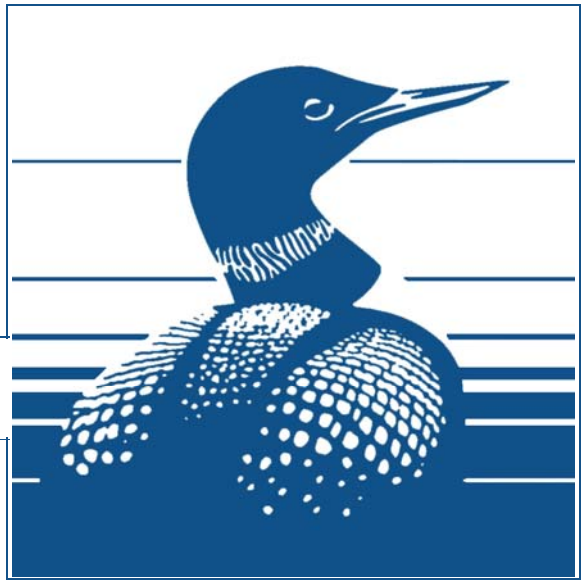
# Limnology and Aquatic Birds: Abstracts and Selected Papers from the Fourth Conference of Societas Internationalis Limnologiae (SIL) Aquatic Birds Working Group

**Alan Hanson, Joseph Kerekes and Julie Paquet (Editors)**

Atlantic Region



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# Limnology and Aquatic Birds:

## Abstracts and Selected Papers from the 4th Conference of the Societas Internationalis Limnologiae (SIL) Aquatic Birds Working Group

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## Introduction

During the SIL Congress in Munich, Germany in 1989, it became apparent to a small group of participants that the time has come that waterbirds can be treated in a limnological context. This led to an *ad hoc* Symposium, "Aquatic Birds in the Trophic Web of Lakes", held in Sackville, New Brunswick, Canada, in August 1991. The proceedings of this symposium were published in Hydrobiologia (1994, vol. 279/280) and Developments in Hydrobiology (1994, vol. 96)[1]. The outstanding success of this symposium led to the formation of the Working Group on Aquatic Birds of Societas Internationalis Limnologiae (SIL) during the XXV$^{th}$ SIL Congress in Barcelona, Spain, in 1992. The first conference of the SIL Working Group on Aquatic Birds was held in Sopron, Hungary in November 1994. These proceedings were published by Wetlands International (1997, Special Publication #43)[2]. The second conference was convened in Mérida, Yucatan, Mexico in November 1997[3]. The third conference took place in Trebon, Czehia in May 2000[4].

The Working Group on Aquatic Birds also held workshops and paper sessions during the SIL congresses in São Paulo, Brazil (1995), Dublin, Ireland (1998) and Melbourne, Australia (2001).

The main objective of the Working Group on Aquatic Birds is to integrate waterbirds into hydrobiology and treat waterbird studies in a limnological context. To achieve this goal, the Working Group organizes conferences to facilitate communications among limnologists interested in aquatic birds and ornithologists interested in the aquatic habitat. These conferences are held at least once every three years between SIL Congresses. The conference in Sackville "Limnology and Waterbirds 2003" was the fourth such conference. This CWS Technical Report contains Abstracts and Selected Papers from the Conference and supplements papers contained in Hanson and Kerekes (2006)[5].

The Editors and Authors are grateful for the technical assistance of Isabelle Robichaud in preparing this document.

[1]Kerekes, J. J. and B. Pollard (eds). 1994. Symposium Proceedings. Aquatic Birds in the Trophic Web of Lakes. Sackville, New Brunswick, Canada. Aug. 19–22, 1991. (Developments in Hydrobiology, vol. 96, 524 pp.) Hydrobiologia, vol. 279/280.

[2]Faragó, S. and J. Kerekes (eds). 1997. Workshop Proceedings. Limnology and Waterfowl: Monitoring, modelling and management. Working Group on Aquatic Birds, Societas Internationalis Limnologiae and International Waterfowl and Wetlands Research Bureau. Sarród/Sopron, Hungary, 21–23 November, 1994 Wetlands Internat. Publication 43 and Hungarian Waterfowl Publication 3. 362 pp.

[3]Comín, F., J.A. Herrera-Silvera and J. Ramirez-Ramirez (eds). 2000. Proceedings. Limnology and Aquatic Birds: Monitoring, Modelling and Management. Working Group, Societas Internationalis Limnologiae. Mérida, México, November 24–27, 1997. Universidad Autonoma de Yucatan. Merida, Mexico. 305 pp.

[4]Musil, P. J. and T. Albrecht. Abstracts of the Third Conference of Aquatic Birds Working Group of Societas Internationalis Limnologiae (SIL). Sylvia 36, Suppl. 68 pp.

[5]Hanson, A.R. and J.J Kerekes (eds). 2006. Limnology and Aquatic Birds. Hydrobiologia Volume 567. Kluwer Publishers, Dordrecht, The Netherlands. 349 pp.

# SECTION I

# LOONS — POPULATION TRENDS, BEHAVIOUR, HABITAT USE AND ECOTOXICOLOGY

# Feeding behaviour and modeled energetic intake of common loon (*Gavia immer*) adults and chicks on small lakes with and without fish

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The full article can be found in Hydrobiologia 567:247–261.

## Abstract

We examined the behavior of common loons, *Gavia immer* (Brünnich), breeding on small, shallow lakes in central Alberta, Canada that were naturally fishless or contained only small-bodied fishes (minnow lake). For both lake types, adults spent >90% of their time on the nesting lake and >50% of their time foraging. Adult loons on fishless lakes dove more frequently, but dives were of shorter duration than loons on lakes with fish. On two intensively studied fishless lakes, adults fed chicks macroinvertebrates, particularly leeches, whereas on a focal minnow lake, fish made up >70% of prey items delivered by adults. Chicks >36 days of age on a minnow lake spent >50% of their time foraging, whereas older chicks on fishless lakes were highly dependent on food provisioning by adults. Models based on observed foraging patterns indicated that prey size was a better predictor of success in meeting energetic requirements than was feeding behavior (e.g., dive rate, dive success). For most models, estimated energetic intake was higher for loons on minnow lakes than on fishless lakes. Our behavioral observations and model results are consistent with surveys in central Alberta that indicate that breeding Common Loons frequently establish territories on small lakes, but that chicks hatched on lakes completely lacking fish rarely fledge and only if sufficient large invertebrates such as leeches are available.

# Testing hypotheses of social gatherings of common loons (*Gavia immer*)

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The full article can be found in Hydrobiologia 567:237–245.

## Abstract

Three hypotheses are tested to explain the function of common loon social gatherings: Cooperative Foraging, Familiarity, and Reconnaissance. From 1993–1999, I studied social gatherings through behavioral observations in Michigan, Wisconsin and Maine. There was no or little evidence for the Cooperative Foraging Hypothesis. Partial or indirect evidence for the Familiarity Hypothesis included the following: (1) social gatherings lasted both longer and occurred more frequently later in the breeding season (2) approximately 25% of all the social gatherings observed occurred on neutral territories, and (3) social gatherings consisted of the same individuals on consecutive days. Predictions from the Reconnaissance Hypothesis were also supported in that a large proportion of individuals participating in social gatherings were non-breeders and that the number of social gatherings observed were not equally distributed across loon territories, but instead increased on territories that had recently undergone a divorce. No one hypothesis was adequate to explain social gatherings and more observations on uniquely marked individuals are needed to further substantiate these initial findings.

# Evidence for facultative brood reduction in Red-throated, Pacific, and Yellow-billed Loons

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**Abstract**

Six years of data on 3 sympatrically breeding loon species in northern Alaska are used to investigate whether patterns of chick mortality were consistent with adaptive brood reduction. During 1995–2000, Red-throated, Pacific, and Yellow-billed Loon nests and broods were monitored weekly from early incubation through 6 weeks post-hatch (total nests per species = 318, 387, and 83, respectively). In each of the 3 species, nearly all pairs produced 2 eggs (76%, 79%, and 88%, respectively) but few were able to raise 2 young (17%, 4%, and 12%, respectively). Over 700 hours of time budgets indicated that chicks were dependent on parental feeding through at least 6 weeks post-hatch. Results are consistent with adaptive brood reduction. First, the daily individual chick mortality rate was brood-size dependent, with rates nearly 3 times higher in 2-chick broods than 1-chick broods. Second, the timing of most mortality during the first 2 weeks post-hatch, observations of chicks growing increasingly weaker, and the recovery of dead chicks indicate that mortality was primarily due to starvation rather than predation. Third, one chick per brood had an initial competitive advantage because of a 1–3 day hatching asynchrony and an initial egg size asymmetry, with the largest egg being laid first. Fourth, this initial advantage was reinforced by parental behaviour of feeding the nearest chick, which was almost always the larger and stronger chick. The smallest chick died in each of 20 cases of single-chick loss in marked broods.

# Factors influencing productivity of common loons (*Gavia immer*) breeding on circumneutral lakes in Nova Scotia, Canada

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The full article can be found in Hydrobiologia 567:215–226.

## Abstract

Common loons (*Gavia immer*) are top predators that are sensitive to biotic and abiotic conditions associated with their breeding lakes, so factors such as lake chemistry and human activity or disturbance are thought to influence their seasonal and long-term reproductive success. We used two indices of loon productivity to evaluate 1) temporal patterns and 2) relationships with physical and chemical lake characteristics and human activities. Data collected from 1991–2000 by volunteers of the Canadian Lakes Loon Survey (CLLS) in Nova Scotia showed that loon productivity, as indexed by both the proportion of resident pairs that produced at least one large young ($P_{s1}$) or the proportion of successful pairs that produced two large young ($P_{s2}$), did not vary substantially from year to year and showed no linear trend from 1991–2000. Average estimates (1991–2000) for $P_{s1}$ and $P_{s2}$ were 0.49 ± 0.02 and 0.43 ± 0.03, respectively, and the mean number of chicks per residential pair over that time was 0.75 ± 0.04. We found that human disturbance and shoreline development did not influence loon productivity during the prefledging stage on lakes surveyed by CLLS volunteers. Proportion of resident pairs rearing at least one large young was independent of dissolved organic carbon (DOC) concentrations of breeding lakes, but there was a positive relationship between the proportion of successful pairs rearing two large young and DOC. Both indices of loon productivity tended to be negatively correlated with lake pH. These results were not consistent with other findings that loon productivity generally declines with lake acidity, but likely reflect the preponderance of circumneutral (pH 6.5–7.0) lakes surveyed by the CLLS volunteers in Nova Scotia.

# Temporal patterns in Ontario Common Loon breeding success, 1987–2002

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## Abstract

The common loon (*Gavia immer*) is an important and culturally popular waterbird of boreal shield lakes, many of which are sensitive to acidifying pollutants. Although loon reproductive success is known to be positively associated with lake size and pH, little is known about geographically broad scale temporal patterns in loon breeding success or temporal variation in the influence of lake attributes. We used 16 years of data (1987–2002) from the Ontario portion of the Canadian Lakes Loon Survey, a volunteer-based survey of breeding loons, to assess temporal patterns in loon breeding success and to investigate whether these patterns varied with lake acidity, surface area or degree of human disturbance. Data from approximately 1000 lakes across central Ontario were available, with nearly half surveyed in two or more years. Successful breeding was defined for each pair of adult loons observed based on the number of chicks seen with them that were estimated to be six weeks or older (large young or LY). Two independent measures of breeding success were assigned to each lake and year combination: a) proportion successful — the proportion of all pairs observed with at least one LY, and b) proportion very successful — the proportion of successful pairs observed with at least two LY. We used logistic regression to estimate temporal effects and assess the response of breeding success to lake area, pH and indices of human disturbance. Results corroborated the importance of lake area and pH, indicated strong annual variation, and suggested that the effects of the human disturbance measures may have had minimal influence beyond temporal variation.

# Six years of monitoring the common loon (*Gavia immer*) population on 16 lakes in Kejimkujik National Park, Nova Scotia, Canada

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This paper can be cited as Hope, P. 2006. Six years of monitoring the common loon (*Gavia immer*) population on 16 lakes in Kejimkujik National Park, Nova Scotia, Canada. Pp. 8–16 *in* A. Hanson, J. Kerekes and J. Paquet. 2006. Limnology and Aquatic Birds: Abstracts and Selected Papers from the 4th Conference of the Societas Internationalis Limnologiae (SIL) Aquatic Birds Working Group. Canadian Wildlife Service Technical Report Series No. 474. Atlantic Region. xii + 203 pp.

## Abstract

The common loon (*Gavia immer*) population was monitored from 1996 to 2001 to determine its status and trends on 16 lakes in Kejimkujik National Park, Nova Scotia. The 16 study lakes vary from 25.7 to 246 ha in area and are very shallow. The lakes are oligotrophic with very low total phosphorus concentration and specific conductance with pH values between 4.79 and 5.9. The loon monitoring combined data gathered from intensive loon watch days involving many volunteers, plus public observations and repeated surveys by National Park staff. Most surveys were carried out from early June until late August with some follow-up monitoring of chicks into the fall. During the six year period, from 16 to 18 territorial pairs of common loons inhabited the study lakes. Observations showed that from 9 to 11 pairs of loons bred each year and produced between 5 and 10 broods from which 4 to 15 loon chicks survived until mid August. This level of reproductive success is comparable with that reported in other studies in Nova Scotia and in New Hampshire, USA. The characteristics of the seven most productive lakes are defined as a larger size (>42.9 ha, mean 120.4 ha) and lower human visitation.

## Introduction

The common loon, *Gavia immer* (Brünnich) is a prominent waterbird inhabiting most of the 40 lakes within Kejimkujik National Park (KNP), Nova Scotia, Canada. The species is both highly visible and vocal and is considered by the public to be a symbol of wilderness lakes.

Staff at KNP began to record observations of many types of wildlife, with some common loon data dating back to 1968. These observations were intended to document both flora and fauna so that park staff could more clearly understand and manage park resources and communicate the findings to the public. Throughout the 1970's, an avifaunal survey was completed and increased efforts were made to document loons and note their breeding success. Loon nest data was recorded and submitted to the Maritime Nest Record

scheme maintained by the Canadian Wildlife Service. From 1982 to 1984 park staff developed a more intensive program to define and document the loon population (Bacon and Hope 1997).

From 1988 to 1995, the Canadian Wildlife Service carried out a common loon survey of park lakes, and determined a resident loon population of 39 pairs on 25 lakes (Kerekes et al. 1995). It was determined that loons utilized lakes of 20 ha or more and usually bred successfully on lakes averaging 40 ha or greater in area (Kerekes 1990, Kerekes et al. 1994).

The current KNP Management Plan states as its first guiding principle, "The protection of the resources, both natural and cultural, and the processes that interact with them is the highest priority" (Anon. 1995). During the preparation of the plan concerns were raised about the impacts on the park's common loon population by atmospheric pollutants originating outside the park. Other research indicated high mercury levels in the park's common loons (Burgess and Hobson 2006) and detected altered behaviour (Nocera and Taylor 1998). At the same time there was increased visitor use of lakes. In response, the current monitoring program, designed to be a long-term monitoring of the common loon, was initiated in 1996. The objectives of the study are 1) to monitor the loon population on 16 selected lakes within Kejimkujik National Park; 2) to document annually changes in the breeding status of adult loons and survival of their chicks on a lake by lake basis and 3) to provide information which can be used to educate and control park visitor movements to reduce disturbance of loons, their nests and broods.

## Study Area

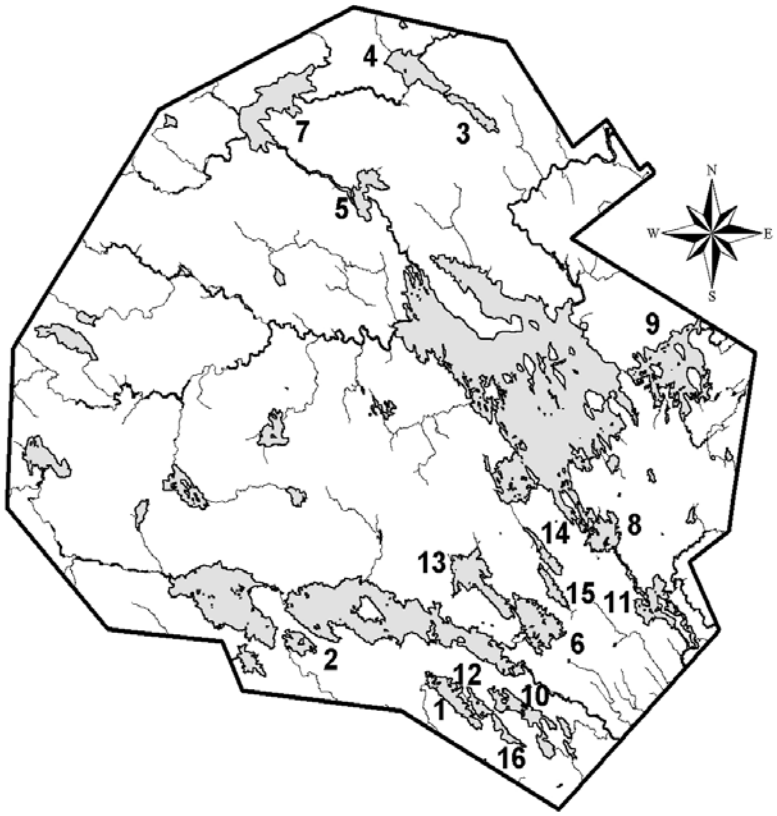
The sixteen study lakes selected all lie within the 382 $km^2$ area of the inland portion of Kejimkujik National Park (44˚20'N, 65˚20'W) in southwestern Nova Scotia. While the study lakes are scattered across much of the park, they can be characterized as the most accessible lakes and did not include Kejimkujik's two largest lakes, which proved to be too complex to properly monitor in this fashion (Figure 1).

The study lakes vary in size from 25.7 to 246 ha and are shallow, with mean depths from 1.1 to 4.2 metres. They are all oligotrophic lakes, varying in colour from 10 to 110 Hazen units while pH ranges from 4.79 to 5.9. Specific conductance varies from 20.5 to 30.6 mho/cm and total phosphorus concentration varies from 3.0 to 9.0 mho/cm (Vaidya 1998) (Table 1). During this study the mean pH for precipitation was 4.6 as determined from samples collected at the Canadian Air and Precipitation Monitoring Network station (CAPMoN) within KNP (Beattie et al. 2000).

## Methods

The current common loon monitoring program was initiated in 1996. The key population indicators recorded in this program include; the number of resident pairs of loons, the number of breeding pairs (determined by observations of either nests or broods) and the number of chicks surviving until the late August Loon Watch survey date. To include observations from several sources a standardized data collection form was developed, with

a set of defined terms. The location of all observations was recorded by their UTM coordinates. Loon observations were incorporated from several sources. Regular reports were submitted by Kejimkujik's backcountry patrol staff, whose duties include the patrol, on an almost weekly basis, of six of the study lakes during July and August. These staff also make frequent visits, during the summer, to many other study lakes. Occasional loon observations, made from May until October, were received from various park staff for all lakes.




1) Back
2) Beaverskin
3) Big Dam East
4) Big Dam West
5) Channel
6) Cobrielle
7) Frozen Ocean
8) George
9) Grafton
10) Hilchemakaar
11) Loon
12) Lower Silver
13) Mountain
14) North Cranberry
15) Puzzle
16) Upper Silver

*Figure 1.* Kejimkujik National Park showing the location of the 16 study lakes.

An additional program called the Loon Watch, utilized trained volunteers in a co-ordinated effort. On each designated date, all participants simultaneously surveyed their assigned lake within a three-hour observation period beginning at noon. Most or all of the study lakes were covered depending upon the number of participants. All Loon Watch participants were screened for their ability to canoe and cover assigned lakes, to identify

loons and classify young by age and accurately report findings. These volunteers were given training, plus provided with maps, identification sheets and data forms. Many of the same volunteers have taken part in more than one of these surveys, so there has been consistency in data collected. Each year there were two Loon Watch days. The first Loon Watch day was held in early June, to document resident pairs of loons, as the nesting season was about to begin. The second Loon Watch occurred during the third week of August, so that loon broods may be reported and the post-nesting number and distribution of adult loons can be determined.

*Table 1*. Summary of key physical and chemical properties of 16 study lakes in Kejimkujik National Park.

| Lake | Surface area (ha) | Mean depth (m) | Colour (Hazen units) | pH | Specific conductance (mho/cm) | Total phosphorus (g/l) |
|---|---|---|---|---|---|---|
| Back | 82.6 | 2.18 | 27.9 | 5.37 | 21.8 | 8.0 |
| Beaverskin | 42.9 | 2.19 | 11.7 | 5.4 | 21.4 | 5.0 |
| Big Dam E | 45.5 | 2.32 | 20.7 | 5.9 | 24.0 | 5.0 |
| Big Dam W | 105 | 2.47 | 93.6 | 5.0 | 29.6 | 8.0 |
| Channel | 73.6 | 1.14 | 106.7 | 4.76 | 28.7 | 9.0 |
| Cobrielle | 132 | 1.97 | 27.5 | 5.36 | 21.2 | 3.0 |
| Frozen Ocean | 246 | 1.86 | 97.1 | 4.85 | 28.7 | 9.0 |
| George | 77.8 | 2.37 | 62.5 | 5.06 | 26.9 | 8.0 |
| Grafton | 160 | - | 47.1 | 5.85 | 30.6 | 8.0 |
| Hilchemakaar | 101.8 | 2.02 | 52.5 | 5.42 | 25.5 | - |
| Loon | 82.5 | 1.99 | 63.3 | 5.11 | 26.8 | 8.0 |
| Lower Silver | 26.7 | 1.82 | 19.4 | 5.65 | 20.9 | - |
| Mountain | 136 | 4.26 | 25.0 | 5.3 | 21.5 | 4.0 |
| North Cranberry | 36.7 | 1.45 | 29.0 | 5.14 | 21.1 | - |
| Puzzle | 35.9 | 2.70 | 17.5 | 5.3 | 20.5 | - |
| Upper Silver | 25.7 | 2.33 | 18.2 | 5.9 | 22.1 | 4.0 |

Park visitor sightings of loons were solicited since these canoeists cover all of the study lakes and see things not observed by park staff. These backcountry canoeists were often the first to discover broods and nests. Their sightings, when verified by repeat observation by park staff, were entered into the database while unconfirmed reports are not utilized.

The guiding principal was to avoid any intensive or prolonged monitoring activity that could contribute either to nest failure or death of young chicks. Based upon earlier work, it was realized that a nest search would require manpower resources beyond what was available. Therefore, the only nests observed were those accidentally discovered while travelling the lakes.

The greatest emphasis and definition was placed upon brood observations from the end of June until early September. Chicks were defined as downy young (covered in dark grey down, less than 1/3 adult length, up to 3 weeks old) small young (lighter brown/grey down, 1/3 to 2/3 adult length, 3 to 6 weeks old) and large young (coat of light and dark grey feathers, 2/3 adult length or more, over 6 weeks of age). All observed mortality was documented. Many of the lakes were reported on every week during this study. Observations of resident pairs and broods were often re-confirmed by multiple sightings, from park staff and visitors.

## Results

By combining the results from all the survey methods, the total number of observations of common loons during this study provided sufficient data to determine the number of resident pairs. All observations between the end of May and mid July were used to determine if a pair of loons consistently frequented, and were in residence on, a section of a lake. At least two observations of a pair of adults within this time, or the confirmation of breeding, were required to confirm a resident pair. The common loon population on the 16 study lakes was determined to be 16–18 resident pairs (Table 2). The number of pairs inhabiting each of the lakes ranged from none, in some years, to a one year high of three on Grafton Lake. One additional lake, Hilchemakaar Lake, had more than one resident pair of loons. The number of resident pairs of loons remained constant at one pair every year on 12 of the lakes.

*Table 2*. Six-year summary of the common loon population on 16 lakes in Kejimkujik National Park.

| Year | No. Residential Pairs | No. Breeding Pairs | No. Broods | No. Chicks | No. chicks alive mid-August |
|---|---|---|---|---|---|
| 1996 | 18 | 10 | 8 | 11 | 6 |
| 1997 | 18 | 10 | 5 | 8 | 4 |
| 1998 | 17 | 10 | 10 | 16 | 15 |
| 1999 | 16 | 11 | 7 | 10 | 7 |
| 2000 | 17 | 9 | 8 | 11 | 8 |
| 2001 | 18 | 10 | 9 | 12 | 6 |
| Range | 16–18 | 9–11 | 5–10 | 8–16 | 4–15 |

The second objective was to determine breeding status of these pairs by noting either nests or broods. The only nests reported were ones that were coincidentally discovered during travels on lakes. During this six year monitoring program there were from 9 to 11 pairs of loons confirmed as breeding each year on the study lakes (Table 2). Forty-seven loon broods, totalling 68 chicks were located (mean 1.45 chicks per brood). The annual production varied from 5 to 10 (mean 7.8) broods with from 8 to 16 (mean 11.3) chicks (Table 2). Loon chick survival was noted during the August Loon Watch, held during the

third week of the month. By that date, an average 0.98 chicks were estimated to be surviving per brood. On an annual basis this was from 4 to 15 (mean 7.6) chicks alive in late August (Table 2).

## Discussion

The results of monitoring from 1996 to 2001 suggest only minor fluctuations in the overall loon population on the study lakes. The total number of resident pairs varied from 16 to 18 pairs, however, the population remained constant at one pair on each of 12 lakes. The number of observed breeding pairs was constant at 10 pairs for four years, but did vary from 9 to 11 pairs (Table 2). It appears that the overall common loon population and breeding levels were stable over the short term. Little change was noted from results of a comparable intensive one-year study in 1984 which indicated there were 18 resident loon pairs with 9 confirmed as breeding pairs on these same lakes (Bacon and Hope 1997). Since common loons are long-lived birds, a monitoring program carried out over a greater number of years would be more likely to reflect long-term trends.

While the primary intent of this monitoring was to document the Kejimkujik National Park common loon population, it was felt desirable to compare the findings with loon population studies elsewhere. A recent common loon monitoring program carried out in New Hampshire (Taylor and Vogel 2001) developed several ratios to describe the relationship of their territorial pairs to several measurements of breeding success which closely parallel those terms used in this study. At Kejimkujik the ratio of breeding pairs to resident pairs varied annually from 0.53 to 0.69, with a mean of 0.58 (Table 3). Over a similar time-frame a mean of 0.65 breeding pairs to resident pairs was recorded from New Hampshire (Table 4). While the Kejimkujik ratio of chick surviving to resident pairs varied greatly from 0.22 to 0.88, the mean value was 0.45 over the six years. Kerekes in a seven year loon study of 40 lakes, all within Kejimkujik National Park and including all of the lakes in this present study, reported a mean of 0.28 chicks per resident pair (Kerekes et al. 1995), which falls within the range of values reported here. A10 year loon study of 283 Nova Scotia lakes reported a range of 0.50 to 1.19 chicks per resident pair with a mean of 0.75 (Badzinski and Timmermans 2006). The higher productivity of chicks per resident

*Table 3*. Common loon population ratios for Kejimkujik National Park.

| Year | Breeding Pair/ Resident Pair ratio | Chicks Surviving/ Resident Pair ratio | Chicks Surviving/ Breeding Pair ratio |
|---|---|---|---|
| 1996 | 0.56 | 0.33 | 0.60 |
| 1997 | 0.56 | 0.22 | 0.40 |
| 1998 | 0.59 | 0.88 | 1.50 |
| 1999 | 0.69 | 0.44 | 0.64 |
| 2000 | 0.53 | 0.47 | 0.89 |
| 2001 | 0.56 | 0.33 | 0.60 |
| Mean | 0.58 | 0.45 | 0.77 |

*Table 4.* Comparison of breeding pair to resident pair ratio of common loons and comparison of chick survival* to resident pair ratio of common loons in Kejimkujik National Park with a New Hampshire study.

| study | breeding pair/ resident pair ratio | | chick survival/ resident pair ratio | |
|---|---|---|---|---|
| | Kejimkujik NP 1996–2001 | New Hampshire 1997–2001 | Kejimkujik NP 1996–2001 | New Hampshire 1997–2001 |
| mean | 0.58 | 0.65 | 0.45 | 0.48 |
| range | 0.53–0.69 | | 0.22–0.88 | |

*Chicks surviving to mid-August

pair can likely be attributed to a broader geographic representation of lakes with higher pH (70% of the lakes had pH from 6.5 to 7.5) with resulting greater range of abiotic and biotic attributes. The Kejimkujik mean for this study of 0.45 chicks per resident pair is very similar to the New Hampshire ratio of 0.48 (Table 4). It is also within a range reported elsewhere (McIntyre and Barr 1997) that noted fledged young per pair per year can be as low as 0.22 where high loon populations utilize marginal lakes, a situation consistent with Kejimkujik. During this monitoring program it was not possible to complete extensive nest searches. As a result the number of breeding pairs could be under reported. That could occur when nests, which are unsuccessful at producing chicks, were not found while they contained eggs. The result would be that fewer breeding pairs were identified.

As expected, some of the larger lakes were more productive. Two lakes with surface areas over 100 ha were notably more productive during this study. Hilchemakaar Lake, 101.8 ha, was the only lake to support at least one breeding loon pair for each of the six years. Grafton Lake, 160 ha, was the only lake to have up to three pairs of resident loons. It was home to breeding pairs of loons for five years, and was the only lake to report two breeding pairs in the same year. Over this study, Grafton Lake produced six chicks that survived until late August, the highest for all study lakes. Surviving loon broods were noted on all but two lakes. However, seven lakes accounted for 63% of all chicks alive by mid August. Those seven lakes included Back, Beaverskin, Channel, Frozen Ocean, Grafton, Hilchemakaar and Mountain lakes. Some factors seem to create these more favourable conditions. The seven lakes are larger in size, with a mean surface area of 120.4 ha as compared to the 88.2 ha for all the study lakes. The other factor is lower human visitation on the seven lakes, or at least on most of the area of each lake.

## Conclusion

From this monitoring study, several conclusions can be made.
1) This approach, of utilizing several methods to gather observations, provided enough records to monitor the Kejimkujik National Park common loon population on 16 lakes.
2) The Kejimkujik National Park loon population appeared stable over the time of this monitoring and seems consistent with the population reported in 1984. Considerable variation was noted in the number of broods produced from year to year.

**Acknowledgements**

This study has been sponsored by Kejimkujik National Park and initiated by park staff, to whom I am indebted. Notably, Chief Park Warden B. Thexton, Science Information Management Specialist S. O'Grady and backcountry patrol staff B. Mailman and C. Waterman. Many other park employees, including interpreters, wardens, works and visitor services staff, provided loon observations. Joseph Kerekes, emeritus research scientist with the Canadian Wildlife Service participated throughout this survey and acted as a consultant and mentor to the author. Information, assistance and support have come from CWS staff N. Burgess and graduate student Joseph Nocera.

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# Sixteen years of monitoring Common Loon populations in La Mauricie National Park, Quebec

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## Abstract

Since 1987, the status and breeding success of the common loon population of La Mauricie National Park (536 km$^2$) has been monitored. Two aerial censuses are conducted annually on all lakes exceeding 3 ha ($n$ = 76) and ground counts are also executed during the breeding season. Since 1987, the number of territorial pairs is fairly stable (average 25.2, range 18–32). The number of breeding pairs (average 14.4, range 11–20) and the number of egg per nest remained stable (average 1.79). The nesting success has slowly declined with a significantly decrease of 15% (average 69% to 54%, 1987–94:95–02). The reproductive success (number of young surviving to six weeks of age) has significantly decreased (average 15.1 to 10.8, 1987–94:95–02). This decrease cannot be related only to the nesting success, other factors are involved such as acidification and mercury exposure. The human disturbance is excluded because this decrease is also observed on lakes not used by visitors. The lakes used for breeding ($n$ = 32), compared to all other lakes used by loons ($n$ = 42), are large, deep, irregularly shaped with islands, and have a low trophic level (oligotrophic) and a low alkalinity. Occasionally, small lakes (7–10 ha) are used for breeding. The reproductive success (1987 to 2002) was significantly lower for smaller lakes (<25 ha), lakes with low pH (<5.5) and alkalinity (<2 mg/l) and those with higher levels of human presence (>15 person-year/ha). Three large lakes abandoned for loon reproduction (1980–1996) were reused since 1997 with a high success. This success can be associated with the decrease in the number of fisherman-day on these lakes (2500 to 450). Many actions have been taken by the park to reduce conflicts between visitors and loons. Since 1997, lead sinkers have also been prohibited. The water quality and fish population are being monitored in order to better document effects of acid precipitation, human disturbance and other factors on breeding loons. This monitoring program was also integrated with an assessment of mercury exposure and effects in Common Loon in Quebec with the Canadian Wildlife Service.

# Southcentral Alaska Loon survey

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**Abstract**

Common (*Gavia immer*), Pacific (*G. pacifica*), and occasional Red-throated loons (*G. stellata*) occupying lakes in the lower Matanuska-Susitna Valley and the northern Kenai Peninsula in southcentral Alaska may be impacted by increasing human settlement and disturbance associated with the use of lakes for recreation. In May 2001, we began an aerial survey to determine the distribution, abundance, productivity, and population trend of loons in southcentral Alaska. We used both a standard aerial survey sample with systematic transects and an unconventional aerial survey design and analysis procedure termed a "meandering design". One thousand Common Loons and 300 Pacific Loons were estimated for the entire survey area. Loons were found to be associated with larger size lakes; 345 lakes having 1 or more loons averaged 14.23 hectares (90% confidence interval = 1.07–189.30) compared to an average size for all 4425 lakes in the study area of 1.38 hectares (0.08–22.85). When survey designs were compared, the meandering design proved advantageous for detecting loons and producing population estimates; the total distance flown was about 20% less, a slightly larger percent of the flight time was spent on transect, and more loons were observed per kilometre flown. The data gathered during surveys will establish baseline information on loon populations useful for monitoring, assessment, and management decisions.

# Changes in loon and grebe populations in the lower Matanuska-Sustina Valley, Alaska

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## Abstract

Common Loons (*Gavia immer*), Pacific Loons (*G. pacifica*), and Red-necked Grebes (*Podiceps grisegena*) breeding on lakes in the Matanuska-Susitna Valley (Mat-Su Valley) of Alaska may be impacted by increasing human settlement and disturbance associated with the use of lakes for recreation. To address concerns over the susceptibility of loons and grebes to rising anthropogenic pressures, I compared changes in loon and grebe lake occupancy and productivity to changes in the human population and settlement patterns from years 1987 to 1999. There has been both a temporal and spatial shift in the population distribution of Common Loons, Pacific Loons, and Red-necked Grebes in the Mat-Su Valley since 1987. Significantly ($P = 0.0003$) fewer lakes had any specie of loon or grebe present in 1999 compared to 1987 while productivity remained stable. There has also been a spatial shift in lake occupancy by loons and grebes from the southwest to the northwest region of the study area. Most of the lakes that are no longer used by breeding loons and grebes have been located in an area that has also experienced the most human growth. Such changes in lake occupancy may be indicative of declining loon and grebe populations or may reflect large-scale emigration due to the loss of suitable nesting habitat from shoreline development and human recreational disturbance.

# Status and trends of loons breeding in Alaska, 1977–2002

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**Abstract**

In northern Alaska, loons have been monitored by one annual aerial survey begun in 1986, and a second begun in 1992 and flown at twice the intensity over a subset of the area. Elsewhere in Alaska, loons have been monitored reliably on a third survey since 1977. Survey areas cover most of the loon nesting habitats in Alaska. Breeding population trends and minimum population size estimates will be presented for Red-throated Loons, Pacific Loons, Common Loons, and Yellow-billed Loons. For example, for the Yellow-billed Loon, which is the rarest species, the current 6-year average breeding population size estimate in northern Alaska, adjusted by a visibility correction factor, is 2407 individuals (95% confidence interval of 1286–3528), and the entire Alaska population is only 3187 individuals. Most of the population occurs between the Colville and Meade Rivers, with 84% occurring within 15% of the area. There is no evidence of a long-term population trend since 1986 (annual change = -1.2%, $P$ = 0.56). However, a significant short-term decline has occurred since 1992 (annual change = -7.8% for one survey and -3.4% for both surveys combined). Similarly, when observer effects are minimized by using data from only the pilot, both surveys indicate marginally significant short-term declines. For Yellow-billed Loons, but not the other loon species, the two individual surveys have relatively low power to detect a decline of interest (here considered to be a 3.4% annual decline), but when the two trends are combined, power is 62%.

# A landscape-scale model of yellow-billed loon (*Gavia adamsii*) habitat preferences in northern Alaska

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The full article can be found in Hydrobiologia 567:227–236.

## Abstract

We modeled yellow-billed loon (*Gavia adamsii*) habitat preferences in a 23,500 km$^2$ area of northern Alaska using intensive aerial surveys and landscape-scale habitat descriptors. Of the 757 lakes censused, yellow-billed loons occupied 15% and Pacific loons (*G. pacifica*) 42%. Lake area, depth, proportion of shoreline in aquatic vegetation, shoreline complexity, hydrological connectivity (stream present within 100 m or absent), and an area×connectivity interaction were positive, significant predictors of yellow-billed loon presence in a multivariate logistic regression model, but distance to nearest river or Beaufort Sea coast were not. Predicted yellow-billed loon presence was 13 and 4.7 times more likely on deep and medium lakes, respectively, than on shallow lakes that freeze to the bottom. On small lakes (<60 ha), predicted yellow-billed loon presence was 4.8 to 1.7 times more likely on lakes with hydrological connectivity than without, but connectivity was not important at most lake sizes (65–750 ha). Yellow-billed loon broods depend on fish available in the brood-rearing lake, and we suggest that a dependable supply of fish is more likely in larger lakes, those deep enough to have open water under winter ice, and those near streams. Highly convoluted shorelines and those with aquatic vegetation provide loon nesting and brood-rearing sites, as well as fish habitat. Pacific loon absence was a significant, positive predictor when added to the habitat model, indicating that yellow-billed loons were 4 times more likely on lakes without Pacific loons.

# Measuring the quality of breeding habitat for the Common Loon

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## Abstract

Anthropogenic stressors on lakes can degrade breeding habitat for the Common Loon (*Gavia immer*). Stressors causing impacts at the individual and population level have been documented in many parts of the loon's breeding range. In some cases, local governing bodies, as well as state and federal governments have subsequently set policies. To appropriately evaluate and quantify the ecological impacts from multiple stressors, we developed a simplified stressor-risk ranking matrix. This model accounts for major stressors to breeding loons and is validated with long-term, standardized productivity databases. Measured stressors include shoreline development, water-based recreational activities, ingestion potential of lead, risk to atmospheric deposition of toxins including mercury, lake acidity, dam-based water level fluctuations, prey availability, direct habitat degradation such as water clarity, and avian and mammalian predation. Although birds in spatially heterogeneous environments can maintain large sink populations in an evolutionary stable manner, we feel that the extremely restrictive dispersal abilities of breeding loons (<2 km) combined with chronic breeding ground stressors (e.g., mercury and acid rain) and unpredictable but frequent winter stressors (e.g., marine oil spills) produces enough population level uncertainty that cumulative stressors need to be quantified in many areas of the loon's breeding range. Identification of high quality loon breeding habitat is critical to maintain breeding population integrity, avoid increased habitat patchiness, and prioritize conservation-oriented actions.

# Habitat use by breeding loons in Atlantic Canada

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## Abstract

The breeding Common Loon populations are monitored where they occur in the National Parks in the Atlantic Region (Kejimkujik, Cape Breton Highlands, Fundy, Terra Nova, Gros Morne) and in the Experimental Ponds Area, ~100 km west of Terra Nova National Park in Newfoundland (Figure 1). The monitoring effort goes back to 1982 in Kejimkujik National Park while it commenced in 1997 in Terra Nova and Gros Morne national parks. The lakes range from oligotrophic to ultra-oligotrophic. Overall, the adult population remained stable, with considerable year-to-year variation in reproductive success (Kerekes et al. 1997, Kerekes and Masse 2000). Nutrients (phosphorus) through fish production controlled the lake size that is required for breeding success (Kerekes 1998). In oligotrophic lakes, ≅ 40 ha were required to support a chick to fledging while in ultra-oligotrophic lakes, >120 ha or several smaller lakes were needed as a territory to raise chicks (Kerekes 1990, Kerekes et al. 1994, Kerekes et al. 2000). Smaller lakes ≅ 20 ha or less, close to the sea or to large lakes where adults could fly to the sea to feed, were able to support chicks to fledging (Fundy, Terra Nova) (Clay et al. 2004, Kerekes et al. 2000). In spite of the great abundance of lakes of different sizes, breeding loons were observed only in one lake in Gros Morne National Park in Western Newfoundland. The reason the absence of loons in the vast majority of lakes is not known.


Figure1. National parks in the Atlantic Region of Canada.

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# Common Loon populations at Morro Bay, California: Summary of an eight month fall-to-spring study

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## Abstract

Loon populations using Morro Bay, California, USA were monitored weekly over an eight-month period, fall to spring. A brief summary of wintering loon ecology is given, and the study area introduced. The key objectives of the study were to quantitatively describe the loon species composition within the bay over the period, and to identify the areas within the bay having the highest and lowest occupational frequencies for a given species, age, and tidal condition. By abundance, it was determined that common loons consistently and prominently outranked all other species throughout the study period and throughout all areas of the bay. Slower fall population infiltration and rapid spring egress of adult loons were noted, with a sustained population of immature loons remaining, thus following expected seasonal migration patterns. All species uniformly occupied the bay, with no area significantly preferred by any one species. Relationships between the sections of the bay used, date, tidal activity, food abundance, loon age, and other variables and anomalies are investigated. Overall, the northwestern portion of the bay closest to the entrance was most heavily occupied by all species, while the southeastern portion of the bay farthest from the entrance was the least occupied. At high tide, the central and northwestern portion of the bay experienced significantly higher use by common loons, while adjacent areas and the entrance channel were avoided during high tides and favoured during ebb tides. Food concentrations and currents influenced by the tides appeared to dictate this activity. The far northwestern portion of the bay was consistently favored by immature common loons, mainly due to repeated engagement in social rafting at that particular location during evenings. Hypotheses, interpretations, and conclusions about the dynamics of the loon populations that occupy Morro Bay, and the effectiveness of the study, are supplied and discussed.

## Introduction

Most behavioral and ecological studies of loon populations have been conducted on their breeding lakes (McIntyre 1975, Barr 1996, Evers 1994, Mager 1995, Piper et al 1997, Paruk 1999), limiting our knowledge of their winter behavior and ecology, especially on

the Pacific Coast of North America (McIntyre and Barr 1997, Barr et al. 2000, Russell 2002). Despite this, loons face substantially higher levels of environmental pressure during periods of migration and overwintering than during breeding periods (Evers 2001). For example, surveys in North America show that loons experience levels of winter mortality far higher than all other seabirds combined, especially among adults (Simons 1985, Alexander 1991). This is partially due to complete wing and body molts during the winter, which demand large amounts of energy and impede mobility between food sources, causing loons to become much more susceptible to lethal levels of emaciation (Spitzer 1995).

Morro Bay is known for its large populations of adult and subadult Common Loons (*Gavia immer*); the latter found throughout the year (D. Long, unpub. data). This study examined usage patterns and tidal conditions associated with aggregations of the loons in Morro Bay from September 2002 through May 2003.

## Study site and Methods

Morro Bay is located exactly halfway between Los Angeles and San Francisco, California. This estuary is approximately 6.8 km long (from northernmost to southernmost shore), 2.5 km in breadth at its midpoint, and has an area of 8.03 km² in high-tide water. Two breakwaters at the entrance to the harbor extend the swell protection to 700m into the ocean (Fig. 1).

Morro Bay was surveyed weekly for the duration from the 29th of September, 2002 to the 25th of May, 2003 ($n$ = 32). All counts were performed between the hours of 14:00 and 17:00, to minimize time of day effects.

The Bay was divided into 13 areas, lettered A to M, and surveyed in the same order each visit. Spot counts were conducted from a specific location within each area (numbered triangle) using a 35–50× spotting scope; under adverse viewing conditions survey locations were shifted (circles; Fig. 1). Data collected included: station, area, species, and age, start and end times, inner-bay tidal stage, weather conditions, and Secchi-scale water clarity.

## Results

*Species composition*

In total, 926 loons ($\overline{x}$ = 28.94 loons/ visit), of three species types, were counted over the study period: 95% Common Loons, 4% Red-throated Loons *(G. stellata)*, and 1% Pacific Loons *(G. pacifica)*. The two highest counts of combined species occurred on 22 December ($n$ = 55) and 16 March ($n$ = 62). Although small numbers of Yellow-billed Loons *(G. adamsii)* and Arctic Loons *(G. arctica)* are present in this area during the winter, none were noted during this study. The bulk of this study is focused on the Common Loons, as no significantly conclusive data analyses could be performed on either Red-throated Loons or Pacific Loons due to small sample size.

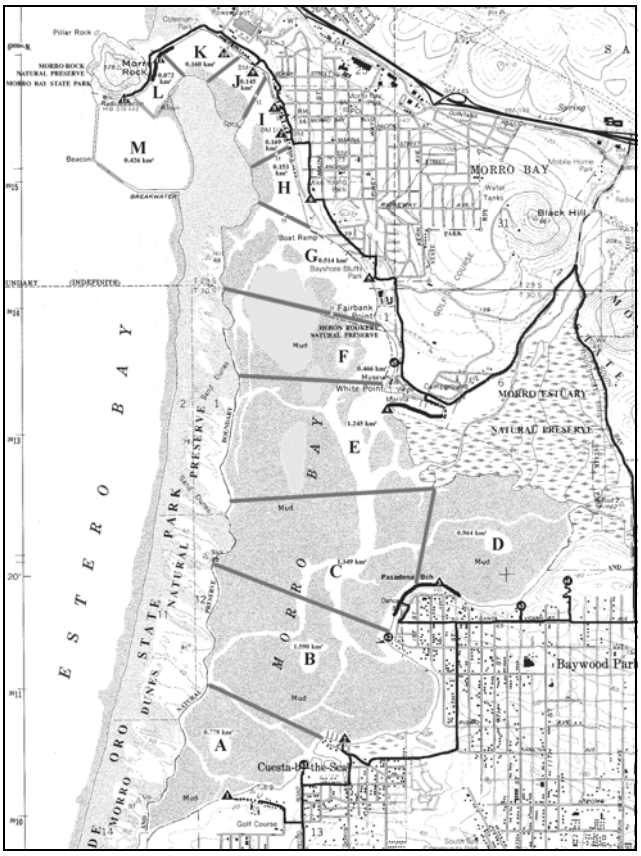


*Figure 1*. Morro Bay study area

*Age composition*

Using plumage, loons were aged as "adult" (over two years), "subadult" (under two years) or "unknown". The percent age composition for each species was: Common Loons ($n$ = 878), 42% (366) adult, 36% (321) subadult, and 22% (191) unknown; Red-throated Loons ($n$ = 35), 40% adult, 40% subadult and 20% (7) unknown; Pacific Loons ($n$ = 13), 62% (8) adult and 38% (5) subadult.

The fall influx of both adult and subadult Common Loons occurred over a nine-week period beginning on the 20th of October. The adult and subadult populations increased at about the same rate, and then leveled off with adult numbers averaging 21 birds/survey and subadult numbers between 10 and 15 individuals/survey. A maximum number of subadults (25) was noted on 16 March and a minimum (9–13) between 20th of April to the 25th of May. The spring egress of adults occurred much more rapidly than the fall arrival. The average number of adults per survey dropped sharply from 21 birds to one individual over three weeks (13th of April to the 4th May), leaving only subadult loons in the bay (Figure 2).

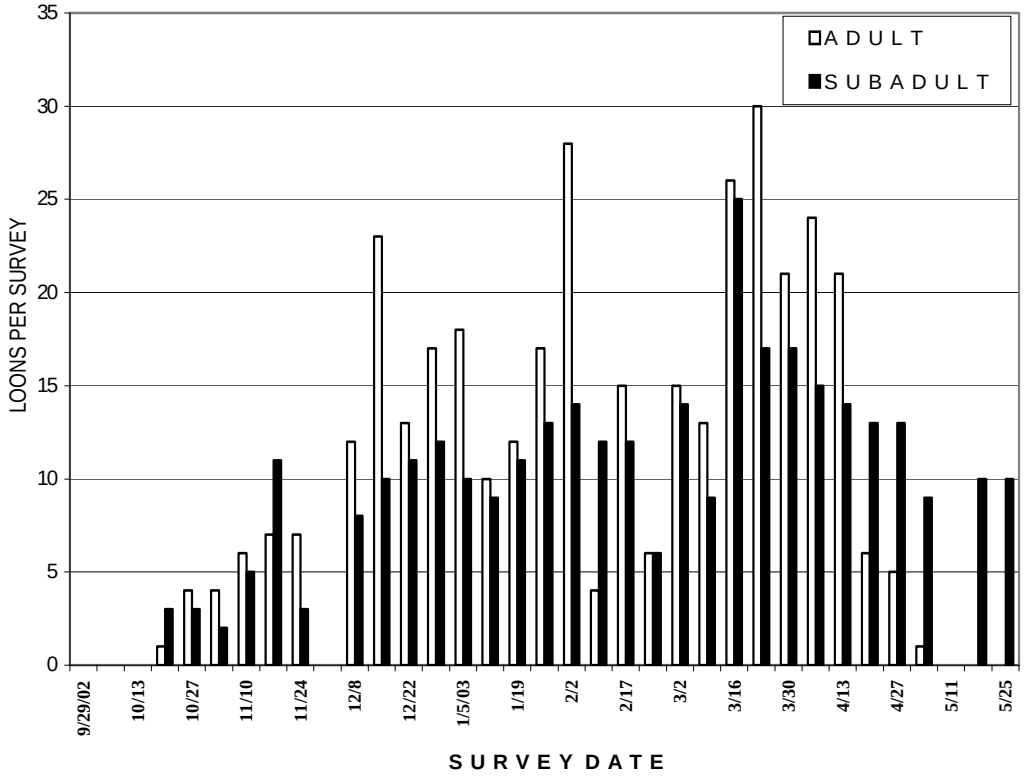


*Figure 2*. Common Loon age composition

*Distribution of Common Loons*

Both age groups of Common Loons preferred the same areas, with the exception of area K, which had 75% more subadults than adults ($\chi^2 = 6.5454$, $P < 0.05$) (Figure 3). Tide level did not seem to affect the number of Common Loons in the southern portion of Morro Bay. However, in the northern portion of the bay, Common Loons preferred areas G, K, and M, during high tides, and areas I, J, and L during ebb tides. Analysis showed no difference in distribution of adult and subadult Common Loons based on tide level.

## Discussion

Common Loons prefer calmer, sheltered conditions with a stable food supply during winter, unlike their Red-throated or Pacific counterparts which are commonly found offshore in open ocean (Baltz and Morejohn 1977; Ford and Gieg 1995; Spitzer 1995; D. Long, pers. obs.). The water in Morro Bay is calm, relatively clear, and 1 to 5 m deep in most areas, providing good visibility to seek prey items such as small fishes, crabs, and echinoderms which are abundant. These characteristics seem to be key variables in making Morro Bay an ideal location for wintering subadult and adult Common Loons.

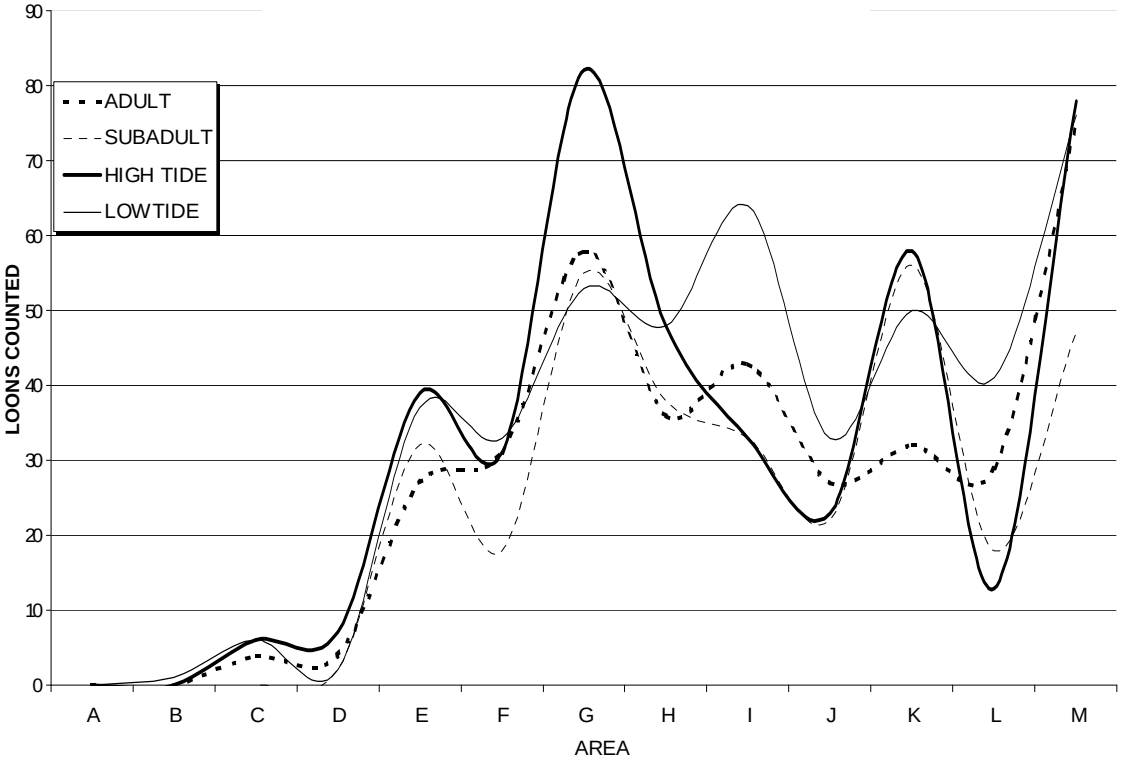


*Figure 3.* Area occupation for Common Loons by tidal stage and age (totals for all surveys).

Monitoring progeny of Common Loons at specific overwintering locales may be useful for evaluating breeding success of regional populations within the northwestern U.S. and Canada. Literature suggests that subadults occupy their first wintering territory for two to three years before their first northward migration as an adult (McIntyre and Barr 1997). This is consistent with first-year (juvenal) Common Loons in Morro Bay, identified by their plumage of scalloped back feathers and worn-edged primaries, which remained after the adults began their northern migration (Figure 2). The large numbers of loons overwintering at Morro Bay make it a potential location to monitor the year-to-year reproductive success of the western Common Loon population in this area from the previous year. Timing of surveys would be crucial; other studies conducted in Morro Bay suggest subadults leave the area after the beginning of June possibly due to the influx of other piscivorous birds (numerous subadult brown pelicans, cormorants, and gulls) and their impact on food availability (D. Long, unpub. data). The extent to which these juveniles represent the Common Loon population would be clarified by examining the geographic relationships between the maturation territories of subadult Common Loons and their natal regions through the use of capture and banding on both the wintering and breeding territories (McIntyre and Barr 1997), and through comparative genetic fingerprinting analyses to detect possible lineages between them (D. C. Evers, J. D. Paruk, pers. comm.).

*Migration of Common Loons*

The main spring migration push for Common Loons occurred in late March and early April. The onset of Pacific Loon migration along the southern and central California coast during spring is believed to be correlated to the seasonal transition to coastal upwelling of zooplankton-rich deep water along the area offshore of Pt. Conception (Russell and Lehman 1994). As Common Loons participate to a certain extent within this nearshore spring migration traffic, they can easily stop and perform staging in these bays as they work their way up the Pacific Coast (Corkran 1988).

Fall migration is much more gradual for all loon species and is not yet fully understood for Common Loons (McIntyre 1997, Russell 2002, Barr et al. 2000). Studies of Pacific Loon fall migratory movements show that southward flights are performed well offshore in loose, spread-out groups, following the continental shelf, before turning toward shore. On the West Coast, fewer than a hundred fall migrants per hour are tallied at locations where thousands were seen in the spring, and arrival time is spread out over two or three months rather than a couple of weeks (Russell 2002; D. Long, pers. obs.). The more gradual rise in numbers at Morro Bay in the fall reflects a similar pattern (Figure 2).

During fall migration, both adults and subadults infiltrate the Bay at nearly equal rates. Although adults are documented to depart their breeding lakes well before their subadult offspring in most cases (McIntyre and Bar 1997), other accounts suggest synchronous departure of one or both parents and offspring from breeding territories (G. Gumm and D. Poleschook, pers. comm.; D. Long, unpub. data). The relationship between parent and offspring departure during fall migration may be characteristic of certain populations rather than the species as a whole.

*Distribution of Common Loons occupying Morro Bay*

With the exception of area K, adults and subadults preferred the same areas. Adult Common Loons become markedly less territorial and more tolerant during the winter months with large numbers of loons foraging and rafting together, likely increasing food detection and subadult foraging success and decreasing predation rates (McIntyre 1978, McIntyre 1988, Daub 1989, McIntyre and Barr 1997, Paruk 1999). Areas G, K, and M were preferentially used by Common Loons of both age groups. Area G has a large surface area, and features a dense population of invertebrate prey, particularly crabs, on the sandbar side. The water is fairly calm, yet shallow during all tides. Area K is preferred by subadult Common Loons as the primary location for night rafts, probably due to calm water and decreased currents and wind with Morro Rock and other topography providing some shelter. Area M had a large surface area, coupled with very good feeding habitat under modest shelter of the breakwaters.

Areas A, B, C and L had considerably fewer loons because they do not support an adequate food supply. In addition, area L had strong currents during tidal exchanges, resulting in a decreased chance for any large number of loons to be present and counted at any given time. Area L is also the smallest sampling Area in the Bay (only about 0.072 $km^2$).

Area G showed markedly higher usage by Common Loons during high tides, when the salt marsh and its high density of crabs, was under water and accessible. During the

survey, Common Loons regularly congregated within that region of Area G, working the shallow sandy waters, sometimes as little as 20 cm deep, with crabs being the most noted food item consumed. Area I was favored during low tide was avoided during high tide. During ebb tide fish may be trapped in areas where water is calm and not subjected to strong in or outflow during tidal exchanges, making it easier for loons to fish for them (McIntyre 1978). The small sandspit projecting from the sandbar on the boundary of Areas I and J remains relatively shallow and calm during low tide and when the tide begins to rise the water on the south side of this small spit rotates clockwise creating a countercurrent and possibly trapping prey items. During high tide prey would no longer be trapped and Area G nearby would become more attractive to the loons for feeding.

Common Loons avoided area L during high tide and preferred it during low tide. Hypothetically, the time of day area L was sampled combined with the tidal schedule may have influenced the results. All samples were taken just before sunset and Common Loons prefer to spend their sleeping hours in calm, sheltered areas. During low tide conditions inside the Bay, the current begins flowing back into the bay through area L. Therefore, any loons in the relatively unprotected Area M, or out beyond the breakwaters, may have been counted as they used the inflow current (through area L) to move back into the Bay for the night. Conversely, when the tide inside the Bay was high, the loons may have remained farther back in the Bay to avoid being pushed back out to sea by the outbound current through Area L, thereby resulting in lower counts there during high tide.

The unequally-sized spot-count areas, based on visual landmarks, may have had an effect on the data presented. Normalizing count totals from each survey area to equal surface areas of 0.618 km² results in dramatically amplified counts within the northwestern portion of the bay. The area L total increases to over 3700 Common Loons, becoming the highest potentially-occupied area in the bay, and areas E through M become the lowest, which better describes occupancy and usage enhancing the value of the statistical data.

Water turbidity did not seem to affect loon population density within Morro Bay, and did not dip below 1.5 m. Normally, extreme turbidity causes loons and other seabirds to avoid certain areas, as they cannot visually locate prey items (Vlietstra 1998). Strong storms will raise turbidity with heavy precipitation running off into bays, and strong breakers outside of bays will stir up sediments, which can wash into a bay during high tide, causing loons to seek clearer waters elsewhere (Spitzer 1995). But even during elevated in-bay turbidity due to strong storms or high surf, Common Loons preferred to retreat into Morro Bay. Many areas of Morro Bay are so shallow and calm with very complete water exchange from the ocean during tidal cycles that even during rainy conditions, there is sufficient visibility to allow for relatively easy foraging and detection of prey. There is not a major sediment-carrying runoff source, such as a river or large creek, draining into Morro Bay; only storm drain and salt marsh runoff.

## Acknowledgments

This study may not have materialized had it not been for a suggestion from Lynn Kelly of the Montana Loon Society that I seriously consider focusing study upon the wintering ecology of loons occupying the west coast of North America. Judith McIntyre provided encouragement and guidance for which I am grateful. I am further indebted to Dr. David Evers and his staff at BioDiversity Research Institute for their priceless assistance, field

training, and partnership during the past decade. Daniel Poleschook and Ginger Gumm of North American Loon Fund have lent a tremendous amount of encouragement, while supplying detailed guidance and advice in photography and optics. Lastly, I am grateful to Dr. Jim Paruk who has spent tireless hours by my side, during easy times and difficult, offering his direction and expertise on investigating the world and conveying information, while opening doors for me to new study opportunities in loon biology. Jim Paruk also spent many hours going over this manuscript with me and for that I am very appreciative.

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# Assessment of mercury exposure and potential effects on common loons (*Gavia immer*) in Québec

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The full article can be found in Hydrobiologia 567:263–274.

## Abstract

Results from recent studies report increases in mercury in the environment and increased bioaccumulation in aquatic food webs. The Canadian Wildlife Service (CWS) and the Canadian National Park Service initiated this study to determine whether common loons (*Gavia immer*) are exposed to sufficiently high mercury concentrations in prey fish to impair their reproduction and survival. Monitoring of loon reproduction, measurement of lake physicochemistry, and fish sampling for mercury analysis were conducted in various regions in Québec, Canada, during summers from 1997 to 2002. Reproductive success was assessed and loons were captured at night and banded. Collection of feathers and blood was done to measure mercury. Mean blood and feather Hg concentrations in males (2.6 µg/g w.w. and 17.6 µg/g d.w.) and females (1.8 µg/g w.w. and 8.9 µg/g d.w.) were within the normal range of samples from north-eastern North America. However, one third (33%) of the loons sampled had mercury levels in blood or feathers exceeding the high risk levels for health and reproduction. Loons from western Québec showed significantly lower Hg levels than those from eastern Québec, both in blood and feathers. This study will help determine the potential effects of mercury on the Québec and North-American loon population and provide information to assist in decisions on pollution abatement policies.

# Bioaccumulation of mercury in yellow perch (*Perca flavescens*) and common loons (*Gavia immer*) in relation to lake chemistry in Atlantic Canada

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The full article can be found in Hydrobiologia 567:275–282.

## Abstract

Mercury biomagnifies in aquatic foodwebs in freshwater lakes, and common loons (*Gavia immer*) breeding in eastern Canada can be exposed to reproductively toxic concentrations of mercury in their fish prey. We assessed the bioaccumulation and biomagnification of mercury in juvenile and adult common loons, and their preferred prey: yellow perch (*Perca flavescens*) in Kejimkujik National Park (KNP), Nova Scotia by measuring mercury levels and stable isotope ratios in tissues. Total mercury levels and stable-carbon ($\delta^{13}C$) and nitrogen isotope ratios ($\delta^{15}N$) were determined in composite whole-fish samples from lakes in KNP and blood samples from juvenile and adult loons captured on lakes in KNP and southern New Brunswick. Geometric mean mercury concentrations were 0.15 and 0.38 μg/g (wet wt.) in small (9-cm fork length) and large (17-cm fork length) yellow perch, and were 0.43 and 2.7 μg/g (wet wt.) in blood of juvenile and adult common loons, respectively. Mercury concentrations in perch and loons were positively associated with body mass and $\delta^{15}N$ values. Juvenile loons and large yellow perch had similar mercury levels and $\delta^{15}N$ values, indicating similar trophic status despite their 22-fold difference in body mass. Mercury concentrations were higher in yellow perch and common loons in acidic lakes. Our findings highlight the importance of both chemical and ecological factors in understanding mercury biomagnification in lakes and associated risks to fish-eating wildlife.

# SECTION II

# AQUATIC BIRDS — ECOTOXICOLOGY

# Temporal and spatial trends in contaminant levels in Herring Gull eggs from the Great Lakes, 1974–2002

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## Abstract

Herring Gull eggs have been collected annually and analyzed for DDE, PCBs, mirex, dieldrin, HCB, heptachlor epoxide, TCDD and mercury from up to 15 sites from throughout the Great Lakes since 1974. Change-point (piecewise) regression analysis shows that more than 72% of 105 colony-contaminant comparisons (15 sites × 7 compounds) are currently declining as fast or faster than they were during the early years of the study; this is most evident for dieldrin, heptachlor epoxide, HCB and mirex. Over 21% of the comparisons are declining more slowly now than previously (primarily PCBs and DDE) and less than 6% are not showing any temporal trend; this is almost solely TCDD. Sites at Green Bay (LM), Lakes Huron and Erie and in the St. Lawrence River most often show continued rapid rates of decline; sites in Lake Ontario and the Detroit River show the most cases of a slowing down of the rates of decline. Spatially, based on mean values from 1998–2002, Saginaw Bay (LH), Gull (LM), Snake I. (LO), Granite I. (LS) and Hamilton Harbour (LO) comprise the 5 most contaminated sites, while both sites from Lake Erie, Chantry I. (LH), the Niagara River and Agawa Rocks (LS) comprise the 5 least contaminated sites.

# Contaminants in Lesser Scaup and Greater Scaup Staging on the Lower Great Lakes

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## Abstract

The decline and subsequent lack of recovery of the North American scaup population has raised concerns about contaminants acquired during migration. We collected 189 fall- and spring-migrant lesser (*Aythya affinis*) and greater scaup (*Aythya marila*) on the lower Great Lakes (LGL) to determine if organic contaminants and trace elements in livers were elevated and to evaluate sources of variation in selenium (Se) burdens. We found that all organic contaminants were below toxic levels. Of 18 trace elements, only Se was detected at elevated (> 10 ppm dry mass) levels. Selenium in lesser scaup increased, but remained constant in greater scaup, throughout fall; levels were elevated in 14% of lesser scaup and 46% of greater scaup. During spring, Se increased in lesser scaup but decreased slightly in greater scaup; levels were elevated in 75% of lesser scaup and 93% of greater scaup. We suggest that Se may be problematic for some breeding females after departing the LGL, but more research is needed to determine the extent to which it affects scaup demographics.

# Endocrine disruption and immune responses in Great Lakes gulls (*Larus* spp.)

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## Abstract

Great black-backed gulls (*Larus marinus*) breeding at contaminated colonies on the Great Lakes have higher levels of organochlorine contaminants than herring gulls (*L. argentatus*) at the same locations. The objective of this research was to determine if significant differences in contaminant levels were associated with endocrine disruption in adults (measured by presence/absence of vitellogenin in males) or altered immune function in chicks. Results confirmed that in Lake Ontario, contaminants were significantly ($P < 0.05$) higher in black-backed gull than in herring gull eggs for most (80%) compounds analyzed. For birds nesting at the control site in Bay of Fundy (New Brunswick, Canada), there were no differences in contaminant levels between species for organochlorines, though total mercury was significantly higher in black-backed gulls. Plasma was collected from 82 adults, vitellogenin was not detected in any males from contaminated ($n = 29$) or control sites ($n = 26$). T-cell mediated immunity was significantly lower in herring gull chicks from one contaminated site, relative to the control. There were no significant differences in T-cell mediated immunity between sites for black-backed gulls. Antibody-mediated immunity was assessed at one contaminated site, where there were no significant differences between species.

# Mercury levels in colonial waterbirds nesting on the Great Lakes (1973–2002)

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## Abstract

As part of the Great Lakes egg contaminants monitoring program, the Canadian Wildlife Service has monitored (total) mercury levels in several species of colonial waterbirds. Data accumulated for Herring Gulls (*Larus argentatus*), Great Black-backed Gulls (*L. marinus*) and Black-crowned Night-Herons (*Nycticorax nycticorax*) were sufficient for inter-species comparisons and trend analysis. In 2000, for eggs collected at four colonies located in Lakes Huron, Erie and Ontario and the Niagara River, levels in night-herons were 30% higher than in Herring Gulls (0.21 and 0.16 μg/g wet weight, respectively) ($P = 0.28$). In 2001, at two colonies in eastern Lake Ontario, levels were three times greater in Great Black-backed Gulls (0.64 μg/g) than they were in Herring Gulls (0.21 μg/g) ($P < 0.0001$). Temporal trend analysis was conducted for Herring Gull eggs from fifteen colonies throughout the Great Lakes, samples were collected since the early 1970s (eight sites) and early 1980s (seven sites). In 2002, values ranged from 0.08 to 0.21 μg/g (wet weight), levels were lowest in Eastern Lake Erie and highest in Eastern Lake Ontario. Results indicated significant declining trends at eleven colonies and non-significant declines at three sites. Significant declines occurred at all sites sampled on Lakes Ontario, Erie, Superior, the Niagara and Detroit Rivers and two sites on Lake Huron non-significant declines occurred at both sites on Lake Michigan and one on he St. Lawrence River. A non-significant increasing trend was observed at Saginaw Bay, Lake Huron.

# Total mercury concentrations in fish from constructed freshwater wetlands on Bay of Fundy dykeland soils in New Brunswick, Canada

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## Abstract

We determined mercury concentrations in fish from six freshwater impoundments built on Acadian soils along the upper Bay of Fundy in the Canadian province of New Brunswick. Two species of freshwater fish, nine-spine stickleback (*Pungitius pungitius*) and mummichogs (*Fundulus heteroclitus*), were sampled in November 1998. Total mercury concentrations in composite samples of 20 fish each ranged from 0.04–0.12 μg/g (wet wt.) in stickleback (n=18) from six impoundments and from 0.04–0.07 in mummichog (n=3) from one impoundment. These mercury concentrations are low compared to human consumption guidelines, risk thresholds for most wildlife, and concentrations in larger fish species from lakes and rivers in Atlantic Canada. Fish mercury levels were highest in the most recently flooded impoundment and were positively correlated with pH. We conclude that construction of freshwater impoundments on Bay of Fundy dykeland soils does not result in elevated levels of bioavailable mercury in these wetlands or their biota, and that mercury risks associated with these wetland restoration activities are minimal.

## Introduction

Inorganic mercury (Hg), naturally present in soils and surface water, or deposited from the atmosphere, poses little threat to wildlife (Wiener et al. 2003). The methylation of mercury, however, produces toxic methylmercury (MeHg), and chronic exposure to MeHg is associated with adverse effects including neurotoxicity, reduced growth, abnormal behaviour, and reduced reproductive success in fish and wildlife (see reviews by Wiener et al. 2003; Burgess 2005; Driscoll et al. 2007; Scheuhammer et al., *in press*). MeHg bioaccumulates and biomagnifies in aquatic food webs, and therefore even low concentrations of MeHg in water can pose a risk to species at higher trophic levels (Weiner et al. 2003). Methylation of inorganic Hg in aquatic environments is enhanced by several factors, including anoxia, the presence of sulfate-reducing bacteria, fluctuating water levels, low pH, and dissolved organic carbon concentrations (Winfrey and Rudd 1990,

Wiener et al. 2003, Burgess 2005). Wetlands and newly created large reservoirs are among the environments most likely to exhibit the aforementioned characteristics, and thus most likely to promote Hg methylation (Helfield and Diamond 1997, Bringham et al. 2002, St. Louis et al. 2004). Wetlands are known to be both a sink for Hg and an important source of MeHg (Galloway and Branfireun 2003, Watras et al. 2005), with variation among wetland types in the relative amount of MeHg produced (Siciliano et al. 2003, Loseto 2004, Kongchum 2006, Rumbold and Fink 2006).

Given the relationship between wetlands and MeHg, it is paradoxical that both Hg contamination and loss of wetlands are environmental concerns in Atlantic Canada. Mercury concentrations exceeding Health Canada consumption advisories have been found in freshwater fish in southern Nova Scotia (Drysdale et al. 2005), and the blood Hg levels of common loons (*Gavia immer*) in southern Nova Scotia were twice those found in other North American loon populations (Burgess et al. 2005). Also, coastal wetlands in Atlantic Canada have been reduced to one-third of their original extent resulting in the loss of the ecological, social, and economic benefits they provide (Government of Canada 1991). After a near 400-year history of dyking and draining (Milligan 1987, Bleakney 2004) wetland loss is particularly pronounced along the Bay of Fundy coast (Reed and Smith 1972). In response to this loss, many Atlantic Canadian agencies and environmental organizations have promoted the restoration and creation of Bay of Fundy wetlands. Creation and restoration projects are undertaken to compensate for unavoidable wetland loss, to provide recreational opportunities, to improve storm-water management, and to create wildlife habitat, among other goals. With increasing awareness of Hg toxicity and the role of wetlands in creating MeHg, there is concern that the creation of wetlands may inadvertently lead to elevated mercury levels in fish and wildlife (Helfield and Diamond 1997, Rumbold and Fink 2006). However, the variation in the amount of methylmercury produced in different wetlands makes it hard to predict the impact of specific wetland restoration projects.

In this study, two species of secondary consumers, nine-spine stickleback (*Pungitius pungitius*) and mummichog (*Fundulus heteroclitus*), were sampled in six freshwater impoundment sites along the upper Bay of Fundy coast in southeastern New Brunswick and analyzed for total mercury concentration (THg) to assess whether these wetlands and their associated MeHg production created a toxicological risk to wildlife.

## Methods

### *Study sites*

Six study sites were selected from freshwater impoundments that had been constructed on the extensive dykelands of the upper Bay of Fundy in southeastern New Brunswick. The Acadian soils that develop over time following the draining of salt marshes and exclusion of tidal inundation are composed of approximately 12% sand, 52% silt and 36% clay in the top 0.30 m and normally have a very high magnesium and potash content, a low to medium calcium concentration and a very low phosphorus content (Milligan 1987, Collette 1995). All study wetlands are classified as freshwater marsh. Water samples from dykeland freshwater impoundments are typically circumneutral in pH and mesotrophic (Hanson et

al. 1994). At the time of sampling, the sites ranged in age from 1 to 17 years since first being impounded, and from 9.3 to 27.5 ha in size (Table 1).

Table 1: Limnological and physical data for each impoundment.

| Variable | Beausejour 1 (BSJ1) | Beausejour 2 (BSJ2) | Tantramar High School (TRHS) | New Horton D (NHD) | New Horton E (NHE) | Calhoun |
|---|---|---|---|---|---|---|
| Color (rel. units) | 75 | 90 | 75 | 70 | 65 | 110 |
| Conductance (µS) | 435 | 416 | 290 | 495 | 258 | 253 |
| $NO_3$ (mg/l) | 0.21 | 0.17 | 0.14 | 0.17 | 0.10 | 0.20 |
| TN* (mg/l) | 0.58 | 0.73 | 0.36 | 0.47 | 0.35 | 0.49 |
| Alkalinity (mg/l) | 51.7 | 38.3 | 48.25 | 2.12 | 17.7 | 16.7 |
| pH (pH units) | 7.22 | 7.26 | 7.29 | 5.90 | 6.88 | 6.9 |
| Na (mg/l) | 59.86 | 52.50 | 28.69 | 71.71 | 37.18 | 33.93 |
| Mg (mg/l) | 12.00 | 11.40 | 6.08 | 7.42 | 4.44 | 5.90 |
| P (mg/l) | 0.1580 | 0.11230 | 0.07 | 0.0530 | 0.0980 | 0.1160 |
| $SO_4$ (mg/l) | 32.10 | 38.40 | 20.90 | 12.80 | 8.75 | 17.70 |
| Cl (mg/l) | 76.00 | 72.90 | 41.8 | 136.0 | 58.2 | 49.70 |
| K (mg/l) | 5.63 | 6.87 | 4.51 | 6.13 | 3.23 | 4.58 |
| Ca (mg/l) | 4.91 | 4.79 | 14.9 | 5.05 | 2.43 | 2.19 |
| TIC** (mg/l) | 12.3 | 9.0 | 12.2 | 0.5 | 6.7 | 4.2 |
| TOC*** (mg/l) | 14.9 | 16.4 | 11.3 | 8.5 | 11.2 | 15.0 |
| Date Sampled | 27/11/1998 | 27/11/1998 | 27/11/1998 | 7/11/1997 | 27/11/1998 | 27/11/1998 |
| Wetland age (yrs) | 3 | 3 | 1 | 17 | 4 | 3 |
| Wetland size (ha) | 22.3 | 15.8 | 9.3 | 17.0 | 26.9 | 27.5 |
| Station number | NB01BT 0061 | NB01BT 0062 | NB01BT 0063 | NB01BV 0061 | NB01BV 0119 | NB01BV 0130 |
| Stn latitude (˚N) | 45.8703 | 45.8642 | 45.9094 | 45.6817 | 45.6778 | 45.7167 |
| Stn longitude (˚W) | 64.2972 | 64.2986 | 64.3692 | 64.7039 | 64.7058 | 64.7611 |

*TN: total nitrogen, **TIC: total inorganic carbon, ***TOC: total organic carbon.

*Study species*

Two fish species were collected in this study: mummichog, which grows to an average length of 76 mm, and nine-spine stickleback, which grows to an average of 64 mm (Scott and Crossman 1973). Both species are primarily planktivorous. The mummichog feeds on diatoms, small crustaceans, vegetation, small fish, and fish eggs, while the diet of nine-spine stickleback is composed of aquatic insects and small crustaceans (Scott and Crossman 1973). Both species are widespread in Atlantic coastal and brackish waters, and both comprise a large part of the diet of other fish and predators (Scott and Crossman 1973). Mummichog are low feeders in the food chain, fairly abundant, and indigenous to the area and have been used previously as an indicator species (Brun et al. 1998).

*Field procedures*

Fish and water samples were collected from each of the six study sites in November 1998. The water sample from New Horton D was damaged in transit and therefore data from a sample collected in November 1997 was used in its place. The sample collected in November 1997 was representative of the previously collected water samples (n=56) from this site (Hanson, unpubl. data). Approximately 60 nine-spine sticklebacks were collected from each site using minnow traps. At Beausejour 1, approximately 35 mummichogs were collected in addition to sticklebacks. Fish were placed on ice upon collection, and then frozen until transfer to the Environment Canada Atlantic Region Laboratory (EC Lab), Moncton, New Brunswick, for analysis. The lab is accredited through Canadian Society of Chemists/Canadian Association of Environmental Laboratories (SC/CAEL). One surface water sample was collected at the outflow from each wetland using 1L polyethylene bottles, and these too were stored on ice and then refrigerated until transfer to the EC Lab.

*Analytical procedures*

After thawing fish at the EC Lab, individual fork length and mass measurements were taken. Fish were assigned to fork-length categories, and approximately 20 individual nine-spine sticklebacks from a single site were pooled to create a total of 18 composite nine-spine stickleback tissue samples (three per site). Individual mummichog samples from Beausejour 1 were similarly pooled to create three composite samples, but the mid-length (50–70 mm) and large-length (>70 mm) mummichog samples contained fewer than 20 fish (12 and 5 fish, respectively). Whole fish were homogenized and the composite tissue samples were analyzed for THg. In higher trophic organisms, such as fish, most of the Hg present in body tissues is comprised of MeHg (Bloom 1992, Wiener et al. 2003) and therefore THg was used as to assess toxicological risk.

Composite samples of whole-body fish homogenate were analysed for THg by cold-vapour atomic-absorption spectrometry (CVAAS), following Environment Canada (1982). The methodology can be briefly described as follows: organomercury compounds in the fish samples are oxidized to inorganic Hg by sulfuric acid, dichromate, and UV photooxidation. The mercuric ions are then reduced with stannous sulfate (10% w/v) in hydroxylamine sulfate-sodium chloride solution (12% w/v) to elemental Hg. Total Hg content is then measured using CVAAS (Thermo Separation Products, Mercury Monitor 1255). Quality assurance procedures in this lab included analyses of method blanks, sample replicates, spiked tissues, and dogfish muscle (DORM–1) standard reference material (SRM). Recoveries of Hg in SRM were 88–101% (n=6), and mean recovery (±1 SE) of spiked tissues was 90 ± 4% (n=33). Mercury concentrations are expressed as µg/g on a wet weight (wet wt.) basis. Further details on Hg analysis methods can be found in Carter et al. (2001) and Drysdale et al. (2005).

Water samples from each site were analyzed at the EC Lab for major ions, nutrients, and physical parameters (Table 1).

*Statistical procedures*

Mean fork length and fish mass was calculated for each of the composite fish samples.

Since fish Hg concentrations are usually correlated with fish length (Wiener et al. 2003), we used analysis of covariance (ANCOVA) with fish length as the covariate to compare least-square mean THg levels (hereafter called length-adjusted means) in nine-spine stickleback among impoundments. Tukey pairwise comparisons were used to test for differences in length-adjusted mean THg concentrations between individual impoundments. The Pearson correlation between limnological and impoundment variables and sample THg concentration was determined. Spearman rank correlations between length-adjusted mean THg levels in stickleback, stickleback length and site and water parameters were also determined. All statistical analysis was carried out using Systat® for Windows software, version 7.0 (SPSS Inc., Chicago Illinois, 1997).

## Results

THg concentrations in composite fish samples ranged from 0.04 to 0.12 μg/g (wet wt.) in nine-spine stickleback (n=18 composite samples) from six impoundments and from 0.04 to 0.07 μg/g in mummichog (n=3) from one impoundment (Table 2). Physical parameters and chemical limnology of each site are presented in Table 1. Statistical analysis was limited to nine-spine stickleback data, because mummichog data was available for one site only. Across sites, THg in nine-spine stickleback was highly correlated with fish length ($r^2$ = 0.54, $n$ = 18) (Figure 1). Mean THg concentrations for each impoundment were therefore adjusted for fish length in subsequent data analysis using ANCOVA. Length-adjusted mean THg levels in nine-spine stickleback differed significantly across the six impoundments (ANCOVA, $P$ = 0.0003) (Fig. 2). Pairwise comparisons of the length-adjusted mean THg concentrations indicated that stickleback in the TRHS impoundment had higher Hg levels and those in the New Horton E had lower Hg levels than stickleback in the remaining four impoundments (ANCOVA Tukey comparisons, $P < 0.05$) (Fig. 2).

Across the six impoundments, a significant positive correlation was found between length-adjusted mean THg levels in stickleback and water pH ($r_s$ = 0.94, $n$ = 6, $P < 0.05$), while a significant negative correlation was detected between stickleback THg concentrations and wetland age ($r_s$ = -0.88, $n$ = 6, $P < 0.05$) (Table 3). There was a marginal correlation, albeit non-significant, between stickleback THg and sulfate concentrations ($r_s$ = 0.83, $P < 0.10$) (Table 3).

Table 2: Summary statistics for fish samples.

| Species | Site[1] | Sample # | *n* | [THg] (µg/g) | Mean length (mm) | Mean mass (g) |
|---|---|---|---|---|---|---|
| *P. pungitius* | BSJ1 | 1 | 20 | 0.07 | 57 | 1.5 |
| | | 2 | 20 | 0.09 | 55 | 1.3 |
| | | 3 | 20 | 0.09 | 52 | 1.0 |
| | BSJ2 | 1 | 20 | 0.08 | 52 | 1.0 |
| | | 2 | 20 | 0.09 | 53 | 1.1 |
| | | 3 | 20 | 0.09 | 53 | 1.1 |
| | THRS | 1 | 20 | 0.11 | 55 | 1.3 |
| | | 2 | 20 | 0.12 | 57 | 1.4 |
| | | 3 | 20 | 0.10 | 54 | 1.2 |
| | NHD | 1 | 20 | 0.05 | 48 | 0.7 |
| | | 2 | 20 | 0.06 | 47 | 0.7 |
| | | 3 | 20 | 0.06 | 48 | 0.7 |
| | NHE | 1 | 20 | 0.04 | 49 | 0.9 |
| | | 2 | 20 | 0.05 | 48 | 0.8 |
| | | 3 | 20 | 0.04 | 47 | 0.8 |
| | Calhoun | 1 | 20 | 0.06 | 54 | 1.2 |
| | | 2 | 20 | 0.06 | 53 | 1.1 |
| | | 3 | 20 | 0.06 | 53 | 1.1 |
| *F. heteroclitus* | BSJ1 | 1 | 20 | 0.04 | 45 | 1.1 |
| | | 2 | 12 | 0.05 | 53 | 1.9 |
| | | 3 | 5 | 0.07 | 74 | 5.4 |

[1]Site abbreviations explained in Table 1.

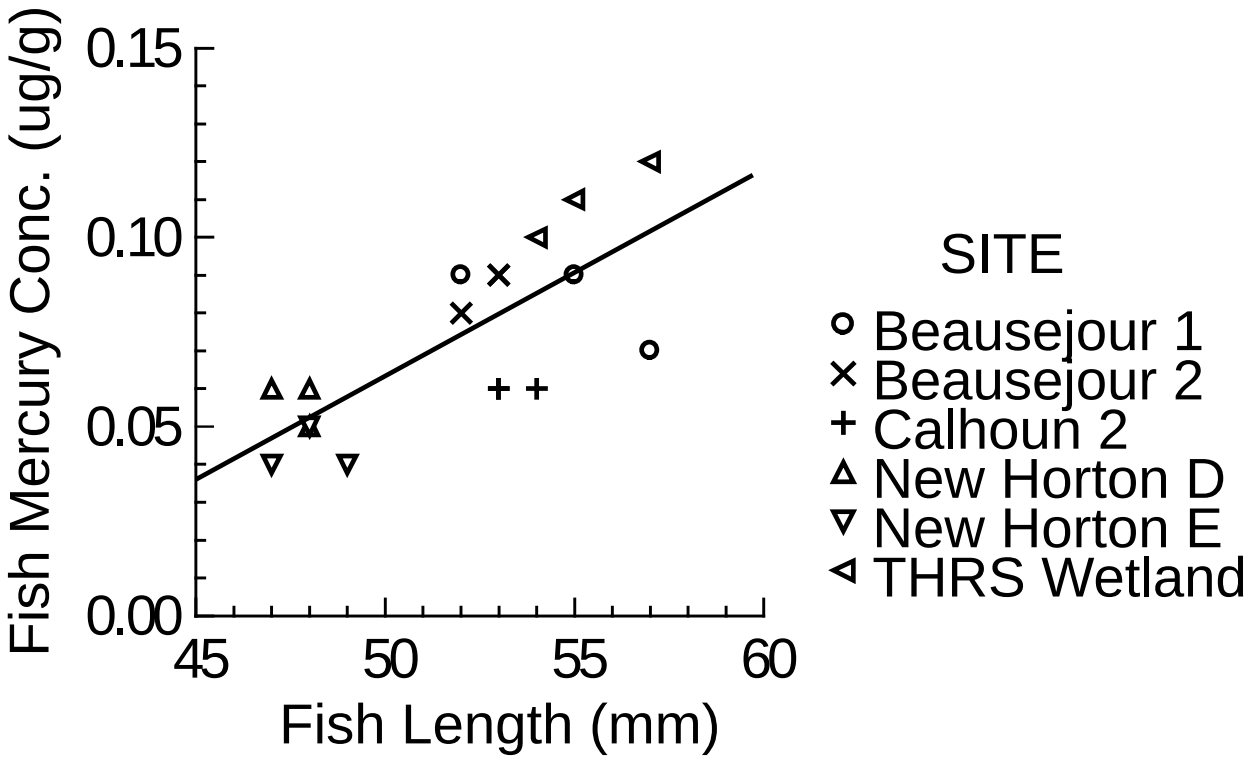


Figure 1. Relationship between fish length and total mercury concentration ($n$ = 18, $R^2$ = 0.54) for composite samples of nine-spine stickleback.

**Discussion**

Mercury concentrations in fish result from both the amount of methylmercury in the foodweb and the diet of the individual fish. In this study, the THg concentrations in nine-spine stickleback collected from six freshwater impoundments on dykeland soils ranged from 0.04 to 0.12 µg/g. Barry and Curry (1998) observed mean Hg concentrations of 0.05 to 0.34 µg/g in nine-spine stickleback collected from eight lakes in south-eastern New Brunswick. In a metadata analysis of Hg concentrations in freshwater fish across northeast North America, Kamman et al. (2005) reported a mean value of 0.19 µg/g for stickleback species.

In this study, the 3 composite mummichog samples from one impoundment had Hg levels of 0.04 to 0.07 µg/g. Mummichogs collected from estuaries in New Brunswick near Aldouane, Indian Island and Richibucto had mean Hg concentrations of 0.021, 0.022, and 0.021 µg/g, respectively (Brun et al. 1998). Mean mercury levels in mummichogs collected from nine locations in the Richibucto watershed ranged from 0.022 to 0.040 µg/g (Surette et al. 2002). Barry and Curry (1998) sampled the congeneric banded killifish (*Fundulus diaphanous*) in three freshwater lakes in south-eastern New Brunswick and observed mean Hg concentrations of 0.06 to 0.14 µg/g. Kamman et al. (2005) reported a mean of 0.066 µg/g Hg in killifish species, which was the lowest mean Hg concentration in the 40 freshwater fish taxa examined.

The maximum Hg concentration observed in fish in this study was 0.11 µg/g. This Hg

level is well below the dietary criteria commonly used to identify Hg risks to fish-eating birds of 0.3 µg/g or fish-eating mammals of 0.5 µg/g (Burgess 2005; Scheuhammer et al., *in press*). Similarly, the observed fish Hg levels were far below the Health Canada guideline for Hg in commercially sold fish of 0.5 µg/g (Health Canada 2002). Thus, no Hg risks to wildlife or humans are associated with the observed Hg levels in fish in the six impoundments.

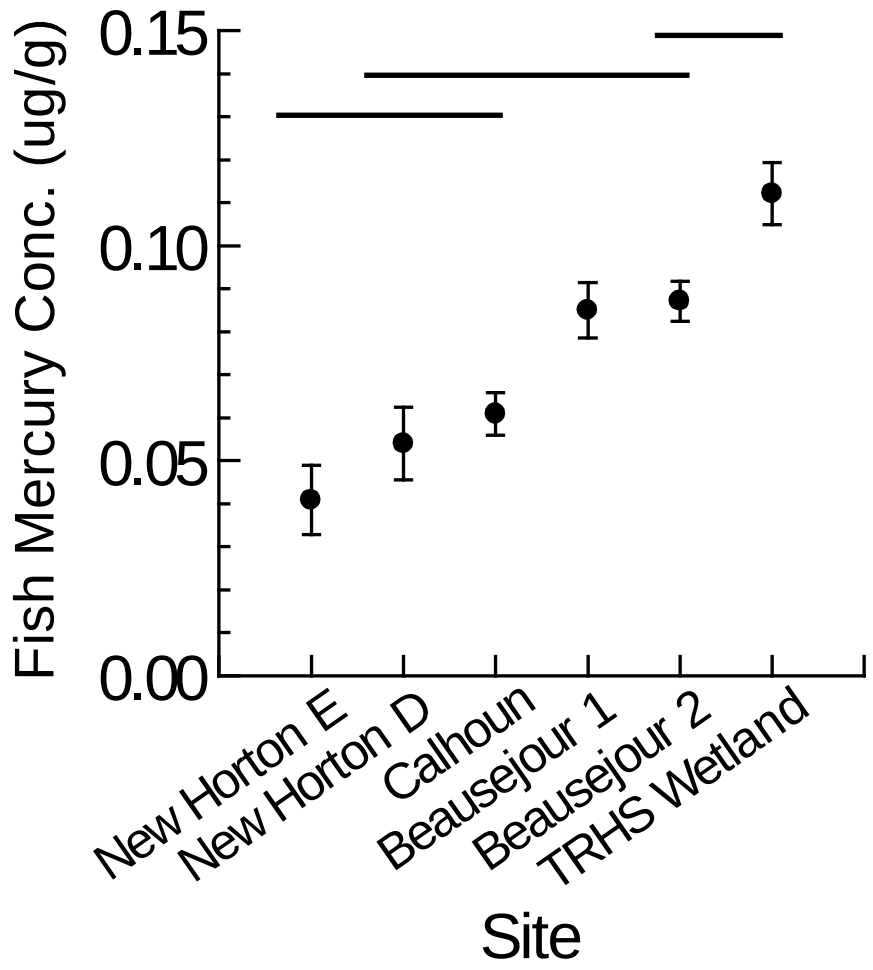


Figure 2. Length-adjusted mean mercury concentrations (µg/g, wet wt.) in nine-spine stickleback in six impoundments. Horizontal lines join means that are not significantly different.

The low Hg concentrations in mummichog and nine-spine stickleback observed in this study compared to those reported for similar species elsewhere is an indication that the amount of MeHg produced in these freshwater impoundments is relatively low. It is known that MeHg concentrations in fish will increase with increasing trophic level. Kamman et al. (2005) observed the highest fish Hg levels in the large, fish-eating predatory species at the top of aquatic food webs, while the lowest Hg levels were seen in fish species feeding

lower in the food web (e.g. feeding on plankton and invertebrates). This pattern, which reflects the biomagnification of MeHg in aquatic food webs, has been observed consistently throughout North America (e.g. Kidd et al. 1995, Simonin and Meyer 1998, Schetagne and Verdon 1999, Meuller and Serdar 2002). Although we only used minnow traps to sample fish in these freshwater species, we are confident that higher-order predatory fish species such as yellow and white perch are absent or very uncommon in these dykeland impoundments. This opinion is based on unpublished sampling data from other impoundments, shallow impoundment depths, hydrological isolation of impoundments and the fact that that the impoundments were constructed on dry agricultural land.

Table 3. Spearman's rank correlations among fish (nine-spine stickleback) and limnological parameters. Bold text indicates significance at $\alpha = 0.05$ ($n = 6$)[1].

| | Fish | | Limnological | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | THg[2] | LEN | AGE | AREA | COL | SpC | N | pH | ALK | P | $SO_4$ | TOC |
| THg | 1 | | | | | | | | | | | |
| LEN | 0.77 | 1 | | | | | | | | | | |
| AGE | **-0.88** | **-0.94** | 1 | | | | | | | | | |
| AREA | -0.71 | -0.26 | 0.39 | 1 | | | | | | | | |
| COL | 0.55 | 0.46 | -0.59 | 0.06 | 1 | | | | | | | |
| SpC | 0.09 | -0.26 | 0.33 | -0.49 | -0.32 | 1 | | | | | | |
| TN | 0.43 | 0.14 | -0.21 | -0.09 | 0.70 | 0.31 | 1 | | | | | |
| pH | **0.94** | 0.83 | **-0.94** | -0.60 | 0.49 | -0.14 | 0.31 | 1 | | | | |
| ALK | 0.66 | 0.77 | -0.70 | -0.37 | 0.12 | 0.09 | 0.26 | 0.77 | 1 | | | |
| P | 0.14 | 0.43 | -0.33 | 0.49 | 0.55 | -0.26 | 0.60 | 0.26 | 0.49 | 1 | | |
| $SO_4$ | 0.83 | 0.54 | -0.64 | -0.49 | 0.64 | 0.26 | 0.83 | 0.77 | 0.66 | 0.49 | 1 | |
| TOC | 0.54 | 0.43 | -0.58 | 0.03 | 0.87 | -0.31 | 0.77 | 0.60 | 0.37 | 0.71 | 0.77 | 1 |

[1]$P = 0.05$ when $r = 0.886$.

[2]Abbreviations: THg – length-adjusted mean total mercury in stickleback; LEN – mean fork length of fish; AGE – impoundment age; AREA – impoundment surface area; COL – water colour; SpC – specific conductance; N – nitrogen; ALK – alkalinity; P – phosphorus; $SO_4$ – sulfate; TOC – total organic carbon.

Although THg concentrations were relatively low in the sticklebacks collected in this study, there were significant differences among the impoundments in THg. The high Hg concentration in the recently built TRHS wetland (1 year old at the time of sampling) contributes strongly to the high negative correlation between wetland age and Hg concentration in fish. Whereas this was a preliminary investigation, sample size was too small to allow for a complete statistical analysis of all the various factors that could

influence fish Hg concentrations such as impoundment age, soil and water chemistry, and food web structure. However the chemical limnology does provide some insight into why fish Hg levels may be higher in the TRHS wetland. It is known that there is a pronounced increase in MeHg for several years following construction of reservoirs due to the anaerobic decomposition of terrestrial vegetation, and this effect may last for 10 to 20 years when forested areas are flooded (Brigham et al. 2002). In our study, the relationships between limnological characteristics of the freshwater impoundments and Hg levels in fish are confounded by the high Hg values observed in TRHS wetland and the overriding effect of impoundment age since flooding. The only limnological characteristic associated with the short duration of flooding was calcium. The associations normally observed between fish Hg levels and water chemistry parameters such as pH, colour and total organic carbon in other studies were not present in these wetlands. Indeed the positive correlation observed between fish Hg levels and pH seen in this study is the opposite of what is normally seen in freshwater lakes (Wiener et al. 2003). These wetlands are of marine origin, receiving aerial deposition of sea salt, and therefore flooding causes a release of chloride and sulfate ions and inorganic carbon from the soils. Amendments of sulfate have resulted in increased amounts of MeHg in wetlands due to increased activity of anaerobic sulfate-reducing bacteria (Harmon et al. 2005).

The draining of Bay of Fundy salt marsh began when Acadian settlers in the 1600s built dykes to create agricultural land. The dykes allow water to drain off the coastal marshes, while preventing saline tidal water from entering. After a few years of precipitation, the Acadians were able to desalinize the fertile alluvial soils. Because the dykelands were formerly salt marsh, their soils are formed from shale and sandstone particles from the sea floor and shoreline (Roland 1982, Bleakney 2004). The flooding of dykelands to create marsh habitat initiates interesting geochemical processes (Whitman 1976, Hanson et al. 1994). Factors that have been reported to increase the bioavailability of MeHg such as routine flooding and drying, low pH and high dissolved organic carbon (Wiener et al. 2003, Evers et al. 2007) are not present in these freshwater impoundments built on dykeland soils. In comparison with lakes in Kejimkujik National Park, Nova Scotia, where wetlands and lithology are conducive to the methylation of Hg (Siciliano et al. 2003), the mean Hg concentration in yellow perch is 0.25 µg/g (Drysdale et al. 2005) and in adult common loon blood it is 5.5 µg/g (Burgess et al. 2005). In a wetland constructed to remove nutrients from agricultural surface runoff in Florida, Hg concentrations in mosquitofish, sunfish, and largemouth bass were 0.430, 0.930, and 2.0 µg/g respectively (Rumbold and Fink 2006).

The routine flooding and drying of wetlands is thought to increase the bioavailability of Hg (Snodgrass et al. 2000) and may be responsible for higher MeHg levels commonly observed in salt marshes (Langer et al. 2001, Hung and Chmura 2006, Shriver et al.2006). Mercury exposure may be lower in freshwater impoundments than in naturally occurring salt marsh, although generalities should be avoided in the absence of field data. Because of the limnological conditions and fish species present, the construction of freshwater impoundments on Acadian soils in the upper Bay of Fundy does not greatly increase the bioavailability of mercury in the environment and any associated toxicological risk is minimal compared to the benefits of creating wetland habitat.

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# SECTION III

# AQUATIC BIRDS — FEEDING ECOLOGY, HABITAT USE AND CHEMICAL LIMNOLOGY

# A comparison of three methods to investigate the diet of breeding double-crested cormorants (*Phalacrocorax auritus*) in the Beaver Archipelago, northern Lake Michigan

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## Abstract

In order to understand the role of waterbirds in aquatic food webs it is important to first get an accurate depiction of their diet. Three methods of dietary assessment (pellets, regurgitate and stomach contents) are compared here for breeding double-crested cormorants (*Phalacrocorax auritus*) of the Beaver Archipelago, northern Lake Michigan. By numerical frequency (percent number), each method yielded different depictions of the diet. However, in terms of presence and absence (percent frequency) of possible prey types, stomach content data did agree with both pellets and regurgitate data. However, differences were noted between regurgitate and pellets. In terms of biomass measured (percent biomass) in regurgitate and stomachs, data gathered agreed. In essence, pellets underestimate the importance of alewife (*Alosa pseudoharengus*) and overestimate the importance of crayfish (*Orconectes* sp.) in the diet when compared to both regurgitate and stomach analysis. The non-lethal method of regurgitate collection and analysis appears most practical in assessing cormorant diet in this system. In combination with information on avian foraging ecology and prey populations, these data may be used to investigate the relationships among cormorants and their prey, and lead to a better understanding of Great Lake food web dynamics.

# Fish consumption by cormorants in Hungary

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## Abstract

The authors studied the fish consumption by cormorants (*Phalacrocorax carbo sinensis*) in two artificial fishponds (Rétszilas fishponds and Szeged Fehér Lake) and a natural river (the Danube area in Hungary) based on the examination of the stomach contents of birds (*n*=125), collected in 2001 and 2002. The average mass of stomach contents were 91.59 g and 85.29 g in the fish pond samples, as opposed to 235.6 g in the Danube samples. The length of fish caught in the Danube was considerably greater than the length of fish caught in the fish ponds. The greater mass of stomach contents of specimens feeding in natural waters may be explained by less frequent feedings, as indicated by the greater proportion (3-fold) of empty stomachs for birds feeding in natural waters. *Pseudorasbora parva* and *Cyprinus carpio* (53.5% and 29.5%), were the most common fish species found in the stomachs of cormorants collected at the Szeged Fehér Lake fishponds. Based on biomass values (86.2%), *C. carpio* stood out as the dominant food source. Based on the number of fish examined in the Rétszilas fishponds, *Carassius auratus* and *C. carpio* (40.9% and 22.7%) were dominant both in terms of numbers and biomass (46.7% and 46.2%). We found 4 species in the stomachs of cormorants from the Danube River: *C. carpio, Leuciscus cephalus, Rutilus rutilus*, and *Acipenser rutenus*. Protected fish species were not found in the cormorant's diet. Hence, cormorants are not an issue for nature conservation. According to our calculations, cormorants consume approximately 2428 tons/year of fish in Hungary. It can be said that in the future, it will not be possible to avoid the issue of compensation for damages caused by cormorants. However, for a more accurate assessment, it is necessary to analyze changes in their diet throughout the year in each area, so as to realistically establish a quantitative predator/prey relationship. Population control and bird-scaring tactics should be used with caution, particularly in regards to protected bird species and increasingly protected coexisting bird species, as well as during the breeding (nesting, chick raising) periods.

## Introduction

The feeding ecology of the cormorant, *Phalacrocorax carbo sinensis* (L.), generates inevitable conflicts between commercial fisheries and nature conservation. However the nature of the conflict, particularly the quantitative and therefore economical aspects, has not yet been satisfactorily explored.

Since sections of Hungary's protected areas are in proximity to fishponds, we cannot disregard the disturbance to other bird species that the scaring or shooting of fish-eating species can entail. It is also very difficult to determine with exact methods the significant material losses that the cormorant causes to commercial fisheries. Furthermore, there are no funds available to compensate for the material damage. This is not only a problem in Hungary; the cormorant causes similar conflicts in Europe, particularly Central Europe, in Germany, Austria, the Czech Republic, but also in Southern Europe, in Italy and Spain. Our research aims to define cormorant foraging ecology under contemporary environmental and regulatory conditions, and to determine amounts of food consumed.

## Materials and methods

*Study areas*

We studied the fish consumption of the cormorant both in artificial fishponds and in natural wetlands. The study areas were chosen based on information gained about the occurrence of cormorants at survey sites during the Hungarian Waterfowl Monitoring (HWM; Faragó and Kerekes, *this volume*; Faragó and Gosztonyi, *this volume*). The three bodies of water are hypertrophic based on total phosphorus concentrations (>100 $\mu g \cdot L^{-1}$) according to the OECD trophic classification system (Vollenweider and Kerekes 1980). Nature conservation considerations influenced the scope of the collection. On the basis of these factors, three sample areas were selected (Figure 1).

1) River Danube between Gönyű and Szob
Coordinates: Gönyű: 47˚44'N, 17˚50'E; Szob: 47˚48'N, 18˚53'E; Altitude: 109–115 m.
An 83-km long reach of the River Danube, between river kilometers 1791 and 1708, forming the border with Slovakia. The lower reaches of the river begin at this section. The region is characterized by a large industrial agglomeration comprising several important towns along both sides of the Danube River. The number of branches is relatively small, but severe siltation occurs; therefore dredging is performed regularly. Shallows, holms, masonry dams, and also the water surface of the river itself, serve as important resting places and roosting sites for waterbirds. There is no protected area on the Hungarian side. On the Slovakian side of the river, two areas have been declared protected along the banks of the Danube between river kilometers 1785–1780 and 1715–1712, respectively. IBA site – Code: HU-016.

2) Fishponds at Rétszilas
Coordinates: 46˚50'N, 18˚35'E.
The area of the fishponds are approximately 840 ha (588 ha free water surface and 252 ha

reeds). Up to the late 19th century there was a marshland. After the reclamation, some efforts were made to grow rice. The fishpond system was developed in the 1940s, its water supply being provided by the Sárvíz-Nádas canal running at the eastern boundary of the area and by the Malom canal at the western side. Due to the large area of reeds, the ponds possess a highly natural character. The area is not subject to any restrictions regarding nature conservation.

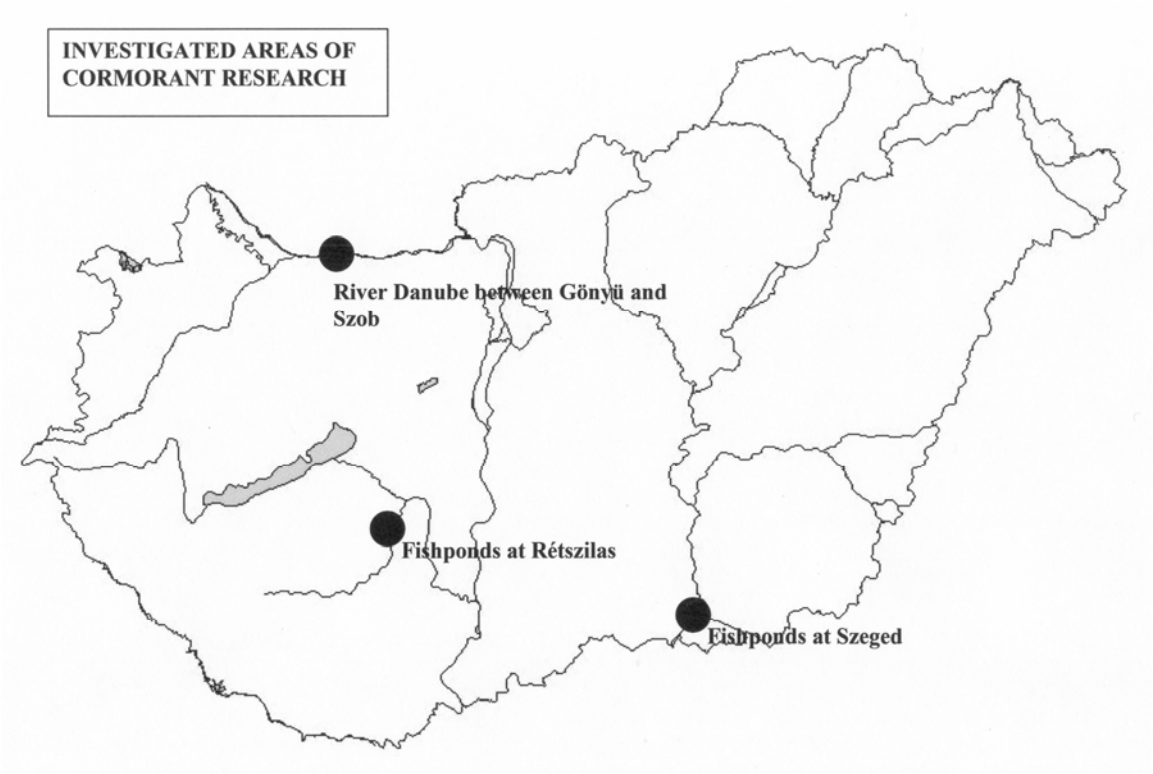


*Figure 1.* Cormorant fish consumption study sites in Hungary, 2001–2002.

3) Lake Fehér at Szeged

Coordinates: 46˚20'N, 20˚07'E, Altitude: 81–88 m

The area of the lake is 13 km$^2$. Before the regulation of the Tisza, the bed of Lake Fehér belonged to the floodplain of the river. In 1872, 1928–1930 and 1941–1942 a network of canals was established throughout the area, stabilizing the water level of the lake. Over the period 1928–1964 a system of fishponds was developed here, gradually reaching its present form. The original alkaline water of the ponds has been replaced by the fresh water of the River Tisza and the previously shallow water depth increased to 1.0–1.3 m. The Lake Fehér holds birds arriving from two different directions: flocks migrating along the River Tisza as well as those flying along the chain of lakes and ponds in the region between the Danube and the Tisza rivers stage there. It is therefore one of the most important wetlands of international importance in the southern part of the Great Hungarian Plain. In 1935 the first bird sanctuary in Hungary was established here (200 ha). Since

1976 it has been part of the Pusztaszer Landscape Protection Area, and since 1979 a Ramsar site. IBA site – Code: HU-026.

*Collection and processing*

Research began in the fall of 2001. The fish consumption of cormorants from the three sample areas was established by autopsies performed in the laboratory, and by studying collected and frozen individuals. After recording body size data, cormorants were opened on the abdominal side. Proventriculus and gizzard contents were measured and stored it in an 80% alcohol solution until the prey species were identified. The digestive tracts contained prey remains at different stages of digestion. For prey fish specimens, species was determined, and specimens were aged, weighed and measured. We used a digital analytical scale for the measurement of body weight (g) and a tape-measure to assess body length (cm). We took into account body size data and the number of annual rings on scales to assess age (Knollseisen 1996). For many specimens, we could only rely on the pharyngeal teeth found in the stomachs because of the advanced stage of digestion. We analyzed the results of the stomach contents by counting the number of individuals of each fish species, and by calculating the total biomass per fish species. We also determined average prey size per fish species. Finally, we determined the ratio of cormorants with empty stomachs vs. cormorants with "not empty stomachs" collected from the sample areas, and the average body weight of the fish remains that we found.

Based on the cormorant counts conducted in the three sample areas (Faragó and Gosztonyi, *this volume*) one can calculate the minimum, average and maximum number of cormorants per month, for the period of the 9 months of the HWM, and for the entire year. For the calculation of the total fish quantity consumed (G), we used the average food quantity of 0.5 kg/day/cormorant.

## Results

*Feeding studies*

The average weight of the fish remains found in the digestive tracts of the cormorants from Lake Fehér at Szeged ($n$ = 108) was 91.59 g. The ratio of individuals with empty stomachs vs. those with stomachs that contained fish remains was 1:3.16 (24%:76%). The average weight of the fish remains found in the digestive tracts of the cormorants from the fishponds at Rétszilas ($n$ = 26) was 85.29 g. The ratio of individuals with empty stomachs vs. those with stomachs that contained fish remains was 1:2.7 (27%:73%). The average weight of the fish remains found in the digestive tracts of the cormorant from the reach of the River Danube between Gönyű and Szob ($n$ = 17), was 235.6 g. The ratio of individuals with empty stomachs vs. those with stomachs that contained fish remains was 1.44:1 (59%:41%).

There was no significant difference in the species of fish consumed by cormorants at the two fishponds (Tables 1 and 2). A high number and biomass value of *Cyprinus carpio* (L.) was consumed at both sites (29.5% and 86.7%, Szeged; 22.7% and 46.2%, Rétszilas). In Rétszilas, the other most commonly consumed fish species was *Carassius auratus (L.)*

(40.9% and 46.6%), and in Szeged, it was *Pseudorasbora parva* (Temminck and Schlegel) (53.5% and 3.9%). In case of Rétszilas the dominance of *C. auratus* can be explained by the fact that part of the birds were shot at the Nádor-channel, in which this species is abundant. The high number of *P. parva* in the samples coming from the Lake Fehér at Szeged is attributable to the high number (96 individuals) found in one bird. The samples from the River Danube (Table 3) were also dominated by the *C. carpio* (50.0% and 29.9%), but we also found fish typical of natural waters such as *Acipenser rutenus* (L.) (25.0% and 14.3%), *Rutilus rutilus* (Jakowlew) (12.5% and 25.9%) and *Leuciscus cephalus* (L.) (12.5% and 29.9%).

*Table 1*. Dominant (%) prey species by number of individuals and by biomass in the stomachs of cormorants at the Lake Fehér at Szeged.

| Fish species | Number of individuals (%) | Biomass (%) |
|---|---|---|
| *Abramis brama* | 1.0 | 0.1 |
| *Cyprinus carpio* | 29.5 | 86.7 |
| *Hypophthalamichthys molitrix, Aristichthys nobilis* | 0.5 | + |
| *Carassius auratus* | 5.0 | 1.6 |
| *Pseudorasbora parva* | 53.5 | 3.9 |
| *Ictalurus nebulosus* | 1.5 | 1.4 |
| *Silurus glanis* | 0.5 | 3.1 |
| *Perca fluviatilis* | 1.5 | 3.1 |
| *Gymnocephalus cernuus* | 1.0 | 0.1 |
| Unidentified | 6.0 | + |
| T o t a l | 100.0 | 100.0 |

+: only pharyngeal teeth in the stomachs

The average body weight, length and species-composition of the fish remains found in the digestive tracts of cormorants show significant differences only in relation to the differences between natural waters and fishponds. The average weight of digestive tract contents of cormorants from the River Danube (235.6 g) is more than twice as much as those from the fishponds (91.59 g and 85.29 g). The larger amount of fish remains found in the stomachs of birds feeding at the River Danube can be explained by less frequent feedings, as indicated by the proportion (three times) of empty stomachs for birds sampled at this site.

The study of the average values of the body length of prey fish leads us to a similar conclusion. The average body lengths of fish from the Danube — *L. cephalus*: 26.5 cm, *R. rutilus*: 28 cm and *A. rutenus*: 33 cm — are also considerably greater than the average lengths of the same species from the commercial fishery (Table 4).

*Table 2*. Dominant (%) prey species by number of individuals and by biomass in the stomachs of cormorants at the Fishponds near Rétszilas.

| Fish species | Number of individuals (%) | Biomass (%) |
|---|---|---|
| *Ctenoparyngodon idella* | 4.5 | 4.4 |
| *Cyprinus carpio* | 22.7 | 46.2 |
| *Carassius auratus* | 40.9 | 46.6 |
| *Pseudorasbora parva* | 13.7 | 0.4 |
| *Esox lucius* | 4.5 | 2.4 |
| Unidentified | 13.7 | + |
| T o t a l | 100.0 | 100.0 |

+: only pharyngeal teeth in the stomachs

*Table 3*. Dominant (%) prey species by number of individuals and by biomass in the stomachs of cormorants at the Danube River between Gönyű and Szob.

| Fish species | Number of individuals (%) | Biomass (%) |
|---|---|---|
| *Acipenser ruthenus* | 25.0 | 14.3 |
| *Rutilus rutilus* | 12.5 | 25.9 |
| *Leuciscus cephalus* | 12.5 | 29.9 |
| *Cyprinus carpio* | 50.0 | 29.9 |
| T o t a l | 100.0 | 100.0 |

*Fish consumption of the cormorant*

Cormorants observed feeding at the reach of the River Danube between Gönyű and Szob would consume on average 1.5 t of fish between August and April, if the minimum number of individuals were always present. If we use the monthly mean number of cormorants as the basis of our calculation, the amount of fish consumed would be 49.3 t. If we use maximum numbers, the fish consumption for 9 months would amount to 155.8 t (Table 5).

Cormorants observed at the Fishponds at Rétszilas would consume an amount of 0.8 t of fish between August and April, if the minimum number of individuals were always present. By using the monthly mean number of cormorants, the amount of fish consumed would be 6.3 t. If we use maximum numbers, the fish consumption for 9 months would amount to 13.3 t (Table 6).

Cormorants observed at the Lake Fehér at Szeged would consume an amount of 1.6 t of fish between August and April if the minimum number of individuals were always

present. By using the monthly mean number of cormorants, the amount of fish consumed would be 10.4 t. If we use maximum numbers, the fish consumption for 9 months would amount to 25.4 t (Table 7).

Cormorants feeding at the HWM survey sites would consume a total amount of 319.2 t of fish between August and April if the minimum number of individuals were always present. By using the monthly mean number of cormorants, the amount of fish consumed would be 460.6 t. If we use maximum numbers, the fish consumption for 9 months would amount to 602.9 t (Table 8).

According to our calculations, adult cormorants in Hungary consume 2425.5 t of fish per year. To this we add 2.2 t of fish, fed to an average of 4400 young cormorants fledged yearly. By summing up these data we can estimate that in Hungary, cormorants consume on average 2428 t fish annually (Table 9).

*Table 4.* Average body length of fish species consumed by cormorants in Hungary.

| Fish species | Body length (cm) |
|---|---|
| *Acipenser ruthenus* (River Danube) | 33.0 |
| *Ctenoparyngodon idella* | 22.0 |
| *Rutilus rutilus* (River Danube) | 28.0 |
| *Leuciscus cephalus* (River Danube) | 26.5 |
| *Abramis brama* | 6.0 |
| *Cyprinus carpio* | 14.1 |
| *Carassius auratus* | 8.3 |
| *Pseudorasbora parva* | 2.7 |
| *Ictalurus nebulosus* | 11.3 |
| *Silurus glanis* | 27.5 |
| *Esox lucius* | 16.0 |
| *Perca fluviatilis* | 21.5 |
| *Gymnocephalus cernuus* | 4.8 |

## Discussion

There is a huge and diverse literature on daily fish consumption of cormorants, prey size, and prey species composition. Guti and Keresztessy (1997) and Fűrész (1998) suggest a value of 400–600 g for the daily amount of fish consumed by cormorants. Schenk (1997) used 400 g as a daily fish consumption value in his analysis of the problems of Italian fishermen related to cormorants. During their research at the Kis-Balaton, Gere and Andrikovics (1986) found a value of 573 g/day for the fish consumption of a 26 day-old nestling, and a value of 550 g/day for an adult cormorant (with a minimal body weight of

2200 g). A Hungarian study analyzing cormorant damage to fishponds uses a value of 500 g/day (Oláh et al. 2001). In a French study, Marion (1997) mentions a value of 386 g/day.

For the size of fish prey, Gere and Andrikovics (1986) give a value of 12.8–22.6 cm for *C. carpio*, and 36.9–56.5 cm for *Anguilla anguilla* (L.). We can also find a value of 8.16–31.94 cm for *Esox lucius* (L.), and 19–21cm for *Stizostedion lucioperca* (L.) (Marion 1997). In more literature, the length of fish prey is estimated to be 12.8–20.4 cm (Stempniewicz and Grochowski 1997), 7–18 cm (Gogu-Bogdan 1997) and 10–30 cm (Fűrész 1998) regardless of the species.

Regarding the species composition of prey, cormorants consume any fish that is easy to swallow (Fűrész 1998). Based on biomass values, a study conducted in France (Marion 1997) showed that cormorants feeding at Lake Grand Lieu had a prey species composition of 21.59% *Tinca tinca* (L.), 16.73% *Abramis brama* (L.), 11.78% *E. lucius*, 11.62% *Ictalurus nebulosus* (LeSueur), 7.38% *Blicca bjoerkna* (L.), 7.35% *R. rutilus*, 7.06% *A. anguilla*, 5.77%, *Scardinius erythrophthalmus* (L.), 4.33% *C. carpio,* and 4.9% of other prey items. Researchers conducting investigations at the Danube-delta found a composition of 63.8% pelagic, and 36.2% bentonic fish species (Gogu-Bogdan 1997). According to an investigation based on the collected pellets of cormorants at the Kis-Balaton, the fish species consumed consisted of *C. carpio* (73%), *A. anguilla* (15%), *R. rutilus* (about 2%)*, Abramis brama* (L.) (about 2%), *C. auratus* (about 2%), *T. tinca* (about 2%) and, to a smaller extent, *Hypophthalmichthys molitrix* (Valenciennes), *Aristichthys nobilis* (Richardson)*, Perca fluviatilis* (L.), and *Pelecus cultratus* (L.) (Gere and Andrikovics 1986).

In our own research, the observed differences between the fishponds and the natural river ecosystem in the Danube can be attributed to various complex reasons. First, the Danube is a relatively constant natural environment in which the birds can fish in stable, relaxed conditions throughout the year. In this site, they are much less influenced by the more dynamic changes and threats of the artificial environment (alarming, hunting, and disturbance) of the fishponds. Therefore they have more time and opportunity to feed sufficiently and make a simultaneous selection in body size and composition of prey fish. At the same time, in a commercial fishery there are only a few fish species of a given size that are "available" for feeding. Another reason for the differences is the period of collection. The majority of the birds examined were collected during the fall and winter months, when fish populations preparing for wintering gather in groups in natural waters. During this period, it is more advantageous for cormorants to search for larger individuals to spare energy. In this way they can gain a greater amount of prey fish with respect to length and weight by investing the same amount of energy.

At fishponds (except during winter months), a "laid table" awaits the cormorants. Because of the high fish density and the shallow water, they can secure their daily fish consumption needs much more easily than by fishing in natural waters. Furthermore, the size of the bred fish fully satisfies the cormorant needs, as can be clearly seen from our results (10–17 cm). It is no wonder that the birds enjoy this type of feeding site at least as much as natural waters. This is supported by the high number of cormorants observed at the fishponds and the higher ratio of individuals with stomachs containing food.

*Table 5*. Mass of the fish consumed by cormorants at the River Danube between Gönyű and Szob.

| | August<br>31 days | September<br>30 days | October<br>31 days | November<br>30 days | December<br>31 days | January<br>31 days | February<br>28 days | March<br>31 days | April<br>30 days |
|---|---|---|---|---|---|---|---|---|---|
| 1 bird/day (kg) | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| 1 bird/month (kg) | 15.5 | 15.0 | 15.5 | 15.0 | 15.5 | 15.5 | 14.0 | 15.5 | 15.0 |
| Minimum number | 1 | 1 | 1 | 5 | 1 | 2 | 3 | 64 | 19 |
| Average number | 85 | 219 | 740 | 493 | 423 | 386 | 404 | 300 | 197 |
| Maximum number | 308 | 1010 | 3000 | 1765 | 1409 | 796 | 923 | 637 | 396 |
| $G^*_{min}$ (kg/month) | 16 | 15 | 16 | 75 | 16 | 31 | 42 | 992 | 285 |
| $G_{ave}$ (kg/month) | 1312 | 3292 | 11,473 | 7388 | 6556 | 5990 | 5658 | 4656 | 2955 |
| $G_{max}$ (kg/month) | 4774 | 15,150 | 46,500 | 26,475 | 21,840 | 12,338 | 12,922 | 9,874 | 5,940 |

*G=Total fish quantity consumed

*Table 6*. Mass of the fish consumed by cormorants at the fishponds at Rétszilas.

| | August<br>31 days | September<br>30 days | October<br>31 days | November<br>30 days | December<br>31 days | January<br>31 days | February<br>28 days | March<br>31 days | April<br>30 days |
|---|---|---|---|---|---|---|---|---|---|
| 1 bird/day (kg) | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| 1 bird/month (kg) | 15.5 | 15.0 | 15.5 | 15.0 | 15.5 | 15.5 | 14.0 | 15.5 | 15.0 |
| Minimum | 15 | 4 | 1 | 3 | 5 | 1 | 5 | 12 | 4 |
| Average | 47 | 59 | 44 | 31 | 28 | 7 | 74 | 91 | 42 |
| Maximum | 63 | 187 | 110 | 56 | 47 | 19 | 117 | 207 | 72 |
| $G^*_{min}$ (kg) | 233 | 60 | 16 | 45 | 78 | 16 | 70 | 186 | 60 |
| $G_{ave}$ (kg) | 725 | 878 | 674 | 460 | 430 | 109 | 1039 | 1411 | 630 |
| $G_{max}$ (kg) | 977 | 2805 | 1705 | 840 | 729 | 295 | 1638 | 3209 | 1080 |

*G=Total fish quantity consumed

*Table 7*. Mass of the fish consumed by cormorants at the fishponds at Lake Fehér at Szeged.

| | August 31 days | September 30 days | October 31 days | November 30 days | December 31 days | January 31 days | February 28 days | March 31 days | April 30 days |
|---|---|---|---|---|---|---|---|---|---|
| 1 bird/day (kg) | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| 1 bird/month (kg) | 15.5 | 15.0 | 15.5 | 15.0 | 15.5 | 15.5 | 14.0 | 15.5 | 15.0 |
| Minimum number | 1 | 7 | 7 | 4 | 11 | 10 | 2 | 62 | 2 |
| Average number | 22 | 64 | 84 | 144 | 103 | 19 | 56 | 144 | 47 |
| Maximum number | 45 | 135 | 169 | 570 | 176 | 26 | 135 | 296 | 129 |
| $G^*_{min}$ (kg/month) | 16 | 105 | 109 | 60 | 171 | 155 | 28 | 961 | 30 |
| $G_{ave}$ (kg/month) | 335 | 960 | 1297 | 2165 | 1600 | 289 | 784 | 2237 | 711 |
| $G_{max}$ (kg/month) | 698 | 2025 | 2620 | 8550 | 2728 | 403 | 1890 | 4588 | 1935 |

*G=Total fish quantity consumed

*Table 8*. Mass of the fish consumed by cormorants at sites of the Hungarian Waterfowl Monitoring (HWM).

| | August 31 days | September 30 days | October 31 days | November 30 days | December 31 days | January 31 days | February 28 days | March 31 days | April 30 days |
|---|---|---|---|---|---|---|---|---|---|
| 1 bird/day (kg) | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| 1 bird/month (kg) | 15.5 | 15.0 | 15.5 | 15.0 | 15.5 | 15.5 | 14.0 | 15.5 | 15.0 |
| Minimum number | 2422 | 2819 | 4443 | 3906 | 1695 | 1091 | 1179 | 1831 | 1591 |
| Average number | 2853 | 3755 | 6059 | 5416 | 3362 | 1785 | 2098 | 2930 | 2027 |
| Maximum number | 3810 | 4377 | 7029 | 6681 | 4999 | 3183 | 3320 | 3730 | 2529 |
| $G^*_{min}$ (kg/month) | 37,541 | 42,285 | 68,867 | 58,590 | 26,273 | 16,911 | 16,506 | 28,381 | 23,865 |
| $G_{ave}$ (kg/month) | 44,215 | 56,322 | 93,917 | 81,233 | 52,114 | 27,670 | 29,367 | 45,418 | 30,405 |
| $G_{max}$ (kg/month) | 59,055 | 65,655 | 108,950 | 100,215 | 77,485 | 49,337 | 46,480 | 57,815 | 37,935 |

*G=Total fish quantity consumed

*Table 9*. Calculated mass of the fish consumed by cormorants in Hungary.

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number | 2000 | 14,000 | 14,000 | 14,000 | 10,000 | 10,000 | 20,000 | 20,000 | 25,000 | 25,000 | 25,000 | 3,000 |
| Cormorant×day | 62,000 | 392,000 | 434,000 | 420,000 | 310,000 | 300,000 | 620,000 | 620,000 | 750,000 | 775,000 | 75,000 | 93,000 |
| No. of Ad. | 2000 | 14,000 | 14,000 | 14,000 | 10,000 | 10,000 | 20,000 | 20,000 | 25,000 | 25,000 | 25,000 | 3,000 |
| No. of Juv. | 0 | 0 | 0 | 0 | 4400 | 4400 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 2000 | 14,000 | 14,000 | 14,000 | 14,400 | 14,400 | 20,000 | 20,000 | 25,000 | 25,000 | 25,000 | 3,000 |
| $G^*_{ad}$ (kg/month) | 31,000 | 196,000 | 217,000 | 210,000 | 155,000 | 150,000 | 310,000 | 310,000 | 375,000 | 387,500 | 37,500 | 46,500 |
| $G_{juv}$ (kg/month) | 0 | 0 | 0 | 0 | 1100 | 1100 | 0 | 0 | 0 | 0 | 0 | 0 |
| $G_{total}$ (kg/month) | 31,000 | 196,000 | 217,000 | 210,000 | 156,100 | 151,100 | 310,000 | 310,000 | 375,000 | 387,500 | 37,500 | 46,500 |

*G=Total fish quantity consumed

Taking into account all of our results in the sample areas we can state that cormorants will consume the most easily available and acceptable prey fish species. That is to say the prey fish species that were present in the highest numbers or in the greatest mass, and whose size fell within the required range.

## Conclusions

As a result of our research, the following conclusions can be made:

- The weight of the average stomach content was 91.59 g and 85.29 g at the fishponds, while 235.6 g at the River Danube. The larger amount of fish remains found in the stomachs of birds feeding at the River Danube can be explained by less frequent feedings, as indicated by the greater proportion (three times) of empty stomachs for birds sampled at this site.
- In the natural water samples (of the River Danube) the lengths of the fish species were significantly greater than that of the same species found in fishponds.
- Cormorants consumed the most easily available fish species, that is to say the prey fish species that were present in the highest numbers or in the greatest mass, and whose size fell within the required range.
- Protected fish species were not included in the diet of cormorants. Hence, cormorants are not an issue for nature conservation.
- According to our calculations, cormorants consume approximately 2428 tons/year of fish in Hungary, which can be considered as a significant economical factor.
- For an assessment of the damages done to fishpond managers and for the calculation of compensation, it is necessary to determine cormorant population trends and to analyze variations in the number of secondary fish species in fishponds. The consumption of sick and disabled individuals can influence compensation.
- For a more accurate determination of damages done by cormorants, it is necessary to analyze variations in their diet throughout the year.
- It can be stated that in the future, it will not be possible to avoid the issue of compensation for damages caused by cormorants.
- We can state that it is important to raise the issue of compensation for the damages done by cormorants to private property.
- Population control and bird-scaring tactics should be used with caution, particularly in regards to protected bird species and increasingly protected coexisting bird species, as well as during the breeding (nesting, chick raising) periods.

## Acknowledgments

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# Diurnal time-activity budgets of redheads (*Aythya americana*) wintering in seagrass beds and coastal ponds in Louisiana and Texas

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## Abstract

Diurnal time-activity budgets were determined for wintering redheads (*Aythya americana*) from estuarine seagrass beds in Louisiana (Chandeleur Sound) and Texas (Laguna Madre) and from ponds adjacent to the Laguna Madre. Activities differed ($P < 0.0001$) by location, month, and diurnal time period. Resting and feeding were the most frequent activities of redheads at the two estuarine sites, while drinking was almost nonexistent. Birds on ponds in Texas engaged most frequently in resting and drinking, but feeding was very infrequent. Redheads from the Louisiana estuarine site rested less than birds in Texas at either the Laguna Madre or freshwater ponds. Redheads in Louisiana fed more than birds in Texas; this was partially because of weather differences (colder temperatures in Louisiana), but the location effect was still significant even when we adjusted the model for weather effects. Redheads in Louisiana showed increased resting and decreased feeding as winter progressed, but redheads in Texas did not exhibit a seasonal pattern in either resting or feeding. In Louisiana, birds maintained a high level of feeding activity during the early morning throughout the winter, whereas afternoon feeding tapered off in mid- to late winter. Texas birds showed a shift from morning feeding in early winter to afternoon feeding in late winter. Males and females at both Chandeleur Sound and Laguna Madre showed differences in their activities, but because the absolute difference seldom exceeded 2%, biological significance is questionable. Diurnal time-activity budgets of redheads on the wintering grounds are influenced by water salinities and the use of dietary fresh water, as well as by weather conditions, tides, and perhaps vegetation differences between sites. The opportunity to osmoregulate via dietary freshwater, versus via nasal salt glands, may have a significant effect on behavioral allocations.

# Foraging behaviour of redheads (*Aythya americana*) wintering in Texas and Louisiana

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## Abstract

Redheads, *Aythya americana*, concentrate in large numbers annually in traditional wintering areas along the western and northern rim of the Gulf of Mexico. Two of these areas are the Laguna Madre of Texas and Chandeleur Sound of Louisiana. We collected data on 54,340 activities from 103 redhead flocks in Texas and 51,650 activities from 57 redhead flocks in Louisiana. Males and females fed similarly, differing neither in levels of feeding (percent of all birds in flock that were feeding) ($P > 0.90$) nor in percentages of birds feeding by diving, tipping, dipping, or gleaning from the surface ($P > 0.10$). The foraging level of redheads in the upper Laguna Madre region was relatively constant throughout two winters. Foraging of redheads in early winter in Louisiana was significantly greater than redhead foraging in the upper Laguna Madre, but by late winter, foraging by redheads in Louisiana had declined to the same level as that shown by redheads foraging in the upper Laguna Madre. The overall foraging level of redheads from Chandeleur Sound was greater (41%) than that of redheads in the upper Laguna Madre (26%), yet it was quite similar to the 46% foraging level reported for redheads from the lower Laguna Madre. Redheads in the upper Laguna Madre region of Texas fed more by diving than did those in the Chandeleur Sound and the lower Laguna Madre. Diving increased in frequency in late winter. Greater reliance by redheads on diving in January and February indicates that the birds altered their foraging to feed in deeper water, suggesting that the large concentrations of redheads staging at this time for spring migration may have displaced some birds to alternative foraging sites. Our results imply that the most likely period for food resources to become limiting for wintering redheads is when they are staging in late winter.

# Temporal processes and duck populations: examples from Mývatn

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## Abstract

Studies of temporal processes at Lake Mývatn, Iceland, on three scales, millennial, centennial and decadal, are reviewed and a summary is presented of the main results of waterfowl population monitoring studies conducted over the past three decades. The characteristics of shallow, subarctic Lake Mývatn and its volcanic environment are outlined, as well as recent conflicts between development and conservation. Mining of the bottom sediment of Lake Mývatn has been a major agent causing habitat destruction and damage to the food web. Population limitation of waterbirds at Mývatn is discussed, as three research questions and emerging answers: (1) How is reproductive output determined? All species studied showed positive correlations of production of young with levels of aquatic insects, catastrophic weather was rarely important; (2) How is the dispersion of breeding ducks determined? Densities of migratory species are determined mainly by resource levels on the breeding ground in the year before they return to the breeding area; a year-round resident species, *Bucephala islandica*, adjusts its density to the current availability of insect food in each of two main habitats used; (3) How are flyway populations of ducks determined? For most species, there is not enough information on total numbers and the state of the habitat on a flyway scale. In B. islandica, there are indications that the total population is limited by resources in winter. The Mývatn study area is dominated by a single, shallow and eutrophic lake and for many waterbird species the area seems to form a single functional unit. This leads to significant correlations when comparing demography with environmental conditions, such as food resources.

# Waterbird and water chemistry relations in shallow wetland basins in the Western Boreal Forest

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## Abstract

The Western Boreal Forest (WBF) is the second most important waterfowl habitat in North America and is undergoing dramatic changes as a result of anthropogenic influences. Understanding the relation between waterbirds and productivity in shallow-pond wetlands is a crucial component of conservation planning. Ducks Unlimited is attempting to promote sustainable industry practices around riparian and wetland habitat and identification of the use of wetlands by waterbirds is being conducted in several areas of the WBF. In association with the waterbird inventory a suite of water chemistry parameters and landscape features were measured for selected wetlands. Waterbird use is related to wetland surface water chemistry. Landscape features associated with water chemistry and wetland productivity may provide useful indices to predict wetland production and waterfowl use essential for conservation planning at the regional scale.

# The relations between waterfowl numbers and trophic status of wetland sites

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## Abstract

Cotswold Water Park is a complex of over 130 flooded gravel pits and is the most extensive marl lake system in Britain. The complex supports nationally important wintering numbers of Pochard (*Aythya ferina*). Long term trends in wintering Pochard numbers shows a rapid increase in numbers up to the early 1970's, but with evidence of a decline in the late 1980s and 1990s. Previous work has demonstrated a link between the age and trophic status of lakes at this site, which could suggest a natural process of eutrophication occurring over time. In this study, twenty lakes were studied in detail and information on water chemistry, macrophyte abundance and phytoplankton communities were collected. Winter bird counts were carried out during both the day and night to collect data on Pochard distribution and feeding behaviour. Historical bird data from the Wildfowl and Wetlands Trust WeBS database were also used to analyse long-term changes. The presence of Charophytes in the macrophyte community was a major determinant of Pochard distribution within the Water Park. Phosphate, nitrate and chlorophyll $\alpha$ concentrations were significantly different between the lakes but were not directly linked to Pochard numbers. However, trophic ranking scores calculated from macrophyte data were significantly related to Pochard numbers. Our results show that differing macrophyte communities had a significant effect on the feeding behaviour of Pochard and also the maximum number that the lake supported. Results of this study will be of particular relevance for the development of conservation and management strategies for wintering waterfowl.

# Effects of water quality on habitat use by lesser scaup (*Aythya affinis*) broods in the boreal Northwest Territories, Canada

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## Abstract

Populations of lesser scaup (*Aythya affinis*), an abundant duck in the northwestern boreal forest of Canada, have declined markedly over the past few decades. The limnological characteristics of northern wetlands used by lesser scaup and other waterfowl are inadequately documented and the possible effects of habitat quality or other factors on the use of water bodies by scaup are poorly understood. Waterfowl and limnological data, collected on a 38 km$^2$ area roadside study area near Yellowknife, Northwest Territories, were used to describe the characteristics of ponds and evaluate potential variables influencing use of water bodies by lesser scaup (and might therefore limit the growth of the lesser scaup population). The specific objectives of this study were to (1) describe and compare the water quality of natural ponds and roadside borrow pits created during highway construction; and (2) evaluate habitat preferences of lesser scaup broods by comparing water quality, physical features and invertebrate abundance in natural ponds and borrow pits that were used or avoided by brood-rearing lesser scaup. Twenty eight water quality, physical and biotic characteristics of ponds were measured in the field or from water samples collected at 48 water bodies. Waters are weakly alkaline, hard, non-saline, and meso-eutrophic. Natural ponds and artificial borrow pits created during highway construction had statistically significant differences ($P < 0.05$) in ten water quality variables, many of which can be attributed to the origin of the water bodies. Water bodies used by brood-rearing lesser scaup had significantly higher particulate organic carbon ($P = 0.01$), particulate organic nitrogen ($P = 0.01$), dissolved potassium ($P = 0.04$), and density of amphipod crustaceans ($P = 0.01$) than those water bodies without lesser scaup. Multiple regression analysis indicated that pond area and depth had a dominant effect on the presence of scaup broods but the effects of other water quality or biotic variables were unclear.

# Characterization of breeding habitats for black and surf scoters in the eastern boreal forest and subarctic regions of Canada

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## Abstract

We analyzed characteristics of wetland habitats used by breeding black scoters (*Melanitta nigra*) and surf scoters (*M. perspicillata*) in the eastern boreal forest and subarctic regions of Canada based on satellite telemetry data collected in the spring and summer. During 2002 and 2004, nine black scoters (four males, five females) were tracked to breeding areas in Quebec, Manitoba, and Northwest Territories. In addition, in 2001–04, seven surf scoters (three males, four females) were tracked to breeding areas in Labrador, Quebec, Northwest Territories, and Nunavut. Based on satellite telemetry data, locations of black and surf scoters in breeding areas were not significantly different in regard to latitude and longitude. Presumed breeding areas were manually plotted on topographic maps and percent cover type and water were estimated. Breeding habitat of black scoters was significantly different than that for surf scoters, with black scoters mainly using open (tundra) areas (44%) and surf scoters using mainly forest areas (66%). Surf scoters presumed breeding areas were at significantly higher elevations than areas used by black scoters. Some breeding areas were associated with islands, but the role of islands for breeding areas is equivocal. These results aid in the identification of potentially critical breeding areas and provide a baseline classification of breeding habitats used by these two species.

## Introduction

Little is known about the location or habitat characteristics of breeding areas for black scoters (*Melanitta nigra*) or surf scoters (*M. perspicillata*) in the eastern boreal forest and subarctic regions of Canada. Habitat loss of breeding areas from logging, mining, and hydro-electric power production (Elliot 1997), may be possible explanations for population declines for black and surf scoters that winter in the Chesapeake Bay area (Perry and Deller 1995) and other areas of the Atlantic Flyway (Caithamer et al. 2000). Additional information is needed about the location of the breeding areas of scoters so managers can determine, if possible, threats that impact recruitment. Black and surf scoters are of special concern as they are the least studied among the waterfowl (Godfrey 1986, Bordage and

Savard 1995). Additionally, the black scoter is the least numerous of the three scoter species (Kehoe 1994).

The breeding habitat of these two species in eastern Canada has received little study due to the remote and large breeding areas they use (Bordage and Savard 1995, Savard et al. 1998). Early naturalists and researchers were restricted to lower latitudes and to the actual size of the area they could study, due to accessibility restrictions that prevailed until the advent of aircraft use for field studies.

The main objective of this study was to delineate breeding populations of black and surf scoters randomly selected in wintering and staging areas for instrumentation with satellite transmitters. A secondary objective of this study was to determine the habitat conditions in the breeding areas using satellite telemetry combined with mapping techniques.

## Methods

### *Telemetry*

We captured surf scoters on the Chesapeake Bay with a net gun, shot from the bow of a fast moving boat. On the Restigouche River, we captured black scoters with standard night-lighting procedures, which use hand-held dip nets from the bow of a slowly moving boat with the aid of bright lights. Males and females were used for the telemetry aspect of this study as both sexes go to the breeding areas, although males move to molting areas shortly after initiation of incubation, providing additional data.

Captured ducks were surgically implanted with a 39 g PTT-100 satellite transmitter, manufactured by Microwave, Inc., Columbia, Maryland. Surgery followed general procedures outlined in other telemetry studies (Korschgen et al. 1984, Korschgen et al. 1996). Duty cycle of the transmitter varied slightly each year, but was in the range of 6–8 hours transmitting and 48–60 hours not transmitting. Each duck was held post-surgery for 1–3 days and then released at the site of capture.

All data from transmitters implanted in black and surf scoters were collected from the Argos System, which is carried aboard the NOAA Polar-orbiting Operational Environmental Satellites (POES), through Service Argos, Inc. in Landover, Maryland. The data were analyzed and filtered at Patuxent Wildlife Research Center by staff using Statistical Analyses Software (SAS; SAS Institute, Inc. 1990) and a software program designed to process telemetry data (Dave Douglas, pers. comm.). The filtering process (User Manual, Argos, Inc., Landover, MD) removes data with no estimation of location accuracy (level 0) and data deemed invalid by Argos (level Z). Filtered data (levels 3, 2, and 1) were then plotted using Geographic Information Systems (ArcGIS 8.2; ESRI, Redlands, CA) maps maintained on the Atlantic Seaduck Project website of Patuxent Wildlife Research Center. Satellite telemetry was used to delineate the breeding populations, because it is the optimum technique to determine movements and locations of long-distance migrating birds going to remote areas of large inaccessible northern habitats.

*Habitat mapping*

Telemetry data from 2001 to 2004 with the highest spatial accuracy (level 3 <150 m) were selected and their locations plotted on a digital NIMA (National Imagery and Mapping Agency) Arc Digitized Raster Graphics (ADRG) of Canada using ArcGIS 8.2. Clusters of points associated with the breeding period were identified as presumed breeding locations and analyzed to determine the length of stay at the different locations. For males, which remain at the breeding area during courtship, time periods greater than 2 weeks were used to select ducks for study. For females, which remain at the breeding lake for several months, length of stay greater than a month was used.

Topographical maps were used in conjunction with ADRG to characterize the breeding habitat, and habitat types were manually accessed from the maps. Digital acquisition of habitat data would have been preferred as a faster and more accurate process, but was not available for the areas of interest in this study. In addition, the NIMA ADRG maps did not provide adequate resolution to discern specific breeding habitats. Therefore, we evaluated the habitat characteristics of breeding areas by transferring the location of the centroid for each cluster of location points to a 1:50,000 topographic maps (National Topographic System, Natural Resource, Canada) and establishing a 4-km square plot centered over the presumed breeding area.

These areas were examined to estimate percent land and water cover for each habitat type. Various icons described in the legends of the maps represented habitat type, including open (tundra), forest, marsh, swamp (wooded wetland), and lake. We had hoped to classify wetlands in detail using descriptions given by the National Wetlands Working Group (1988), but the maps used were not at that level of description. We determined percentages by using a grid (0.25 km) over the map and recording the habitat type at each intersection of the horizontal and vertical lines ($n$ = 256). Size and configuration of lakes, origin of water, presence of islands, and the number of lakes within the square plot were also determined. Elevation and topography (major changes in elevation) of the surrounding area were also determined. Obviously, these data would be more accurately measured in the field, but due to the inaccessibility of the northern area and the high cost to travel there, we attempted to use this less direct approach. All data were analyzed using multi-way analysis of variance (ANOVAs) in SAS (Proc Mixed; SAS Institute, Inc. 1990). All analyses were considered significant at the 5% level.

## Results

*Telemetry coordinates*

Sixteen scoters instrumented with satellite transmitters were tracked to presumed breeding areas in Labrador, Quebec, Manitoba, Nunavut, and the Northwest Territories (Figure 1). Fifteen of the scoters were located in the taiga shield, with three of these located near the taiga shield/tundra line. Nine scoters (4 black and 5 surf scoters) were located east of Hudson Bay and six (4 black and 2 surf scoters) were located west of Hudson Bay. One female black scoter was located in tundra habitat in Northwest Territory.

It was not possible to confirm breeding activity or determine the exact location of any breeding areas, as funds were not available for ground inspections. The mean latitude of breeding areas for the nine black scoters was 59˚27' N, which was not significantly different ($F_{1,14}$ = 3.85, $P$ = 0.069) from the mean latitude of 56˚44' N for the breeding areas for the seven surf scoters (Table 1). The mean longitude for the breeding areas for the nine black scoters was 89˚26' W. This was not significantly farther west than the surf scoters ($F_{1,14}$ = 2.39, $P$ = 0.144), which had a mean longitude of 76˚08' W. The duck that nested the farthest west was also located farthest north and was a female black scoter in the Northwest Territories at 64˚34' N/111˚36' W.

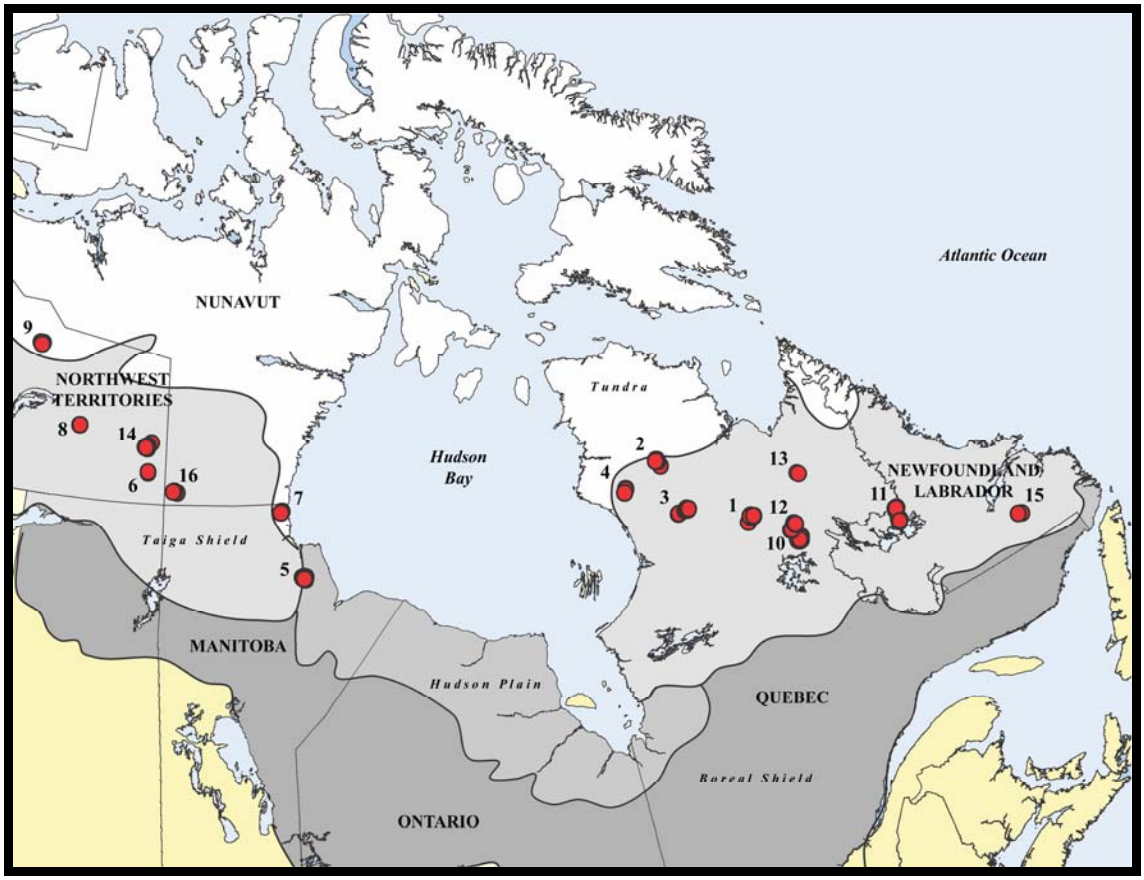


*Figure 1*. Location of sixteen scoters instrumented with satellite transmitters and tracked to presumed breeding areas in Labrador, Quebec, Manitoba, Nunavut, and the Northwest Territories.

*Hydro-Morphology*

The hydrology at the presumed breeding areas identified by satellite telemetry was evaluated with map analyses as part of the scoter habitat assessment. The nine breeding areas used by black scoters were all associated with ponds and small lakes that varied in shape from circular to elongate. The mean size of the presumed breeding lake for black

*Table 1*. Breeding habitat types used in Labrador, Quebec, Manitoba, Nunavut, and Northwest Territories by black and surf scoters during spring and summer 2001–04, based on locations determined by satellite telemetry.

| Scoter Species | No. | Sex | PTT No. | Year | Location | Latitude/Longitude | Elev. (m) | Percent Cover | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Open[1] | Forest | Marsh | Swamp | Lake |
| Black | 1 | M | 36024 | 2002 | Quebec | 56˚20' N / 70˚17' W | 400 | 10 | 77 | 2 | 7 | 4 |
| | 2 | M | 36198 | 2002 | Quebec | 58˚52' N / 73˚51' W | 220 | 70 | 0 | 0 | 0 | 30 |
| | 3 | M | 36200 | 2002 | Quebec | 57˚16' N / 73˚20' W | 325 | 80 | 0 | 0 | 0 | 20 |
| | 4 | M | 36201 | 2002 | Quebec | 58˚23' N / 75˚59' W | 180 | 72 | 0 | 0 | 0 | 28 |
| | 5 | F | 36366 | 2002 | Manitoba | 57˚50' N / 94˚13' W | 80 | 0 | 5 | 60 | 15 | 20 |
| | 6 | F | 49435 | 2004 | NW Terr. | 60˚55' N / 103˚3' W | 400 | 8 | 42 | 2 | 24 | 24 |
| | 7 | F | 49437 | 2004 | Manitoba | 59˚45' N / 95˚13' W | 60 | 59 | 13 | 0 | 1 | 27 |
| | 8 | F | 49440 | 2004 | NW Terr. | 62˚6' N / 107˚24' W | 400 | 16 | 40 | 0 | 18 | 26 |
| | 9 | F | 49441 | 2004 | NW Terr. | 64˚34' N / 111˚36' W | 450 | 81 | 0 | 1 | 0 | 18 |
| | | | | | Mean: | 59˚27' N / 89˚26' W | 279 | 44 | 20 | 7 | 7 | 22 |
| Surf | 10 | M | 20658 | 2001 | Quebec | 55˚11' N / 68˚45' W | 580 | 0 | 77 | 0 | 0 | 23 |
| | 11 | M | 20660 | 2002 | Quebec | 54˚43' N / 63˚56' W | 510 | 15 | 60 | 0 | 5 | 20 |
| | 12 | M | 20668 | 2002 | Quebec | 55˚32' N / 68˚51' W | 450 | 0 | 90 | 0 | 0 | 10 |
| | 13 | F | 40761 | 2003 | Quebec | 56˚50' N / 67˚8' W | 300 | 0 | 92 | 0 | 0 | 8 |
| | 14 | F | 40762 | 2003 | NW Terr. | 61˚38' N / 103˚18' W | 320 | 60 | 5 | 5 | 0 | 30 |
| | 15 | F | 40772 | 2004 | Labrador. | 52˚52' N / 59˚34' W | 400 | 0 | 69 | 25 | 0 | 6 |
| | 16 | F | 49434 | 2004 | Nunavut | 60˚24' N / 101˚26' W | 410 | 4 | 70 | 0 | 0 | 26 |
| | | | | | Mean: | 56˚44' N / 76˚08' W | 424 | 11 | 66 | 4 | 1 | 18 |

[1]Open habitat is considered tundra

scoters was 87 ha with a range of 1–305 ha. All lakes were associated with small rivers. There were five lakes of the same or equal size varying from 0.1–1.3 km in distance from the lake where black scoters were presumed to be breeding.

The seven presumed breeding areas used by surf scoters were also associated with ponds and small lakes that varied in shape from circular to elongate. The mean size of the breeding wetland for surf scoters was 22 ha with a range of 5–69 ha, which was not significantly different than the mean size of lakes used by black scoters ($F_{1,14} = 3.32$, $P = 0.090$). All lakes presumed to be used by surf scoter for breeding were associated with small rivers. There were 22 lakes of the same or equal size varying from 0.1–1.1 km in distance from the presumed breeding lake used by the instrumented surf scoters.

*Topographic Data*

Analyses of data obtained from topographic maps based on the telemetry locations showed differences between the two scoter species for composition of the landscape (Table 1). The average elevation of habitat used by the nine black scoters (279 m) was significantly less ($F_{1,14} = 4.91$, $P = 0.044$) than the average elevation of habitat used by the seven surf scoters (424 m).

Open (tundra) habitat was the predominant cover type that black scoters selected for breeding areas and comprised 44% compared to 11% open habitat for surf scoters ($F_{1,14} = 4.72$, $P = 0.047$). Forest habitat was the predominant cover type for surf scoter breeding areas and comprised 66% compared to 20% for black scoters ($F_{1,14} = 10.66$, $P = 0.006$). Lakes accounted for the third highest cover type overall with a mean of 22% for black scoters and comprised 18% for surf scoters ($F_{1,14} = 1.03$, $P = 0.327$). Marsh habitat comprised 7% of the cover for black scoters and 4% for surf scoters ($F_{1,14} = 0.13$, $P = 0.722$). Habitat classified as swamp (forested wetland) made up 7% of the habitat for black scoters and 1% for surf scoters ($F_{1,14} = 3.21$, $P = 0.095$). The four largest lakes associated with black scoters had islands, but the three smaller lakes did not.

## Discussion

This project, which used satellite telemetry to locate breeding areas of two species of scoters and then applied mapping techniques to determine habitat conditions, has potential for future waterfowl studies, especially with species that reside in remote locations such as scoters.

The nesting data for black and surf scoters provided by early naturalists (Audubon 1838, Thompson 1891, Preble 1902, Bent 1925, Austin 1932) provide information about areas that were accessible to these investigators. Other reports (Manning 1952, Harper 1958, Gillespie and Wetmore 1974, Ross 1983, Goudie and Whitman 1987) increased the information on scoters, but observations were still restricted to the lower latitudes or limited in the size of the area they could study. With aircraft support, scientists were able to study areas that were in northern latitudes and were larger in size. Research conducted by Savard and Lamothe (1991) with helicopter support found the highest densities of black and surf scoters reported in North America in the Lac Bienville area of Quebec at 55˚N, and that densities of scoters increased with higher latitudes.

The lack of digital mapping data in this study made determination of the habitats in these remote areas very time consuming. Based on data derived from satellite telemetry and NTS maps, both species of scoter appear to be associated with the Taiga Shield ecozone, a patchwork of lakes, wetlands, open (tundra), forests, shrublands, and meadows marking the transition from the boreal forest in the south and the open (tundra) to the north (Environment Canada website, http://www.ec.gc.ca, 2004). However, specific local habitats used by the two scoters were different, with black scoters preferring open (tundra) environments and surf scoters preferring forest environments. This difference is further supported by the southern extreme known surf scoter breeding areas located within the boreal forest, at Lac Malbaie, near Quebec City (Reed et al. 1994), and the northern extreme female black scoter that presumably nested within the tundra in this study. Both species appear to nest in habitats with a similar land/water ratio, which is expected considering the large area affected by the glacial history of Canada, but in areas that differ in the amount of surrounding woody vegetation.

The size of lakes used by the two species of scoters as presumed breeding habitat based on our telemetry data were similar to the very limited data previously reported. In Quebec, black scoters were reported to use shallow lakes (<5 m) for breeding in the size range of 10–30 ha and that large deep lakes were avoided (Consortium Gauthier and Guillemette – GREBE 1993). Surf scoters in Quebec also used shallow lakes less than 10 ha in size and avoided large deep lakes (Decarie et al. 1995). Large fish that prey on ducklings may not be able to survive in shallow lakes during winter due to ice cover, whereas, the non-predatory brook trout (*Salvelinus fontinalis*), which are common in shallow lakes such as Lac Malbaie, can overwinter in rivers adjoining the lakes. The role of fish, especially predatory fish, in breeding lakes may be an important limiting factor in the size and depth of lakes selected by scoters as breeding areas (Eriksson 1983, McNicol and Wayland 1992 Mallory et al. 1994). Unfortunately, our data, without ground investigation, were unable to substantially clarify this issue.

Some of the presumed breeding areas in this study were in areas where islands existed within the selected lake habitat. However, there was no indication from the telemetry data that scoters were actually selecting lakes that had islands or that they were nesting on islands. The possibility exists that this is an important factor for northern breeding ducks exposed to several species of mammalian predators. Several well-known breeding areas of scoters do have prominent islands. Lac Malbaie is the southernmost known nesting area for surf scoters and this area has two prominent islands where most of the nesting is believed to occur (Reed et al. 1994, Savard et al. 1998). Highest density of nesting for white-winged scoters has been reported on islands (Brown and Fredrickson 1997) and Redberry Lake in Saskatchewan is a notable example with nesting islands (Brown and Brown 1981).

Islands and the presence of ducks were recorded in the extensive waterfowl surveys conducted in Fennoscandia (northern Finland, Norway, and Sweden) in 1972–76, but not reported (Haapanen and Nilsson 1979). Analysis of these data (L. Nilsson, pers. comm.) showed that there was not a significant difference ($F_{3,28} = 0.87$, $P = 0.47$) in the number of breeding pairs of the European black scoter recorded on lakes with no islands and those that had one, two, or three islands. The telemetry/mapping techniques used with our study are considered adequate to detect large islands; however, ground inspection may be necessary to detect small islands. With more data and more detailed maps, researchers will be in a better position to describe the role of islands as a habitat characteristic that could be

influencing nest site selection by scoters.

This investigation of the breeding habitat of black and surf scoters is preliminary, but we feel the techniques and habitat issues for further study include the ones we examined. More research is necessary to determine the importance biotic and abiotic characteristics such as islands, water depth, predatory fish, and food resources that could be influencing nest site selection. More accurate assessment of scoter breeding habitat in the northeast, similar to that done with lesser scaup (*Aythya affinis*; Fast et al. 2004), will only be possible with a much greater funding effort to provide aircraft to support ground activities. The breeding areas are especially important to study due to their value in scoter population recruitment. The use of satellite radio telemetry tracking in association with a series of mapping techniques will be helpful in future studies of inaccessible and remote areas such as the scoter breeding grounds. Once waterfowl managers have a better understanding of the habitat requirements of scoter populations, they will have a greater awareness of the problems confronting these species.

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# Chemical limnology of aquatic habitats, and distribution of breeding American Black ducks in Atlantic Canada

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## Abstract

This study investigated the ability of landscape-level descriptors of habitat to explain the observed distribution of breeding American Black Ducks (*Anas rubripes*) in the Canadian Maritime Provinces of New Brunswick and Nova Scotia. Data were obtained from the Canadian Soil Information Survey, Maritime Wetlands Inventory, ecological land classifications, provincial soil surveys, digital elevation models and topographical maps. Data on the chemical limnology of surface waters in survey plots were obtained from over 1000 water samples collected during 1996–98, and from Environment Canada databases. Variation in chemical limnology due to survey plot location was orders of magnitude greater than variation due to aquatic habitat type, although both factors were significant. Chemical limnology of surface waters was correlated to soil chemistry and other landscape-level attributes. Akaike's Information Criterion was used to determine which statistical models best predicted the number of breeding Black Ducks in survey plots. Although phosphorus and nitrogen concentrations in surface waters were significantly correlated with the number of breeding Black Ducks, better lower order models were derived by using variables describing wetland biophysical form, number or areal extent. The best higher order statistical models incorporated both descriptors of wetlands and nutrient availability. However nutrient availability variables contributed only a relatively small amount of explanatory power to these models. Based on these results, and considering the cost of collecting and analysing water samples, we conclude that predictive models of regional Black Duck distributions in Atlantic Canada can be derived based solely on information from the Maritime Wetlands Inventory.

# Waterbird habitat associations and temporal change in acid-sensitive Ontario lakes

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## Abstract

Water bodies sensitive to anthropogenic acidification are important and geographically widespread habitat for Ontario's breeding waterbirds. Models of breeding waterbird habitat associations and an understanding of temporal effects are necessary to predict waterbird responses to future acid deposition scenarios. The objectives of these analyses were to identify the best approximating models describing habitat associations of common waterbird species, validate the efficacy of selected models and estimate temporal variability after accounting for habitat associations. We used waterbird pair and young survey data (1987 to 2002) for over 600 lakes in three acid-sensitive regions in Ontario, along with accompanying water chemistry and fish data (1987 to 2002), and lake physical attributes. We developed sets of time-invariant (e.g., median water chemistries) candidate models describing general habitat associations of breeding pairs and young for nine waterbird species. We ranked models using Akaike's Information Criterion (AIC) and averaged them to estimate the relative importance of explanatory variables. Randomization techniques were used to generate concordance values and evaluate averaged models. We then used lake-year waterbird, chemistry and fish data in a repeated measures analysis to estimate temporal effects. The resulting empirical estimates of waterbird habitat associations and temporal change will help improve assessments of existing and projected acidifying emission controls.

# Waterbird guilds in Hungarian wetlands

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## Abstract

In recent years, revealing the influence of migratory birds in Hungary has been significantly facilitated by framing a material circulation guild concept of waterbirds, assessing the quantitative parameters of the most important guilds and aggregating them from literary sources, as well as demonstrating the applicability of the obtained results in Hungary. The implementation of the guild concept for waterbird species is a very useful approach in limnology and nature conservation. Examining the material circulation activities and the role of waterbirds in the metabolism of shallow waters, we can say that in Hungary the 165 species of waterbirds have been divided into three guild groups and 9 guilds on the basis of their nutrition, types of defecation and mechanical activities. These material transporters can increase or decrease the trophic state of wetlands by bringing in or taking out nutrients from the system. The decomposition accelerating and bioturbing guild groups help decrease the organic material content through their digestion and bio-elimination in the wetland. A similar influence can be detected for the bioturbing guild group that also accelerates decomposition directly by its metabolism and indirectly by its mechanical activities.

## Introduction

Waterbirds play an outstanding, measurable role in material circulation in wetlands. In order to understand and quantitatively assess their role, it is important to classify these waterbirds into material circulation guilds on the basis of their feeding activities, movements and behaviour (Savard et al. 1994, Bishop and Myers 2005).

The application of functional guild groups can help to understand the functioning of the ecosystem which, in turn, provides valuable information for nature conservation. Thus, defining the guilds is an important tool for environmental protection and nature conservation. The arrangement of guild groups is determined by the properties of the given ecosystem and the degree of breakdown. According to Walker (1992), it is important to classify species by finding the functional types that have the deepest influence on the

system.

This paper presents the implementation of the guild concept in order to group these waterbird species, feeding and resting in the shallow waters of the Great Plain of Hungary, into functional guilds.

Material circulation guilds for these waterbirds will be suggested, and the major Hungarian species will be classified accordingly. Related studies include quantitative measurements of the daily feces production of the birds belonging to the material transporter group, as well as on the nutrient content of the feces, and the collection of connected data from literary sources (Brooks and Croonquist 1990, Kalivadova and Darolova 1995, Bishop and Myers 2005). Quantitative field assessments were performed on the frequency of feeding and defecation for the bioturbing guild group. The above procedures allow good estimations on the role of waterbirds in material circulation and function of shallow-water ecosystems (Boyer and Psujek 1977, Mulhern et al. 1985, Hanson and Butler 1994, Lillie and Evrard 1994, Bishop 2000, Bishop and Myers 2005).

## Materials and methods

### *Establishing guilds*

To establish and describe the waterbird material circulation guilds, as well as to classify Hungarian waterbird species, Walker's four-step procedure was followed (Walker 1992). Material circulation was selected as the process limiting/determining the functioning of the ecosystem. Guild groups having particular functions in the material circulation were distinguished on the basis of the waterbird species' role in material transport, the acceleration of decomposition and bioturbing (Savard et al. 1994, Woollhead 1994). In O'Connel et al. (1998), 18 functional guilds were identified, representing specific avian behaviors or habitat use. Wetland obligate species (Brooks and Croonquist 1990) were treated as a separate guild.

Considering other functional properties, further sub-grouping was performed within our guild groups, thus material circulation guilds are suggested. The contribution of waterbirds to material circulation is primarily determined by the mode of nutrient uptake, metabolism, feces production, mechanical activities, nutrient transport, as well as resting, nesting and migratory behaviors.

For the creation of guilds for Hungarian bird species, the most significant activities linked to material circulation were taken into account. For instance, the sludge-prodding, thus oxygenizing and gas-releasing activity of the black-tailed godwit, *Limosa limosa* (L.), was given priority over the decomposition accelerating role of benthos organisms. Accordingly, the godwit was assigned to the prodding-bioturbing guild of the bioturbing guild group, although, feeding on benthos, it contributes to the decomposition accelerating activity of the benthos, too. Species having two material circulation activities of nearly identical significance were classified into both related guilds.

### *Study areas*

Field studies on the feeding and defecation activities of the material transporter guild

group, and feces collection for the measurement of nitrogen and phosphorus content were performed in the shallow waters of Kiskunság National Park (Kelemenszék), Hortobágy National Park (Hortobágy Fish ponds) and Körös-Maros National Park (Kardoskút-Fehértó) (Figure 1).

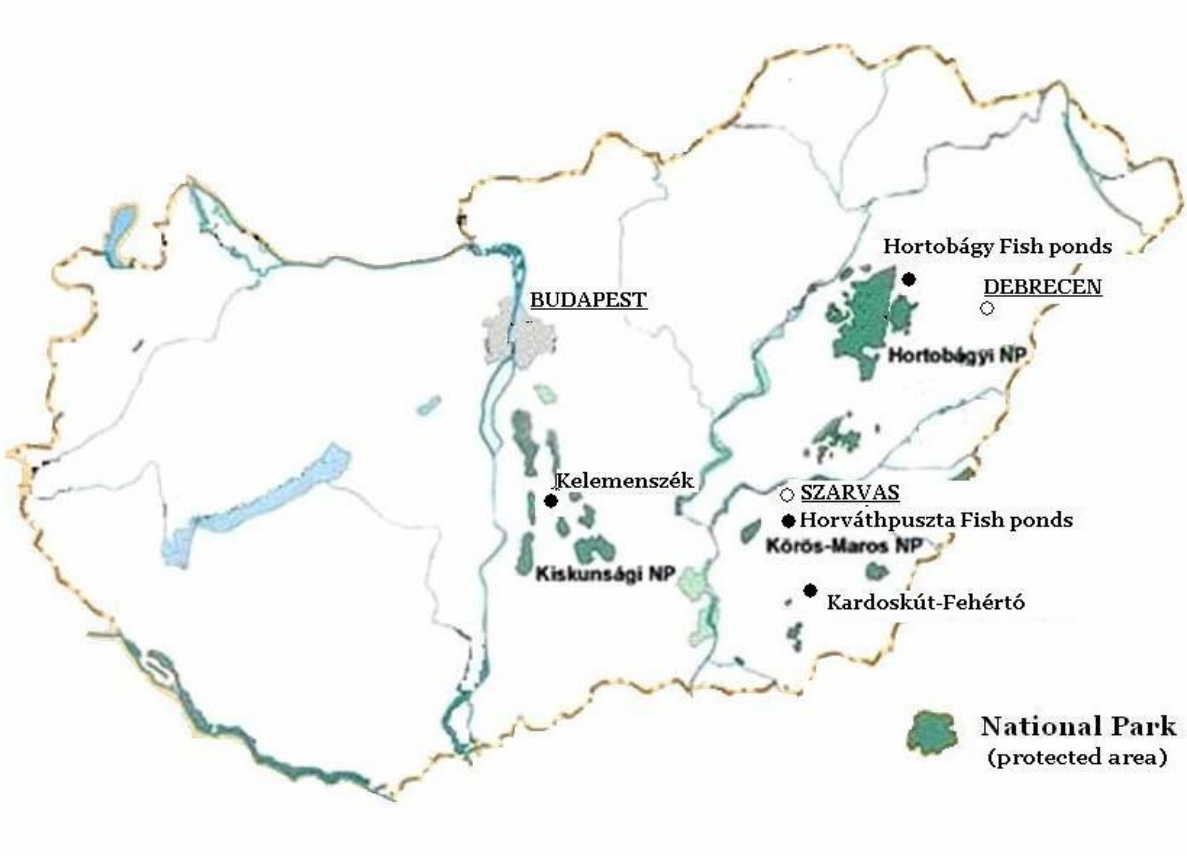


*Figure 1*. The habitats of waterbirds studied in Hungary.

For the bioturbing guild group, field studies of foraging and defecation, and the collection of feces, took place in the above mentioned waterbodies, as well as at the fish ponds of Horváthpuszta in Szarvas. Measurements, experiments on the mechanical gas release and oxygen introduction of bioturbing were carried out in the same fish ponds.

To gain an insight into the quantitative role of material circulation of waterbird guilds, measurements on the material circulation activities of certain birds were determined by the quantitative assessment of bird populations. Populations of grazing importer geese (*Anser* spp.), as well as of collecting export–importer gulls (*Larus* spp.) and common cranes, *Grus grus* (L.) were estimated in Fehértó of Kardoskút, while the spring migration dynamics and quantitative trends of the prodding bioturbing black-tailed godwit were surveyed in the fish ponds of Horváthpuszta, in Szarvas (Table 1).

*Population estimates and daily activity-budgets*

When assessing the daily activity-budgets of geese, gulls, cranes and other waterbirds, we focused on the periods spent foraging, resting, drinking and sleeping, and made

measurement by the hour. For example, field counts on Kelemenszék, Hortobágy Fish ponds, Kardoskút-Fehértó and Horváthpuszta Fish ponds, on the minutely picking (wood sandpiper, *Tringa glareola* (L.)), progging (curlew sandpiper, *Calidris ferruginea* (Pontoppidan)) and prodding (black-tailed godwit) activities for the quantitative assessment of bioturbing mechanical aerating effects were performed with ED 78A Nikon and Optolyth 80HD Fluorite telescopes.

*Table 1.* Wetlands studied in Hungary.

| Area | Kiskunság NP | Hortobágy NP | Körös-Maros NP | Szarvas |
|---|---|---|---|---|
| Name of wetland | Kelemenszék | Hortobágy Fish ponds | Kardoskút-Fehértó | Horváth. Fish ponds |
| Ecological character | protected area | extensive fishery | protected area | intensive fishery |
| Water quality | highly alkaline eutrophic state | alkaline, meso-trophic state | highly alkaline eutrophic state | eutrophic dirty water state |
| Study period | 1994 and 2000 | 1994 and 2000 | 1994 and 2000 1998–1999 | 1993–1995 1995–1998 |

Plastic gas-exchange bulbs were used to measure the gas-exchange effects of artificial prodding frequency. Gas concentrations were measured with a Multi-gas Monitor Typa 1302 Brüel and Kjaer acoustic infrared carbon-dioxide, methane and di-nitrogen oxide gas analyzer. Field measurements on the released gases as related to various numbers of prods were aided by the use of a black-tailed godwit artificial beak. Prodding activities were imitated by wagging the artificial beak inserted into the bulb wall with rubber binding. The frequency of defecation of waterbirds and common cranes was assessed by telescopic counting. The nitrogen and phosphorus content of the collected littoral-bird, goose, gull and crane feces were determined by Felföldy's (1987) wet digestion method. The number of defecation events, the weight and nutrient content of the feces, and the number of birds made up the nutrient loading of the lake, while the frequency of waterbird defecation, the weight and nutrient content of the feces, and the number of birds were indicative of the metabolism of the locally feeding littoral birds, as well as its accelerating effect on decomposition.

## Results and discussion

### *Material circulation waterbird guilds*

Material circulation activities and the role of waterbirds in shallow waters metabolism are determined by foraging modes, defecation types, and mechanical activities. Corresponding to the general material circulation laws of material balance and circulation rate, different guild groups can be distinguished: material transporters affecting the material balance,

species accelerating the circulation rate directly through their own metabolic processes, and the bioturbing guild group, whose feeding activities exercise an indirect influence.

Material transporters are able to increase or decrease the trophic state by modifying the material balance with nutrients taken into or out of the system from or to the wider environment, respectively. Through these activities, material transporters determine the quality and utility of the water.

The metabolism of bioturbing species can accelerate circulation, yet their mechanical activities also contribute to the quickening of decomposition indirectly. Quite frequently, this indirect effect proves to be more powerful. In the individual guild groups, there can be any number of guilds depending on the different feeding practices of the associated species.

*An outline of waterbird material circulation guilds*

An understanding of shallow-water ecosystems can be gained if their structural, functional and species characteristics are classified on the basis of specific functions determining the processes on-going in these ecosystems. These functional groups comprise the functional types of the species that can be found in the given ecosystems, which is the same as the functional guilds of the species. Every species, structural element, and functional process can be present in many ecosystem functions, and their aggregate role played in the ecosystem equals to the complexity of the functions they take part in. In this case, functional groups are made up of species that exercise a similar effect on the material circulation processes of the given organizational level in the ecosystem.

The application and analysis of functional groups helps considerably in understanding of the functioning of the ecosystem. The beneficial outcome largely depends on whether sufficient knowledge and information is available to comprehend the relationship between the various functional groups and the behaviour of the ecosystem as a whole. For this reason, the functional groups studied in the wetland ecosystems were determined (Table 2).

*Material transporter guild group*

The material transporter guild group consists of waterbird guilds which, through their foraging, defecation, behaviour and movements, transport various materials into and out of the shallow-water ecosystems. These activities influence nutrient balance and water quality. The group consists of grazing importer, collecting export-importer and fish-consuming export-importer material circulating guilds. Considering foraging modes, the categories established include grazing importer material transporter guilds (e.g. geese) and collecting export-importer material transporter guilds (e.g. common crane). This group is made up of geese, cranes, gulls and other waterbird species that feed onshore, but spend the night on the water. They frequent the water also in daytime to rest, drink, swim and preen. The nutrients taken with the onshore food, such as organic carbon, nitrogen and phosphorus, fertilize the water in the form of feces.

The importer material circulation guilds of waterbirds have proven to have the most significant role in the metabolism of shallow waters (Gere 1983, Gere and Andrikovics 1992, Janes 1994). It is therefore not a surprise that the possible role of waterbirds as material transporters emerged during studies of eutrophication as far back as nearly three

decades ago (Manny et al. 1975). In oligotrophic lakes, where nutrient intake from other sources is insignificant, imports by geese, cranes and gulls which stay overnight are determinant factors in the nutrient supply of the system (Kerekes 1990, Kerekes et al. 1994).

*Table 2.* The suggested material circulation guild system of waterbirds in Hungary.

| Guild system | Typical species in Hungary |
|---|---|
| Material transporter guild group | |
| Grazing importer material transporter guild | *Anser fabalis, Anser albifrons* |
| Collecting export-importer material transporter guild | *Larus ridibundus, Grus grus* |
| Nekton-consumer export-importer material transporter guild | *Ciconia nigra, Ardea cinerea* |
| Decomposition accelerating guild group | |
| Macrophyte decomposition accelerating guild | *Porzana parva, Fulica atra* |
| Plankton decomposition accelerating guild | *Recurvirostra avosetta, Himantopus himantopus* |
| Benthos decomposition accelerating guild | *Vanellus vanellus, Charadrius alexandrinus* |
| Nekton-consumer decomposition accelerating guild | *Botaurus stellaris, Mergus merganser* |
| Bioturbing guild group | |
| Prodding bioturbing guild | *Limosa limosa, Numenius arquata* |
| Progging bioturbing guild | *Calidris alpina, Calidris minuta* |

The fish-consuming export-importer material transporter guild consists of cormorants, *Phalacrocorax carbo* (L.), grebes (*Podiceps* spp.), egrets (*Egretta* spp.) and other waterbirds that feed on fish and other larger aquatic animals. They often fish and hunt in areas far away from their nesting sites. Preys are transported from other locations to the nest sites. Furthermore, these species frequently nest in groups, and overload the local environment of the colonies with the nutrients in their feces. Regarding foraging modes, the fish-consuming export-importer material circulation guild is the only markedly distinguishable functional group, yet there are other waterbird species that perform export-import activities of material circulation on a periodical or occasional basis. Studies of the material circulation role of fish-consuming export-importer waterbirds have been boosted by the damages caused by their fish consumption (Gere and Andrikovics 1994, Kerekes et al. 1994).

*Decomposition accelerating guild group*

This group contains mallards, *Anas platyrhynchos* (L.), common teals, *Anas crecca* (L.), pochards, *Aythya ferina* (L.), ferruginous ducks, *Aythya nyroca* (Güldenstädt), eurasian coots, *Fulica atra* (L.) and other waterbirds that mainly feed on the plant and animal food sources from the given habitat. Organic carbon, nitrogen and phosphorus nutrients consumed with the food organisms are directly returned to the water with the feces. Through this material circulation activity, they accelerate the recirculation of nutrients stored in the food organisms. Within this group, guilds can be differentiated by their different foraging modes, or more precisely the different food organisms the bird consume.

The benthos decomposition accelerating guild of the common merganser, *Mergus merganser* (L.), feeding on the benthos communities of shallow lakes is of outstanding significance, as they manage to mobilize the nutrients stored in invertebrates that live on lake-bottom. Considerable nutrient mobility is generated by the macrophyte decomposition accelerating guild of surface ducks grazing plants and the connected invertebrates, as well as the fish-consuming decomposition accelerating guild of grebes. Through their activities, they are able to recycle nutrients stored in macrophytes, invertebrates and fish for the entire season. In Hungarian waters, the plankton decomposition accelerating guild is represented by the avocet, *Recurvirostra avosetta* (L.), which typically feeds on planktonic organisms alongside with some *Anas* species.

*Bioturbing guild group*

In the metabolism of sludge sediments and shallow waters (tidal coasts, water reservoirs, fish ponds, alkaline lakes) over-saturated with nutrients, bioturbation by littoral birds can play an essential role. Similarly to the accelerating guild group, the fast metabolic processes of these waterbirds largely facilitate decomposition, in addition their mechanical activities also contribute to the course of breakdown. Feeding in shallow waters and sludge surfaces, they use their long beaks to find food in the sludge, and the deep prods considerably help to aerate the reduced and oxygen-deficient water-sludge interface. Apart from the anaerobic decomposition of the sludge, the bioturbing activities of these waterbirds import oxygen, which accelerates aerobic inorganic decomposition.

The decomposition of organic materials is also aided by the fast metabolism of the birds. Invertebrates found in the sludge are subjected to a rapid digestive process. Preliminary field measurements show that the defecation of the feeding littoral birds is quite frequent and fast, it hardly takes five minutes for the smaller species. The bioturbing activities of littoral birds have special significance in the vast sludge surfaces of extensive sandy beaches, on the sediments of water reservoirs that are left dry on a seasonal basis, in paddy fields, in the littoral zones of shallow lakes, as well as on the sediments of fish ponds that are under drainage and offer an abundance of nutritive organisms in the freshly dried regions. Considering the mode of nutrition, the bioturbing guild groups have prodding and progging bioturbing guilds.

*Classification of Hungarian waterbird species into the material circulation guilds*

According to the Wetland International Species List (Magyar et al. 1998), out of 380 birds species recorded in Hungary, 165 are waterbirds. Fifty of these species are rare migrant species, therefore the number of waterbird species with regular occurrence in Hungary amounts to approximately 115.

Irrespective of their status in Hungary, we tried to classify all waterbird species into functional guilds. When classifying the species, minor problems arose regarding the system of criteria having been selected and generated for this purpose. The following aims to give a detailed discussion of which species belongs to which guild on the basis of foraging mode. In the case of some species that are generally categorized as waterbirds, but whose life activities have slight or no connections to water, this classification may seem to be forced, however, they have also been grouped for the sake of completeness. Nevertheless, concerning material circulation, they play a rather insignificant role, e.g. turnstone, *Arenaria interpres* (L.), collared pratincole, *Glareola pratincola* (L.), Eurasian dotterel, *Eudromias morinellus* (L.), and buff-breasted sandpiper, *Tryngites subruficollis* (Vieillot).

*Nutrient dejection of grazing importer and collecting export-importer guilds*

The role of birds in the material transportation of various aquatic systems has just recently come to the fore of scientific studies (Reynaud and Thiolouse 2000). Reliable data based on detailed field studies and direct laboratory measurements to establish quantitatively the precise contribution to material circulation is still small. Yet, this study has made a simple effort to compile the available literature, and use its figures to estimate the role of geese, cranes, ducks and gulls in material circulation (Kear 1963; Gould and Fletcher 1978; Clark et al. 1986; Gere and Andrikovics 1992, 1994; Bishop and Myers 2005).

These studies of material circulation were done to assess the daily activity-budgets for given waterbirds (i.e. species present in the studied shallow water bodies), as well as to determine the frequency and quantity of defecation, and the nitrogen and phosphorus content of the feces. To determine nutrient import and nutrient loading by grazing geese, information on their daily activities was indispensable. The defecation frequency of waterbirds varies widely. To assess the part this process takes in the material circulation of water bodies, reliable information needed to be collected on the amount of time spent on the water and on the frequency of nocturnal defecation.

The feces of fish-consuming birds contain far more phosphorus than nitrogen. The amounts of daily nitrogen from defecation of the four goose species, greylag goose, *Anser anser* (L.), white-fronted goose, *A. albifrons* (Scopoli), lesser white-fronted goose, *A. erythropus* (L.), and bean goose, *A. fabalis* (Latham), are quite close to each other in the narrow range of 0.57 g to 1.57 g. Consequently, the nutrient loading by the geese on the shallow lake can be calculated reliably on the basis of the number of the individuals present on the shallow lake.

In spring, wild geese feed on the neighboring agricultural corn beds, while in autumn it is the maize and wheat fields that provide them with nutrients. Arriving in large masses, the birds use the shallow lakes as a drinking, roosting and nocturnal resting site, and at the same time they load it steadily with their feces.

Masses of birds concentrated in a small area in huge numbers offer an excellent opportunity to demonstrate the applicability of the material circulation guilds. Relying on the quantitative tables of the material circulation guilds that contain data both obtained in the course of the investigations and collected from literary sources (Portnay and Soukup 1990, Manny et al. 1994), nitrogen and phosphorus imported by the birds can be calculated.

This paper attempts to summarize the nutrient loading data of bird species with mass occurrence which belong to the grazing importer and collecting export-importer guilds, restricted to the two-year study of Kardoskút-Fehértó wetland. The aggregated annual nitrogen loading by the five bird species meeting the above criteria, such as the common crane, bean goose, white-fronted goose, black-headed gull, *L. ridibundus* (L.), and Caspian gull, *L. cachinnans* (Pallas), was observed to be the following: 2021 kg in 1998 and 2176 kg in 1999. Values of phosphorus for the same periods were 699 kg and 911 kg. Consequently, functional studies of the material circulation guilds require more than the guild indicator approach — quantitative assessments on the activities call for the application of all the guild concepts.

## Conclusion

Determining the influence of migratory birds on shallow waterbodies would be significantly facilitated by framing a waterbird material circulation guild concept, assessing the quantitative parameters of the most important guilds and aggregating them from literary sources, as well as demonstrating the applicability of the results obtained in Hungary.

Migrating waterbirds, ducks, geese, cranes and gulls can appear in such large numbers that they can considerably influence the material circulation and quality of water.

The material circulation activities of waterbirds, as well as part they take in the metabolism of wetlands are shaped by their foraging habits, defecation types, and mechanical activities. The related activities have been taken into account to set up 3 guild groups making up 9 guilds altogether. Material transporters manage to enhance or reduce the trophic state by importing or exporting nutrients to and from the system.

Members of the decomposition accelerating guild group use their digestion and respiration to hasten the breakdown of organic materials in the wetlands. As for the bioturbing guild group, material circulation is accelerated directly by their metabolism, and indirectly by their mechanical activities. The 165 waterbird species found in Hungary were all classified in the 9 material circulation guilds.

The applicability of the quantitative tables for nature conservation, and the material circulation activities performed by waterbirds in Hungarian shallow waters, was demonstrated by this case study in the Kardoskút-Fehértó wetland and in the Horváthpuszta Fish ponds in Szarvas.

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# A comparison between aquatic birds of lakes and coastal rivers in Florida

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## Abstract

Aquatic birds were counted on five Gulf coast Florida rivers to determine if these river systems supported densities, biomass and species richness similar to those found on Florida lakes. Forty-two species were identified and for the species that were found on both Florida streams and lakes similar densities, and biomass were encountered. As with Florida lakes, stream bird abundance and species richness were higher in winter months than in summer months, a consequence of migratory bird populations. Both total bird abundance and biomass per unit of phosphorus, and species richness per unit of area were also similar to data collected on Florida lakes. Thus, Florida rivers are capable of supplying sufficient resources to maintain bird densities, biomass and species richness values similar to lakes of equal size and nutrient concentrations and are therefore important habitats for aquatic bird populations. An examination of individual habitat characteristics indicates that water depth was inversely correlated and submersed aquatic vegetation was positively correlated with bird density, biomass and species richness within the river systems. While both habitat characteristics are important they are also inversely related making it difficult to separate the individual significance of each characteristic.

# Macroinvertebrate abundance, water chemistry, and wetland characteristics affect use of wetlands by avian species in Maine

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## Abstract

Our objective was to determine use by avian species (e.g., piscivores, marsh birds, waterfowl, selected passerines) of 29 wetlands in areas with low (<200 $\mu eq \cdot L^{-1}$) acid-neutralizing capacity (ANC) in southeastern Maine. We documented bird, pair, and brood use during 1982–1984 and in 1982 we sampled 10 wetlands with a sweep net to collect invertebrates. We related mean numbers of invertebrates per wetland to water chemistry, basin characteristics, and avian use of different wetland types. Shallow, beaver (*Castor canadensis*)-created wetlands with the highest phosphorus levels and abundant and varied macrophyte assemblages supported greater densities of macroinvertebrates and numbers of duck broods (88.3% of all broods) in contrast to deep, glacial type wetlands with sparse vegetation and lower invertebrate densities that supported fewer broods (11.7%). Low pH may have affected some acid-intolerant invertebrate taxa (i.e., Ephemeroptera), but high mean numbers of Insecta per wetland were recorded from wetlands with a pH of 5.51. Other Classes and Orders of invertebrates were more abundant on wetlands with pH >5.51. All years combined use of wetlands by broods was greater on wetlands with pH ≤ 5.51 (77.4%) in contrast to wetlands with pH > 5.51 that supported 21.8% of the broods. High mean brood density was associated with mean number of Insecta per wetland. For lentic wetlands created by beaver, those habitats contained vegetative structure and nutrients necessary to provide cover to support invertebrate populations that are prey of omnivore and insectivore species. The fishless status of a few wetlands may have affected use by some waterfowl species and obligate piscivores.

# Chemical limnology and waterbird community of an urban constructed wetland

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## Abstract

The Sackville Waterfowl Park is a 19-ha shallow freshwater wetland located in Sackville, New Brunswick, Canada. The wetland was created in 1988 by re-flooding land that had been previously drained for agriculture. The objective of this study was to determine the relationships between chemical limnology, primary productivity, macroinvertebrate abundance, and waterbird density in the wetland and to determine if these changed over time. Water samples indicated that this wetland had high levels of available nutrients, and chlorophyll-a concentration. Annual means did not decline during the study. Associated with high primary productivity was an abundance of macro-invertebrates. Minnow traps caught six different species of fish, with mean number caught per trap-day increasing from 10 to 27 during 1993–1996. The urban setting of the Park has not deterred wildlife from using it. Over 160 species of birds have been observed, of which 26 have been confirmed breeding. During 1991–96, there was an average of 50 broods of waterbird broods produced annually. This is one of the highest reported brood densities in Atlantic Canada. The 3.2 km of trails and boardwalks in the park afford nature-viewing and recreational opportunities for community residents and tourists alike. The Sackville Waterfowl Park has demonstrated that constructing wetlands in an urban environment can provide unsurpassed educational opportunities that will foster support for wetland conservation and can also create excellent wildlife habitat.

# SECTION IV

# TROPHIC DYNAMICS

# Shorebirds, snails, and the amphipod (*Corophium volutator)* in the upper Bay of Fundy: top-down vs. bottom-up factors, and the influence of compensatory interactions on mudflat ecology

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## Abstract

During their annual mid- to late-summer southward migration, Semipalmated Sandpipers (*Calidris pusilla*) feed intensively on the amphipod *Corophium volutator* on intertidal mudflats in the Bay of Fundy. *Corophium*, in turn, feed on diatoms and bacteria. Using a series of bird exclosures and fertilizer addition, we examined top-down and bottom-up effects, and investigated the presence of a trophic cascade in the mudflat community during the period when birds are abundant. Although both top-down and bottom-up forces were present in this system, neither transmitted beyond a single trophic link. Predation by shorebirds, which may be less size-selective than previously thought, reduced *Corophium* abundance in control plots by approximately 80% relative to exclosures, but most other species were unaffected. Shorebird predation did not result in an increase in diatom abundance, as predicted under the trophic cascade hypothesis. Fertilizer increased diatom abundance, but had no effect on *Corophium* abundance or bird predation, and little effect on other mudflat invertebrates. The only indirect effect observed was on mud snails (*Ilyanassa obsoleta*), which, by rapidly responding to changes in diatom abundance, compensated for both bird exclusion and fertilizer addition, and prevented the trophic cascade. This population response by snails, possibly stemming from competition with *Corophium*, probably contributed to the stability of the community. Our results provide an example of short-term compensation in a simple intertidal community, and highlight the importance of considering direct and indirect effects in community ecological studies. We conclude that while compensatory interactions that block trophic cascades may be more common in more complex ecosystems, they are not restricted to them.

# Trophic structure and avian communities across a salinity gradient in evaporation ponds of the San Francisco Bay estuary

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## Abstract

Commercial salt evaporation ponds comprise a large proportion of baylands adjacent to the San Francisco Bay, a highly urbanized estuary. In the past two centuries, more than 79% of the historic tidal wetlands in this estuary have been lost. Resource management agencies have acquired more than 10,000 ha of commercial salt ponds with plans to undertake one of the largest wetland restoration projects in North America. However, these plans have created debate about the ecological importance of salt ponds for migratory bird communities in western North America. Salt ponds are unique mesohaline (5–18 $g \cdot l^{-1}$) to hyperhaline (>40 $g \cdot l^{-1}$) wetlands, but little is known of their ecological structure or value. Thus, we studied decommissioned salt ponds in the North Bay of the San Francisco Bay estuary from January 1999 through November 2001. We measured water quality parameters (salinity, DO, pH, temperature), nutrient concentrations, primary productivity, zooplankton, macroinvertebrates, fish, and birds across a range of salinities from 24 $g \cdot l^{-1}$ to 264 $g \cdot l^{-1}$. Our studies documented how unique limnological characteristics of salt ponds were related to nutrient levels, primary productivity rates, invertebrate biomass and taxa richness, prey fish, and avian predator numbers. Salt ponds were shown to have unique trophic and physical attributes that supported large numbers of migratory birds. Therefore, managers should carefully weigh the benefits of increasing habitat for native tidal marsh species with the costs of losing these unique hypersaline systems.

# Spatial and temporal fluctuations in presence and use of chironomid prey by shorebirds in the Odiel saltpans, south-west Spain

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## Abstract

We studied the seasonal variation in abundance and distribution of shorebirds and chironomid *Chironomus salinarius* larvae in both traditional and industrial salines in the Odiel marshes, south-west Spain, in 2001. We selected 12 ponds that were representative of the different phases of the salt production process. The benthic chironomids were sampled in each pond every two months, and the birds were counted weekly. Chironomid larvae were most abundant in spring and autumn, and in the ponds of lower salinity. The density of larvae averaged 7023 ± 392 $m^{-2}$ (± s.e) over the six sampling events. Shorebirds were always more abundant at high tide than at low tide, and were especially abundant during the spring and autumn migration periods when up to 20,775 birds were counted. A total of 24 species were recorded, six of which were present in internationally important numbers. The salines were especially important as foraging and roosting habitat during migration. The percentage of birds that were feeding in the ponds was positively correlated with the abundance of chironomid larvae at accessible depths. The number of feeding birds was also higher in ponds with more chironomid larvae available. Despite more intensive management, industrial salines held higher densities of birds and a similar abundance of chironomids when compared with traditional salines.

# Eutrophication, sewage diversion and biomanipulation: piscivorous birds in the changing foodweb of a large temperate lake

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## Abstract

The numbers and biomass of aquatic birds were monitored in the Enonselkä basin (2600 ha) of Lake Vesijärvi in South Finland I) after maximal eutrophication caused by excessive nutrient loading in 1977–78, II) after sewage diversion during a prolonged period of internal nutrient loading and blooms of cyanobacteria in 1987–89 and III) during successful restoration by large scale fish removal (63–102 $kg \cdot ha^{-1} \cdot y^{-1}$) in the 1990's. The piscivorous Great Crested Grebe (*Podiceps cristatus*) was the dominant species. The biomass of its breeding population (up to 0.55 $kg \cdot ha^{-1}$) was higher than the combined biomass of dabbling and diving ducks (0.26 $kg \cdot ha^{-1}$). The fish consumption by birds was c. 34 $kg \cdot ha^{-1}$ in the 1970's, 25 $kg \cdot ha^{-1}$ in the 1980´s and 12 $kg \cdot ha^{-1}$ after biomanipulation. These amounts were less than 10% of the estimated fish biomass. The numbers of migrating piscivorous birds (grebes, terns and gulls) were more radically reduced by biomanipulation than those of breeding grebes. Changes in the numbers and food consumption of piscivorous birds vs. total phosphorus, chlorophyll *a*, turbidity and fish removal suggested that the high initial density of piscivorous birds was a bottom-up indication of high fish density and a foodchain with functionally three levels i.e. a marginal impact of the piscivorous fish.

# Changes in composition of aquatic birds and limnology in the ATTZ — Aquatic Terrestrial Transition Zone — of the Pantanal wetland, Brazil

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## Abstract

The Pantanal Mato-Grossense wetland, in Brazil, represents the largest floodplain in the world, incorporating a mosaic of different habitats, and sustaining a rich aquatic and terrestrial biota. The habitat mosaics are well represented by the Chacororé and Sinhá Mariana lake System. These parental lakes of the Cuiabá River, a tributary of the Upper Paraguay River, are known for their aquatic productivity and scenic beauty. The characteristics of these lakes and their floodplains are shown through the difference between their waters, the diversity of the aquatic macrophytes communities, fish communities and aquatic birds. Our study looked at changes in limnological variables as well as diversity of aquatic birds, during the high water or flooded phase, the medium water or receding phase, and the low water or dry phase. We used a temporary small lagoon in the floodplain of this system as our study area. The flood pulse is the main ecological factor affecting the Pantanal; it modifies ecological process and species composition. The water depth decreases during the dry season, decreasing secchi depth, and nitrate, dissolved oxygen and biomass of aquatic macrophytes; and increasing, conductivity, turbidity, total phosphorus and total nitrogen, we also observed increase in species richness and abundance of aquatic birds during the receding phase, results show that the number of species (density) of aquatic birds increased from 10 to 30 species and the numbers of individuals from 40 to 936. The maximum richness and abundance of aquatic birds was registered during the receding phase.

## Introduction

The Pantanal Mato-Grossense wetland, Brazil, represents the largest floodplain in the world. It includes a mosaic of different habitats, which sustains a rich aquatic and terrestrial biota. It consists of different water bodies that have their origins and connections in the main river channel of the Upper Paraguai River and its tributaries. The landscape units of the Pantanal region are well represented by the Chacororé and Sinhá Mariana lake system. These parental lakes of the Cuiaba River, a tributary of the Upper Paraguay River, are well known for their aquatic productivity and scenic beauty. The water characteristics of these lakes and their floodplains are demonstrated through the difference in their waters, the diversity of aquatic macrophyte communities, fish communities and aquatic birds (Pinto et al. 1999, Da Silva and Figueiredo 1999, Nunes 2003).

The Pantanal is the richest region of the continent in wading birds (Sick 1997). Studies estimate 730 regional species, including migrants, accidental visits and introduced species, with 500 species in the Pantanal region alone (Da Silva et al. 2001). Of the 500 species, about 80 are aquatic (Cintra and Yamashita 1990).

The objective of this study was to examine the effect of flood stage limnological variables as well as aquatic bird species composition, density and diversity in the Aquatic Terrestrial Transition Zone (hereafter ATTZ) of this lake system (Junk et al. 1989).

## Methodology

A census was done during each hydrological period in order to obtain the number of the aquatic birds. During the high and receding phase, the census was conducted by boat around the lake during the early morning and in the afternoon. In the dry phase, observers walk around the dry lakes. All species observations around the edge of the lake were confirmed with binoculars (7×50mm), and transects were defined with a GPS. The systematic ordination of the transects was done according to Sick (1997), and the English names of the species were identified with Souza (2002).

Equipment used for the physico-chemical analyses of the water in the ATTZ included: pH meter 320 SET/WTW, Oximeter 196 WTW, conductimeter, 196 WTW, Mercury Bulb Thermometer, Termistor of the oximeter 196 WTW, rope with weight and band measure, Secchi disk, Turbidimeter 2100 – HACH.

Particulate nitrogen was analyzed using methodology from Anderson and Ingram (1996). Ammonium ion, nitrate, total phosphorus and the orthophosphate were analyzed using methods from Golterman et al. (1978), Mackereth et al. (1978), and Carmouze (1994).

## Study area

The Chacorore-Sinhá Mariana lake system is located between the South latitudes 16º14' and 16º16' and West longitudes 55º57' and 55º58', in the basin of the Cuiaba river in the municipality of Santo Antonio de Leverger and Barão de Melgaço, Mato Grosso state, on the left side of the Cuiaba river. This lake system connects with the Cuiabá river, through a complex net of channels locally called “corixos”. Chacororé lake is characterized by a low nutrient amount, conductivity, turbidity and low water transparency, while Sinhá Mariana lake is characterized by black water, low nutrient concentrations, conductivity, turbidity

and very high water transparency (Da Silva and Figueiredo 1999, Nunes and Da Silva, in prep.) (Figure 1). The period of high water occurs between January and March and the receding phase between April and June. During high water, water accumulates in the ATTZ forming a small lake in a base that we call the "Lake of Dreams".

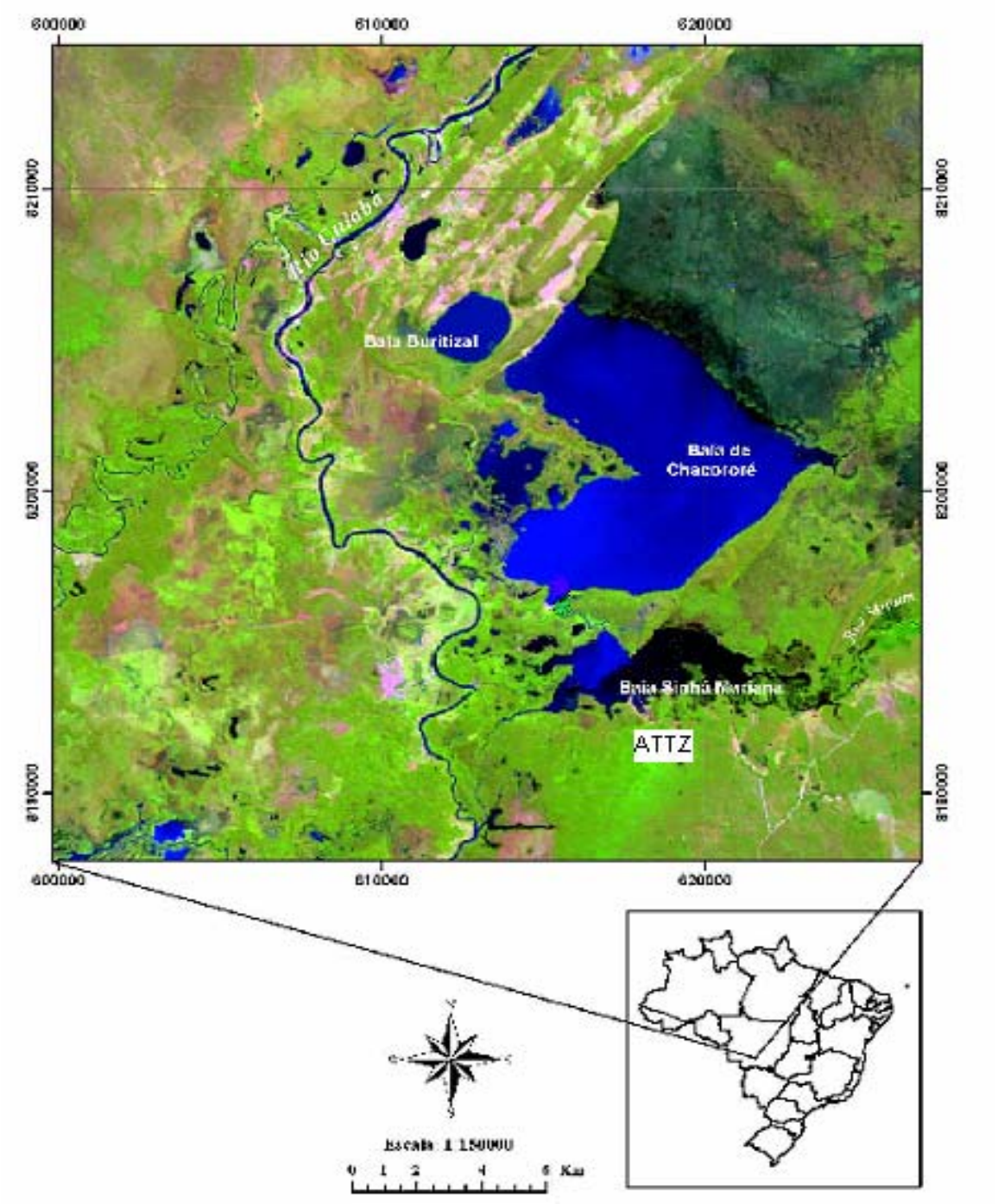


*Figure 1*. The study area location (ATTZ) in the Chacororé-Sinhá Mariana lake system, Pantanal Mato-grossense, Barão de Melgaço, Mato Grosso state, Brazil (July 2001).

## Results and discussion

The limnology of the ATTZ depends on the connectivity with the lakes or rivers, the geological composition, the rate of decomposition of aquatic macrophytes, and the growth rate of terrestrial herbaceous plants, respectively, during flooding and drying periods. The lateral connectivity into the "Lake of Dreams" comes from the Sinhá Mariana, through a decreasing elevation. The difference in water levels, between the low and high water periods, was 3 meters. Water transparency followed the same pattern as the water level, increasing when the water level rose, and decreasing as the water receded (Figure 2). Studies made in this system of lakes, as well as in a different system, show similar patterns (Da Silva and Esteves 1995, Pinto et al. 1999, Da Silva and Figueiredo 1999, Abdo 1999, Abdo and Da Silva 2004).

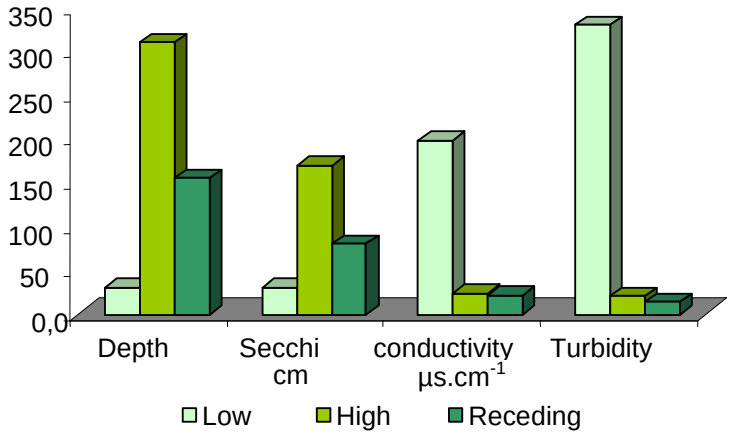


*Figure 2*. Values of water depth (cm), Secchi depth (cm), conductivity (µs), and turbidity (NTU) in the ATTZ during the low water of 2001, and high water and receding water of 2003, in the Chacororé-Sinhá Mariana Lake system.

Conductivity (198.6 $\mu s \cdot cm^{-1}$) and turbidity (1650 NTU) were much higher at low water, showing a high amount of nutrients and suspended materials in the water at this time (Figure 2). This result is contrary to results obtained for Acurizal e Porto de For a lakes (Da Silva and Esteves 1995); and Sinhá Mariana lakes in chacororé (Da Silva and Figueiredo 1999, Nunes 2003), where conductivity was higher during low water, when the population densities of aquatic birds like nursery birds (Abdo and Da Silva 2004), and animals like caimans, is larger (Nogueira et al. 2002). Our results indicate that the conductivity and turbidity patterns in the Pantanal are related to the flood pulse. This indicates that there is a positive relationship between conductivity and the flood pulse when the system is controlled by geological factors, and a negative relationship with the flood pulse when the system is controlled by animals.

The air temperature was higher in the receding period (April, 30˚C), and lower in the low water period (August, 22.5˚C), similar to the observation made by Da Silva and

Figueiredo (1999). Nunes (2003) found that the oxygen concentrations were greater during high water period (100%) when compared to the low water period (55%) (all measurements were made in the early morning). pH varied with flood stage, which is similar to what Da Silva and Figueiredo (1999) and Nunes (2003), observed when studying this area (Figure 3).

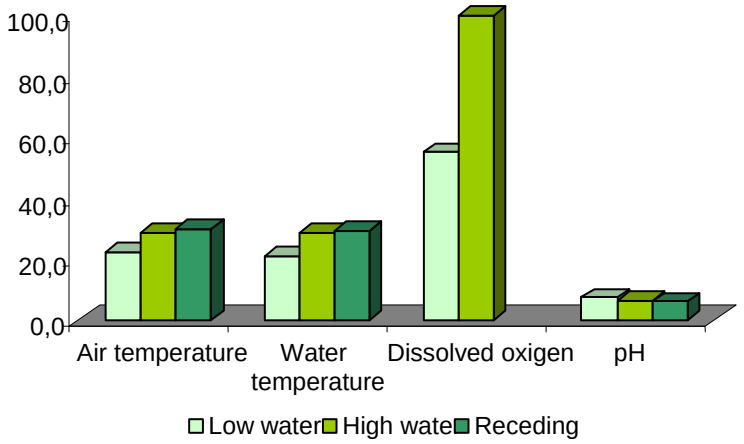


*Figure 3*. Values of air and water temperature (˚C), dissolved oxygen (%), and pH in the ATTZ during the low water of 2001, and high water and receding water of 2003, in the Chacororé-Sinhá Mariana Lake system.

Total phosphorus was 0.703 $mg \cdot L^{-1}$ during low water and 0.358 $mg \cdot L^{-1}$ during high water (Figure 4). Dissolved phosphorus did not show any variation throughout hydrological cycles. The highest value was 0.094 $mg \cdot L^{-1}$ during high water and 0.073 $mg \cdot L^{-1}$ during low water (Figure 4). Total nitrogen was 1.171 $mg \cdot L^{-1}$ during low water and 0.668 $mg \cdot L^{-1}$ during high water. Ammonium was 0.698 $mg \cdot L^{-1}$ during low water and 0.323 $mg \cdot L^{-1}$during high water. Nitrate values were 0.164 $mg \cdot L^{-1}$ during low water and 0.284$mg \cdot L^{-1}$ during high water (Figure 4). These values were higher for the same system investigating by Nunes (2003).

Tables 1 and 2 show the type and number of bird species observed in the Lake of Dreams during the flood stages. The largest number of species (30) were observed during the periods of receding water. The smallest number of species (10) were observed during high water. The numbers of individuals was also higher in the receding phase; the most abundant species were *Phaetusa simplex* (JF Gmelin) (225 individuals), *Sterna superciliaris* (Vieillot) (211 individuals) and *Rynchops niger* (L.) (162 individuals). This occurs because the lake is isolated in the receding phase, and the fish and mollusks are captive, becoming an easily accessible food source for birds. The high water period had the smallest number of individuals. *Phalacrocorax brasilianus* (JF Gmelin), *Ardea cocoi* (L.), *Casmerodius albus* (L.), *Egretta thula* (Molina), *Sterna superciliaris*, and *Ceryle torquata* (L.) occurred in all periods of observation. However, the number of individuals varies during the flood stage. In the flood phase, only species which dive for fish can remain in the area, for example *P. brasilianus.* The highest numbers of birds were observed along the shoreline of the lake, most likely because these areas are shallow enough to allow the

aquatic birds to walk and look for food. The same pattern was observed by Hoyer and Canfield (1994), and Hoyer and Canfield (1990).

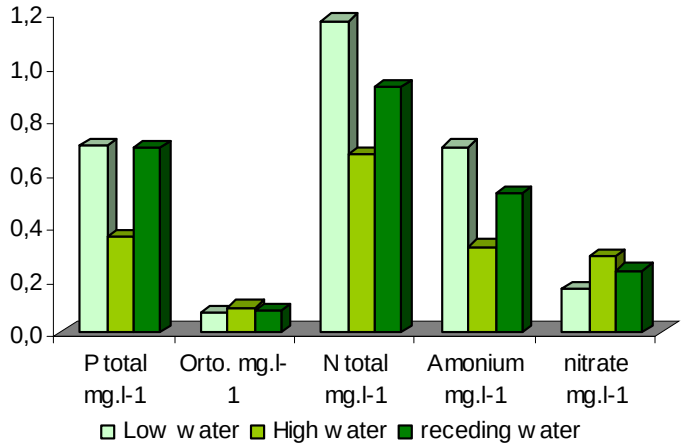


*Figure 4*. Values of dissolved phosphorus (Orthophosphate, $mg \cdot L^{-1}$), ion ammonium ($mg \cdot L^{-1}$), nitrate ($mg \cdot L^{-1}$), total nitrogen ($mg \cdot L^{-1}$), and total phosphorus ($mg \cdot L^{-1}$) in the ATTZ during the low water of 2001, and high water and receding water of 2003, in the Chacororé-Sinhá Mariana Lake System.

Shannon diversity was higher during the receding water phase and lower during the high water phase. During the receding phase, the number of individuals was four times higher than during the low water period, and 23 times higher than during the high water period. Receding and low water periods decrease the water volume and increase the concentration of fish populations, improving foraging conditions for aquatic birds. The limnological conditions associated with dissolved oxygen, water temperature, and transparency, favor the survival of a great concentration of fish, which serve as basic food for aquatic birds.

Erwin (1996) showed that small waterbodies with depths of 1m or less attract large densities of aquatic birds, mainly herons, which prefer foraging in shallow depths and areas without vegetation or grasses along the border. *E. thula* feeds in areas without or with very little river-side vegetation, and was rarely found in groups, with the exception of areas with big concentrations of fish. *A. cocoi* feeds in the same waterbodies that *C. albus* prefers, i.e. also in shallow water without vegetation (Morales et al. 1981, Willard 1988).

Many bird species are visual foragers, making transparency and depth important determinants of foraging areas. According to Whingham and Young (2001), many aquatic bird species use depth and water level variation as parameters to delimitate the foraging area and/or breeding area.

Willard (1988), showed that piscivorous species can be divided into classes based on foraging behavior: 1 — *swimming* – *Anhinga anhinga* (L.), and *P. brasilianus* look for prey under water, demanding a high depth and transparency; 2 — *wading* – such as *Tigrisoma* (Swainson) spp., *Ardea* spp., *Egretta* spp., *Casmerodius* spp., *Butorides* (Blyth) spp., which use habitats without vegetation and low depth, 3 — *wait perch* – kingfishers (*Ceryle* spp.), which wait on a branch and then dive to capture identified prey, making

availability of perches important, and 4 — *cruising* – common behavior to *Pandion haliaetus* (L.), which conducts aerial/visual hunts and therefore needs habitat with high transparency and low turbidity. Kushlan et al. (1988) showed that the differences in the length of foraging and the behavior linked to foraging of species hunting in the same place worked so that Ardeidae and Alcedinidae avoided direct competition.

The maintenance of this kind of habitat favors the life strategies of many aquatic birds, which depend on the quality of habitats defined by limnological variables, mainly depth, transparency, turbidity and dissolved oxygen.

*Table 1*. Number of the bird species observed in the ATTZ.

| Species | Portuguese name | English name | Receding | Low water | High water |
|---|---|---|---|---|---|
| **PELECANIFORMES** | | | | | |
| **Phalacrocoracidae** | | | | | |
| *Phalacrocorax brasilianus* (JF Gmelin) | biguá | olivaceous cormorant | 28 | 13 | 30 |
| **Anhingidae** | | | | | |
| *Anhinga anhinga* (L.) | biguatinga | anhinga | 9 | | 4 |
| **CICONIIFORMES** | | | | | |
| **Ardeidae** | | | | | |
| *Ardea cocoi* (L.) | garça-maguari | white-necked heron | 2 | 3 | 3 |
| *Casmerodius albus* (L.) | garça-branca-grande | great egret | 41 | 1 | 2 |
| *Egretta thula* (Molina) | garça-branca-pequena | snowy egret | 34 | 2 | 2 |
| *Butorides striatus* (L.) | socozinho | striated heron | 13 | | |
| *Botaurus pinnatus* (Wagler) | socó-boi-baio | | 2 | | |
| *Nycticorax nycticorax* (L.) | aquá (garça-dorminhoca) | black-crowned night-heron | 5 | | |
| **Threskiornithidae** | | | | | |
| *Phimosus infuscatus* (Lichtenstein) | tapicuru-frango-d'água | bare-faced ibis | 8 | | |
| *Theristicus caudatus* (Boddaert) | curicaca | buff-necked ibis | 5 | 9 | |
| *Platalea ajaja* (L.) | colhereiro | roseate spoonbill | 33 | 9 | |
| *Mesembrinibis cayennensis* (JF Gmelin) | frango d'água | green ibis | | 3 | |
| **Ciconiidae** | | | | | |
| *Mycteria americana* (L.) | cabeça-seca | | 6 | 1 | |
| *Jabiru mycteria* (Lichtenstein) | tuiuiú | | 2 | 1 | |
| **ANSERIFORMES** | | | | | |
| **Anatidae** | | | | | |
| *Dendrocygna autumnalis* (L.) | marreca-peba | black-bellied whistling duck | 16 | | |
| *Dendrocygna viduata* (L.) | irerê | white-faced whistling duck | 12 | 12 | |

*Table 1*. (continued)

| Species | Portuguese name | English name | Receding | Low water | High water |
|---|---|---|---|---|---|
| **Anatidae** | | | | | |
| *Dendrocygna bicolor* (Vieillot) | | fulvous whistling duck | 21 | | |
| *Cairina moschata* (L.) | pato-do-mato | muscovy duck | 15 | | 2 |
| *Amazonetta brasiliensis* (JF Gmelin) | sinhazinha | Brazilian duck | | 82 | |
| **Anhimidae** | | | | | |
| *Chauna torquata* (Oken) | inhuma, tacha | southern screamer | 2 | | |
| **FALCONIFORMES** | | | | | |
| **Accipitridae** | | | | | |
| *Rostrhamus sociabilis* (Vieillot) | caramujeiro | snail kite | 2 | | 2 |
| *Busarellus nigricollis* (Latham) | gavião-belo | black-collared hawk | | | 3 |
| **GRUIFORMES** | | | | | |
| **Aramidae** | | | | | |
| *Aramus guarauna* (L.) | carão | limpkin | 1 | | |
| **Rallidae** | | | | | |
| *Aramides cajanea* (Muller) | saracura | grey-necked wood-rail | | 2 | |
| **CHARADRIIFORMES** | | | | | |
| **Jacanidae** | | | | | |
| *Jacana jacana* (L.) | cafezinho | wattled jaçanã | 11 | | |
| **Charadriidae** | | | | | |
| *Vanellus chilensis* (Molina) | quero-quero | pied plover | 1 | 26 | |
| *Charadrius collaris* (Vieillot) | batuira-de-coleira | collared plover | 20 | 2 | |
| **Recurvirostridae** | | | | | |
| *Himantopus himantopus* (L.) | maçarico, perna-longa | common stilt | 14 | 2 | |

*Table 1*. (continued)

| Species | Portuguese name | English name | Receding | Low water | High water |
|---|---|---|---|---|---|
| **Laridae** | | | | | |
| *Sterna superciliaris* (Vieillot) | trinta-réis-anão | yellow-billed tern | 211 | 35 | 40 |
| *Phaetusa simplex* (JF Gmelin) | trinta-réis-grande | large-billed tern | 255 | 12 | |
| **Rynchopidae** | | | | | |
| *Rynchops niger* (L.) | trinta-réis-preto, talhamar | black skimmer | 162 | 2 | |
| **CORACIIFORMES** | | | | | |
| **Alcedinidae** | | | | | |
| *Ceryle torquata* (L.) | martim-pescador-grande | ringed kingfisher | 1 | 1 | 2 |
| *Chloroceryle amazona* (Latham) | martim-pescador-verde | amazona kingfisher | 1 | | |
| *Chloroceryle americana* (JF Gmelin) | martim-pescador-pequeno | green kingfisher | 3 | | |
| **Passeriformes** | | | | | |
| **Troglodytidae** | | | | | |
| *Donacobius atricapillus* (L.) | capivareiro | black-capped mockingthrush | | 2 | |

*Table 2*. Number of individuals, species and Shannon diversity observed in the receding, low and high water period.

| | Receding | Low Water | High Water |
|---|---|---|---|
| Number of individuals | 936 | 220 | 40 |
| Number of species | 30 | 20 | 10 |
| Shannon Diversity | 2.29 | 2.11 | 1.51 |

## Conclusions

Our study shows that the flood stage affects limnological conditions, concentration, number of species, and abundance of aquatic birds in the ATTZ of the Chacororé-Sinhá Mariana lake system. During shallow water (low and receding water periods), diversity and abundance of birds are high. Changes in the flood pulse that would favor extremes such as permanence water or complete dryness may affect these variables and diminish the ecological and ecotouristic value of the system.

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# Mallard waste production and effects on water quality in small water bodies

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## Abstract

Field observations indicated that migrating Mallards may total several hundreds of thousands in the Carpathian Basin. The number of wetlands and other aquatic habitats has decreased drastically in the Carpathian Basin. It is therefore conceivable that large populations of wintering and migrating Mallards may cause eutrophication in small water bodies. Waste matter output of six fledgling and six adult Mallards was studied in order to determine Mallard waste production and chemical composition and to better understand potential impacts of Mallards on water quality. The nitrogen and phosphorus contents of the excrement of adult birds were not significantly different than that of juvenile birds.

## Introduction

Because of their high population density and active metabolism, waterfowl can play an important role in organic matter cycling in freshwater systems. Therefore, the study of their waste production and composition is very important to understanding nutrient dynamics. In addition to determining the amount of waste production and assimilation efficiency, the different diets of waterfowl guilds are reflected in the composition of their excrement. The nitrogen content of the feces produced by piscivorous cormorants, *Phalacrocorax carbo sinensis* (L.), was approximately eight times the value observed for the herbivorous greylag goose, *Anser anser* (L.). The nitrogen content of feces from omnivorous ducks is intermediate. Consequently, it is important to study the feeding habits of various groups of waterfowl when attempting to determine their effect on water quality. Several studies have focused on cormorants, which take a significant amount of organic matter out of the water in the form of fish (Gere and Andrikovics 1991a, b; 1992a, b). Greylag geese, characterized by herbivorous feeding, have also been investigated (Juhász et al. 1998). Studies of omnivorous wild ducks (Gere and Andrikovics 1994) have shown that their effect on water quality seems to be more complex than that of greylag geese and

cormorants.

## Methods

*Feeding experiments with juvenile Mallards*

Thirty– to thirty-five–days-old Mallard (*Anas platyrhynchos*) nestlings (n=6) were used in the feeding experiments. The animals, which were previously habituated to closed spaces, were individually kept in 1.5 × 1.5-m cages. The bottom of the cages was made of plastic grids, and a removable tray was put beneath the grid in order to collect the birds' feces. The animals were supplied with a measured amount of food every day, and the remaining food was measured after 24 hours. Thus, food consumption could be calculated. The amount of excrement produced and the changes in the animals' weight were also measured. In the first phase, a food blend was used, which, according to observations, best satisfies the nutritional demands of Mallards. The blend contained 16.5% crude protein, 3% fat and 5.5% plant fiber. The second group of birds were fed with cob-meal, while in the third group, they were given a mixture of corn, grass, insect larvae and snails. The weight was measured as dry weight, except for grass, which was measured as fresh wet weight. The water content of grass was determined in a control sample and a given amount of the food was converted into dry weight. Water content of the animals was considered to be 74% based on Austin (1976).

*Feeding experiments with adult Mallards*

The experiments were performed with adult Mallards (n=6) hatched in May 1998. The animals were kept under semi-wild circumstances, in a section of a garden covered with foil. The dimensions of the garden section were 5 × 6 m. The animals subject to study were divided into two groups. Each group was made up of 3 animals. The feeding study methods were the same as for juvenile Mallards.

*Chemical analysis*

The nitrogen content of the samples was determined via the Kjeldahl method, and the phosphorus content was determined with the photometrical method (see Gere et al., *this volume*). The method was modified in the following way: a mixture of nitric acid and hydrogen peroxide was used to achieve lower carbonization. During atmospheric sulphuric acid dissolution, a considerable amount of active carbon is produced, which, due to its high adsorption ability, adsorbs materials to be measured, causing a high possibility of errors.

## Results

*Field monitoring*

The following data were obtained from bird counts at Kis-Balaton Lake. We estimated 500–650 nesting pairs. The number of animals in winter migration and roosting sites varied between 2500 and 10,300 between October 1997 and April 1998. According to observations, juvenile wild ducks feed on the water, but rest and defecate on the shore; hence, these animals take a significant amount of materials from the water to the shore. Accordingly, in this case, eutrophication is decreased by these birds. In most cases, adult birds tend to feed on the shore, and release a significant part of their feces into the water, thereby enhancing eutrophication. Accordingly, the effect on water quality by ducks is rather complex.

*Laboratory experiments with juvenile Mallards*

The data pertaining to food consumption and the quantity of feces produced are summarized in Table 1. In all cases, the data refer to values relating to a single animal on a given day. The special blend prepared for Mallards was the most optimal nutrition for these animals since the excretion rate was the lowest. This value varied between 18.26% and 27.72% (Table 1). The phosphorus content of juvenile Mallard feces ranged from 0.58 to 1.03 mg/kg (Table 2).

*Laboratory experiments with adult Mallards*

The average weight of animals remained the same during the investigations (values between 1.20 kg and 1.50 kg), hence there was no weight gain in the case of adult birds. Nearly all food consumed was devoted to the production of energy required for the maintenance of vital processes (Table 3). The nitrogen content of adult bird excrement averaged 3.54% on a dry-weight basis while phosphorus averaged 0.94 mg/kg (Table 4).

## Discussion

The nitrogen content of the feces of omnivorous Mallards observed in this study ranged from 2.44–4.21%, which intermediate to that of piscivorous cormorants (13–16%, Gere and Andrikovics 1991a) and herbivorous greylag geese (2.2%, Juhász et al. 1998). The difference in diet of the birds is reflected in the different nitrogen content of their feces. It is noteworthy that considerably less phosphorus (under 0.01%) was contained in the feces of Mallards compared to the feces of cormorants or greylag geese. The phosphorus content of excrement produced by cormorants varied between 4.5 and 5.5% (Gere and Andrikovics 1991a), while 0.43% was measured for greylag geese (Juhász et al. 1998). The dry mass of daily defecation of one Mallard has been reported to be 12.2 g by Marion et al. (1994) and 16.7 g by Gere and Andrikovics (1994). The nitrogen and phosphorus content of feces has been reported at 2.62% and 1.32% (Marion et al. 1994), consistent with the results reported herein.

*Table 1.* Food consumption, weight change, excretion, production efficiency, and

excretion rate of 30–35-day old Mallard nestlings during a 24-hr period. Results are for individual nestlings. *C* = dry weight mass of consumption, *P* = production (increase in dry weight), *E* = excretion (feces + urine), *P*×100/*C* = production efficiency (change in mass in relation to food consumption), *E*×100/*C* = excretion rate (excretion in relation to food consumption).

| Group | Date (1998) | Food Type | *C* (g) | Change in Mass (g) | | *E* (g) | *P*×100/*C* | *E*×100/*C* |
|---|---|---|---|---|---|---|---|---|
| | | | | Wet | Dry (*P*) | | | |
| A | 06.06 | Blend | 117.9 | 38.66 | 10.05 | 32.22 | 8.58 | 27.32 |
| | 06.07 | Blend | 89.44 | 25.33 | 6.58 | 16.34 | 7.35 | 18.26 |
| | 06.10 | Corn | 63 | -12.66 | -3.29 | 6.4 | -5.22 | 10.15 |
| | 06.11 | Corn | 69.03 | 2.61 | 0.67 | 28.06 | 0.97 | 40.64 |
| | 06.15 | Mixed* | 38.58 | 12 | 3.12 | 10.72 | 8.08 | 27.78 |
| | 06.16 | Mixed* | 41.72 | 13.2 | 3.43 | 17.85 | 8.22 | 42.78 |
| | 06.22 | Blend | 36.66 | 14 | 3.64 | 9.11 | 9.92 | 24.84 |
| | 06.23 | Blend | 43.86 | 14.92 | 3.87 | 10.65 | 8.82 | 24.28 |
| | 07.31 | Mixed* | 46.98 | 14 | 3.64 | 10.42 | 7.74 | 22.17 |
| | 08.01 | Mixed* | 54.21 | 17.3 | 4.49 | 20.05 | 8.28 | 36.98 |
| B | 06.06 | Blend | 70.52 | 25.30 | 6.57 | 13.85 | 9.31 | 19.63 |
| | 06.07 | Blend | 22.52 | 10.66 | 2.77 | 6.07 | 10.30 | 23.65 |
| | 06.10 | Corn | 49.60 | -4.00 | -1.04 | 9.81 | -0.02 | 10.77 |
| | 06.11 | Corn | 57.80 | 13.70 | 3.56 | 30.01 | 6.15 | 51.92 |
| | 06.15 | Mixed* | 44.59 | 20.00 | 5.20 | 13.27 | 11.66 | 29.76 |
| | 06.16 | Mixed* | 59.16 | 21.30 | 5.53 | 18.09 | 9.34 | 30.57 |
| | 06.22 | Blend | 110.61 | 26.00 | 6.76 | 27.01 | 6.11 | 20.99 |
| | 06.23 | Blend | 91.08 | 19.00 | 4.94 | 23.00 | 5.42 | 25.25 |
| | 07.31 | Mixed* | 58.91 | 10.66 | 2.77 | 22.03 | 4.70 | 37.39 |
| | 08.01 | Mixed* | 67.38 | 14.70 | 3.82 | 30.11 | 5.66 | 44.68 |

*Food ingredients: corn, grass, insect larva, snails.

*Table 2*. Nitrogen and phosphorus content of nestling Mallard feces. N: nitrogen content; $PO^{3-}_4$: phosphate content; P: phosphorus content.

| Date (1998) | Food type | N (%) | Defecation (mg/kg) | |
|---|---|---|---|---|
| | | | $PO^{3-}_4$ | P |
| 06.06 | Special Blend | 3.43 | 2.52 | 0.82 |
| 06.07 | Special Blend | 3.40 | 2.92 | 0.95 |
| 06.10 | Corn | 3.37 | 2.70 | 0.88 |
| 06.15 | Mixed* | 2.44 | 3.16 | 1.03 |
| 06.22 | Special Blend | 3.84 | 2.60 | 0.84 |
| 07.31 | Mixed* | 4.21 | 1.80 | 0.58 |

*Food ingredients: corn, grass, insect larva and snails.

*Table 3*. Food consumption and defecation of adult Mallards.

*C* = dry weight mass of consumption, *E* = excretion (feces + urine), *E*×100/*C* = excretion rate (excretion in relation to food consumption).

| Group | Date (1999) | Food type | *C* (g) | *E* (g) | *E*×100/*C* |
|---|---|---|---|---|---|
| A | 05.05 | Special Blend | 103.25 | 35.36 | 34.25 |
| | 05.06 | Special Blend | 102.41 | 36.92 | 36.05 |
| | 06.01 | Corn | 98.36 | 31.73 | 32.26 |
| | 06.02 | Corn | 97.25 | 32.09 | 33.00 |
| | 06.10 | Mixed* | 100.21 | 30.07 | 30.00 |
| | 06.11 | Mixed* | 102.38 | 31.99 | 31.25 |
| | 07.08 | Special Blend | 119.75 | 40.09 | 33.48 |
| | 07.09 | Special Blend | 110.00 | 38.57 | 35.06 |
| | 08.04 | Mixed* | 107.98 | 39.62 | 36.70 |
| | 08.05 | Mixed* | 116.53 | 42.89 | 36.81 |
| B | 05.05 | Special Blend | 105.30 | 37.21 | 35.33 |
| | 05.06 | Special Blend | 110.71 | 41.27 | 37.27 |
| | 06.01 | Corn | 110.08 | 30.22 | 30.20 |
| | 06.02 | Corn | 96.07 | 32.83 | 34.17 |
| | 06.10 | Mixed* | 106.69 | 38.63 | 36.21 |
| | 06.11 | Mixed* | 101.67 | 33.74 | 33.19 |
| | 07.08 | Special Blend | 117.31 | 44.17 | 37.65 |
| | 07.09 | Special Blend | 120.18 | 42.38 | 35.26 |
| | 08.04 | Mixed* | 103.29 | 38.33 | 37.11 |
| | 08.05 | Mixed* | 111.47 | 40.17 | 36.04 |

*Food ingredients: corn, grass, insect larva and snails.

*Table 4*. Nitrogen and phosphorus content of adult Mallard feces. N = nitrogen content, P = phosphorus content.

| Date (1999) | Food type | Defecation | |
|---|---|---|---|
| | | N (%) | P (mg/kg) |
| 05.05 | Blend | 4.01 | 0.88 |
| 05.06 | Blend | 3.93 | 0.97 |
| 06.01 | Corn | 3.41 | 0.79 |
| 06.10 | Mixed* | 2.99 | 1.12 |
| 07.08 | Blend | 3.93 | 0.87 |
| 08.04 | Mixed* | 3.01 | 1.02 |
| Average: | | 3.54 | 0.94 |
| Min: | | 3.01 | 0.79 |
| Max: | | 4.01 | 1.12 |
| Coefficient of variation: | | 0.474 | 0.118 |

*Food ingredients: corn, grass, insect larva and snails.

The number of Mallards in Hungarian monitoring territories varies between 23,612

and 100,763 (Faragó 1997). This species is the most abundant nesting duck. The nesting population in the Eastern Europe, Mediterranean territory and Black Sea consists of about 2,250,000 individuals. Consequently, the total Mallard population in Eastern Europe could produce 12,150 tons of feces containing 318 tons of nitrogen and 196 tons of phosphorus. In February, up to 10,000 Mallards can often be found around fishponds. Together, they produce 3.4 tons of feces per month. This means that about 89 kg of nitrogen and 44.8 kg of phosphorus are released. The territory of wetlands and other aquatic habitats in the Carpathian Basin have decreased drastically; therefore, the large stocks of wintering and migrating Mallards could likely cause eutrophication in the relatively small bodies of water.

## Acknowledgements

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# Anostracans and microcrustaceans as potential food sources of waterbirds on sodic pans of the Hungarian plain

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## Abstract

Hungarian sodic water bodies have a rich macro- and microcrustacean fauna due to the lack of fish populations. The crustacean population is very abundant, for this reason these wetlands provide good feeding resources for waterbirds. The density of macro- and microcrustacean populations together with feeding waterbirds was investigated in March, April, and May of 2002, on two characteristic sodic pans, "Kelemen-szék" and "Zab-szék". The following dabbling-filtering waterfowls and pelagic forager wader species were counted: northern pintail (*Anas acuta*), northern shoveler (*Anas clypeata*), garganey (*A. querquedula*), common teal (*A. crecca*), avocet (*Recurvirostra avosetta*), spotted redshank (*Tringa erythropus*), greenshank (*T. nebularia*), and marsh sandpiper (*T. stagnatilis*). The dominant macrocrustacean species was the [Anostraca-Branchinectidae] natronophile *Branchinecta orientalis,* and its density was significantly higher in Zab-szék than in Kelemen-szék. The microcrustacean zooplankton community was also different in the pans, [Cladocera] *Daphnia magna* density was significantly higher in Kelemen-szék than in Zab-szék, but the density of the [Copepoda] natronophile *Arctodiaptomus spinosus*, was higher in Zab-szék than in Kelemen-szék. The density of the investigated waterbird species was also significantly higher in Zab-szék than in Kelemen-szék during spring. We can conclude that the macrocrustacean *B. orientalis* is one of the most important potential food resources for migrating pelagic foraging waders in spring on characteristic Hungarian sodic pans. However, the most abundant available food item for waterbirds are copepod microcrustacean zooplankton, which have a biomass that is larger by approximately one order of magnitude than the macrocrustacean zooplankton biomass. Considering the lack of submerged water vegetation, we suggest that planktonic microcrustaceans are an important food resource for dabbling-filtering ducks because they can utilise the small crustacean biomass more effectively than the less abundant and rapidly moving macrocrustacean *B. orientalis*.

# Foraging guilds of aquatic birds on productive boreal lakes: environmental relations and concordance patterns

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## Abstract

We surveyed aquatic birds on 41 eutrophic lakes at the southern edge of the boreal forest in Alberta, Canada to determine if patterns of species composition of five foraging guilds paralleled patterns of lake characteristics (morphometry, water chemistry, fish assemblage, and landscape features) and if composition patterns were concordant among guilds. We encountered 49 species of nonpasserine birds that could be classified into five foraging guilds: Diving Carnivores, Diving Omnivores, Herbivores, Surface-foraging Carnivores, and Shoreline Omnivores. Individual lakes supported three to five guilds and guild composition was most strongly and frequently related to lake area, maximum depth, water color, pH, a fish assemblage index, and catchment slope. Randomization tests of matrix concordance based on Principal Components Analyses indicated similar patterns between lake characteristics and species composition for four of five guilds (Diving Carnivores excepted). Randomization tests also showed that patterns of species composition among lakes were similar between foraging guilds for eight out of 10 pairwise comparisons (both exceptions involved Surface-foraging Carnivores). Because of the largely concordant patterns among different guilds, monitoring the status of one guild should provide a useful bioindicator of the status of the aquatic bird assemblages as a whole.

# Waterbird food chains in acid-sensitive Ontario lakes: status and temporal change in macroinvertebrate communities

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## Abstract

A large proportion of small headwater lakes in Ontario's boreal shield ecozone are important breeding habitats for waterbirds and are also sensitive to anthropogenic acidification. Macroinvertebrate communities in these lakes constitute an important food source for breeding waterbirds and their young and can be affected by shifts in lake pH and related changes to fish predator communities. An understanding of the status and temporal patterns in macroinvertebrate prey communities can contribute to explaining and predicting breeding waterbird responses to implemented and planned reductions in acidifying emissions. Collections of benthic and nektonic macroinvertebrates were made from 67 lakes in four regions of central and northern Ontario between 1987 and 2002. We used two approaches to summarize macroinvertebrate communities. First, we calculated several metrics commonly employed to detect shifts in benthic invertebrate community composition and dominance patterns. Calculated metrics included: taxonomic richness, Hilsenhoff biotic index, and the proportions of mayflies (Ephemeroptera), amphipods, molluscs, and insects. Using data from both the benthos and nekton, we also used detrended correspondence analysis to define an ordination space in terms of the collected taxa. The taxonomic composition and relative abundance of macroinvertebrates from individual lakes were then used to locate lakes in the ordination space and investigate habitat and other correlates of lake positions. Finally, we report on the temporal patterns in the benthic community metrics and lake positions in ordination space.

# Black-headed gulls (*Larus ridibundus*) and their effects on the water quality of the Lake Kis-Balaton (Hungary)

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## Abstract

The quantitative characteristics of the metabolic conditions of black-headed gulls are of utmost importance because, owing to their population density and active metabolism, these animals play a special role in the cycling of materials. The different feeding methods of individual waterfowl groups are reflected in the composition of their excrement as well. The lowest nitrogen and phosphorus concentrations were obtained in the case of young black-headed gull feces, and this value was closest to the one pertaining to cormorants. By comparison, more phosphorus was found in the excrement of the greylag goose. The number of black-headed gulls reached 2000 at Lake Kis-Balaton in the year 2000. The total amount of excrement produced by these animals is nearly 23 kg/year, in which the amount of nitrogen and phosphorus responsible for eutrophication was small. Only a small part of the excrement produced gets into the water and wetland-type biotopes situated away from the "gull islands"; therefore, black-headed gulls may have only isolated importance in the plant nutrient cycle of the Kis-Balaton Reservoir.

## Introduction

Waterfowl play a substantial role in the material cycling of aquatic assemblages owing to their high density and active metabolism. Unfortunately, their role in biological production is not adequately known, especially data relating to young animals. Fortunately, the number of studies has increased recently.

Several studies deal with cormorants, *Phalacrocorax carbo sinensis* (Blumenbach), (e.g. Gere and Andrikovics 1992a; Faragó et al, *this volume*), birds which take a significant amount of organic matter out of water in the form of fish. Greylag geese, *Anser anser* (L.), characterized by herbivorous nourishment, have also been investigated (Andrikovics et al.

1997), as well as omnivorous wild ducks (Gere and Andrikovics 1994, Juhász and Gere 2001).

Normally, fish and insects are the most important food source for gulls (Rékási 1982). However, recently, the composition of their diet has undergone some changes. They frequently consume waste materials thrown out of ships or coming from domestic garbage. Gulls are not averse to fruit either. They like cherries in particular (A. Lelkes, pers. comm.). In addition, gulls hunt for insects such as *Palingenia* (Burmeister) mayflies, which they tend to consume in large numbers at the time of their swarming (Sterbetz 1966).

Black-headed gull, *Larus ridibundus* (L.), populations are characterized by high densities in aquatic habitats. This holds true for the significant gull population at Lake Kis-Balaton. Hence, the question arises as to what role these birds have in the material-cycling of waters. Ongoing and past investigations by the authors provide an opportunity to compare the various effects on water quality of birds representing different feeding types. The Lake Kis-Balaton Protection System was established to delay and stop the eutrophication processes of Lake Balaton (Szilágyi et al. 1990). River Zala, responsible for 30–40% of the Balaton's nutritive load, is thought to be the main source of this process. This river carries 1500 tons of nitrogen and 100 tons of phosphorus annually into the Keszthely Bay (Joó and Lotz 1980). The water-purifying effect of Lake Hídvégi (Phase 1) has met the expectations: the nutritive balance of the input-output system was relatively favorable. However, extra phosphorus load is released into Lake Balaton from Lake Fenéki area (Phase 2) (Pomogyi 1997). Therefore, it is important to find out whether nutrients released into the water by the most abundant bird species in the region have any impact on this process. It is also important to know the amount of nitrogen and phosphorus being injected into Lake Kis-Balaton annually. In order to obtain this information, the total amount of feces released into the water by key species and the nitrogen and phosphorus content of feces must be known.

## Materials and methods

### *Field monitoring*

Conventional field ornithologist investigations have taken place in the Lake Kis-Balaton region for decades. These investigations have focused on the observation of population sizes, feeding habits, and animal density. According to these studies, the nesting population of the black-headed gull totals 200 specimens in 5 colonies, and their highest number reached 2000 in the year 2000.

### *Feeding experiments*

Ten to thirty-six day old nestlings were used in the experiments. Feeding experiments and chemical analysis were described by Andrikovics et al. (1997) and Gere and Andrikovics (1992a,b). Birds were kept in 1-$m^2$ cages. The bottom of the cages was made of plastic netting, and plastic sheets, on which the feces and urine accumulated, were placed under the cages. The birds were fed with fish by hand. The amount of food, excrement and the

change of the animal's weight were measured. The remaining food was re-measured after 24 hours, thus their consumption could be calculated. The behavior of the gull nestlings reflected that their behavior did not change when compared to that of their counterparts.

*Methods of chemical analysis*

The nitrogen content of the samples was determined via the Kjeldahl method, and the phosphorus content was determined with the photometrical method. The usual analysis was modified in the following way: a mixture of nitric acid and hydrogen peroxide was used because in this way the extent of carbonization became lower. This claim is substantiated by the fact that in the during atmospheric sulfuric acid dissolution a considerable amount of active carbon is produced, which — due to its high adsorption ability — adsorbs materials to be measured, entailing a high possibility of errors.

## Results and discussion

In 1985, 1200 black-headed gulls were observed in the Lake Kis-Balaton reservoir, on 5 islands in total (Figure 1). In 1999, the birds were present on 4 islands in the reservoir, 1000 pairs in total. In the 2nd phase 1200 pairs were found at habitats similar to those of the previous year.

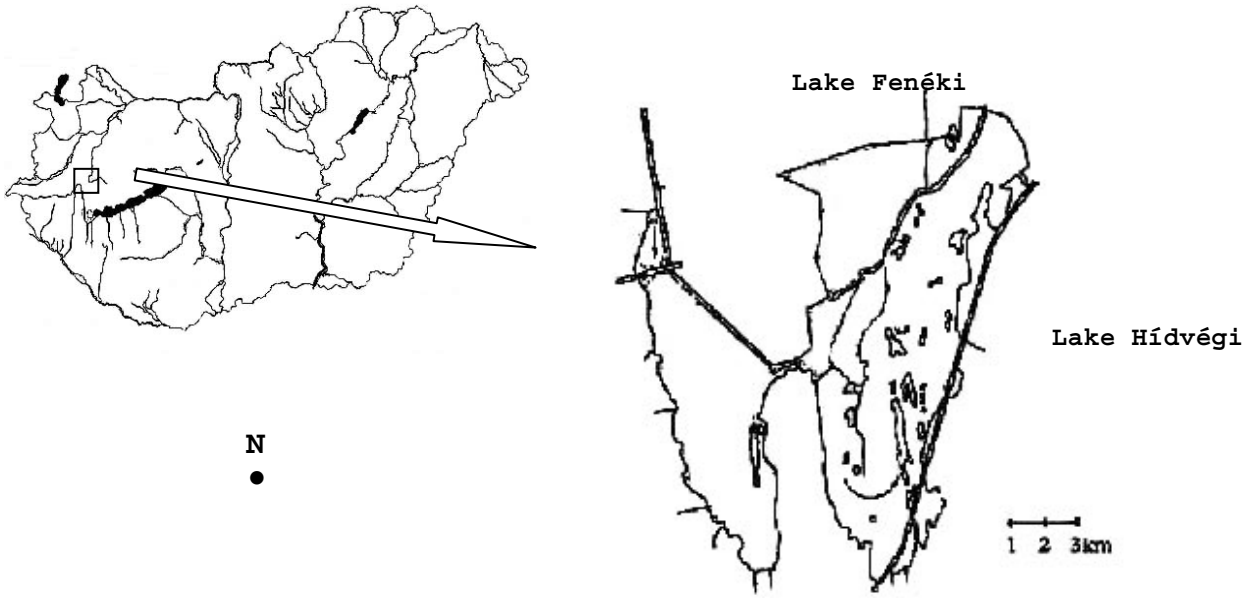


*Figure 1.* Location and sketch map of the Kis-Balaton

Black-headed gulls nest in colonies, where the hatching period lasts for 18–24 days. The parents keep the eggs warm by turns; however, usually both of them leave the nest between 12 and 2 p.m., thereby exposing the eggs to the sun's rays. Nestlings hatch out in early May. Two to four nestlings can be found in each brood.

The nestlings are very lively and soon become capable of eating on their own. They stay in the nest or very close to it for 4–5 days, and then prefer going to the water. The nestlings are also fed by their parents, which bring them fry, insect larvae, and insects. In general, gulls are active from 4–5 a.m. to 11 a.m. and spend 80% of their time flying over the water seeking food. They rest a lot in groups on trees along the banks and on islands from 11 a.m. to approximately 3 p.m. Then they return to the water and fly over it until it gets dark.

*Results of the feeding experiments*

Three birds captured from the gull islands of Lake Kis-Balaton on May 12, 1999 were involved in the feeding experiments (Table 1).

*Table 1.* Parameters of the captured nestlings.

| Serial number | Estimated age at the time of its capture (days) | Weight (g) |
|---|---|---|
| 1 | 12 | 92 |
| 2 | 8 | 61 |
| 3 | 8 | 59 |

The data pertaining to food consumption and the quantity of feces are summarized in Tables 2, 3 and 4. In all cases, the data refer to values relating to one single animal. The food was minced fry.

*Table 2.* Production biological parameters of black-headed gull nestling — I. *P* = production (increase in weight indicated by dry mass). In the course of the calculation the water content of the animals was considered to be 74% — based on Austin (1976) FU = feces+urine, rejected material, C = consumption, air-dry mass of consumption..

| Date (1999) | Food (g) | | Increase in weight (g) | | Defecation (g) | P × 100/C | FU × 100/C |
|---|---|---|---|---|---|---|---|
| | Wet weight | Dry weight | Live weight | Dry weight | | | |
| 05.15 | 33.3 | 8.9 | 5 | 1.30 | 2.49 | 14.60 | 27.97 |
| 05.16 | 16.6 | 5.5 | 2 | 0.52 | 1.70 | 9.45 | 30.90 |
| 05.17 | 40.0 | 11.2 | 5 | 1.30 | 2.57 | 11.60 | 22.94 |
| 05.18 | 42.5 | 13.4 | 6 | 1.56 | 3.01 | 11.64 | 22.46 |
| 05.19 | 44.9 | 14.2 | 7 | 1.82 | 3.99 | 12.81 | 20.05 |
| 05.20 | 67.0 | 19.9 | 12 | 3.12 | 4.21 | 15.67 | 21.15 |
| 05.31 | 32.6 | 10.9 | -4 | -1.04 | 3.02 | - | 18.99 |
| 06.01 | 46.0 | 16.9 | 10 | 2.60 | 4.41 | 16.35 | 27.73 |
| 06.02 | 58.7 | 17.6 | 10 | 2.60 | 5.31 | 14.77 | 30.17 |
| 06.03 | 36.0 | 13.0 | 2 | 0.52 | 5.74 | 4.30 | 7.09 |
| 06.04 | 30.4 | 11.0 | 3 | 0.78 | 4.30 | 9.09 | 39.09 |
| 06.05 | 36.8 | 10.1 | 4 | 1.04 | 4.73 | 10.29 | 46.83 |

*Table 3.* Production biological parameters of black-headed gull nestling — II. P = production, increase in weight indicated in dry mass. In the course of the calculation the water content of the animals was considered to be 74% — based on Austin (1976) FU = feces+urine, rejected material C = consumption, air-dry mass of consumption.

| Date (1999) | Food (g) | | Increase in weight (g) | | Defecation (g) | P × 100/C | FU × 100/C |
|---|---|---|---|---|---|---|---|
| | Wet weight | Dry weight | Live weight | Dry weight | | | |
| 05.15 | 17.0 | 5.1 | 2 | 0.52 | 1.53 | 10.19 | 30.00 |
| 05.16 | 18.2 | 4.9 | 2 | 0.52 | 1.36 | 10.61 | 27.75 |
| 05.17 | 24.7 | 12.9 | 6 | 1.56 | 2.47 | 12.09 | 19.14 |
| 05.18 | 25.3 | 10.1 | 6 | 1.56 | 2.65 | 15.44 | 26.23 |
| 05.19 | 26.9 | 11.0 | 7 | 1.82 | 2.91 | 16.54 | 23.45 |
| 05.20 | 29.0 | 17.1 | 11 | 5.72 | 4.12 | 33.45 | 24.09 |
| 05.31 | 47.3 | 11.2 | 8 | 2.08 | 5.03 | 18.57 | 44.91 |
| 06.01 | 40.6 | 10.9 | 10 | 2.60 | 4.07 | 23.85 | 37.33 |
| 06.02 | 30.0 | 9.7 | 2 | 0.52 | 4.01 | 5.36 | 41.34 |
| 06.03 | 39.9 | 10.9 | 5 | 1.30 | 3.81 | 11.92 | 34.95 |
| 06.04 | 37.0 | 10.1 | 4 | 1.04 | 3.60 | 10.29 | 35.64 |
| 06.05 | 29.9 | 9.9 | 3 | 0.78 | 4.11 | 7.87 | 41.51 |

*Table 4.* Production biological parameters of black-headed gull nestling — III. P = production, increase in weight indicated in dry mass. In the course of the calculation the water content of the animals was considered to be 74% — based on Austin (1976) FU = feces+urine, discarded material C = consumption, air-dry mass of consumption.

| Date (1999) | Food (g) | | Increase in weight (g) | | Defecation (g) | P × 100/C | FU × 100/C |
|---|---|---|---|---|---|---|---|
| | Wet weight | Wet weight | Live weight | Dry weight | | | |
| 05.15 | 18.0 | 5.0 | 1 | 0.26 | 1.62 | 5.20 | 32.40 |
| 05.16 | 21.3 | 5.7 | 5 | 1.30 | 1.74 | 22.80 | 30.52 |
| 05.17 | 30.0 | 7.7 | 8 | 2.08 | 2.13 | 27.01 | 27.66 |
| 05.18 | 20.9 | 5.3 | 4 | 1.04 | 2.01 | 19.62 | 37.92 |
| 05.19 | 11.9 | 3.6 | 3 | 0.78 | 1.56 | 21.66 | 43.33 |
| 05.20 | 32.9 | 12.9 | 11 | 5.72 | 4.15 | 44.34 | 32.17 |
| 05.31 | 47.3 | 14.2 | 8 | 2.08 | 4.28 | 14.64 | 30.14 |
| 06.01 | 40.5 | 13.8 | 6 | 1.56 | 5.01 | 11.30 | 36.30 |
| 06.02 | 51.3 | 11.9 | 0 | 0.00 | 5.12 | - | 43.02 |
| 06.03 | 39.0 | 9.1 | 3 | 0.78 | 4.99 | 8.57 | 54.83 |
| 06.04 | 35.0 | 9.9 | 4 | 1.04 | 4.76 | 10.50 | 48.08 |
| 06.05 | 29.0 | 6.0 | 1 | 0.26 | 3.11 | 4.33 | 51.83 |

The total nitrogen and total phosphorus content was determined in samples taken from the feces. Six samples were taken from the excrement of birds younger than 15 days of age and six samples from the feces of birds older than 15 days of age. The results are summarized in Tables 5 and 6.

*Table 5.* Nitrogen and phosphorus content of feces in the case of birds younger than 15 days of age.

| Serial number | N (%) | P (%) |
|---|---|---|
| 1 | 11.07 | 3.00 |
| 2 | 10.82 | 6.07 |
| 3 | 13.00 | 5.81 |
| 4 | 19.99 | 3.11 |
| 5 | 14.71 | 3.93 |
| 6 | 15.28 | 4.65 |
| Average | 14.15 | 4.48 |
| Minimum | 10.82 | 3.00 |
| Maximum | 19.99 | 6.07 |
| Coefficient of variation | 3.394 | 1.3175 |

*Table 6.* Nitrogen and phosphorus content of feces in the case of birds older than 15 days of age (taken from the feces samples of bird no.1 between 05.15 and 05.20, and from the feces samples of birds no. 2 and 3 taken between 05.31 and 06.05).

| Serial number | N (%) | P (%) |
|---|---|---|
| 1 | 13.07 | 6.91 |
| 2 | 15.09 | 7.00 |
| 3 | 19.17 | 4.03 |
| 4 | 19.08 | 5.72 |
| 5 | 16.29 | 5.16 |
| 6 | 16.73 | 6.12 |
| Average | 16.57 | 5.82 |
| Minimum | 13.07 | 4.03 |
| Maximum | 19.17 | 7.00 |
| Coefficient of variation | 2.349 | 1.124 |

The total nitrogen and phosphorus content of the food consumed by the animals have been measured as well. The results obtained from the samples of food are shown in Table 7.

*Table 7.* Nitrogen and phosphorus content of food.

| Serial number | N (%) | P (%) |
|---|---|---|
| 1 | 12.02 | 4.38 |
| 2 | 12.73 | 5.27 |
| 3 | 13.89 | 5.58 |
| 4 | 14.56 | 5.01 |
| 5 | 12.99 | 3.99 |
| 6 | 14.98 | 4.00 |
| Average | 13.53 | 4.71 |
| Minimum | 12.02 | 3.99 |
| Maximum | 14.98 | 5.58 |
| Coefficient of variation | 1.141 | 0.677 |

The nitrogen content of the excrement of piscivorous cormorants was 13–16% (Gere and Andrikovics 1992b), whereas in the case of herbivorous Greylag Goose this value was 2.2% (Juhász et al. 1998). The nitrogen content of the feces of omnivorous Mallards represented a value in between (2.44–4.21%). The lowest values were obtained in the case of nestling black-headed gulls. The nitrogen content of their feces is 1.4–1.65%, which represents a value closest to that of geese. It is noteworthy that considerably less phosphorus (under 0.01%) is contained in the feces of Mallards than in the feces of cormorants or Greylag geese. The phosphorus content of excrement produced by cormorants varies between 4.5 and 5.5% (Gere and Andrikovics 1992b), whilst 0.43% was measured in the case of Greylag geese (Juhász et al. 1998). The phosphorus content of the feces of young black-headed gulls is only between 0.44% and 0.58%, similarly to the values for Greylag Geese. Consequently, the different feeding habits of birds are reflected in the significantly different nitrogen and phosphorus content of the feces. Based on the foregoing discussion, it is apparent that birds characterized by different feeding habits play different roles in direct eutrophication processes. It is important to note that the quality of feces, their nitrogen and phosphorus contents just as important in the material- and energy-cycling processes as their quantity.

*About the relevance of black-headed gulls in terms of material-cycling*

Feces produced by gulls are responsible for 40% of the phosphorus loading of a small lake (44 ha) situated on the east coast of the United States (Portnoy 1990). However, at Lake KisBalaton, Mallards are responsible for 0.1% of the nitrogen- and 0.7% of the phosphorus

load (Gere and Andrikovics 1994). The same values referring to Greylag geese are even lower; only 0.01% N and 0.03% P (Andrikovics et al. 1997).

Although Portnoy (1990) found that the nutritive load in Cape Cod kettle pond was substantially affected by birds, this study shows that the opposite may also occur. Small lake size, the attractiveness of a region as a gathering place for birds, and anthropogenic feeding opportunities in the surrounding areas may all help to explain high loading ratios.

Data obtained so far (Portnoy 1990, Manny et al. 1994) seem to substantiate that the feces production of birds may have a direct, significant role in the eutrophication processes only as the result of anthropogenic effects (Báldi 2001). These findings are supported by the results obtained by the authors at Lake Kis-Balaton, according to which, the total annual feces production of 2000 specimens of black-headed gulls was 23 kg, which represents only 0.60 kg nitrogen and 0.34 kg phosphorus.

Considering the overall Kis-Balaton reservoir, these results are negligible, yet they might trigger a significant local, terrestrial eutrophication around the gull islands. Nevertheless, being a member of the material importer and decomposition accelerator guild (Andrikovics et al. 2006), the black-headed gull may play an important role in other, less known community processes (e.g. interspecific competition, spreading of propagulums, etc.).

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# Pattern of natural $^{15}N$ abundance in lakeside forest ecosystem affected by cormorant-derived nitrogen

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The full article can be found in Hydrobiologia 567:69–86.

## Abstract

Waterbirds are one of the most important groups of organisms inhabiting the land-water interface, especially with regard to mediating the transport of materials from the aquatic to the terrestrial environment. The great cormorant (*Phalacrocorax carbo*) is a colonial piscivorous bird that transports nutrients from fresh water to forest. We measured cormorant-derived nitrogen at two nesting colonies on the Isaki Peninsula and Chikubu Island at Lake Biwa, Japan, and analyzed the long-term effects of cormorant colonization on the forest nitrogen cycle, and the mechanisms of nitrogen retention. Three sites were examined in each colony: a currently occupied area, a previously occupied but now abandoned area, and a control area never colonized by cormorants. High nitrogen stable isotope ratios of cormorant excreta, the forest floor, mineral soil, and living plants showed cormorant-derived nitrogen in both occupied and abandoned areas. The relationship between $\delta^{15}N$ and N content showed that the high $\delta^{15}N$ of the excreta and N turnover in the soil were important at the occupied sites, whereas high $\delta^{15}N$ of litter was important at the abandoned sites. Physiological changes of various organisms are also important for N decomposition process. In conclusion, cormorant-derived nitrogen remains in the forest ecosystem as a result of two cormorant activities: heavy deposition of excreta and collection of nitrogen-rich nest material. Colony stage (occupied, abandoned, or never inhabited) and historical change of N decomposition process of an area can be identified from the relationship between $\delta^{15}N$ and N content.

# Limnological conditions of Egerszalók Reservoir and functional feeding guilds of aquatic birds

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## Abstract

The reservoir situated at the foot of the Bükk Mountains was created in 1981 along the embankment of Laskó Stream. Currently, it is used for sports, leisure, spare-time activities and angling. The reservoir, created 22 years ago, was subject to serious contamination from Laskó Stream until 1990. The operation of a goose farm established some years ago has now stopped, which accounts for improving the water quality. The water of Laskó Stream changes in the reservoir: its salt, phosphorus, and nitrogen contents tend to drop substantially. The improvement of water quality is especially apparent in reed beds of small size. The benthic, phyto- and zooplankton offer a rich food for the nekton and waterbirds. Cyanobacteria from Laskó Stream are transported into the reservoir. The quality of water improved substantially after leaving the reservoir. After the goose farm was closed, the decrease in water levels caused problems for wildlife. Out of the 217 bird species documented, 97 species nest and 120 species migrate and wander in the vicinity of the reservoir. Notwithstanding the observed fluctuation of and decrease in water level, we have found 100 aquatic bird species along the largest water surface at the foot of the Bükk Mountains. The reservoir is an essential feeding and resting location for groups of geese, mallards and shorebirds. In the first years following the establishment of the reservoir, the migrating exporter-importer groups proved to be the first important functional feeding guilds of aquatic birds. They followed the rich fish stock. During low water periods, the activity of shorebird species increased. Recently, the ratio of the exporter-importer functional group has decreased. Currently, decomposition-accelerators make up the majority of the avifauna. The ratio of nesting species within each guild is lower when compared to the avifauna of other reservoirs that were established earlier. Using the results of plankton, nekton and water-chemistry studies in evaluating the functional feeding guilds of aquatic birds shows that these birds play a major role in the decomposition of organic matters contained in reservoirs. Thereby, aquatic birds contribute to the progress of natural succession processes.

# The abundance of waterbirds, their material cycle guilds and effects on water quality in Hungary

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## Abstract

As a result of river regulations the once huge wetlands have almost completely disappeared from the Carpathian Basin. This was further enhanced by the extensive pollution of water, and consequently, at the turn of the 21st century one should consult ethnographic literature to learn about the legendary richness of fish and waterbird species. It is an interesting paradox, however, that in parallel with the global decline of wildlife, nature-lover citizens tend to take an ever increasing interest in birds, and a number of faunistic publications announce the occurrence of some peculiar fauna elements. No study has been prepared about the effect of waterbird stands on the ecosystem of shallow ponds and rivers yet. Today the number of waterside birds, ducks, geese and galls may be so high on the small wetland territories remaining that these have a significant impact on the material- and energy cycle, as well as on the quality of water. The first data of the investigation of the material cycle came to the fore when hunting bag was investigated, later the laboratory examination of the metabolic processes of key species supplied data, and at the same time data were gained via the collection of faeces and behaviour observations in the field. These data, as well as the results of field ornithology, abundance observations and monitoring together made it possible to estimate the effect of key species on the water ecosystems of Hungary. Considering that bird species do not exert their impact independently of each other, yet in specific communities that are changing both in time and space, in the first step the three basic material-cycle guild groups of water and waterside birds have been developed in relation to some specific water types in Hungary, as follows: the material-transporting group increases or decreases the trophic status of waters via nutrients brought inside from outside (geese) or taken outside the system (cormorants). The guild group responsible for the acceleration of decomposition increases the speed of nutrient decomposition through breathing and digestion. Material cycling is expedited by the bioturbing group directly via metabolism, and also indirectly through its mechanistic activity. Songbirds in the reed and many waterside birds are indirectly connected to the water and consume almost nothing else but water animals in a certain period of their life. The material-cycle guilds created by the authors have been tested by them with respect to the possibility of water quality change caused by aquatic bird communities in various, typical ecosystems in Hungary. According to their findings, the huge number of waterbirds may entail water quality problems in artificial reservoirs and water ponds created by men; however, these at the same time improve water quality in natural shallow waters of larger size.

# SECTION V

# CONSERVATION OF AQUATIC BIRDS AND THEIR HABITAT

# Composition of aquatic birds in the APM Manso dam, upper Paraguay river basin, Mato Grosso – Brazil

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**Abstract**

The Manso river dam belongs to same river basin that feeds the Pantanal wetland. This research shows the initial settlement process by aquatic birds in the area of the dam, analyzing temporal and spatial changes in the species composition. The effects of proximity to the Pantanal in the species composition are also discussed. The Manso dam is located in the municipal district of Chapada dos Guimaraes, between 15˚17'25"S and 55˚58'11", in the Manso river basin. Monthly censuses were carried out, by boat, in the edge of the reservoir from September 2000 to December 2001. The methodology used for the sampling was the fixed transect. Twelve transects of 2 km each were determined. From these, 6 were in open field habitats (open banks) and the other 6 in woodland habitats (woodland banks). The study recorded 1273 individuals distributed in 25 species. 73% of the observed birds were from Ardeidae and Anhingidae families. The higher number of species was registered for piscivorous species (48%) followed by insectivorous (70.8%). Being the open environment, the habitat that registered 68% of the number of individuals ($\chi^2$ = 75,432; df=1; $P$ < 0.00001). The structural composition of the aquatic bird community in the period of this study could have been influenced by the fact that the dam newly formed and by the availability and characteristics of habitats. Medium and long-term studies are needed to define which variables restrict and/or facilitate the settlement and establishment of an aquatic bird community in this new ecosystem.

# Development of hydrologic linkages to Lake Ontario – St. Lawrence river wetland breeding bird communities for use in water regulation plan review

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## Abstract

The International Joint Commission is presently undertaking a study to review the criteria used to regulate water levels and flows on Lake Ontario and the St. Lawrence River. The impacts of current and alternate water regulation plans on near shore biological communities are a study priority. Interactions between late spring-early summer inter-annual water levels and wetland breeding bird communities in different regions of the Lake Ontario and St. Lawrence River system are being investigated as part of an integrated environmental assessment. Assessment of historic water regulation impacts and evaluation of potential alternate water regulation plans are being completed by identifying direct (e.g. nest flooding) and indirect (e.g. plant community distribution and abundance) influences of lake and river hydrology on wetland breeding bird communities. A combination of historic bird nest record data, Great Lakes Marsh Monitoring Program bird survey data and intensive bird and habitat surveys are being utilized for the purpose of this study. Unique assemblages of bird species that rely on specific types of wetland habitat have been identified. Relationships among univariate bird community attributes (species richness, rarity, diversity and integrity indices), local and landscape habitat attributes and hydrological variables are presently being examined. These relationships will enable determination of which Lake Ontario – St. Lawrence River water regulation plan criteria are critical to the maintenance of bird species richness and diversity. These relationships will be incorporated into evaluations and recommendations of alternate regulation criteria within an integrated environmental assessment framework.

# Atlantic Seaduck Project

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**Abstract**

Atlantic Seaduck Project is being conducted to learn more about the breeding and moulting areas of seaducks in northern Canada and more about their feeding ecology on wintering areas, especially Chesapeake Bay. Satellite telemetry is being used to track surf scoters wintering in Chesapeake Bay, Maryland and black scoters on migrational staging areas in New Brunswick, Canada to breeding and moulting areas in northern Canada. Various techniques used to capture the scoters included mist netting, night-lighting, and net capture guns. All captured ducks were transported to a veterinary hospital where surgery was conducted following general anaesthesia procedures. A PTT100 transmitter (39 g) manufactured by Microwave, Inc., Columbia, Maryland was implanted into the duck's abdominal cavity with an external (percutaneous) antenna. Eight of the surf scoters from Chesapeake Bay successfully migrated to possible breeding areas in Canada and all 13 of the black scoters migrated to suspected breeding areas. Ten of the 11 black scoter males migrated to James Bay presumably for moulting. Updated information from the ARGOS Systems aboard the NOAA satellites on scoter movements was made accessible on the Patuxent Website. Habitat cover types of locations using GIS (Geographical Information Systems) and aerial photographs (in conjunction with remote sensing software) are currently being analyzed to build thematic maps with varying cosmetic layer applications. Many factors related to human population increases have been implicated in causing changes in the distribution and abundance of wintering seaducks. Analyses of the gullet (oesophagus and proventriculus) and the gizzard of seaducks are currently being conducted to determine if changes from historical data have occurred. Scoters in the Bay feed predominantly on the hooked mussel and several species of clams. The long-tailed duck appears to select the gem clam in greater amounts than other seaducks, but exhibits a diverse diet of other mollusks and crustaceans. Seaduck food habits in the Maritimes are decidedly different, where all three species of scoters feed extensively on the blue mussel. Understanding the feeding ecology of seaducks in wintering areas such as the Chesapeake Bay and the Maritimes will provide managers with a better understanding of the changes in the distribution and abundance of these ducks. Future studies will attempt to determine the effects of experimental diets varying in protein and energy levels on the physiology and behaviour of captive seaducks. An attempt will be made to determine if seaducks exhibit an endogenous rhythm in regard to body weight and condition during the winter. Foraging energetics in relation to different food sources found in the Chesapeake Bay will be measured in two large aquariums (dive tanks) with scoters and long-tailed ducks. The combined studies being conducted in the Atlantic Seaduck Project will greatly aid the conservation effort for seaducks presently being conducted throughout the world.

# Habitat for waterbirds in the lakes of the Black Sea Biosphere Reserve

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## Abstract

Research on lakes as habitat for wetland birds were carried out in the south of Ukraine in the Black Sea Biosphere Reserve. The Reserve is well-known as a Ramsar Wetland of international value. The reserve includes two oceanic bays; Tendra and Yagorlitsky. It is a unique ocean preserve in Ukraine. Aside from the bays in the reserve, there are more than 200 salty, fresh and ingressive lakes in a 1653-ha area (1.9% of the reserve and 11.7% of the land area). The greatest number of lakes are located on the seaside steppe (Potievsky, with lakes covering 40.9% of the area; Yagorlitsky Kut, 67.9%) and on the forest-steppe (Saltlaked, 20.4%). All inland islands in the reserve have shallow saline lakes. Their total area measures 314.3 ha (16.9% of the area of the islands). The area occupied by lakes on Yagotlitsky bay islands totals 17.6–44.5% (Konsky, Dolgyj), while on Tendra bay islands they total 12.9–30.0% (Orlov, Smaleny). All lakes are highly productive and are of great importance for birds during nesting and migration. One hundred and ten to 125 species of birds have been recorded on these lakes, and of these approximately 30 are cited in the Red Book of Ukraine. In favourable years, the total number of birds nesting near these lakes reaches 300–400 pairs, while during migration, 5000 to 10000 wetland birds use them as a stopover. The economic crisis of the 2000's has led to the destruction of irrigational channels which brought water to the lakes of the Potievsky plot and led to them drying out completely. The bird population on its lakes has markedly decreased.

## Introduction

The Black Sea Biosphere Reserve is the only solely marine reserve in the Ukraine. Tendra and Yarorlitsky bays are well-known wetlands of international importance. The morphology of the bays and a variety of animals and plants within it are well investigated (Grigoriev and Pupkov 1977, Ardamatskaya 1984, Usenko et al. 1988, Pinchuk and Tkachenko 1996, Rudenko 1996).

Other than the saline area, the reserve consists of approximately 200 saline and freshwater lakes as well as coastal lagoons connected to the bays. The lakes included in the Ramsar Wetlands structure are very productive and of great value for the protection of

migrating and nesting birds, but remain poorly studied. The basic purpose of this paper is to describe these lakes, make an estimate of their value as bird habitat, and outline necessary management practices for their restoration.

## Study area and methods

The Black Sea Biosphere Reserve (BSBR) is one of the oldest and biggest reserves in Ukraine. The reserve is situated in southern Ukraine (46.30˚N, 32.30˚E) along the northern coast of the Black Sea. It was created in 1927 for the protection of birds nesting on the islands and coasts of Tendra and Yagorlitsky bays. The area of the Black Sea reserve is approximately 89,129 hectares: 14,148 ha terrestrial, and 56,361 ha aquatic. The territory consists of five continental sites, separated from one another (Figure 1).

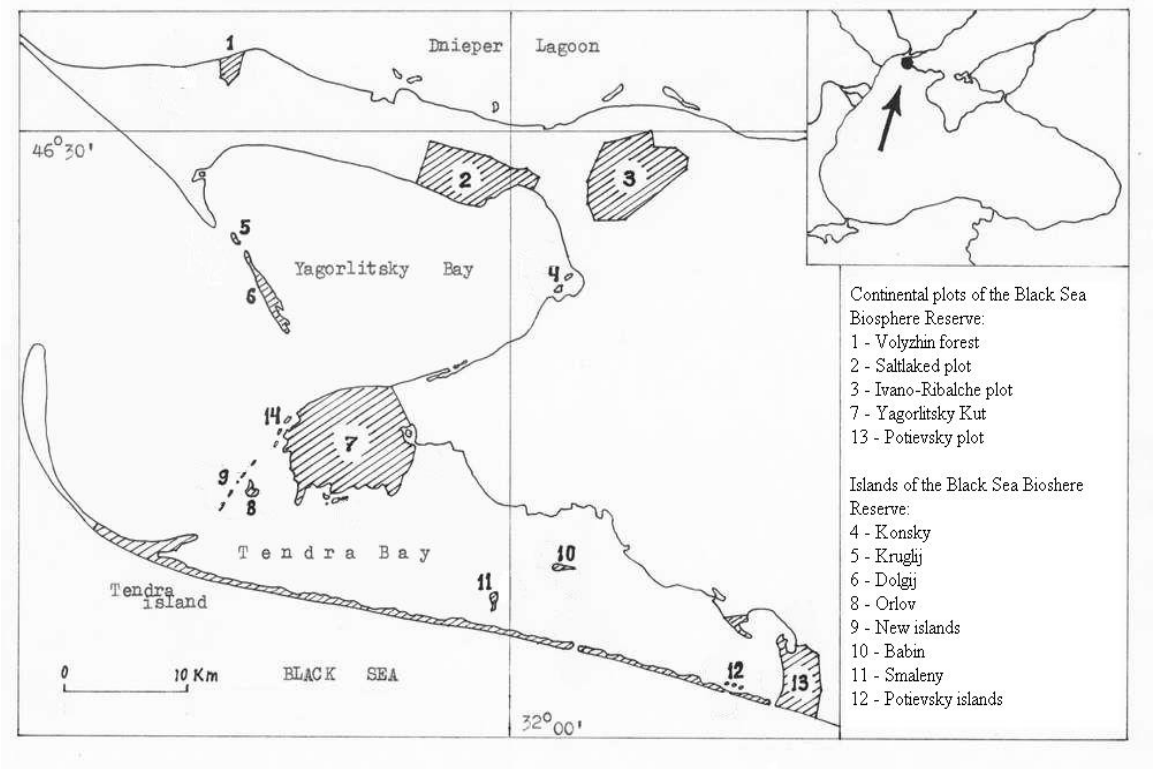


*Figure 1*. Territory of the Black Sea Biosphere Reserve

Continental sites of the BSBR are incorporated into two groups: seaside steppe and sandy forest-steppe. The forest-steppe (5600 ha) is located on the Kinburn peninsula. This set of small groves is part of old growth remnants. The second group (approximately 7000 ha) is a unique desert seaside saline steppe. There are no other known ecosystems of this type on the steppes of western Europe.

Tendra and Yagorlitsky Bays are wetlands of international importance. Tendra Bay (635 $km^2$) is situated in the northwestern section of the Black Sea, and is part of the Black Sea Biosphere Reserve. The bay is 66 km long (east/west axis) and 25 km wide, narrowing to 4 km at the eastern (interior) end. The western part of the bay is deep (15 m), but

becomes gradually shallower towards the east (4–5 m). The northern shore is characterised by bluffs, with shallow little bays and coils. The depths here do not exceed 1 m. Depths in the trough are 2–3 m (Usenko et al. 1988).

Yagorlitsky bay (350 $km^2$) is also protected as part of the Black Sea Biosphere Reserve. Twelve $km^2$ of this bay are protected as buffer zones. This bay has no immediate link to the Black Sea but is connected to deep waters through Tendra Bay. At its deepest, this bay is 12 m, with an average depth of 3–5 m (Grigoriev and Pupkov 1977).

Islands in the Black Sea Reserve are the most valuables ecosystems. Islands located in the shallow waters of Tendra and Yagorlitsky bays of the Black Sea are: Egyptian, Siberian, New, Potievsky, Orlov, Babin, Smaleny, Konsky, Dolgyj, and Kruglyj. The islands have great value as nesting habitat for different species of Pelecaniformes, Laridae, also ducks (Anatidae) and waders (Charadrii). Islands measure from 2 to 28 ha. They are low and covered with reeds when there are internal lakes and small canals. In the BSBR there are two types of islands: continental (remainders of a native born land) and of alluvial origin.

Studies of lakes as habitat for birds were carried out both on continental sites, and on islands. Bird surveys took place during all seasons on all lakes (Rudenko and Yaremchenko 2000a, Rudenko 2002). The lake areas and depths were obtained from existing materials (the Organizational - Economic Plan of the Black Sea Reserve). Water levels were determined qualitatively: high, low, or zero (dry). Field work was carried out in the Potievsky plot.

## Results and Discussion

*Lakes as habitat for waterbirds*

Other than the bay areas, the Black Sea Biological Reserve consists of about 200 saline and freshwater lakes as well as coastal lagoons connected to the bays. The lakes in the reserve total 1653 ha (1.9% of the total territory of the reserve, 11.7% of the land area). The greatest number of lakes are on the seaside steppe (Potievsky, Yagorlitsky Kut) and on the forest-steppe (Saltlaked) (Table 1). All inland islands of the reserve have shallow saline lakes. Their area totals 314.3 ha (16.9% of the area of the islands). The areas occupied by lakes on the islands of Yagotlitsky bay covers 17.6–44.5%, on islands of Tendra bay 12.9–30.0% (Table 2).

The size of the waterbodies varies considerably. In the steppe there is a network of shallow ponds 0.01–0.5 ha that often dry up. The largest lake is 286.5 ha. Such lakes are usually connected to bays. More than 80% of lakes are saline. The pH of the lakes ranges from 8.4–9.9. The inland lakes have sandy-muddy bottoms and shores. The water is usually very shallow: 10–30 cm. The maximum depth of the larger lakes, connected to bays, ranges from 0.5 m to 1.5 m, while the minimum depth ranges from 20–70 cm.

With respect to shoreline vegetation, lakes are of three types: (1) Open — shore is covered by low halophytic vegetation (*Salicornia europea*, *Puccinelia brahilepis*, *P. fominii*, *Suaeda altissima*, *Limonium meyeri*, *Artemisia santonica*, etc.); (2) Closed — with shorelines overgrown by reeds, and sometimes overgrown by bushes in the case of lakes of forest-steppe plots; (3) lakes in which the shores are partially open and partially closed by

reeds.

*Table 1*. Area occupied by lakes on the continental plots of the Black Sea Biosphere Reserve.

| Names of continental Plots of Reserve | Total area of continental plots (ha) | Area occupied by lakes | |
|---|---|---|---|
| | | Absolute (ha) | % from total area of plot |
| Volyzhin forest | 203 | 0.8 | 0.4 |
| Saltlaked | 2293 | 467.87 | 20.4 |
| Ivano-Ribalche | 3104 | 15.96 | 0.5 |
| Yagorlitsky Kut | 5540 | 378.9 | 6.84 |
| Potievsky | 1064 | 473.3 | 44.48 |

*Table 2.* Lakes area on the islands of the Black Sea Biosphere Reserve.

| Names of islands | Total area of islands (ha) | Area occupied by lakes | |
|---|---|---|---|
| | | Absolute (ha) | % from total area of islands |
| Tendra Bay | | | |
| Tendra Spit | 1289 | 94.1 | 7.3 |
| Orlov | 28 | 3.6 | 12.9 |
| Babin | 6 | 0.8 | 13.3 |
| Smaleny | 8 | 2.4 | 30.0 |
| Egypts islands | 17 | 1.0 | 5.9 |
| Yagorlitsky Bay | | | |
| Dolgij | 470 | 209.2 | 44.5 |
| Kruglij | 7 | 0.6 | 7.5 |
| Small Konsky | 7 | 0.5 | 7.1 |
| Big Konsky | 20 | 2.1 | 10.5 |

All waterbodies are rich in invertebrates. The data from the reserve identify more than 50 types of invertebrates from 6–8 classes in the lakes. Most frequent are Polychaeta, Oligochaeta, Crustacea, Insecta, Gastropoda, Bivalvia, and Bryozoa. In lakes connected with a bay, fish frequently enter and attempt to establish themselves. *Cyprinus carpio* (L.) and *Carassius* spp. are found in desalinated lakes, where the greater proportion of the water comes from irrigation system.

*Waterbird population*

The good protection and abundant food supplies in the lakes create favorable living conditions for birds throughout the year. Many birds breed on the lakes and many also rest and feed during migrations. About 110–125 species of waterbirds were recorded on the lakes including 10–15 species associated with the reeds around the lakes. More than 30

species of these birds are included in the Red Book of Ukraine, and *Branta ruficollis*, *Haliaeetus albicilla* and *Numenius tenuirostris* are in the IUCN Red list.

Over a period of a few years, 27–35 species of birds bred on the lake shores, 9 of which are in the Red Book of Ukraine. The total number of nesting pairs is insignificant. The maximum number is 300–400 pairs in the most favorable years (1996–1998). On the mainland, birds more often select the closed lakes in the Potievsky section to nest. These are freshwater springfed lakes measuring 473.3 ha. Species breeding there include 2–4 pairs of *Cygnus olor*, up to 60 pairs of herons (*Arden cinerea*, *A. purpurea*, *Egretta alba*, *E. garzetta*), 3–5 pairs of *Botaurus stellaris*, about 100 pairs of ducks (*Anas platyrhynchos*, *A. strepera*, *A. querquedula*, *Aythya ferina*, *Netta rufina*), 3–8 pairs of *Podiceps cristatus*, 30 pairs of *Fulica atra*, up to 10 pairs of *Gallinula chloropus*, 3 pairs of *Circus aeruginosus*, *Panurus biarmicus*, *Acrocephalus agricola*, *A. arundinaceus* and others. On the open and semi open lakes the most common breeding waders (up to 50 pairs) include *Recurvirostra avocetta*, *Haematopus ostralegus*, *Glareola pratincola*, *Himantopus himantopus*, *Charadrius alexandrinus*, *C. dubius*. Most nesting birds prefer the islands in the lakes. Sixty to eighty percent of colonial birds nest on the lake shores (Rudenko and Yaremchenko 2000b, Yaremchenko and Rudenko 2001).

In recent years the economic crisis in this region has promoted the creation of irrigation canals from the lakes of the Potievsky section. The lakes have grown over and partially dried up (speeded up by the summer heat), and their role as a habitat for waterbirds has been greatly diminished. Bird food supplies are almost completely lost, consequently the number of nesting and migrating individuals is sharply reduced (Table 3).

*Table 3.* The number dynamics of nesting and migrating birds on the inside lakes of Potievsky plot.

| Year | Water level in the lakes | Number of nesting pairs | Number of migrating birds accumulations |
|---|---|---|---|
| 1998 | high | 840 | 5000–7000 |
| 2000 | low | 30 | 500–1500 |
| 2002 | dry | 0 | 0–150 |

The lakes are used most intensively during migrations. The maximal number of birds stopping there to rest and feed total about 4–5 thousand individuals in the spring and up to 10 thousands in the autumn. Anseriformes and waders dominate. During migration the most abundant are the Mallards (1500–3000), *Anas penelope* (800–1000), *A. querquedula* (800–1000), *Tadorna tadorna* (300–500), *Tringa totanus* (2000–4000), *Philomachus pugnax* (2000–4000), *Calidris alpina* (3000–5000), *Numenius* sp. (1000–1500). Herons, gulls and terns, coots, and *Pelecanus onocrotalus* are quite numerous during autumnal migration. These lakes are also by good feeding areas for rare species of terns (*Sterna caspia* and *S. albifrons*). More than 60% of the migrating birds prefer the open lakes. The coastal sheltered lakes are most important for the birds so they can rest and feed during windy periods.

*Necessary management for lake restoration*

Refining habitat conditions for some species of wetland birds (mowing the reeds) and regulation of water delivery from irrigation systems into the lakes of the Potievsky plot is necessary for the proper management of the lakes. The timing of bird arrivals at the lake will determine changes in water levels — with higher levels during the breeding season and lower levels during migration, when rare species of waders (*Numenius* sp., *Limicola falcinellus*, etc.) are present.

The lakes of the reserve represent a unique natural system which is included in the family of the Ramsar wetlands. They have an exceptional value for the conservation of migratory birds, many of which are globally threatened.

## Acknowledgments

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# The Ferruginous Duck (*Aythya nyroca)* as a potential indicator species for tracking ecological changes at the Srebarna Lake managed reserve (NE Bulgaria)

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## Abstract

As the Ferruginous Duck *Aythya nyroca* has always been numerous at Srebarna Lake, it is an obvious choice as a biomonitor. Long-term data on the number of Ferruginous Ducks at Srebarna Lake has been collected since 1987. Despite much speculation on the relationship between Ferruginous Duck numbers and ecological change at Srebarna, this is the first attempt to quantify this statistically. In this paper I have tested, for correlation, the species numbers with a number of limnological parameters – water level, chlorophyll a, dissolved oxygen, zoobenthic biomass, zooplankton biomass and water transparency. Significant positive correlations were found with water level, and water transparency, and a significant negative correlation with the concentration of chlorophyll a. The significance of these correlations increased when ecological parameters were tested with the numbers of Ferruginous Ducks present in the next year. These significant correlations with changes in the ecological parameters suggest that the Ferruginous Duck could be an important indicator species for the condition of wetlands and the Srebarna Lake managed reserve in the specific case.

# Red-necked grebe (*Podiceps grisegena*) — a species of late succession stage wetlands in Bulgaria?

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## Abstract

The red-necked grebe *Podiceps grisegena* is a rare breeding, migrating and wintering species in Bulgaria. In recent years the species has suffered a decline in breeding population mainly due to a loss of nesting habitat. In Bulgaria the species occupies mainly shallow (up to 1.5 m) wetlands in the later stages of succession, heavily overgrown by marsh vegetation with almost no open water. The national breeding population is estimated at 10–30 pairs. This paper describes the breeding distribution of the red-necked grebe based on field studies from 1996 to 2003. The red-necked grebe's selection of wetlands in the later stages of succession makes it highly vulnerable. Its survival as a breeding species in Bulgaria will require special species orientated management of key sites.

## Introduction

The red-necked grebe, *Podiceps grisegena* (Boddaert), is a rare breeding species in Bulgaria, included in the Red Data Book as "endangered" (Ivanov 1985). In the past, the breeding population has been estimated at <50 pairs (Simeonov et al. 1990, Figure 1) and 30–60 pairs (Kostadinova 1997). However, in recent years changes in wetland conditions have reduced both the species numbers range. The red-necked grebe is rare in Bulgaria during migration and winter, but with a widespread distribution, being most numerous along the Black Sea coast. This is the first evaluation of the breeding status, distribution and habitat use of the red-necked grebe in Bulgaria based on field data.

## Methods

Fieldwork was carried out during breeding period from April to June, 1996–2003. Breeding sites were identified as wetlands where pairs were present, where courtship displays were observed or where nests were found. Data from the Bulgarian Society for the Protection of Birds National Database for Ornithological Information was also accessed. Over 130 wetlands of various types were visited, including all suitable breeding sites.

Vegetation coverage, dominant plant species, and water depth were recorded at all breeding sites. The breeding distribution was then mapped on 10 × 10 km UTM grid map.

## Results

*Distribution and numbers in the country*

In the past, the red-necked grebe was found nesting at several locations in western Bulgaria, the Danube riverside marshes, and along the Black Sea with total of 13 breeding sites reported in the literature (Figure 1; Ivanov 1985). In the last six years, the species was found breeding at only eight wetlands (Table 1, Figure 2). The breeding population, currently estimated at 10–30 pairs, has declined considerably, both in range and numbers. The most important breeding sites are now located along the Danube River. Garvan Marsh is the most important site, holding five pairs in a heavily overgrown pond about 100 m long, 25 m wide and 0.5–0.6 m deep. Only "Orsoya Fishpond" and Garvan Marsh held birds in each of the last six years. Many former breeding sites have now been lost, including Aldomirovsko Marsh, Kremikovtsi sedimentation basin, Belene Marshes, Burgas and Varna Lakes.

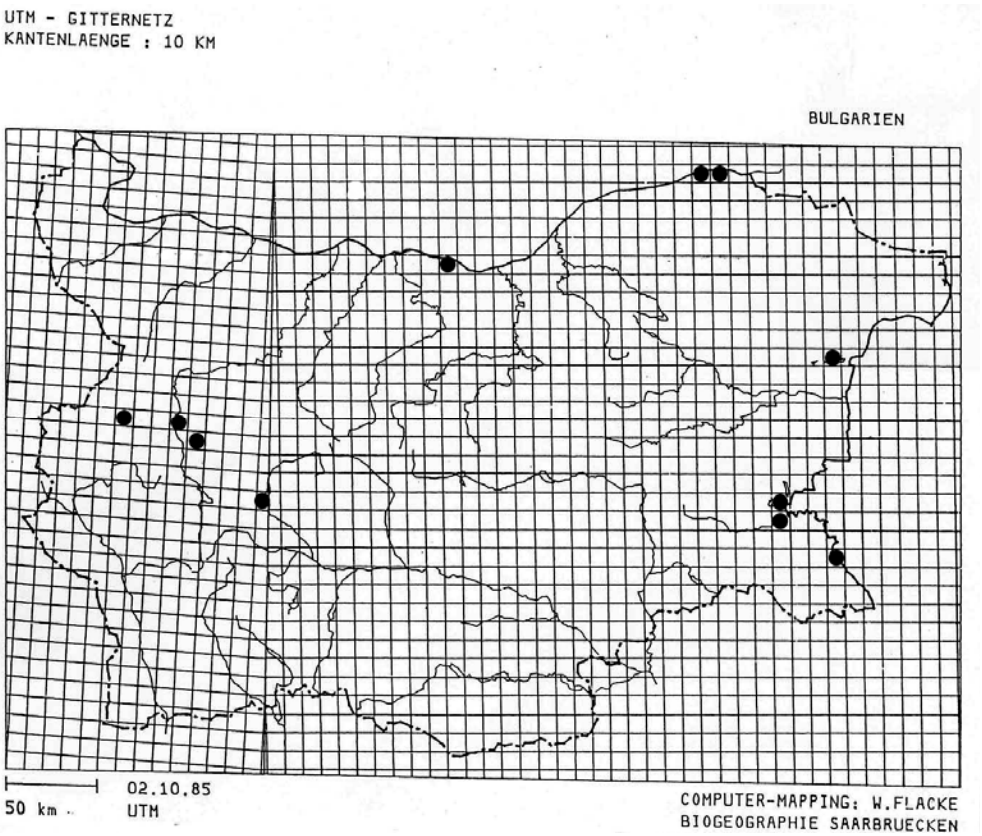


*Figure 1*: Breeding distribution of the Red-necked Grebe in Bulgaria after Ivanov (1985).

*Table 1*. Breeding sites and number of pairs of the Red-necked Grebe in Bulgaria.

| No. | Site | No. of breeding pairs | Years |
|---|---|---|---|
| 1 | Orsoya fishpond | 1–3 | Since 1998 |
| 2 | Dragoman marsh | 0–1 | Irregularly |
| 3 | Pazardgik fishpond | 0–2 | 1999–2001 |
| 4 | Garvan marsh | 5 | Annually |
| 5 | Srebarna lake | 0–2 | Irregularly |
| 6 | Stomopolu marsh | 0–1 | Irregularly |
| 7 | Belene island marshes | 0–4 | Until 2002 |
| 8 | Kalimok fishponds | ?–10 | Regularly until 2000 |

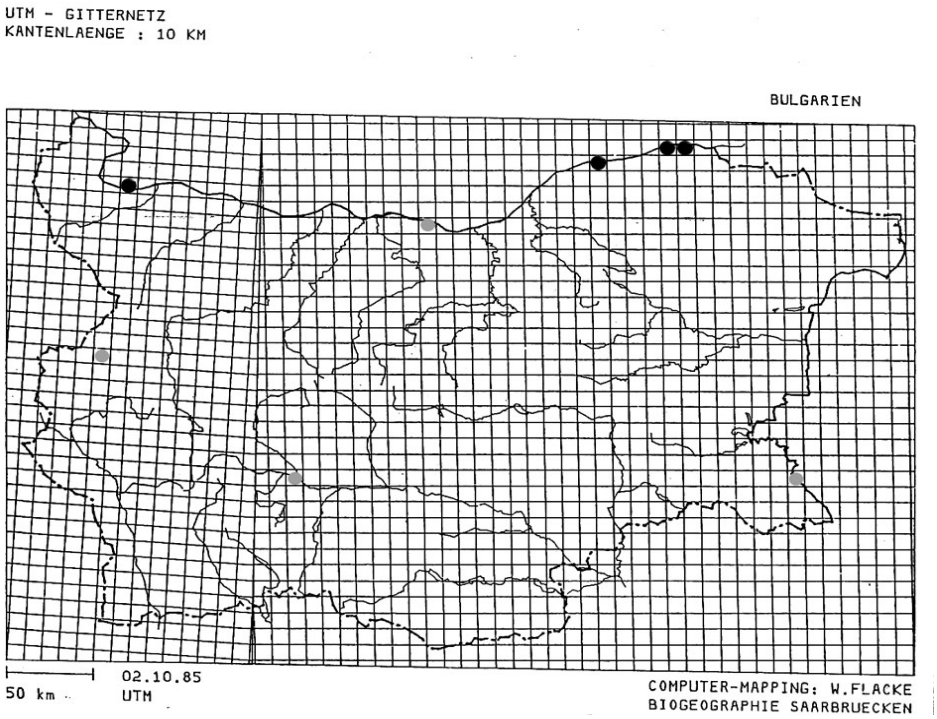


*Figure 2.* Recent breeding distribution of the Red-necked Grebe in Bulgaria up to 2003 (grey dots represent irregular or recently abandoned breeding site; black dots, regular breeding sites).

Aldomirovsko Marsh has now dried up, though in 2002 after heavy rainfall it reappeared to some extent but with scarce wetland vegetation. Only a small number of pairs breed on the degraded marshland of Belene Island. The marshes now dry out in early summer due to the lack of a direct inflow of water from the Danube, while the water level

at Kalimok fishponds is now very low and the site is overgrown by floating, submerged and emergent vegetation, such as common reed, *Phragmites australis* (Cav.), and reedmace, *Typha latifolia* (L.). Although this site previously held 15–20 pairs of breeding red-necked grebes, none were recorded in May-June 2003. The Garvan Marsh is now supplied mainly by surface water and some small springs after its former connection with the Danube River was cut off, reducing the wetland area ten fold. Its existence is therefore highly dependent on the rainfall during the year. Breeding no longer occurs at Pazardgik Fishpond due to a resumption of vegetation management. This has led to the removal of most of the floating and submerged vegetation from the basin where the species used to breed. Only isolated pairs breed at Stomopolu and Dragoman Marsh. At Srebarna Lake, following the restoration of the water level, up to 2 pairs have been recorded. These were however registered when the shallow areas close to the shoreline started to overgrow with *Rorippa palustris* (L.) and *Oenanthe aquatica* (L.).

*Breeding site characteristics*

The average depth of the wetlands occupied by red-necked grebes was 0.76 m ($n$ = 8), varying from 0.4 to 1.5 m. Reedbed coverage varied from 35 to 85% of the whole wetland area, whilst open water made up just 5 to 25%, the remainder comprising floating and emergent vegetation. The average Secchi transparency of red-necked grebe breeding sites was 0.61 m ($n$ = 8, range 0.4–0.9 m, which is typical for eutrophic to hypertrophic wetlands. All breeding sites were of either alkaline or neutral pH (Kochev and Jordanov 1981) and all were in advanced stages of vegetative succession. Floating vegetation included *Nymphoides peltata* (L.), *Trapa natans* (L.), *Hydrocharis morsus-ranae* (L.), *Persicaria amphibian* (L.), *P. hydropiper* (L.), *Ranunculus aquaticus* (L.), and *Lemna* sp. (L.). Hygrophytes, such as *Alisma plantago-aquatica* (L.), *Oenanthe* sp. (Vieillot) and *Rorippa palustris* (L.) were common — in Bulgaria these are typical plants of wetlands in the later stages of succession. Reedbed composition varied from pure *Phragmites* (Adans.) to mixed stands of *Ph. Australis* (Cav.) and *Typha angustifolia* (L.), with accompanying hygrophytic species, such as *Butomus umbelatus* (L.), *Scirpus lacustris* (L.), *Schoenoplectus triquer* (L.), and *Bolboschoenus maritimus* (L.). Submerged vegetation was characterised by *Myriophyllum* sp. (L.), *Ceratophyllum demersus* (L.), *Najas marina* (L.), and *Potamogeton* sp. (L.). All of these species are typical of shallow neutral or alkaline marshes and wetlands (Kochev and Jordanov 1981).

## Discussion

The red-necked grebe is known to inhabit smaller, shallower and considerably more vegetated wetlands than great crested grebe, *Podiceps cristatus* (Skäggdopping), (Cramp and Simmons 1977). In Bulgaria, the species inhabits highly overgrown eutrophic marshes and fishponds with unstable water levels. Red-necked grebes usually appear in new wetlands when they start to be invaded by floating vegetation. For example, the red-necked grebe first bred at Orsoya Fishpond in 1998 when *Nymphoides peltata* and other floating vegetation had almost completely covered the water surface and *Rorippa palustris* and *Buttomus umbelatus* had appeared in the basins. The water level in the basins also dropped

significantly to 0.5–0.6 m. Similarly, the red-necked grebe started to breed at Pazardgik Fishpond in 2000–2001 after the basins started to overgrow with floating vegetation and bottom-rooted hygrophytes, including *Rorippa palustris, Oenanthe* sp. In 2002, no birds bred after the water surface was cleared of floating vegetation. The red-necked grebe probably prefers wetlands overgrown with vegetation as this provides it with its preferred diet, over 50% of which consists of invertebrate food (e.g. Kloskowski 2000). Wetlands covered by submerged and floating vegetation provide excellent conditions for the development of invertebrates.

Kloskowski (2003) suggest that the species is not able to assess appropriately the food availability and resources; this gives a lot of ground for speculating that the habitat structural features are the cue for the selection of a given wetland for breeding site. Studies for some species like shrub and steppe birds have indicated that habitat choice is based on physiognomy characteristics and that it is hierarchical process in which different cues are used in the process (Cody 1985). The records about the appearance or disappearance of the Red-necked Grebe in and from various wetlands in Bulgaria suggest some definite preference for the marsh vegetation formation structure and composition.

## Conclusions

The red-necked grebe breeding population in Bulgaria has declined by 20–50% in recent years to an estimated 10–30 pairs scattered over eight wetlands, the most important of which are located along the Danube River. The main causes of this decline have been habitat loss and degradation.

Conservation measures for the red-necked grebe in Bulgaria need to be species-specific and targeted at a small number of wetlands which are in the later stages of succession. These will need active management to be sustained in their current successional stage. Extensive fishponds start to overgrow because they are abandoned or mismanaged. If they are operated economically, they are managed to have little floating or emergent vegetation. In contrast, natural marshes are not managed in any way.

With its tendency for inhabiting wetlands advanced in their succession, often with distorted water regimes, the red-necked grebe's occurrence is may actually be a sign of alarm. The appearance of the species should be a sign of the need for immediate habitat management activities to prevent further succession of the wetland.

Compared to the other grebe species breeding in Bulgaria, the red-necked grebe prefers similar habitat to the rare black-necked grebe, *Podiceps nigricollis* (Brehm). The other two species of grebes: great crested grebe, and little grebe, *Tachybaptus ruficollis* (Pallas), occupy a much wider range of habitat, from sites with much open water and small reed fringes to heavily overgrown wetlands and temporal marshes. Wetlands occupied by red-necked grebes also support other rare and endangered species for Bulgaria: ferruginous duck, *Aythya nyroca* (Guldenstadt); gadwall, *Anas strepera* (L.); pochard, *Aythya farina* (L.); and whiskered tern, *Chlidonias hybrida* (Pallas). Moreover, many marsh plants in these wetlands are also rare and listed in the Plant Red Data Book. Management activities at red-necked grebe breeding sites need to prevent further vegetative succession whilst sustaining the rich diversity of the wetland ecosystem. This is a challenging task as there is limited experience of wetland management in Bulgaria and the management authorities are

not yet well developed.

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# The evaluation of some key wetlands for waterfowl in central Anatolia, Turkey

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## Abstract

The breeding populations of many bird species across Europe has been declining for over 30 years. The extent of these declines in Turkey is still unknown. This study reviews work conducted from 1998 to 2001 in five different wetlands of national and/or international importance within the Central Anatolia region of Turkey. Comparisons of breeding and wintering population sizes were examined for species that are listed as threatened in Europe. The necessity of protecting Turkey's wetlands is discussed.

# Present waterbird status in St. Martin's Island with their potential conservation measures

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## Abstract

St. Martin Island, also known as Narikel Jinjira, is a small island in the north-eastern part of the Bay of Bengal, about 10 km south of Cox's Bazar-Teknaf peninsular tip. It forms the southernmost tip of Bangladesh, and it contains some of the most unique, but thus far not studied, benthic community associations in Bangladesh. It is about 8 km off the west coast of Myanmar and lies exactly on the mouth of the river Naaf situated roughly between 20°34'–20°38.3'N and 92°18.2'–92°20.8'E. Comprehensive population studies on waterbirds were conducted in this island between March 2002–February 2003 and covered all kind of macrohabitats such as sandy beaches, rocky beaches, tidal mudflats, ponds, lakes, lagoons and mangrove swamps. A total of 71 waterbird species was recorded in this study. Of this 71 species, 14.08% were egrets and herons, 4.23% ducks, 15.49% terns and gulls, 7.04% from the family Rallidae and 43.66% other shorebirds. Subtidal habitats of this island support highly productive and diverse algal/sea grass beds. All ten species of seaweed in Bangladesh's territorial waters are only found around this island. Bird populations on St. Martin Island have declined over the last few years, particularly those of gulls, ducks, herons and egrets, terns and shorebirds. The loss of wilderness areas could be attributed to expansion of agriculture land and increase of human inhabitation on one hand and easy access of local tourists to this island on the other. The continuation of mainlanders purchasing land on the island and developing it for the tourism industry is alarming. Further movement of people along the beach creates disturbances to the waterbirds. There is an urgent need for continuous population monitoring in order to conserve the tremendous Ganges Delta that supports a significant number of migratory shorebirds. Several invertebrate food items for waterbirds inhabit the intertidal and subtidal zones of the beach. Some of them are overexploited and are thus already in an alarming state of decline. Eventually any deficit or extinction of prey species will inevitably disrupt or break the food chain, adversely affecting, directly or indirectly, the aquatic and terrestrial forms. Creation of public awareness should be initiated. A mini-sanctuary should be announced and developed on an urgent basis.

# Space and time pattern of the distribution of cormorants and grey herons in Hungary

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## Abstract

The Hungarian Waterfowl Monitoring (HWM) program, in operation since 1996, covers 51 species of waterbirds. The census is conducted on the Saturday closest to the 15$^{th}$ of every month, in accordance with Wetlands International's days of synchrony. The surveys take place every month for nine months, from August to April inclusively. The observations take place in 23 districts, each containing from two to six areas, for a total of 49 observation units in the HWM. The cormorant (*Phalacrocorax carbo*) and the grey heron (*Ardea cinerea*), as fish-eating birds significant to commercial fisheries, were included in the group of monitored species. Annual peak values of cormorants in Hungary showed a significant increase between 1996 and 1999, with a subsequent stabilization of the population. Long term dynamics showed a modest decrease based on the numbers counted in each month during the investigation. Annual peak values of grey herons in Hungary showed a slight increase. Long term dynamics showed a stable trend based on the numbers counted in each month during the investigation.

## Introduction

Because of the feeding habits of some members of the Hungarian bird fauna, there are or may be conflicts between commercial fisheries and nature conservation. With respect to body size and population levels, two potential "conflict species" can be identified, namely the cormorant, *Phalacrocorax carbo* (L.), and the grey heron, *Ardea cinerea* (L.).
The cormorant was a protected species in Hungary until 1987, with a nominal value of 1000 HUF (= 4 USD). Following an increase in population levels, this protection was abolished with the decree of 8/1993 FM., which allowed cormorant hunting year-round. In the 30/1997 FM. decree, the cormorant was not included in the list of animal species that could be hunted. The law no longer considered it a game species, but there was also no provision for its protection. Consequently, cormorants were added to the group of species of insecure status. It is now included in the Decree of 13/2001 KÖM, in accordance with Appendix 1 of the EU Bird Directives, with a nominal value of 1000 HUF.

The grey heron has always been a protected species in Hungary. Its nominal value of 100 HUF was raised to 10,000 HUF (= 40 USD) in 1993, where it remains until today. According to the decree of 1/1982, it was permitted to kill grey herons at artificial fishponds year-round, but since the decree of 11/2001 KÖM, grey herons have enjoyed full protection. However, as population trends show, control measures at artificial fish ponds did not endanger breeding populations. Nesting colonies have always been protected, even under former regulations.

Today there are clear legal regulations that cover both species. However, their feeding ecology still generates conflicts which have not yet been satisfactorily explored, particularly the qualitative and therefore economical aspects. Our research aims to define the status of these two species under today's environmental and regulatory conditions. We intend to reach this goal by a precise determination and description of their population trends.

## Materials and Methods

In 1996, surveys were conducted on a monthly basis, for six months between October and March. From 1997 onwards, surveys ran from August to April inclusively (nine months) in the framework of the HUNGARIAN WATERFOWL MONITORING (henceforth HWM) (Faragó 1998a; Faragó and Kerekes, *this volume*). Surveys were conducted on the weekend closest to the 15$^{th}$ of each month, in accordance with international conventions on synchrony. Surveys took place in 23 districts, each containing 2–6 areas. Hence the HWM was conducted in 49 observation units. HWM sites are represented on Figure 1, and Table 1 lists the types of waterbodies surveyed. The waters are all eutrophic of hypertrophic based on total phosphorus concentrations according the OECD trophic classification system (Vollenweider and Kerekes 1980). The HWM covers 51 species. The cormorant and the grey heron as fish eating birds were included in the group of species monitored because of their significance to commercial fisheries. The fish consumed by cormorants in Hungary is discussed by Faragó et al. (*this volume*)

For each species, we determined local and national population sizes, as well as national maximum and minimum numbers during each observation period. We also evaluated within-season national population trends for each species. In this way, the HWM could satisfy demands to provide information at the national, regional and local levels. Finally, we assessed the significance of each survey area on the basis of Ramsar Criterion 6 (previously 3C), which says that "A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird." Relevant numerical data come from Rose and Scott (1997) and Wetlands International (2002).

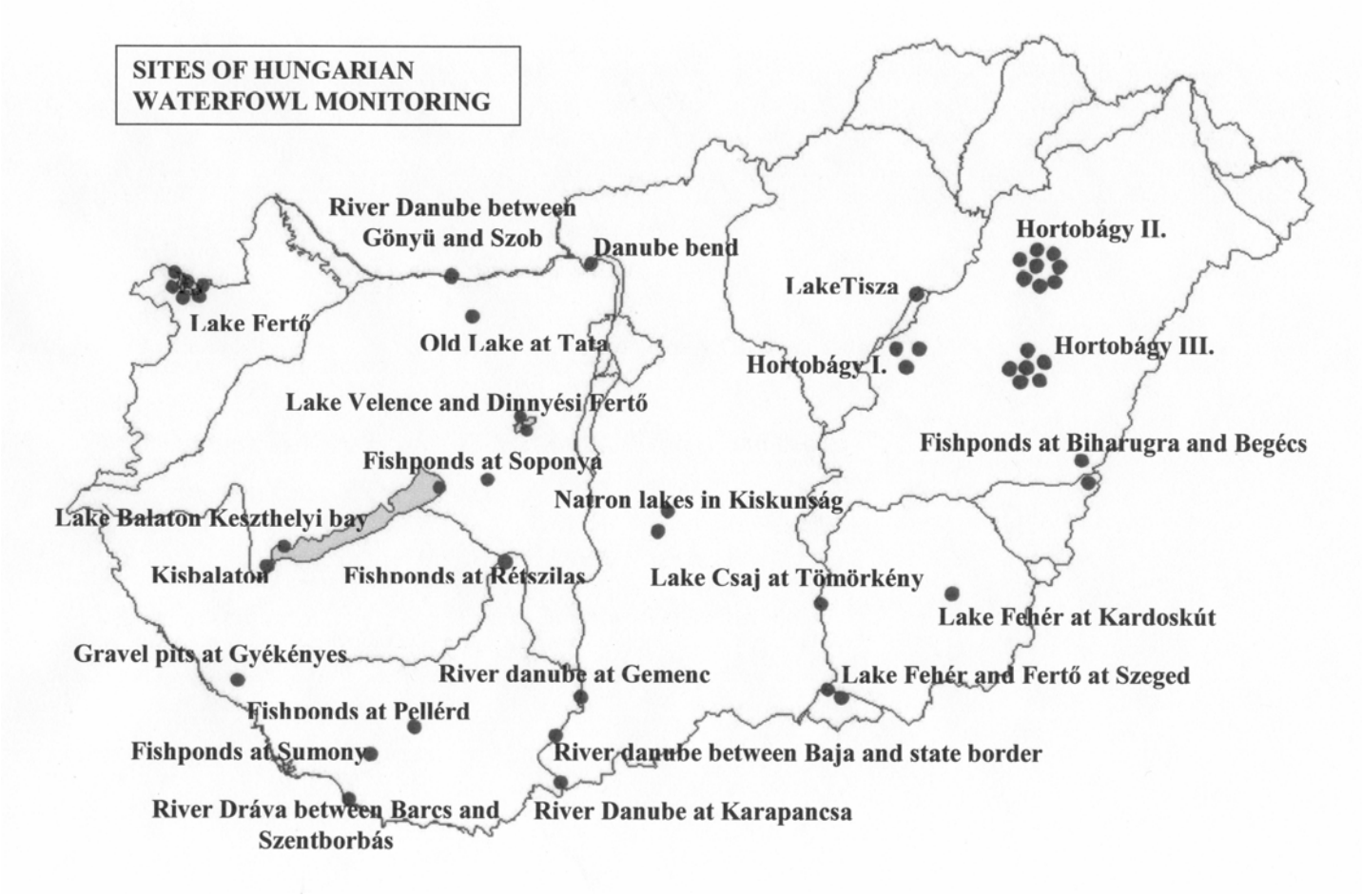


*Figure 1*. Sites of Hungarian Waterfowl Monitoring

*Table 1.* Waterbody types of the Hungarian Waterfowl Monitoring (HWM).

| Waterbody Type | No. of sites | Area (ha) |
|---|---|---|
| Natural and semi-natural wetland habitats | | |
| Rivers | 4 | 10 838 |
| Freshwater lakes (permanent) | 2 | 5 530 |
| Saline lakes (permanent | 7 | 1 918 |
| Saline lakes (intermittent) | 2 | 820 |
| Freshwater marshes (permanent) | 5 | 12 415 |
| Freshwater marshes (intermittent) | 6 | 18 890 |
| Man-made wetland habitats | | |
| Fishponds | 19 | 12 735 |
| Reservoirs | 2 | 3 450 |
| Gravel pits | 1 | 173 |
| Total | 49 | 66 766 |

## Results

*Cormorant*

Over the entire period of the HWM, the annual maximal values were 4876 birds in December 1996 (Faragó 1998b), 6038 birds in October 1997 (Faragó 1999), 7029 birds in October 1998 (Faragó 2001), 6845 birds in October 1999 (Faragó and Gosztonyi 2002), 7131 birds in November 2000 (Faragó 2002), 6870 birds in October 2001 (Faragó and Gosztonyi 2003), and 6826 birds in October 2002 (Faragó and Gosztonyi 2004). The trend of annual peak numbers shows a significant increase between 1996 and 1999, and stable numbers between 1999 and 2003 (Figure 2). Long term dynamics show a modest decrease based on the number of birds counted monthly during each season (Figure 3).

The spatial distribution of cormorants in the 2000/2001 season, showing the maximum number of individuals surveyed each month, can be seen in Figure 4.

Cormorant population trends in each survey area are the following. We found decreasing trends at the fishponds at Soponya, the River Dráva between Barcs and Szenthborbas, the fishponds at Sumony, the reach of the River Danube between Baja and the state border, the natron lakes in Kiskunság, the third (III) area of Hortobágy, and the fishponds at Biharugra and Begécs. We found modestly decreasing trends at Lake Fertő, the reach of the River Danube between Gönyű and Szob, Dinnyési Fertő, Lake Balaton, Keszthelyi-bay, fishponds at Pellérd, and Lake Csaj at Tömörkény. We found stable trends at Lake Velence and at the Danube bend, and we found modestly increasing trends at the Old Lake at Tata, Kisbalaton, Lake Fehér and Fertő at Szeged. Finally, we found increasing trends at the fishponds at Rétszilas, the Gravel Pits at Gyékényes, and the first (I) and second (II) areas of Hortobágy.

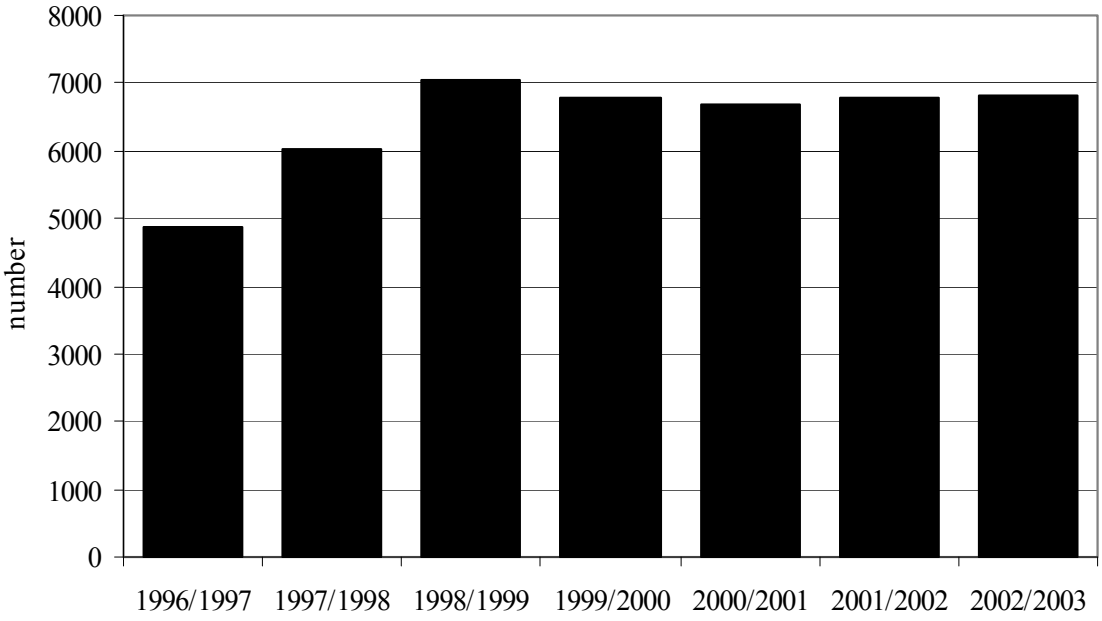


*Figure 2.* Seasonally maximum numbers of cormorants in Hungary.

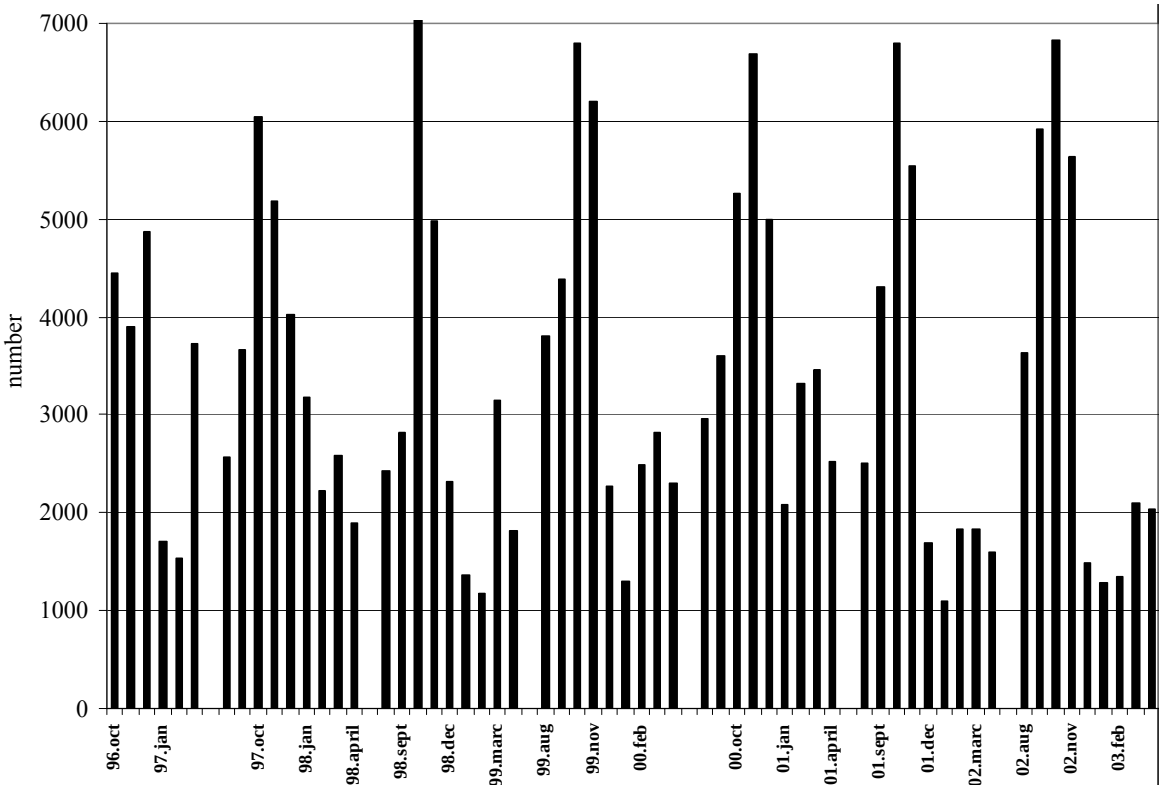


*Figure 3.* Long term dynamics of cormorants in Hungary, 1996–2003.

*Grey heron*

Over the entire period of the HWM, the annual maximal values were 1350 birds in October 1996 (Faragó 1998b), 1415 birds in October 1997 (Faragó 1999), 1352 birds in October 1998 (Faragó 2001), 1719 birds in August 1999 (Faragó and Gosztonyi 2002), 1888 birds in October 2000 (Faragó 2002), 1323 birds in October 2001 (Faragó and Gosztonyi 2003),

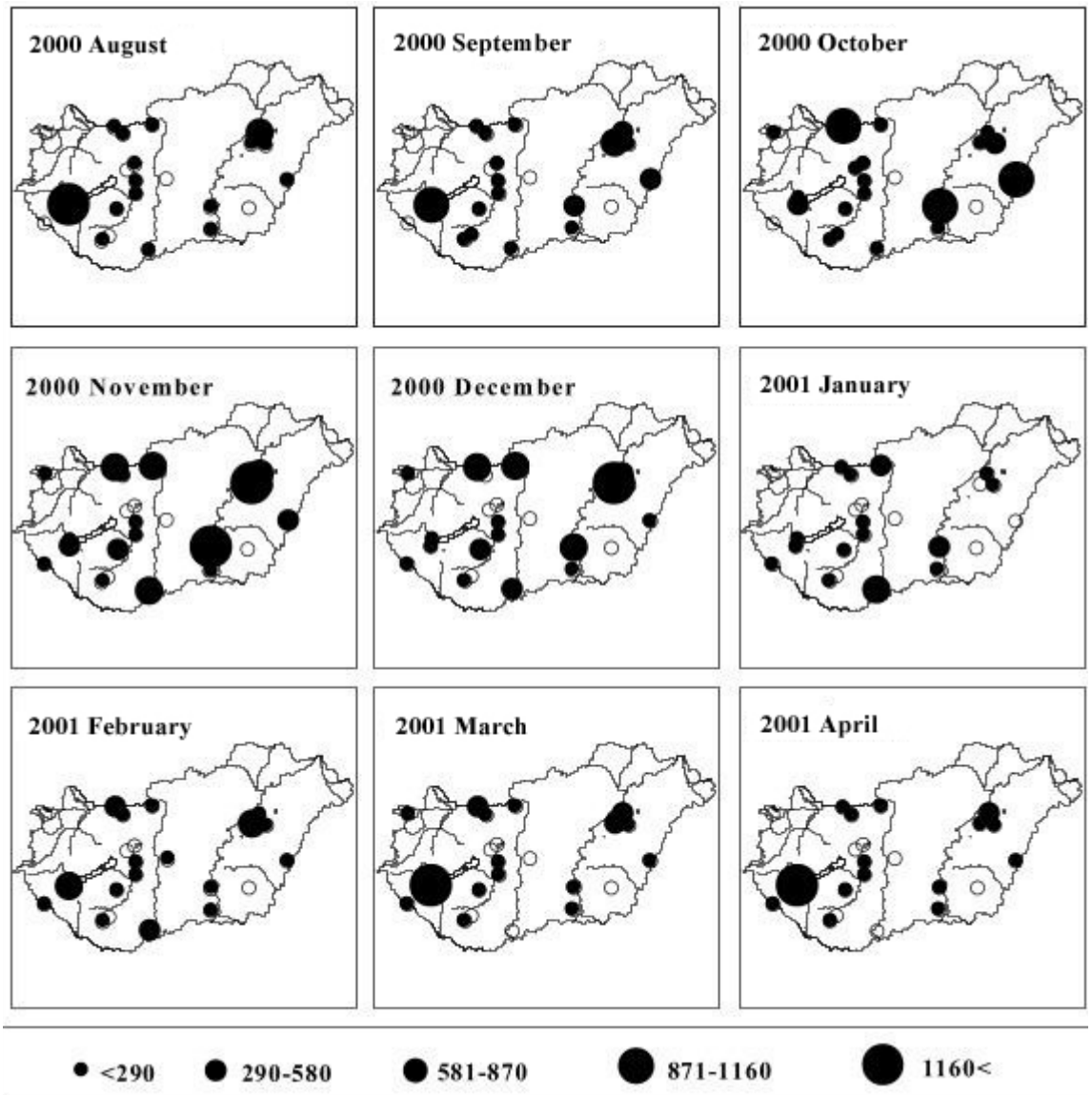


*Figure 4.* Monthly distribution pattern of cormorants in Hungary, 2000–2001.

and 1405 birds in November 2002 (Faragó and Gosztonyi 2004). The overall trend of annual peak values shows a slight increase (Figure 5). Long term dynamics show stable trends based on the numbers counted monthly during each season (Figure 6). The spatial

distribution of grey herons in the 2000/2001 season, showing the maximum number of individuals surveyed each month, can be seen in Figure 7.

Grey heron population trends in each survey area are the following. We found decreasing trends at the River Dráva between Barcs and Szenthborbas, the reach of the River Danube between Baja and the state border, the third (III) area of Hortobágy, and the Lake Csaj at Tömörkény. We found modestly decreasing trends at the Old Lake at Tata, Dinnyési Fertő, the fishponds at Soponya, the fishponds at Pellérd, the first (I) area of Hortobágy, and Lake Fehér and Fertő at Szeged. We found stable trends at Lake Fertő, the reach of the River Danube between Gönyű and Szob, the fishponds at Sumony, the Natron Lakes of the Kiskunság, and Lake Fehér at Kardoskút. We found modestly increasing trends at Lake Velence, the Gravel Pits at Gyékényes, the Danube bend, and the third (II) area of Hortobágy. And finally, we found increasing trends at the fishponds at Rétszilas, Kisbalaton, and the fishponds at Biharugra and Begécs.

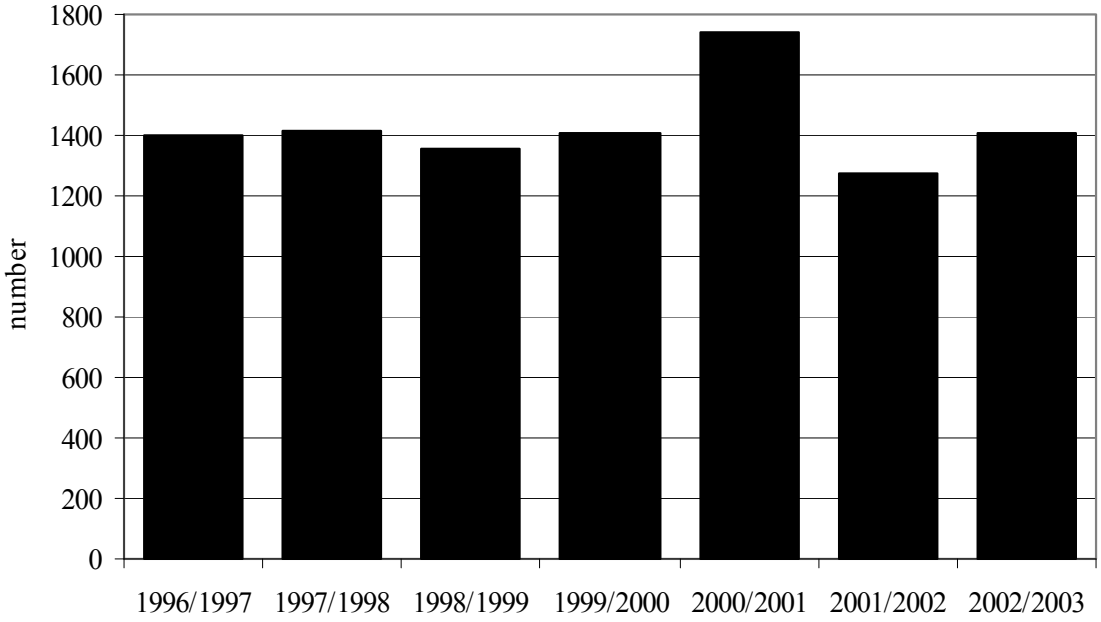


*Figure 5*. Seasonally maximum numbers of grey herons in Hungary.

## Discussion

Rose and Scott (1997) estimated the size of the Northern and Central European population of *Phalacrocorax carbo sinensis* (Blumenbach) to 200,000 individuals, and the population of the Black Sea and the Mediterranean to an additional 100,000 individuals. On the basis of these data, the European stock of the *P. c. sinensis* numbers 300,000 individuals. According to another estimate (Tucker and Heath 1994), the European population of the species numbers at a minimum of 140,000 pairs. According to recent data (Wetlands International 2002), the Northern and Central European cormorant population numbers between 275,000 and 340,000 individuals, and that of the Black Sea and the Mediterranean

between 130,000 and 160,000 individuals. This would give a total of 405,000 to 500,000 individuals for the European population. The European cormorant population has been increasing since the beginning of the 1970s. A slight and regional increase characterizes the subspecies *P. c. carbo* (L.), and a massive increase can be observed in case of the *P. c. sinensis*. The cormorant populations of Central and Northern Europe increased from the 15,000 breeding pairs registered in 1981/1982 (28 nesting colonies) to the 81,000 breeding pairs of 1992 (170 nesting colonies) (Marion et al. in Hagemeijer and Blair 1997). Today they number between 134,000 and 166,000 pairs (Wetlands International 2002). This increase can be explained with complex reasons such as nesting and feeding habitat, increased of food supply, and the reduced or eliminated use of chlorinated hydrocarbons (DDT, HCH). Breeding in Hungary was previously hardly known. The first breeding attempt (10 pairs) took place at Kisbalaton in 1947 (Keve 1973). Until the mid 1970's, this was the only nesting site that existed in Hungary. Since that time, the nesting population has greatly increased. In the mid 1980's, the nesting population was estimated to number 1700 pairs, and in the beginning of the 1990's, the estimate was as high as 3,000 pairs. In 1996 there were 1,740 nesting pairs in Hungary (Lőrincz in Haraszthy 1998). A similar value (1700–1800 pairs) is given in Magyar et al. (1998).

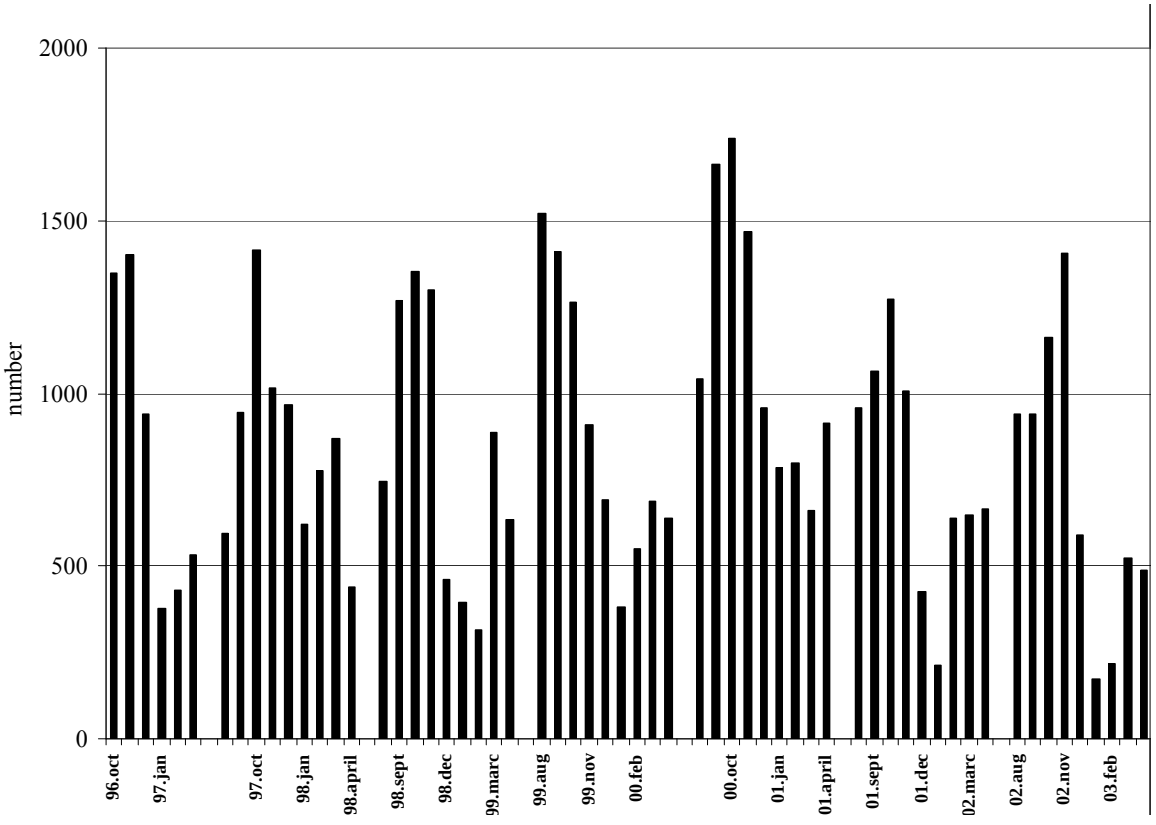


*Figure 6.* Long term dynamics of grey herons in Hungary, 1996–2003.

The 1% population threshold of Ramsar 6 (formerly 3C) was previously 2000 individuals for cormorants (Rose and Scott 1997). During the 1996/1997 season, all survey

areas had fewer than 2000 individuals, and therefore none of these could be considered internationally significant. However, during the 1997/1998 season at the reach of the River Danube between Gönyű and Szob (October: 2271 birds), the 1998/1999 season at Kisbalaton (October: 2530 birds), and the 1999/2000 season at the reach of the River Danube between Gönyű and Szob (October: 2038 birds), cormorant numbers were sufficiently high for these areas to be considered of international significance. During the 2000/2001 season, all survey areas had fewer than 2000 individuals, and therefore none of these could be considered internationally significant. However, during the 2001/2002 season at Kisbalaton (September: 2581 birds; October: 2540 birds), and the 2002/2003 season at Kisbalaton (September: 2728 birds; October: 2034 birds) and the northern (I) areas of the Hortobágy (October: 2350 birds), numbers exceeded the criterion level of 1%, and these areas could be considered of international significance. In the light of recent stock conditions, the 1% population threshold was raised to 3,100 individuals. Taking this into account, we can state that there are no wetland areas in Hungary that are internationally significant because of the cormorant.

The European and Northern African nesting populations of the *A. c. cinerea* (L.) was estimated to number between 400,000 and 500,000 individuals, and the trend of population size was defined as increasing. The breeding population of the Eastern basin of the Mediterranean and W-SW Asia were estimated to number between 10,000 and 100,000 pairs (Rose and Scott 1997). Two other authors give an estimate of 130,000 pairs (Tucker and Heath 1994) and 150,000 pairs (Knief et al. in Hagemeijer and Blair 1997) for the European grey heron population size. According to recent data, the Western European and Northwestern African breeding population numbers between 263,000 and 286,000 birds, and the Central and Eastern European population consists of 189,000 to 256,000 individuals. If we sum up these data, we get a total number of 452,000–542,000 individuals for the European grey heron population (Wetlands International 2002). According to a 1951 survey, *A. cinerea* is the most common species of heron in Hungary. Its population was estimated to number 982 pairs (Szíjj 1954) in the 1950's, while the total population is now estimated to be twice as many, approximately 1900 pairs (Molnár in Haraszthy 1998). During surveys conducted in 70 colonies between 1976 and 1982, the size of the breeding population varied between 600 and 1200 pairs. The 1996 breeding population was estimated at 1760 pairs (Molnár in Haraszthy 1998). Today, the breeding population is estimated to be between 1600 and 1900 nesting pairs (Magyar et al. 1988). Taking into account natural population fluctuations, the breeding population has been practically stable for the past 40 years.

The 1% population threshold of the Ramsar 6 criterion (formerly 3C) was previously 4500 individuals (Rose and Scott 1997). None of the Hungarian survey areas satisfied this criterion, and therefore of them could be considered internationally significant. In light of recent population changes (the Western European breeding populations were separated from their Central and Eastern European counterparts), the 1% population threshold was decreased to 2200 individuals. In spite of this decrease of more than 50% of the population threshold, there is no wetland area in Hungary that is internationally significant because of the grey heron, since even the total national number does not reach the threshold of 2200 individuals (max: 1888 birds in October 2000).

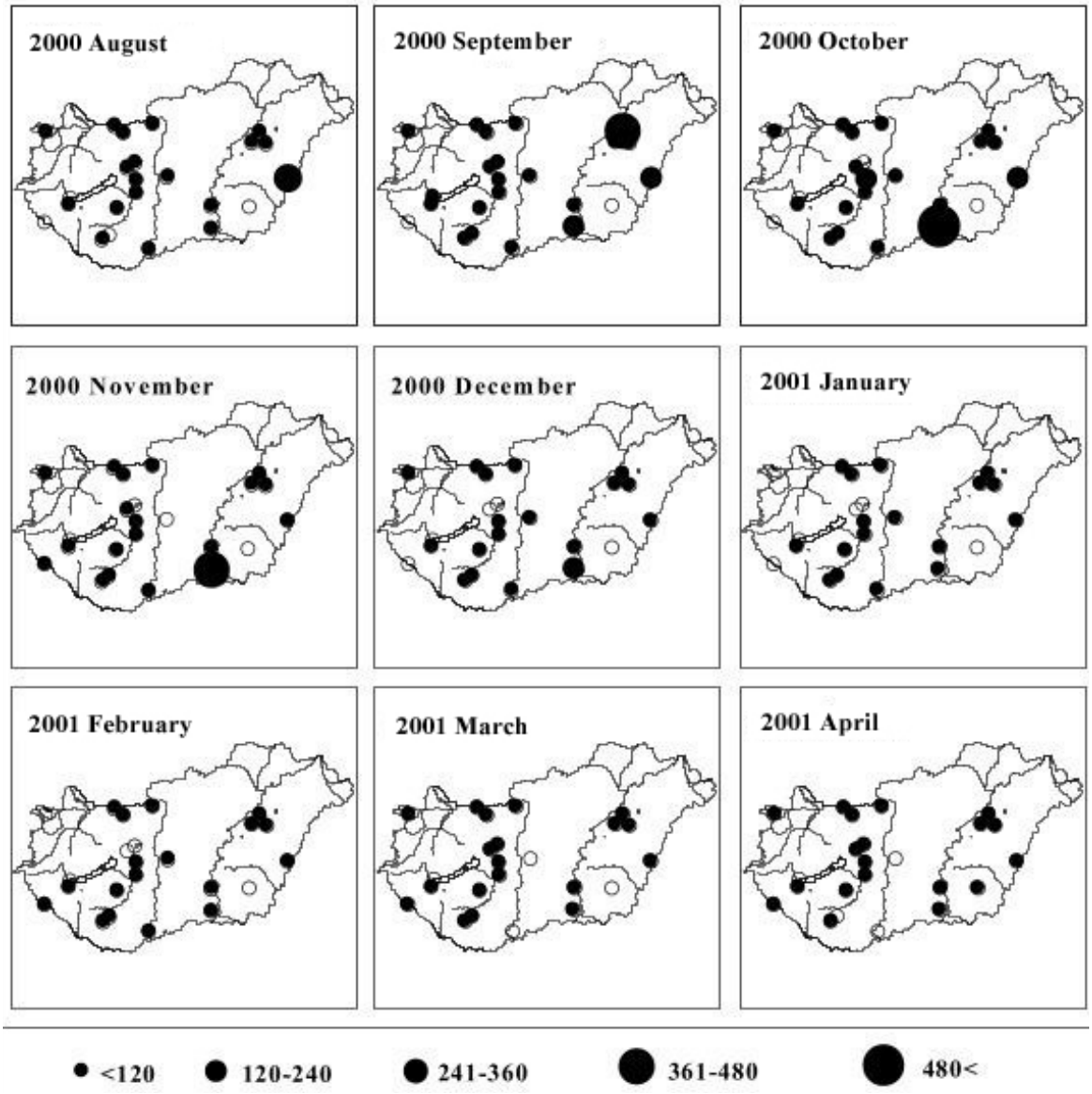


*Figure 7.* The spatial distribution of grey herons in the 2000/2001 season, showing the maximum number of individuals surveyed each month.

**Acknowledgments**

We would like to express our gratitude to every observer of the HWM, who supported our Monitoring with his/her work. We are also grateful to Balázs Hóber for his help with the preparation of the maps. HWM is supported by the Department of Game Management and Fishery of the Ministry of Agriculture and Regional Development and the Office of Nature Conservation of the Ministry of Environment and Water in Hungary.

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# Rapid increase in the Lower Great Lakes population of feral Mute Swans: a review and recommendations

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## Abstract

Mute swans (*Cygnus olor*) are an exotic species whose population has increased throughout the lower Great Lakes since their introduction during the mid-twentieth century. We used 3 independent data sources to estimate the rate of increase of mute swans on the lower Great Lakes: aerial surveys in spring and autumn at Long Point, Lake Erie, Ontario, Canada 1971–2000; mid-winter waterfowl inventory of the north shore of Lake Ontario, 1980–2000; and Christmas Bird Counts on both the United States and Canadian shores of the lakes, 1980–2000. The average estimated population growth rate varied from 10–18% per year. The most conservative growth rate estimate of 10% per year indicates a doubling of the mute swan population every 7–8 years. These high growth rates indicate that mute swans have found a favourable environment in the lower Great Lakes. It is climatically somewhat similar to their native range in Europe, with low natural predation rates and minimal human interference (they are legally protected in Canada and the United States under the Migratory Birds Convention, 1916). If the carrying capacity of the lower Great Lakes for mute swans is similar to portions of the species' native European range and growth rates continue, the Canadian population could reach as many as 30,000 birds within 30 years. Given that the species is non native, and its ecological impact potentially could be large, we suggest control measures be implemented before the population grows much larger

# Recolonization of waterbirds after wetland rehabilitation (Hortobágy National Park, Hungary)

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## Abstract

The rehabilitation of the Egyek-Pusztakócs Marshes (Hortobágy National Park) was started in 1976 and was carried out in four phases. In 1997 the water supply system was completed, and the marshes were filled with water. Studies of the recolonization processes and of the rehabilitation of these marshes were conducted to give new guidelines for nature conservation management and rehabilitation projects. Based on these experiments, proposals for the rehabilitation of other marshes (Meggyes-lapos, Fekete-rét) were prepared. During this study, the implemented wetland rehabilitation plan was evaluated by monitoring water quality, flora transitions, and recolonization by waterbirds. From this, the authors obtained valuable information which will serve to improve nature conservation management methods and work out a limnological conservation approach. Results show that communities possessing a mosaic-like structure show a greater diversity due to a phenomenon called "internal edge effect". The mosaic communities responded the most favourably to the rapid changes following rehabilitation. On the basis of the avian recolonization process study results, we tried to show the species composition changes in waterbird communities, tendencies, and causalities. This paper presents the most important limnological and ornithological results of the Egyek-Pusztakócs marsh rehabilitation study.

## Introduction

Temperate-zone ecological systems never collapse in a disastrous way, but undergo continuous changes that produce states of new properties and composition of species (Mühlenberg et al. 1991). These often undetectable, or at least not obvious, changes usually lead to serious habitat degradation.

Moyle and Leidy (1992) showed that aquatic ecological systems have lost much of their diversity, yet this fact has been paid little attention. Sala et al. (2000) showed that the biodiversity of freshwater systems have probably been degrading more rapidly than any terrestrial systems, even including those that have been hit by environmental impacts.

Seitz (1994) thinks that the most stable systems are the moderately complex — temporally and spatially differentiated — ones. This stability is to be defined as homeostasis. Important consequences of nature conservation treatments are when large residual spots are preserved and we are to concentrate on internal effects. In the case of small residual areas the basic issue of treatment lies in the control of external influences (Saunders et al. 1991).

Consequently, any effort should be made to preserve remaining wetlands, and to recover damaged ones, if possible. The results of this study intended to contribute to this task. In order to interpret the structural and functional properties of the wetlands examined in this study, some suggestions have been made to conceive a few ecological principles that we have regarded as crucial in this context, and we use the obtained results in nature conservation treatments and regional rehabilitation.

The results of the research not only try to be applicable in the investigation area, but also attempt to contribute to the long-term nature conservation treatment of similar wetlands and provide new information.

## Materials and methods

*The investigated area*

The 40,730-hectare Egyek-Pusztakócs Marsh System (47°34'N, 20°55'E) is situated in the administrative circumference of the settlements of Tiszafüred and Egyek; its southern edge is crossed by the main road no. 33, which is only coursed by Sarkad Stream. Its altitude exceeds the 88–92-m height above sea level — typical of the Hortobágy region. It has belonged to the Hortobágy National Park since 1973. Fekete-rét, Jusztus-mocsár and Hagymás-lapos are also preserved by the Ramsar Convention as wetlands of international importance (Gőri 2001).

In the region of the Egyek-Pusztakócsi Marshes, the most typical wetland types and plant associations of Hortobágy are concentrated in a relatively small area. The landscape is segmented by belt shallows that have been built by the River Tisza, and its tributaries are strikingly different from that of the Hortobágy plain, the “puszta”. The region is variegated by mosaiced meadows of terraced, soaked saline associations, marshes bordered by dry saline grasslands, bare spots, loess grass remnants and small woody sites. Gentle or abrupt ridges surround saline marshes. The southeastern waterfront of Meggyes runs away in saline grasses spotted with natural saline lands. Villongó and Tarhos offer diverse landscapes with highly terraced saline grasses, ridge vegetation, and natural saline spots in the southeastern edge. Only the tiny loess grass fragments resemble the saline grasslands of Hortobágy.

Considerable areas of the marshes are covered with reed stands (*Scirpo-Phramitetum* /reed community). The reed stocks mixed with narrow-leaved and common cattails, *Typha angustifolia* (L.), *T. latifolia* (L.), bog rushes, *Schoenoplectus lacustris* (L.), are especially valuable. Extensive reed stands are also present in Fekete-rétet and in the area of Meggyes-lapos, yet small spots can be found on all the marshes.

The hydrobiological rehabilitation of the marshes started in 1976, and continued in 1981–82 in Fekete-rét; later, in 1996–97 the flooding channel system threading Bőgő-

lapos, Kis-Jusztus, Meggyes, Hagymás and Csattag was completed.

*Meggyes-lapos*

This is a region 1700 m in length, 500 m at its widest point, and with an area of 70 ha. The valley of Meggyes-lapos has north to south orientation, and the basin is bordered by a series of relatively high belt shallows in the Hortobágy environment, which undoubtedly proves that the region was shaped by the river. In the middle segment of the bed, the level differences are considerable, exceeding three meters in some locations.

Before the rehabilitation, the marsh bed could be filled in exceptionally rainy periods, yet in these cases the water level was over one meter at the deepest points. In the northern part of the marsh, an extensive tussock habitat with a field of foxtails has survived where the species of saline meadows and saline marshes intermingle.

To the west of the marsh, there are two significantly smaller (5 ha both) piece of land extending north to south, as divided by a series of parallel zone of shallows, which — for the sake of simplicity — have been named Meggyes-I and Meggyes-II from the east to the west. These lands no longer receive water supply, their water solely originates from the rainwater arriving from the local catchment areas. In spring, they have considerable water cover, yet usually dry out by the end of summer.

To evaluate the rearrangement of the vegetation as an effect of rehabilitation, a botanical survey on Meggyes-lapos was carried out (aerial photographs, transects) in the first year of its fill-up (1997). The results can have long-term significance in revealing the causes of later changes.

*Investigations of the avifauna*

The effectiveness of the rehabilitative interventions was evaluated on the basis of impacts on avifauna, tracing the recolonization of the area, as well as in comparisons between the nesting bird communities of the rehabilitated areas with those of the various wetlands in Hortobágy. The related studies took place in 1991–2001, as a continuation of the research that documented the full-scale impacts of rehabilitation of the Egyek-Pusztakócs Marshes, and helped detected the effectiveness of the interventions.

The applied method, which is the evaluation of wetlands through avifaunal diversity, is a device often used in this field of studies (Cable et al. 1989, Anselin et al. 1989). In the nesting period, ornithological–faunistical information was collected from the entire area on a weekly basis, by surveying the marshes. The lists of species were compiled based on the individuals seen and heard during field surveys. Individuals flying or feeding over the area were also recorded. The observations were supported with 10×40 binoculars and scopes (32×, 50×).

## Results

*Rehabilitation implementation*

The rehabilitation of Egyek-Pusztakócs Marshes was started in 1976 with the construction of the water-supply channel on the low-lying Fekete-rét, part of the area having preserved the most numerous and diverse marshy characteristics. The water-supply channel connects the marsh to River Tisza via Main Channel West, creating conditions that resemble the flood periods before the river regulations.

By ensuring the water supply of Meggyes-lapos, another area of the marshland having permanent water cover, (over one meter in some places) was preserved. After flooding, reactions of the avifauna were the most striking in Meggyes-lapos; the nesting bird community which was characterized by small species and small numbers in the previous years was replaced by a rich marshland nesting population. Species that prefer shallow waters appeared, and all four Hungarian grebes and three tern species started to nest in the area. The fill-up of Meggyes-lapos had a beneficial influence on the avifauna of the two smaller marshlands, as well; greylag geese, ducks and terns visited these sites to feed.

From March to September 1997, water samples were collected from some pre-selected sites of Meggyes-lapos and Meggyes-I marshes, while vegetation mapping took place in the summer.

Through the flooding system, only Meggyes-lapos could be charged, while the two smaller lands did not have connection to Meggyes-lapos and the fill channels. They just collected rainwater.

The results of the water chemistry tests clearly indicated seasonal changes, and concentration and intensification of saline properties, especially for the Meggyes-I aquatic habitat, where the measured value of conductivity reflecting salt content exceeded 3000 μS/cm (Gőri et al. 2000).

*Survey of the Meggyes vegetation in the initial phase of the rehabilitation*

In the period of the first fill-ups in 1997, Meggyes-lapos was selected for vegetation succession studies. The most remarkable changes were expected to occur there, owing to the fact that this relatively deep, semi-static marsh had attained an advanced state of degradation as a result of prolonged dry periods. In the course of repeated field surveys on Meggyes-lapos and on the two small, parallel marshes (Meggyes-I, Meggyes-II), lists of species were prepared (Table 1). The extension of the plant stands was established along the summer transects and coverage of the dominant plant communities of Meggyes I. Marsh were determined (see Table 2).

At the beginning of the Meggyes-lapos rehabilitation, the avifauna became an outstandingly valuable aspect, thus studies on the interrelations of the water supply and water quality, as well as of the nesting birds and various plant associations were given top priority.

*Table 1.* Hortobágy-Meggyes Marsh (1997. 08), list of plants.

| Plant species | **Meggyes-I** | **Meggyes-II** | **Meggyes-lapos** |
|---|---|---|---|
| *Alisma plantago-aquatica* L. | | + | + |
| *Alopecurus geniculatus* L. | + | + | |
| *Alopecurus pratensis* L. | + | + | + |
| *Agrostis stolonifera* L. | + | + | + |
| *Beckmannia eruciformis* (L.) Host | + | + | + |
| *Bolboschoenus maritimus* (L.) Palla | + | + | + |
| *Carex acutiformis* Ehrh. | + | + | + |
| *Carex riparia* Curt. | + | + | |
| *Ceratophyllum submersum* L. | + | + | + |
| *Elatine alsinastrum* L. | | + | |
| *Eleocharis palustris* (L.) R. et Sch. | + | + | + |
| *Glyceria fluitans* (L.) R. Br. | + | + | |
| *Glyceria maxima* (Hartm.) Holmbg. | + | + | + |
| *Lemna minor* L. | + | + | + |
| *Lemna trisulca* L. | | + | + |
| *Lycopus europaeus* L. | + | + | + |
| *Lythrum salicaria* L. | + | + | |
| *Lythrum virgatum* L. | + | + | + |
| *Phalaroides arundinacea* (L.) Rauschert | + | + | |
| *Phragmites australis* (Cav.) Trin ex Steudel | + | + | + |
| *Polygonum amphibium* L. | | + | |
| *Potamogeton pectinatus* L. | | + | |
| *Potamogeton natans* L. | | + | |
| *Rumex hydrolapathum* Huds. | + | + | + |
| *Schoenoplectus lacustris* (L.) Palla | + | + | + |
| *Schoenoplectus tabernaemontani* (C. C. Gmel. Palla | + | + | + |
| *Sparganium erectum* L. | | + | |
| *Typha angustifolia* L. | + | + | + |
| *Typha latifolia* L. | + | + | + |
| *Utricularia vulgaris* L. | | | + |
| *Chara foetida* A. Br. | | + | |
| *Fontinalis antipyretica* Hedw. | | | + |
| *Salvinia natans* L. | | | + |

*Table 2.* Coverage of dominant plant communities in Meggyes-I.

| Plant community | Coverage | |
|---|---|---|
| | m² | % |
| *Scirpo-Phragmitetum phragmitetosum* | 12019 | 23.3 |
| *Scirpo-Phragmitetum typhetosum* | 3135 | 6.1 |
| *Scirpo-Phragmitetum schoenoplectosum lacustris* | 2100 | 4.1 |
| *Scirpo-Phragmitetum eleocharitosum palustris* | 20 | 0.1 |
| *Glycerietum maximae* | 200 | 0.4 |
| *Caricetum acutiformis-ripariae* | 480 | 0.9 |
| *Bolboschoenetum maritime* | 17790 | 34.5 |
| Open water surface | 15756 | 30.6 |
| Total | 51500 | 100.0 |

*Recolonization of Meggyes-lapos*

Nesting bird populations

Previously, the area was characterized by few species in small numbers, comprising only 2–3 pairs of greylag geese, *Anser anser* (L.), a few mallards, *Anas platyrhynchos* (L.), coots *Fulica atra* (L.), marsh harriers, *Circus aeruginosus* (L.), and the most common reed songbirds. This population was replaced by a more diverse avifauna, which is truly typical of saline marshlands as early as in the first year of the treatment. From among ducks, the mallard, garganey *Anas querquedula* (L.), shoveler *Anas clypeata* (L.), common pochard *Aythya ferina* (L.), and the ferruginous duck *Aythya nyroca* (Guldenstadt*)* nested in the marsh (this species composition has not changed considerably in the recent years). In 1997, a pair of teals, *Anas crecca* (L.), leading their young was observed in the southeastern declivitous shore of the marsh. A similar interesting observation was made in 2000, when a pair of mute swans *Cygnus olor* (JF Gmelin) reared four cygnets in Meggyes-laposban.

In the shallow western and eastern part of the marsh covered with thin reed stands, a typical colony of black-headed gulls and black-necked grebes emerged with 20 pairs of black-headed gulls *Larus ridibundus* (L.) and 10 pairs of black-necked grebes *Podiceps nigricollis* (Brehm). In the same year no black-necked grebes were reported nesting in Fekete-rét. A similar situation was reported by Horváth and Szabó (1978) in 1977, when 100 pairs of black-necked grebes nested in the black-headed gull colony of Fekete-rét, during the first year of flooding. As related to Fekete-rét and considering the data for the following years (in 1998 only 10 pairs nested in Meggyes-lapos), a similarly exceptional number (80–100 pairs) of little grebes *Tachybaptus ruficollis* (Pallas), 1 pair of great-crested grebes *P. cristatus* (Skäggdopping), and 2–3 pairs of red-necked grebes *P. grisegena* (L.) also nested in the marsh.

In May, the three tern species appeared in the area. Whiskered terns *Chlidonias hybridus* (Pallas) and white-winged black terns *C. leucopterus* (Pallas) (10–20 pairs) started to build nests in early May, but abandoned the area by the end of the month for

unknown reasons. Eventually, 4–5 pairs of white-winged black terns and 20–30 pairs of black terns *C. niger* (L.) nested in the western marsh edge of shallow water, in the open-water spots surrounded by *Bolboscoenus*. On the island formed in Meggyes-lapos, a pair of yellow-legged herring gulls *Larus cachinnans michahellis* (Nauman) settled in 1997, and have returned to the area yearly. This was the first nesting record for this species in Hortobágy. In 2000, the pair fledged 3 young, but in 2001 a dead adult was found.

The characteristics of the nesting bird population gradually changed during in the first year (Table 3). By 1998, the mixed colony of black-headed gulls and black-necked grebes had disappeared. The vegetation underwent major changes; the site of the colony was overgrown with reeds extending as far as the foot of the high loess ridge in the western shore. At the beginning of each nesting season, the three tern species returned to the area, with the black and whiskered terns in massive numbers, but only a part of black and/or whiskered terns would nest, while the white-winged black terns have not nested in the area since 1997. The settlement of cranes on the marsh was a gradual process: the bittern *Botaurus stellaris* (L.) appeared first followed by the little bittern *Ixobrychus minutus* (L.), and then a few pairs of purple herons *Ardea purpurea* (L.) in 1999. In 2000, a surprisingly large purple heron colony comprising 35–40 pairs emerged in a loose, sprawling colony stretching 1200 m from the southern end of the marsh to the north. Great white herons settled in Meggyes-lapos in 2000, and had 112 nests in 2001 (aerial counts).

*Table 3.* Recolonization of Meggyes (1997–2001).

| Species | Number of nesting pairs | |
|---|---|---|
| | 1997 (1st year) | 2001 (5th year) |
| *Tachybaptus ruficollis* (Pall.) | 80–100 | 15–20 |
| *Podiceps nigricollis* C. L. Brehm | 10 | — |
| *Botaurus stellaris* (L.) | — | 5–8 |
| *Ixobrychus minutus* (L.) | — | 6–10 |
| *Egretta alba* (L.) | — | 112 |
| *Ardea purpurea* L. | — | 35–40 |
| *Anser anser* (L.) | 15–20 | 50 |
| *Larus ridibundus* L. | 15–20 | — |
| *Chlidonias hybridus* (Pall.) | (50) | 3 |
| *Chlidonias niger* (L.) | 20–30 | 5–10 |
| *Chlidonias leucopterus* (Temn.) | 4–5 | — |
| *Locustella luscinioides* Savi | — | + |
| *Acrocephalus melanopogon* (Temn.) | — | + |
| *Panurus biarmicus* (L.) | — | + |

Due to the much more favourable habitat conditions relative to previous years, in 1997 a much larger number of reed songbirds were nesting, but the "valuable" species of nature conservation showed up only in later years of the rehabilitation project. For instance, neither bearded tits *Panurus biarmicus* (L.) nor Savi's warblers *Locustella luscinioides* (Savi) hatched in the first year, while in 2001 plenty of them were scattered on the entire area of the marshland.

The last year (2001) was characterised by the establishment of a mixed colony of large purple herons and purple herons, and by the appearance of a large population of greylag geese. At that time, concluding from the number of pairs with young observed in the grasses edging the marsh, a minimum of 50 pairs nested successfully in Meggyes-lapos, which means that the majority of the greylag goose population nesting in the entire area of Egyek-Pusztakócs Marshes hatched in this area. It was probably due to the fact that even in the fifth year, the interior of the marsh maintained its mosaiced structure interspersed with open-water clearings, where the skirt of reedy spots offers excellent nesting sites, and the grasses adjoining the marsh from the south and east proved to be proper grazing lands for the goose families with young.

*Summering, feeding birds*

Meggyes-lapos is a significant feeding site for cranes, and for a large number of spoonbills with their flying young that visit the marsh to feed. It is also a summering site for greylag geese with 1000–2000 individuals, and when the extensions of the shallow parts do not dry out completely in the summer drought, this region is the most important resting and assembling site for littoral birds in the entire marsh system, with an outstanding number of black-tailed godwits (thousands).

The area of the marshland is also a preferred feeding site for predatory birds. Raptors seen at the marshes include: kites, *Milvus milvus* (L.), white-tailed eagles, *Haliaeetus albicilla* (L.), short-toed eagles, *Circaetus gallicus* (JF Gmelin), common buzzards, *Buteo buteo* (L.), rough-legged buzzards, *B. lagopus* (Pontoppidan), long-legged buzzards, *B. rufinus* (Cretzschmar), hen harriers, *Circus cyaneus* (L.), ospreys, *Pandion haliaetus* (L.), peregrine falcons, *Falco peregrinus* (Bonaparte), kestrels, *F. tinnunculus* (L.), red-footed falcons, *F. vespertinus* (L.), hobbies, *F. subbuteo* (L.) and saker falcons, *F. cherrug* (Gray).

*Migration*

The first fill-up of 1997 coincided with the tail-end of wild goose migration, but Meggyes-lapos immediately became a main migratory stopover for wild geese. Since then, Meggyes-lapos has preserved its status as the most important migratory stopover in Hungary for wild geese and ducks. The preferred feeding sites of the autumn–spring migration are the agricultural fields lying between Meggyes-lapos and Kis-Jusztus-mocsár: in the spring of 2001 an unprecedented number of white-fronted geese gathered in the marsh area; 30,000 individuals were feeding on the wheat fields close to Meggyes-lapos, and on the ploughlands of Kócs. It is assumed that this huge mass of birds was attracted by the numerous appropriate resting and feeding areas. The marsh system also plays an important role in crane migration; it is an ideal feeding site (5–10,000 individuals).

## Summary

The studies following the rehabilitation stages have focused on tracing repopulation in the area (Aradi 1984, Gőri et al. 1997). Valuable information has been gathered to improve nature conservation methods and to approach the related issues from a conservation biology point of view.

In order to preserve the mosaic landscapes, thus seen from the standpoint of nature conservation, it is essential to fluctuate the water level of marshes in Hortobágy, and dry them out at certain intervals, as they are stabilization advancing factors. This treatment method properly simulates the peculiarities of the original hydrological patterns of the region, and ensures fluctuating environmental impacts (Hobbs and Huenneke 1992).

In preserving the peculiar structure, and mosaic landscape of the marshes in Hortobágy, fluctuation of the water level seems to be a basic device of nature conservation, as it maintains a dynamic balance in which the survival of the mosaic population structure is guaranteed by the permanently changing conditions due to the fluctuation of the water level. The fluctuation, alongside with drying out, is an essential factor for stabilization. Changes in the water cover offer favourable environmental conditions to a varying set of plant communities, ensuring that no vegetation type can become dominant, and result in relative stability.

Before the commencement of the rehabilitation process, Meggyes-lapos almost lacked pondweed vegetation. After the fill-up, star duckweed *Lemna trisulca* (L.) and floating moss *Salvinia natans* (L.) appeared in relatively large masses. These pondweed stands are gradually extending and they can be protected in the general framework of the treatment. While investigating the recolonisation processes, efforts were made to reveal the characteristics of changes in the composition of species of the bird communities, as well as their tendencies and causalities.

In wetlands managed with fluctuating environmental conditions of changing water cover, the initially strong competition is replaced by an internal stabilization process of 3–4 years that is generally typical of astatic marshes of the Hortobágy marshes.

As it has been pointed out, the preservation of the mosaic structure requires fluctuating water levels in the Hortobágy marshes, simulating the water regime of the River Tisza, occasional drying out, which — according to historical records — was a typical element of their functioning. This management procedure, properly simulating the characteristics of the historical water regime of the region, ensures the fluctuating environmental conditions; the flood pulse that determined the original natural systems. The obtained results offer insight for new rehabilitation projects and reconstruction plans, and serve as baseline data for adaptive management.

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# Breeding waterbird wetland habitat availability and response to water-level management in Saint John River floodplain wetlands, New Brunswick

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## Abstract

Wetland management by the Eastern Habitat Joint Venture (EHJV) has focused primarily on water level control to increase the amount of available brood-rearing habitat for waterfowl along the Saint John River floodplain in New Brunswick. Impounded wetlands make up approximately 13% of the Saint John River Floodplain complex. Study objectives included an evaluation of waterfowl brood, and wetland obligate bird use of impoundments and seasonally flooded wetlands within the Saint John River floodplain. Historical water level data and a GIS wetlands inventory were used to estimate the duration of flooding on seasonally flooded wetland habitats, the distribution and relative amount of brood-rearing habitat throughout the breeding period by region. Aerial brood surveys and call response surveys were used to estimate the relative abundance of waterfowl broods and breeding wetland obligate birds respectively. The overall density of waterfowl broods was greater on impoundments than seasonally flooded wetlands during both years of study but varied by site. Mean species richness of wetland obligate birds was significantly greater on impoundments than on seasonally flooded wetland habitat. Generally, use of seasonally flooded wetlands by wetland obligate birds during late summer declined while the use of impoundments increased. Current habitat management for waterfowl appears to be compatible with habitat requirements of wetland obligate birds by increasing the availability of interspersed open water and emergent vegetation throughout the breeding season. A watershed-based analysis of wetland habitat suggests future wetland management should focus on enhancing current impoundments within the Saint John River floodplain. Resources must be secured for maintenance and water level manipulation within existing managed wetlands rather than the construction of additional impoundments. Further evaluation of the distribution of wetland habitat types in the province is essential to identifying focus areas for waterbird conservation throughout NB.

# The influence of expanding *Phragmites australis* stands on wildlife at Long Point, Lake Erie, Ontario

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## Abstract

*Phragmites australis* is a large perennial rhizomatous reed that grows in aquatic, semi-aquatic, and terrestrial habitats. Within the last decade, it has expanded rapidly throughout many coastal wetlands on the lower Great Lakes. This expansion has caused concern among resource managers due to possible habitat degradation and loss of biodiversity. Long Point, Lake Erie, contains some of the most important wetlands for wildlife on the Great Lakes. To examine the influence of expanding *Phragmites* stands on wildlife at Long Point, we conducted spring, summer, fall, and winter avian surveys during two years (2001 and 2002), and collected amphibians, reptiles and small mammals with pitfall traps during the summer (2001 and 2002). Avian point counts were conducted from 63 25-m fixed radius sample stations within *Phragmites*, *Typha*, marsh meadow, and mixed vegetation habitats. Preliminary analyses indicate that fewer species of marsh nesting obligates were surveyed in large *Phragmites* stands. There was also a positive relationship between marsh meadow size and species richness for marsh nesting obligates. Although species richness of marsh users was high in *Phragmites*, both small marsh meadows and small *Typha* habitats supported equivalent numbers. Winter surveys indicate higher avian richness in *Phragmites* and mixed vegetation compared to other habitats. With respect to amphibians and reptiles, there was a positive relationship between total abundance and small stands for both meadow and *Phragmites* habitats. Species richness of small mammals was positively correlated to large *Phragmites* and small *Typha* stands. These findings warrant further quantitative investigation of expanding *Phragmites* stands on marsh nesting obligates, as well as the continued need for marsh restoration through exploratory control of *Phragmites*.

# Effects of forest harvesting on Bufflehead and Common Loon foraging behavior

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## Abstract

We compared foraging behavior of Bufflehead (*Bucephala albeola* Linnaeus) and Common Loon (*Gavia immer* Brünnich) on eight lakes in harvested and unharvested boreal mixedwood forest in northern Alberta, Canada. For one summer before (1996) and two summers after (1997, 1998) forest harvesting around three of the eight lakes, we recorded the duration of Bufflehead and Common Loon dives. After logging, forested buffer strips 100 m-wide separated cut-blocks from lakes ('harvested lakes'). 'Unharvested lakes' were surrounded by ≥450 m of undisturbed forest throughout the study. There were no detectable differences in dive duration between harvested and unharvested lakes for Bufflehead or Common Loon. Correlations between environmental variables (water clarity, fish biomass, depth) and the duration of Common Loon dives were not significant. However, the duration of Bufflehead dives differed between lakes, unrelated to forest harvesting. The duration of Bufflehead dives was negatively correlated with water clarity but was not significantly correlated with fish biomass. While our study shows that the foraging behavior of Buffleheads was affected by lake conditions, the utility of aquatic birds as indicators of the effects of forestry on western boreal lakes remains unproven.

# Waterbird inventory of wetland basins in the western boreal forest

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## Abstract

Ducks Unlimited has developed a waterbird inventory method that utilizes a GIS-based TM Satellite land cover inventory and mapping program that provides an accurate, digital inventory of all land cover classes. In the Western Boreal Forest (WBF), eight projects have been completed or are in progress, encompassing over 89 million acres providing an invaluable management tool to resource managers. The land-cover inventory is providing us with invaluable information on wetlands in the WBF. Complementing the inventory is the proposed evaluation of the use of selected wetland areas by waterfowl and other wetland-dependent waterbirds. Specific intervals of interest include the breeding, brood rearing, moulting, and fall migration periods. Identification of the waterbird values of various wetland/riparian area types and specific sites are accomplished using four rotary-wing aerial surveys during spring/summer (breeding and brood surveys) and three fixed-wing aerial surveys in late summer and fall (migration/moulting/staging surveys). Waterbird distributions and densities will be presented from project areas in the WBF of the Yukon, NWT, Alberta, Saskatchewan and Manitoba.

# Water quality monitoring in the Hungarian Waterbird Monitoring System

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Natural, artificial lakes and ponds, reservoirs, fish ponds, rivers, marshes are part of the Hungarian Waterbird Monitoring System [(49 sites) Figure 1)]. 51 species of waterbirds listed in Table 1 are counted once a month between August and April in each site. The sites are sampled for selected features of water quality in the spring (April) (Table 2) and every five years for major ions and nutrients (Table 3) since 1999. The bodies of water are highly eutrophic or hypertrophic based on total phosphorus and chlorophyll $\alpha$ concentrations. The excrement of the large flocks of geese, while resting during the nights on some sites, contributes significantly to the nutrient load of some bodies of water. Waterbird abundance is expressed in terms of number of individuals as well as body mass in terms of unit surface area (No. & kg/ha). Waterbird abundance is related to indices of productivity, such as that of nutrient concentration. Examples of the type of studies conducted in the Hungarian Waterbird Monitoring System are presented in this volume by Faragó and Gosztonyi 2006; Faragó et al. 2006.

## Literature cited

Faragó, S. and L. Gosztonyi. *this volume*. Space and time pattern of the distribution of cormorants and grey herons in Hungary.

Faragó, S., L. Gosztonyi, K. Keresztessy and G. Gyói. *this volume*. Fish consumption of cormorants in Hungary.


Figure 1. The location of the monitoring sites of the Hungarian Waterbird Monitoring System.

Table 1. The common names of the 51 species of waterbirds considered in the Hungarian Waterbird Monitoring System.

| Scientific name | Hungarian name | English name |
|---|---|---|
| *Gavia stellata* | Északi búvár | Red-throated Diver |
| *Gavia arctica* | Sarki búvár | Black-throated Diver |
| *Gavia immer* | Jeges búvár | Great Northern Diver |
| *Tachybaptus ruficollis* | Kis vöcsök | Little Grebe |
| *Podiceps cristatus* | Búbos vöcsök | Great Crested Grebe |
| *Podiceps griseigena* | Vörösnyakú vöcsök | Red-necked Grebe |
| *Podiceps auritus* | Füles vöcsök | Slavonian Grebe |
| *Podiceps nigricollis* | Feketenyakú vöcsök | Black-necked Grebe |
| *Phalacrocorax carbo* | Kárókatona | Cormorant |
| *Phalacrocorax pygmeus* | Kis kárókatona | Pygmy Cormorant |
| *Ardea cinerea* | Szürke gém | Grey Heron |
| *Egretta alba* | Nagy kócsag | Great White Egret |
| *Cygnus olor* | Bütykös hattyú | Mute Swan |
| *Cygnus columbianus* | Kis hattyú | Bewick's Swan |
| *Cygnus cygnus* | Énekes hattyú | Whooper Swan |

| | | |
|---|---|---|
| *Anser fabalis* | Vetési lúd | Bean Goose |
| *Anser brachyrhynchus* | Rövidcsőrű lúd | Pink-footed Goose |
| *Anser albifrons* | Nagy lilik | White-fronted Goose |
| *Anser erythropus* | Kis lilik | Lesser White-fronted Goose |
| *Anser anser* | Nyári lúd | Greylag Goose |
| *Branta leucopsis* | Apácalúd | Barnacle Goose |
| *Branta bernicla* | Örvös lúd | Brent Goose |
| *Branta ruficollis* | Vörösnyakú lúd | Red-breasted Goose |
| *Tadorna ferruginea* | Vörös ásólúd | Ruddy Shelduck |
| *Tadorna tadorna* | Bütykös ásólúd | Shelduck |
| *Anas penelope* | Fütyülő réce | Wigeon |
| *Anas strepera* | Kendermagos réce | Gadwall |
| *Anas crecca* | Csörgő réce | Teal |
| *Anas platyrhynchos* | Tőkés réce | Mallard |
| *Anas acuta* | Nyílfarkú réce | Pintail |
| *Anas querquedula* | Böjti réce | Garganey |
| *Anas clypeata* | Kanalas réce | Shoveler |
| *Marmaronetta angustirostris* | Márványos réce | Marbled Teal |
| *Netta rufina* | Üstökösréce | Red-crested Pochard |
| *Aythya ferina* | Barátréce | Pochard |
| *Aythya nyroca* | Cigányréce | Ferruginous Duck |
| *Aythya fuligula* | Kontyos réce | Tufted Duck |
| *Aythya marila* | Hegyi réce | Scaup |
| *Somateria mollissima* | Pehelyréce | Eider |
| *Somateria spectabilis* | Cifra pehelyréce | King Eider |
| *Clangula hyemalis* | Jegesréce | Long-tailed Duck |
| *Melanitta nigra* | Fekete réce | Common Scoter |
| *Melanitta fusca* | Füstös réce | Velvet Scoter |
| *Bucephala clangula* | Kerceréce | Goldeneye |
| *Mergus albellus* | Kis bukó | Smew |
| *Mergus serrator* | Örvös bukó | Red-breasted Merganser |
| *Mergus merganser* | Nagy bukó | Goosander |
| *Oxyura leucocephala* | Kékcsőrű réce | White-headed Duck |
| *Haliaeetus albicilla* | Rétisas | White-tailed Eagle |
| *Fulica atra* | Szárcsa | Coot |
| *Grus grus* | Daru | Crane |

Table 2. Water quality variables measured measured every year.

| **Annual test** | |
|---|---|
| pH | |
| Conductivity | *uS/cm* |
| Total susp. Matter | *mg/l* |
| $NH_4^+$ | *mg/l* |
| $NH_4$ N | *mg/l* |
| $NO_2$ | *mg/l* |
| $NO_2$_N | *mg/l* |
| $NO_3$ | *mg/l* |
| $NO_3$_N | *mg/l* |
| Total N | *mg/l* |
| $PO_4^{3-}$ | *mg/l* |
| $PO_4$_P | *mg/l* |
| Total P | *mg/l* |

Table 3. Water quality variables measured every 5 years.

| **5 year test** | |
|---|---|
| pH | |
| Conductivity | *uS/cm* |
| m-alkalinity | *mmol/l* |
| p-alkalinity | *mmol/l* |
| $KOI_{Mn}$ | *mg/l* |
| $Ca^{2+}$ | *mg/l* |
| $Mg^{2+}$ | *mg/l* |
| $Na^+$ | *mg/l* |
| $K^+$ | *mg/l* |
| Total hardness | *CaO mg/l* |
| Carbonate hardness | *CaO mg/l* |
| $Cl^-$ | *mg/l* |
| $SO_4^{2-}$ | *mg/l* |
| $HCO_3^-$ | *mg/l* |
| Total susp. Matter | *mg/l* |
| $NH_4^+$ | *mg/l* |
| $NH_4$ N | *mg/l* |
| $NO_2$ | *mg/l* |
| $NO_2$_N | *mg/l* |
| $NO_3$ | *mg/l* |
| $NO_3$_N | *mg/l* |
| Total N | *mg/l* |
| $PO_4^{3-}$ | *mg/l* |
| $PO_4$_P | *mg/l* |
| Total P | *mg/l* |
| Chlorophyll a | *mg/m$^3$* |

# Populations of ducks and trout of the River Laxá, Iceland, in relation to variation in food resources

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## Abstract

We examined annual variation in production, recruitment and density of the three most abundant vertebrate species of the River Laxá at Mývatn, Iceland: Barrow's goldeneye, *Bucephala islandica*, harlequin duck, *Histrionicus histrionicus*, and brown trout, *Salmo trutta*, in relation to food resources and other environmental variables. The study is largely based on correlations from long-term monitoring series in the period 1975–2002. Production of young in the harlequin duck was significantly correlated with food resources (the blackfly, *Simulium vittatum*) of the river, as was the recruitment of brown trout to the angling stock. In Barrow's goldeneye, which uses both the lake and the river, dispersion of adults in spring and young in August was influenced by the availability of aquatic insects in each habitat. The dispersion of Barrow's goldeneye tracks the availability of aquatic insects in each of these two main habitats. Introduced American mink, *Mustela vison*, may have affected spring numbers and dispersion of harlequin ducks, but the evidence was not conclusive. Numbers of both duck species and the trout catch were stable for longish periods, although a sharp drop in numbers followed by slow recovery was observed in Barrow's goldeneye, and an increase was observed in harlequin ducks in the first years of study.

# Wetlands and waterbirds: Bangladesh perspective

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**Abstract**

Nature has endowed Bangladesh with a wide variety of birds. Everywhere — in the country coastal mudflats, the mangroves, the high hills, the freshwater wetlands (beel, baor jheel, haor, lakes, ponds) the sal forest and the upper Barind Tract — birds circulate in abundance. Bangladesh is particularly rich in bird species, with approximately 650 species recorded so far. But conversion of wetlands for agriculture and large scale deforestation are considered to be two major factors for globally threatening 28 species of birds from Bangladesh. But ornithologists in the process of preparing the Asian Bird Red Data Book have recently reported the figure of globally threatened bird species from Bangladesh to be 40. In addition, nearly 50 species of birds in Bangladesh are near-threatened. Bangladesh is one of the globally important wintering grounds for nearly 300 species of birds. The country acts as the cross road flyway of two international bird migration flyways. Bay of Bengal with its vast coastal mudflats acts as the staging ground of some globally threatened shorebirds, e.g. Asian Dowitcher, Nordmann's Greenshank, Spotted Redshank, Spoon-billed Sandpiper, Indian Skimmer. So far Bangladesh has identified six "ecologically critical areas" (ECA) that were once rich in biodiversity, but have been under serious threat. The main threats facing sustainable use and biodiversity conservation at the ECAs are excessive cutting of mangrove and sand dune vegetation for fuel-wood; illegal harvesting of threatened turtles and turtle eggs, removal of corals for sale as curios, large-scale marine invertebrate collection for sale as curios and as chicken feed, destructive fishing methods, including (i) fishing for shrimp fry, (ii) high levels of 'trash fish' and turtle by-catch, and (iii) the use of gill nets, etc. In addition, hunting of shorebirds, beach compaction by vehicle, salt pans, tourism infrastructure, pollution and land degradation from agro-chemicals, coastal erosion, coral damage for shell and boulder removal etc. are contributing.

# Waterbird guilds and their feeding connections in the Bodrogzug, Hungary

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## Abstract

Species composition, number, species diversity, and evenness of nesting bird communities were surveyed in 2001 and 2002 in north-east Hungary. The survey was aimed at foraging birds. A higher number of species and species diversity was observed in the oxbows compared to that of the eupotamon-type areas, and was correlated with the more luxuriant vegetation covering the water surface. The species evenness value of the oxbows was lower than that of the flowing river. The number of species and species diversity in riparian areas covered with trees were higher than those in areas covered only by bushes. There was a negative correlation between evenness and the diversity of species for habitats covered with water, and habitats covered with trees and bushes along the banks. The following highly protected bird species nested in the study areas: black stork (*Ciconia nigra*), lesser spotted eagle (*Aquila pomarina*), saker falcon (*Falco cherrug*), red-footed falcon (*F. vespertinus*), and corncrake (*Crex crex*). Compared to the total bird fauna of the investigated area, the highest ratio of aquatic bird species was present in the oxbow areas covered with aquatic vegetation. Considering the role of aquatic birds in material and energy cycles, three main species groups were distinguished: the material-transporting group (highest number of specimens); the bioturbing group (lowest number of specimens); and the decomposition-accelerating group (intermediate numbers).

# Effects of small-bodied fish on invertebrate prey and foraging patterns of waterbirds in Aspen Parkland wetlands

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## Abstract

Competition between large-bodied fish and waterbirds for aquatic invertebrates is well documented in oligotrophic lakes. Recent evidence suggests that small-bodied fish that colonize eutrophic, hypoxia-prone wetlands such as prairie potholes can also reduce aquatic invertebrates, but the effects of these reductions on breeding waterbirds have so far not been directly documented. We added brook stickleback (*Culaea inconstans*) and fathead minnow (*Pimephales promelas*) to a fishless wetland in Aspen Parkland potholes in central Alberta, Canada. We monitored invertebrate biomasses and the foraging effort of blue-winged teal (*Anas discors*) and red-necked grebe (*Podiceps grisegena*) before and after the addition, relative to reference wetlands with and without fish. Fish reduced the biomass of gastropod prey of blue-winged teal, and teals increased foraging effort when fish were added. When the fish failed to overwinter due to hypoxic conditions, gastropod biomass increased, but teal foraging effort did not return to pre-treatment levels. Amphipods and chironomids increased following fish addition, possibly due to indirect positive effects of fish. Red-necked grebes did not exhibit any changes in foraging effort as a result of the fish addition or the subsequent fish extirpation. Grebes in Aspen Parkland appear to treat fish and invertebrates as equivalent prey. This study suggests that small-bodied fish in eutrophic systems can reduce some important invertebrate prey and change foraging behaviour of blue-winged teal and other waterbirds that rely on those invertebrates. Land-use practices that encourage survival of colonizing fish through drought years in Aspen Parkland wetlands, such as wetland consolidation, should not be encouraged.

# Influence of migrant tundra swans (*Cygnus columbianus*) and Canada geese (*Branta Canadensis*) on aquatic vegetation at Long Point, Lake Erie, Ontario

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## Abstract

Numerous studies have shown that large, herbivorous waterfowl can reduce quantity of aquatic plants during the breeding or wintering season, but relatively few document herbivory effects at staging areas. This study was done to determine if feeding activities of tundra swans (*Cygnus columbianus columbianus*) and Canada geese (*Branta canadensis*) had a measurable additive influence on the amount of aquatic plants, primarily muskgrass (*Chara vulgaris*), wild celery (*Vallisneria americana*), and sago pondweed (*Potamogeton pectinatus*), removed during the fall migration period at Long Point, Lake Erie, Ontario. Exclosure experiments done in fall 1998 and 1999 showed that, as compared to ducks and abiotic factors, these two large herbivorous waterfowl did not have any additional impact on above or below ground biomass of those aquatic plants. As expected, however, there were substantial seasonal reductions in above-ground and below-ground biomass of aquatic plants in wetlands that were heavily used by all waterfowl. We suggest that differences in large- and small-scale habitat use, feeding activity, and food preferences between tundra swans and other smaller waterfowl as well as compensatory herbivory contributed to our main finding that large waterfowl did not increase fall reductions of *Chara* spp., *V. Americana*, and *P. pectinatus* biomass.

# Migration chronology of eastern population of Tundra Swans

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## Abstract

We used satellite platform transmitting transmitters (PTTs) to track spring and fall migratory movements of Tundra Swans (1998–2000) captured at Long Point, Ontario. Migration corridors reported here corroborated those identified in previous studies using alpha-numerically coded neck collars. However, PTTs provided additional information on duration of spring and fall migration, duration of stay in different staging regions, time spent on breeding and wintering areas, and migration speed. Birds migrated between the Atlantic coast and northern prairies along a narrow geographic corridor through portions of the southern Great Lakes. From the northern prairies, swans followed 3 corridors to breeding areas on the west coast of Hudson Bay, central high arctic and Mackenzie River Delta. Whereas swans spent considerable time on Great Lakes (27% of spring migration) and northern prairie (40%) staging areas in spring, the northern boreal forest was an important fall staging area (48% of fall migration). Tundra Swans spent 20% of the annual cycle on wintering, 28% on spring staging, 29% on breeding, and 23% on fall staging areas. The long duration of migration and the fact that birds spend half their lives on staging areas underscore the importance of conserving Tundra Swan migratory habitats. Thirty-gram neck-collar-attached PTTs were more suitable than 95-gram Teflon-harness-attached backpack PTTs for tracking Tundra Swans.