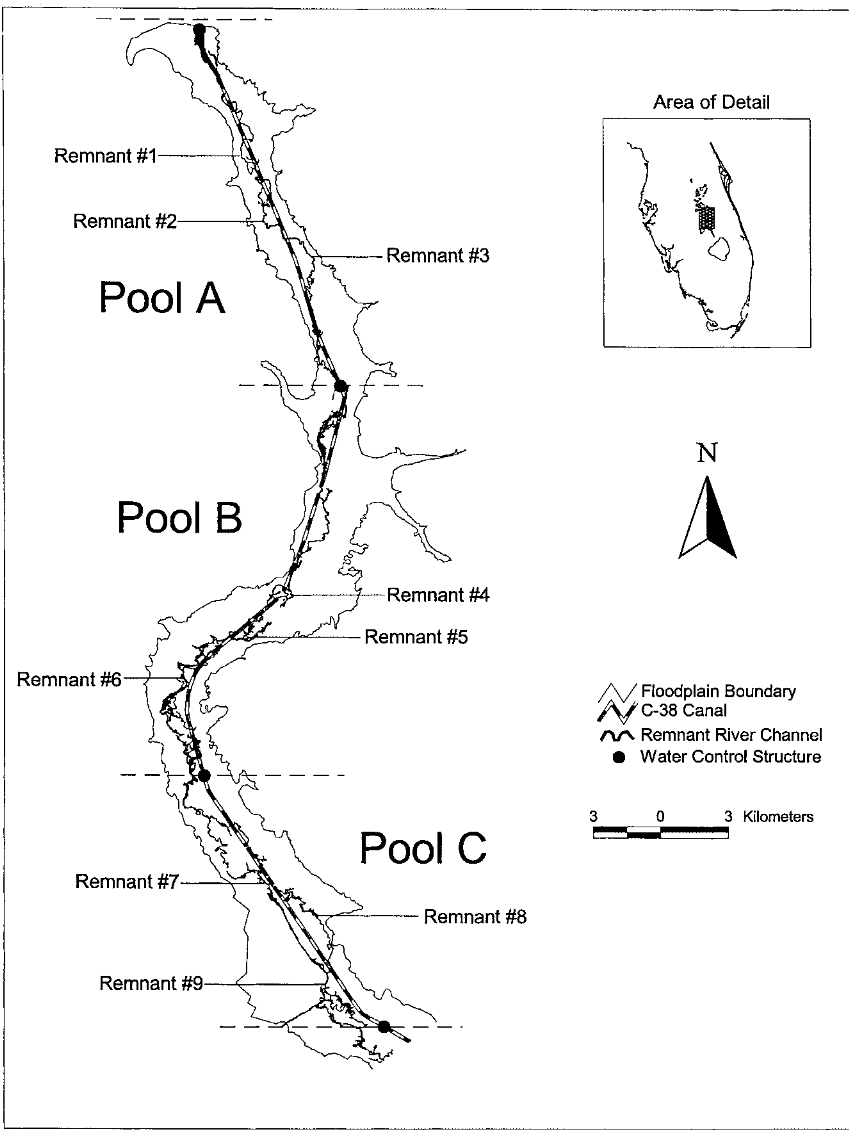

Figure 1. Kissimmee River and floodplain with waterbird study areas delineated and study sites numbered.

canal. All 9 remnant river sections chosen for survey were part of the most recent active river channel prior to channelization. The constructed canal (C-38) was not surveyed because it was not part of the original river system and it will not be present when the surveys are repeated. In addition, the canal's physical characteristics are much different than those of the historic river channel or its remaining sections. The canal is ten times the average width of the river channel, and three times as deep. In general, the canal's depth and steep walls make it inhospitable to most species of waterbirds. Therefore, waterbird surveys were limited to river channel sections that still retain some of their original characteristics, and will be intact after the canal has been eliminated.

Remnant river sections were surveyed monthly from May 1996 through June 1998. A survey was defined as one visit to one section of remnant river channel. Surveys were conducted on three consecutive days (one pool/day) during the first week of each month, and within three hours of sunrise. An airboat was required for conducting surveys because most river sections were impassable by powerboat and the distance traveled each day prevented the use of a non-motorized boat such as a canoe. Observations were made from 1.6 m above the water surface aboard an airboat travelling at 38 km per hour.

Prior to beginning the study, a timed run through each river channel was made at the appropriate speed to determine the length of time required to travel the entire distance. After subtracting 10 minutes for a survey, I knew the maximum number of seconds travel time prior to starting the survey which would leave enough distance to complete an entire survey. A randomly selected number of seconds less than the maximum was chosen to establish the start point for each survey. A 10-minute boat survey resulted in an average of 6.3 km of river section traveled. Distance traveled on each survey was slightly variable due to the difficulty in maintaining steady speed around curves in the river channel. I found that a moderately high rate of speed increased my detection rate by minimizing the time available for birds to flush or move into the cover of littoral vegetation before they could be identified and counted.

The group "waterbirds" included all species that are generally considered to be dependent upon aquatic habitats from the orders Anseriformes, Charadriiformes, Ciconiiformes, Coraciiformes, Gruiformes, Podicipediformes and Pelecaniformes. I was interested only in waterbird use of river channel littoral habitats; therefore, birds using areas outside of the river banks (e.g., perching in trees) were not included in the analysis. I defined the survey area for this study as the river channel and associated littoral habitat located between the top edges of opposite channel banks. River channels were surveyed separately from floodplain habitats because the floodplain is so large that aerial surveys were necessary to adequately cover the entire area. Most waterbird species are too small to be identified from the air, and therefore were more accurately surveyed by boat.

Survey data were separated into two sample years, July 1996-June 1997 (96/97) and July 1997-June 1998 (97/98). Seasons were defined as the following, similar to other local studies (e.g., Leonard 1994): winter (December, January, February), spring (March, April, May), summer (June, July, August), and fall (September, October, November). Initial analysis showed no significant difference among sites, therefore, each visit to a site was considered a replication for that month and sample year. Seasonal analysis included all visits within the 3-month period, resulting in 27 replicate surveys per season within a sample year. Two-way analysis of variance for unbalanced data (PROC GLM; SAS 1990) was used to compare mean number of birds per survey by season and sample year. Differences in means were considered significant if analysis of variance resulted in $P < 0.05$. If the overall model was significant, a means separation test (Least Squared Mean) was performed to further evaluate differences. Species richness was the maximum number of species recorded per survey.

RESULTS

A total of 2015 waterbirds was observed during 177 surveys of remnant river sections. Mean birds per survey was 10.8 ± 1.3 in 1996/97 and 11.9 ± 1.4 in 1997/98 (Table 1) and did not differ significantly between years ($P = 0.56$). Thus, both years were combined for seasonal analysis. The interaction of sample year and season was not significant

Table 1. Abundance and species richness of waterbirds observed during river channel surveys in three pools of the Kissimmee River and four seasons from May 1996 through June 1998. Results are from a two-way analysis of variance test and Least Squared Means separation tests. Means with the same letter are not significantly different from each other at P < 0.05.

Variable	n	Mean birds/ survey ± SE	Mean species richness/ survey ± SE	Species richness range
96/97	87	10.8 ± 1.3 a	2.9 ± 0.02 e	1-9
97/98	90	11.9 ± 1.4 a	3.2 ± 0.02 e	1-10
Fall	47	8.8 ± 1.4 b	2.9 ± 0.3 e	1-8
Spring	44	15.2 ± 2.3 c	3.6 ± 0.4 e	1-10
Summer	40	11.6 ± 1.8 b	2.5 ± 0.2 e	1-6
Winter	46	12.8 ± 1.9 b,c	3.1 ± 0.3 e	1-7

for mean abundance (P = 0.79). However, there was a significant difference in mean abundance among seasons (P = 0.02). Mean abundance in spring was significantly greater than fall (P = 0.01) or summer (P = 0.01; Table 1). Fall and summer mean abundance were not significantly different (P = 0.88). Winter mean abundance was not significantly different from fall (P = 0.11), summer (P = 0.33), or spring (P = 0.10).

Twenty-six species of waterbirds representing six orders (Table 2) were observed during surveys of remnant river sections. Common Moorhens were the most commonly observed species in both sample years, making up 36% of total waterbird abundance (Table 2). During both sample years, birds from the order Ciconiiformes comprised the majority of waterbird observations (49%; Table 3). Gruiformes contributed nearly as much to the overall observations (41%), while Anseriformes represented only 2%. Charadriiformes, Coraciiformes, and Pelecaniformes were represented scarcely (<1% each; Table 3). No birds from the order Podicipediformes were observed during surveys of the channelized Kissimmee River.

Mean species richness was 2.9 ± 0.02 in 96/97 and 3.2 ± 0.02 in 97/98 (Table 1). No significant differences existed among seasons for species richness (P = 0.07; Table 1). Waterbird surveys from the channelized system show a 35% decrease in the number of species compared to the historic system (Table 1; National Audubon Society 1947-55). The majority of species recorded historically but missing from current surveys were shorebirds and waterfowl. Historic surveys list eight species of waterfowl occurring on the Kissimmee River. Currently, only three species have been observed (Blue-winged Teal, Mottled Duck, Wood Duck), representing a 63% decrease in species richness for that group. Seven species of shorebirds were recorded in historic surveys, but I recorded only one species (Least Tern) during my surveys of remnant river sections.

Table 2. Relative abundance (% of total population) of waterbird species observed during river channel surveys of the Kissimmee River (1996-98). Scientific names follow AOU Checklist of North American Birds (1983).

Common name	Scientific name	Relative abundance
American Bittern	*Botaurus lentiginosus*	<1
American Coot	*Fulica americana*	<1
Anhinga	*Anhinga anhinga*	7
Belted Kingfisher	*Ceryle alcyon*	<1
Black-crowned Night-heron	*Nycticorax nycticorax*	2
Blue-winged Teal	*Anas discors*	<1
Cattle Egret	*Bubulcus ibis*	7
Common Moorhen	*Gallinula chloropus*	36
Double-crested Cormorant	*Phalacrocorax auritus*	<1
Glossy Ibis	*Plegadis falcinella*	5
Great Blue Heron	*Ardea herodias*	5
Great Egret	*Casmerodius albus*	6
Green Heron	*Butorides striatus*	6
Least Bittern	*Ixobrychus exilis*	<1
Least Tern	*Sterna antillarum*	<1
Little Blue Heron	*Egretta caerulea*	9
Limpkin	*Aramus guarana*	3
Mottled Duck	*Anas fulvigula*	<1
Purple Gallinule	*Porphyrula martinica*	5
Sandhill Crane	*Grus canadensis*	<1
Snowy Egret	*Egretta thula*	1
Sora	*Porzana carolina*	<1
Tricolored Heron	*Egretta tricolor*	4
White Ibis	*Eudocimus albus*	7
Wood Duck	*Aix sponsa*	<1
Yellow-crowned Night-heron	*Nycticorax violaceus*	1

DISCUSSION

Historical accounts from the pre-channelized Kissimmee River describe a diverse waterbird community comprised of shorebirds, waterfowl, wading birds, gulls, terns, and other water-dependent species (National Audubon Society 1947-55). Channelization of the Kissimmee River converted a flowing river into conditions more indicative of reservoirs, which is reflected in the species composition of the waterbird community. Species diversity on remnant river-channel sections in the channelized system are low. During this study, only one observation of terns was recorded, while gulls and shorebirds were completely absent. However, recent surveys of the Myakka River in southwest Florida report that shorebirds, gulls, and terns make up 4% of waterbird observations from that river (DEP unpubl. data). Waterfowl use of the channelized Kissimmee River also is very sparse, although waterfowl are abundant on the Myakka River, making up more than 12% of all

Table 3. Mean abundance (± SE) per survey, total abundance, and relative abundance (% of total observations) of waterbird groups during 177 river channel surveys of the Kissimmee River from May 1996 through June 1998. Number of species from each group for current surveys, historic surveys (National Audubon Society 1947-55), and the Myakka River (DEP 1993-96).

Order	Mean abundance mean ± SE	Percent of surveys present	Relative abundance	Species richness current KR	Species richness historic KR	Species richness Myakka River
Anseriformes	0.17 ± 0.07	4	2	3	8	3
Charadriiformes	0.01 ± 0.01	<1	<1	1	10	8
Ciconiiformes	5.6 ± 0.58	84	49	13	14	15
Coraciiformes	0.06 ± 0.02	5	<1	1	1	1
Gruiformes	4.7 ± 0.62	53	41	6	6	3
Pelecaniformes	0.85 ± 0.15	27	7	2	3	2
Podicipediformes	0.00 ± 0.00	0	0	0	1	1

waterbird observations (DEP unpubl. data). Common Moorhens, a pond-dwelling species, were the most abundant bird recorded from the channelized system, and had three times the relative abundance of surveys from the Myakka.

Information regarding the presence or absence of individual species is perhaps the most useful metric for illustrating changes that have occurred in the Kissimmee River waterbird community because of channelization. Changes in the waterbird communities of rivers after implementation of water management projects are well documented in several European rivers (Marchant and Hyde 1980, Round and Moss 1984, Raven 1986, Campbell 1988, Fruget 1992, Roche and Frochot 1993), as well as temperate United States (Stevens et al. 1997). Altered hydrologic regimes, including regulated water levels and reduction in flow, changed the habitat structure and prey availability, resulting in decreased waterbird use of impacted rivers. In the channelized Kissimmee River system, waterbird species richness in the channelized system is half of what it was historically (43 species), and 26% less diverse than the Myakka River (33 species; DEP unpubl. data). Although methods for the three studies are slightly different, they are comparable from a presence/absence standpoint. Greater species richness in both the Myakka river and the historic Kissimmee river can primarily be attributed to the presence of shorebirds, which were absent from surveys of remnant river sections in the channelized system.

The absence of shorebirds from my surveys is likely related to the lack of suitable habitat in the remnant river channels. Littoral habitat in the historic Kissimmee River was diverse and included numerous, well-developed sandbars. Sandbars provide ideal loafing habitat for shorebirds such as gulls, terns, and skimmers. In addition, sand bars support a diverse invertebrate community and variable water depths that are used by birds requiring a variety of foraging conditions. In remnant river sections of the channelized Kissimmee, sandbars do not exist, or are completely covered with organic deposition, and the lack of flowing water precludes the formation of new sandbars. Therefore, this very important habitat for shorebirds, gulls, terns, and skimmers, is not available in the channelized system.

Restoration of the Kissimmee River will facilitate the formation of sandbars, especially at curves in the river, fostering an increase in hyporheic oligochaetes and mollusks (Harris et al. 1995). Probing shorebirds such as Black-necked Stilts, Least Sandpipers, Killdeer, Greater and Lesser yellowlegs, which were abundant in the historic system (National Audubon Society 1947-55) will benefit from this reestablished prey source. Species from Order Charadriiformes are expected to be more abundant along the river channel, resulting in relative abundance similar to what is found in the Myakka River system.

Throughout the channelized Kissimmee River, waterbird habitat has been significantly lost or altered. Restoration will re-establish natural water regimes to a large portion of the river channel, restoring habitat structure and ecosystem functions to the river system. Fishes and invertebrates respond quickly to river channel habitat restoration (Wullschleger et al. 1990, Toth 1991), thereby increasing prey availability for waterbirds. In addition, restoration of flow to the river channel limits floating and emergent vegetation to a littoral fringe (Miller et al. 1990), providing a more favorable distribution of open water and vegetated habitats for use by foraging waterbirds. With improved habitat conditions, the waterbird community is expected to respond quickly, resulting in decreased abundance of Common Moorhens and Cattle Egrets and increased use by shorebirds, gulls, and terns. Waterbird abundance and species richness are expected to increase significantly in restored river channels. These changes in the community structure and abundance of waterbirds in restored river channels will provide quantitative measures of restoration success.

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