The Marsh Monitoring Program Annual Report, 1995-2007

Annual indices and trends in bird abundance and amphibian occurrence in the Great Lakes basin

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EXECUTIVE SUMMARY

Wetland loss in some areas of the Great Lakes basin has exceeded 80% since European settlement (Snell 1987, Dahl 1990). Marshes are the most ubiquitous wetland type (Weller 1981), and occur at both isolated inland and exposed lakeshore locations throughout much of the Great Lakes basin. Of all wetland types, marshes support the highest biomass and diversity of floral and faunal species (Weller 1978, Weller 1981), and are perhaps the most important natural mechanism for maintaining water quality to support life, including human life.

Many birds and amphibians frequent and rely heavily on marshes to support their annual life cycle (Weller 1999). With continual degradation and loss of marsh habitat, there has long been a recognized need to monitor populations of avian and amphibian species that rely on these sensitive wetland environments. In 1995, the Marsh Monitoring Program (MMP) was established as a binational Great Lakes basin-wide effort to monitor marsh bird and calling amphibian populations across this globally unique and water-rich region. This has been accomplished through a partnership between Bird Studies Canada, Environment Canada, the United States Environmental Protection Agency, other government agencies, foundations and non-profit organizations, and hundreds of citizen scientists. Through this multi-partner effort, the MMP has succeeded in capturing important and meaningful population and wetland habitat information from hundreds of wetlands throughout the Great Lakes basin.

To survey marsh habitats, MMP volunteers followed a standardized protocol and were guided by detailed written and aural training materials. Surveys were conducted at semi-circular monitoring stations positioned along routes. A nocturnal survey was conducted three times during spring and early summer for calling frogs and toads, and an evening survey was conducted twice during the height of breeding season for marsh birds. The marsh bird survey was augmented by the use of recorded broadcasts to elicit response calls from several secretive species. MMP participants also provided an annual characterization of wetland habitat at each survey station.

Data summaries in this report provide an overview of information contributed by MMP surveyors from 1995 through 2007. Most summaries focus on the Great Lakes basin, but where pertinent, data are also presented for individual lake basins. In total, 967 volunteers submitted data from 1,096 routes during the period 1995 through 2007. Most routes, 91.3 % and 91.2 % of bird and amphibian routes respectively, were within the Great Lakes basin. Lake Ontario, Erie and Huron basins contained the most routes with 250, 234 and 105 amphibian and 223, 222 and 81 bird routes respectively. The Lake Michigan and Superior basins had fewer routes with 80 and 27 amphibian and 59 and 27 bird routes, respectively.

Forty-three species of birds that use marshes for feeding, nesting or both were commonly recorded by MMP observers at Great Lakes basin routes. Among birds that typically feed in the air above marshes, Tree Swallow and Barn

Swallow were most common. Red-winged Blackbird was the most commonly recorded marsh nesting species, followed by Swamp Sparrow, Yellow Warbler, Common Yellowthroat, and Song Sparrow. Several obligate marsh nesting species were also observed at substantial numbers of stations. Many of these species (e.g., Virginia Rail, Black Tern, Common Moorhen, Pied-billed Grebe and Sora) are not well surveyed by other monitoring programs.

Individual bird species varied considerably in their distribution among lake basins. This could be attributed to differences in species' geographic range and variation in wetland habitat characteristics among basins. In general, station occupancy of most bird species tended to be highest in the Lake Erie, Michigan and Ontario basins, intermediate in the Lake Huron basin, and lowest in the Lake Superior basin. Statistically significant declining trends were detected for American Coot, Barn Swallow, Black Tern, Blue-winged Teal, Canada Goose, Common Grackle, Common Moorhen, Common Nighthawk, Forster's Tern, Least Bittern, Moorhen/Coot, Mute Swan, Northern Harrier, Pied-billed Grebe, Red-winged Blackbird, Sora, Tree Swallow and Virginia Rail. Statistically significant increases were detected for Common Yellowthroat, Great Blue Heron, Northern Rough-winged Swallow, Trumpeter Swan, Wood Duck, and Yellow Warbler.

Lake Erie basin and Lake Ontario basin coastal wetland sites each yielded a wide range of marsh bird community-based Indices of Biotic Integrity (IBIs). Among Lake Erie basin sites, the Black Creek Area Wetland, Chenal Ecarte (Snye River) and Lake St. Clair Marshes scored highest, with mean IBIs of 94.31, 93.15 and 82.84, respectively. The Turkey Creek Marsh scored lowest, with a mean IBI of 8.66. Among Lake Ontario basin sites, the French Creek Marsh, Presqu'ille Bay Marsh 4 and Hay Bay Marsh 3 scored hightest, with mean IBIs of 89.11, 88.27 and 87.41, respectively. The Port Britain Wetland scored lowest, with a mean IBI of 15.58.

MMP surveyors recorded 13 species of calling amphibians within the Great Lakes basin between 1995 and 2007. Eight species were detected at greater than 15% of station-years. Of these eight species, Spring Peeper was the most frequently detected species followed by Green Frog. Grey Treefrog, American Toad and Northern Leopard Frog were moderately common, while Chorus Frog, Bullfrog, and Wood Frog were the less common. The distribution of these eight species varied among lake basins. For example, Spring Peeper was encountered frequently in all Great Lake basins but least often in the Lake Ontario basin. Northern Leopard Frog, on the other hand, was detected most frequently in the Lake Ontario and Erie basins. Because the ranges of most species extend the breadth of the Great Lakes basin, patterns are likely due to differences in habitat preference, regional population densities, or to other factors such as timing of survey visits, as opposed to range limitations, with the exception of Fowler's Toad, which has a limited range along sections of Lake Erie's north shore. Significant decreasing temporal trends were calculated for populations of American Toad, Chorus Frog, Green Frog, and Northern Leopard Frog. No commonly detected species exhibited significantly positive population trends.

Lake Erie basin and Lake Ontario basin coastal wetland sites each yielded a wide range of calling amphibian community-based Indices of Biotic Integrity (IBIs). Among Lake Erie basin sites, Mentor Marsh, Long Point Wetland 7 and Turkey Point Wetland scored highest, with mean IBIs of 89.67, 88.80 and 88.25, respectively. The Monroe City Area Wetland scored lowest, with an IBI of 0.00. Among Lake Ontario basin sites, the Presqu'ille Bay Marsh 4, South Bay Marsh 1 and Button Bay 2 marsh scored hightest, with mean IBIs of 99.90, 99.90 and 99.84, respectively. Van Wagner's Marsh scored lowest, with a mean IBI of 5.81.

This report summarizes the thirteen years of MMP operation across the Great Lakes basin and shows how the MMP is playing a role in many of today's (and tomorrow's) conservation issues and actions at different scales. In addition, this report is a statement of appreciation to those agencies and foundations that have supported the MMP throughout the years. Finally, yet importantly, this report is intended to convey to the hundreds of Great Lakes citizens who have volunteered with the program that their contributions remain both highly valued and extremely important.

INTRODUCTION

Numerous marsh bird and amphibian species are believed to be sensitive to habitat disturbances, and many scientists and conservationists consider their populations to be at risk due to continued habitat loss. For instance, marsh birds as a group are believed to have experienced population declines due to historical habitat loss and degradation (Gibbs et al. 1992, Conway 1995, Melvin and Gibbs 1996). Further, concern for declining amphibian populations is recognized internationally (Heyer et al. 1994, Stebbins and Cohen 1995). Efforts to monitor and evaluate relative status of marsh birds and amphibians across the Great Lakes basin are therefore essential to understanding how well marshes across the basin are functioning to maintain ecological integrity.

The Marsh Monitoring Program (MMP) has been monitoring trends in marsh bird and calling amphibian occurrence indices for 14 years. This report summarizes results of bird and calling amphibian (frog and toad) annual abundance and occurrence surveys, respectively, that were performed throughout the Great Lakes basin from 1995 through 2007. The report also describes trends in relative abundance and occurrence of marsh birds and calling amphibians. Finally, this report presents results of marsh bird and amphibian community-based indices of Lake Erie and Lake Ontario coastal wetland biotic integrity. These Indices of Biotic Integrity (IBI), based on MMP data, have recently been developed by Bird Studies Canada and Environment Canada to rank relative health of coastal wetlands, identify sites in need of restoration and remediation, and track recovery of these systems in degraded areas.

These analyses, possible through the participation of hundreds of MMP volunteer participants, are being used to assist efforts to conserve and rehabilitate wetlands, to provide critical information for effective wetland management, and to propose conservation practices to benefit wetland-dependent wildlife and people. MMP data are also used by local groups to better understand and maintain wetlands in their own areas, and contribute to management plans at the regional scale (e.g., Great Lakes Areas of Concern), individual lake basin scale (e.g., Lakewide Management Plans), and to wetland health assessment at the Great Lakes basin scale (e.g., State of the Lakes Ecosystem Conference). Moreover, MMP data serve to increase awareness of marsh bird, amphibian, and wetland habitat conservation issues through volunteer participation and communication to the public, scientists, regulators, and other stakeholders.

In this report, summaries of population trends are provided for marsh birds and amphibians across the 13 years of MMP implementation throughout the Great Lakes basin. General trends are provided for several marsh-dependent bird and calling amphibian species that occur with some regularity across the Great Lakes basin. These data are assessed across the entire Great Lakes basin, and less extensively at the individual lake basin level. Marsh bird and amphibian community-based IBI results are also provided for all Lake Erie and Lake Ontario coastal wetland sites monitored between 1995 and 2007.

METHODS

MMP volunteers in both Canada and the United States contribute their valuable time to monitor abundance and occurrence of marsh birds and amphibians throughout marshes in and around the Great Lakes basin. For the purposes of this report, analyses focused on results of MMP surveys conducted by volunteers within the Great Lakes basin (Figure 1) and concentrated on results for marsh bird and amphibian species believed to be most clearly associated with marshes and other wetland and aquatic habitats. Key elements of MMP sampling methodology are reported herein, and additional detailed information concerning MMP protocol and methodology described in this report can be found in Anonymous (2003).

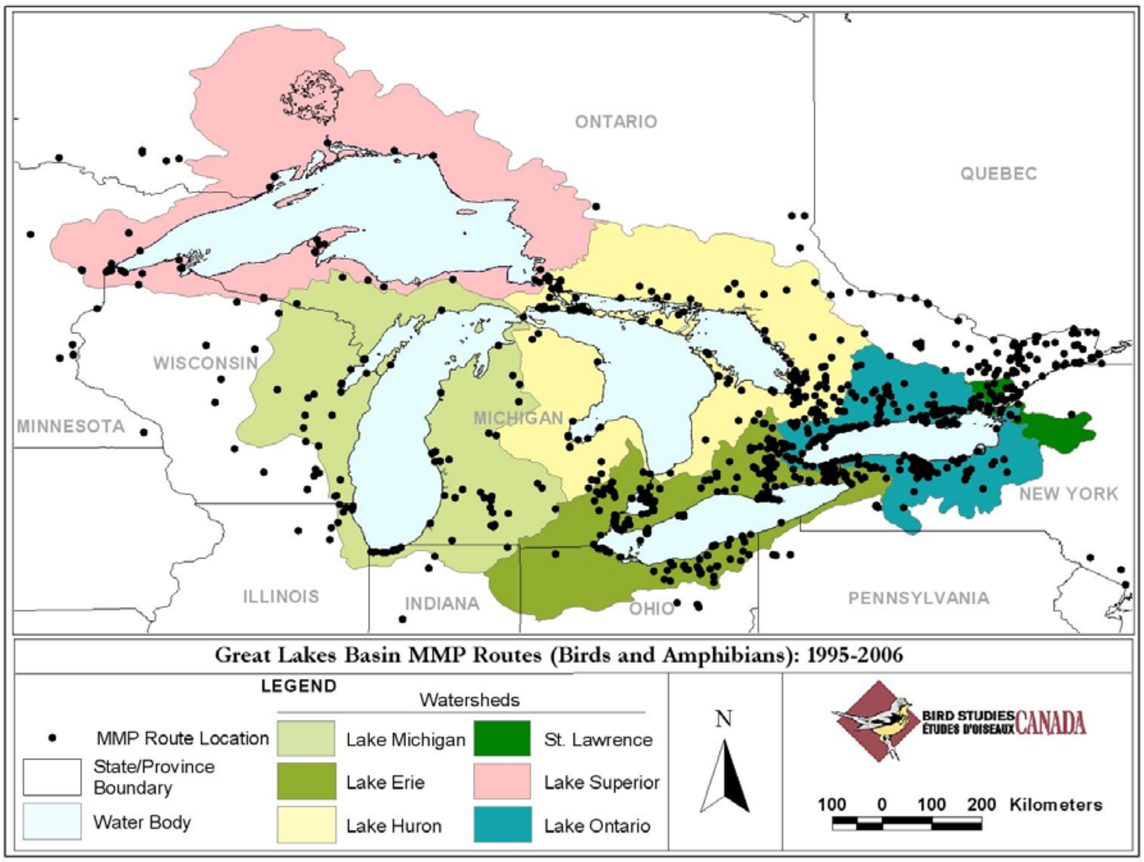

Figure 1. Marsh Monitoring Program (MMP) Route Locations within the Great Lakes basin and surrounding areas.

Selection and Characteristics of Routes and Stations

Upon registering with the MMP, volunteers received training kits that included detailed protocol instruction manuals, field and summary data forms, a Training CD with examples of songs and calls of common marsh birds and amphibians, and a Broadcast CD used to elicit calls from secretive wetland bird species. MMP volunteers established survey routes in marshes at least 1 ha in size. Each route consisted of one to eight monitoring stations depending on factors such as available time and marsh habitat size. Minimum inter-station distances have been developed to reduce instances of double counting and are set at 250 m (275 yd) and 500 m (550 yd) for marsh bird and amphibian routes, respectively.

An MMP station is defined as a 100-m (110-yd) radius semicircle with marsh habitat covering greater than 50% of the semicircular area. Marsh habitat is defined as habitat regularly or periodically wet or flooded to a depth of up to two metres (six feet) where cattail, bulrush, burreed and other non-woody emergent vegetation is predominant. Counts were conducted from a focal point at each station – the surveyor stood at the midpoint of the 200-m (220-yd) semi-circular base and faced the arc of the station perimeter. Where possible, each focal point was permanently marked with a stake and metal tag to facilitate relocation within and between years.

Bird Survey Protocol

The marsh bird survey methodology described in this report pre-dates significant changes made to the protocol in 2008. For information about the current (post-2007) marsh bird survey protocol, please see Bird Studies Canada (2008).

Survey visits for birds were conducted twice each year between May 20 and July 5, with at least 10 days occurring between visits. Visits began after 18:00 h under appropriate survey conditions (i.e., warm, dry weather and little wind). A five-minute Broadcast tape or CD was played at each station during the first half of each 10-minute survey visit. The Broadcast tape/CD contains calls of the normally secretive Virginia Rail, Sora, Least Bittern, Common Moorhen, American Coot and Pied-billed Grebe, and is used to elicit call responses from those species. During the count period, observers recorded onto a field map and data form, all birds heard and/or observed within the survey station. Aerial foragers were also counted and were defined as those species foraging within the station area to a height of 100 m (110 yd). Bird species flying through or detected outside the station were tallied separately.

Amphibian Survey Protocol

Amphibians surveyed by MMP volunteer participants are calling frogs and toads that typically utilize marsh habitat during spring and summer breeding periods. MMP routes were surveyed for calling amphibians on three nights each year, between early April and late July, with at least 15 days occurring between visits. Because peak amphibian calling periods are more strongly associated with temperature and precipitation than with date, visits were scheduled to occur on three separate evenings according to minimum night air temperatures of 5 °C

(41 °F), 10 °C, (50 °F), and 17 °C (63 °F) for the first, second and third visits, respectively.

Amphibian surveys began one-half hour after sunset and ended before or at midnight. In northern areas, this time frame may not have applied and surveys may have continued past midnight according to the duration of daylight hours. Visits were conducted during evenings with little wind, preferably in moist conditions with one of the above corresponding temperatures. During each three-minute survey, observers assigned a Calling Code to each species detected; for two of these levels, estimated numbers of individuals were also recorded. Calling Code 1 was assigned when calls did not overlap and calling individuals could be discretely counted. Calling Code 2 was assigned if calls of individuals overlapped, but the number of individuals could still be reasonably estimated. Calling Code 3 was assigned when an estimate of individuals could not be made because of significant overlap in calls making them seem continuous (i.e., a full chorus).

MMP participants were asked to use their best judgment to distinguish whether each species detected was calling from inside the station boundary only, from outside the station boundary only, or from both inside and outside the station boundary. Combined with habitat information provided for each station by MMP surveyors, this protocol feature contributes important information to allow for amphibian habitat association analyses.

Population Trend Analyses

Abundance and occurrence indices were derived for bird and amphibian species, respectively, in each survey year, across the entire Great Lakes basin.

For marsh birds, abundance indices were based on counts of individuals inside the MMP station boundary and were defined relative to 2007 values. General models (PROC GENMOD; SAS Institute Inc. 1999) were developed to generate annual indices for each marsh bird species. Indices were scaled to correct for over-dispersion before transformation for regression analyses. The overall effect of year as a class variable or as a continuous variable was tested using likelihood ratio tests (PROC GENMOD; SAS Institute Inc. 1999) to determine whether the addition of year to the model significantly increased the fit of the model. For each year, 95% confidence limits around each annual index were calculated. Presented in each table herein are estimated annual percent changes (trends) in abundance of each marsh bird species and the associated upper and lower extremes of the 95% confidence limits for each species trend. Because actual counts of marsh birds provide a Poisson distribution of observations, Poisson regression was used to evaluate year-to-year variance of annual indices and overall direction of trends across years.

For amphibians, basin-wide trends in station occupancy were assessed for those species that were detected on greater than ten survey routes. For each species, a trend was assessed first on a route-by-route basis in terms of annual proportion of stations with each species present. These route-level trends were then combined for an overall assessment of trend for each species, and were defined relative to 2007 values. As with birds, indices were scaled to correct for over dispersion before transformation for regression analyses. The overall effect of year as a class variable or as a continuous variable was tested using likelihood ratio tests (PROC GENMOD; SAS Institute Inc. 1999) to compare deviance of these models to models with no year variable. For each year, 95% confidence limits around each annual index were calculated. Annual percent change (trends) in occurrence of each amphibian species was also estimated, and the associated upper and lower extremes of the 95% confidence limits of each species trend are presented herein. Because amphibian indices were derived based on presence or absence of a species at a station, logistic (or binary) regression was used to evaluate year-to-year variance of annual indices and overall direction of trends in amphibian occurrence across years.

Statistically testing for year-to-year variance of abundance and occurrence indices provides knowledge about whether such indices for a given species were similar or different among years, whereas statistically testing for overall magnitude and direction of trends across years evaluates whether temporal trends differ from a slope of zero (i.e., no change). It is important to emphasize that the most meaningful interpretation of results is done by assessing both year-to-year variance in annual indices as well as overall magnitude and direction of trends. For example, a species may exhibit high year-to-year variance in its annual indices, yet the overall trend through time may not differ from a slope of zero. Similarly, a significant positive or negative trend over time for a given species may be driven by a single outlying year-specific index value that differs considerably from those of all other years combined. In the latter example, significant year-to-year variance in indices may not occur, and such a scenario is less meaningful than if both year-to-year variance and overall direction of a trend has occurred (i.e., each or most years having contributed to the overall increase or decline in trends).

RESULTS

In this report, bird and amphibian results are often summarized in terms of route-years, which considers every route surveyed in a given year as a single observation and does not differentiate between routes surveyed for single or multiple years. Similarly, the term station-year refers to those analyses that considered stations without regard to the number of years that each station was surveyed. Unless otherwise mentioned, most analyses in this report were based on route-year and station-year approaches.

Routes

In total, 967 volunteers submitted data from 1,096 routes from 1995 through 2007. Most routes, 91.3% and 91.2% of bird and amphibian routes respectively, were located within the Great Lakes basin. Of the individual lake basins, the Lake Ontario basin contained the greatest number of routes with 223 bird and 250 amphibian routes, followed by the Lake Erie, Lake Huron, Lake Michigan and Lake Superior basins (Table 1). The Ontario portion of the St. Lawrence River watershed contained 38 bird and 33 amphibian routes. The St. Lawrence results were tabulated separately from the Outside of Basin results. Within the entire Great Lakes basin, survey data from 729 amphibian routes and 712 bird routes were submitted during the 13-year period (Table 1). The mean number of amphibian and marsh bird routes surveyed per year was 181 and 168, respectively, with peak numbers in 2007 for amphibians and in 2006 for birds.

A greater number of amphibian routes than bird routes were surveyed in 12 out of 13 years. The Lake Superior basin contained a greater number of bird routes than amphibian routes during ten out of thirteen years. All other lake basins and the St. Lawrence River watershed featured a greater number of amphibian routes than bird routes across the thirteen years of program operation (Table 1).

Overall, a large percentage of amphibian routes (41.9%) were surveyed for one year only (includes new routes in 2007), fewer for two or three years (17.2% and 8.6%, respectively), 7.3% for four years, and the remainder close to or below 5% (Table 2). Similarly, a large percentage of bird routes (43.5%) were surveyed for only one year (Table 2). A total of 18.3% of bird routes were monitored for two years, and below 10% for additional years. A higher proportion of bird routes were monitored for the full 13-year period (1.8%), than were amphibian routes (1.0%).

Table 1. Number of routes surveyed for marsh birds and amphibians within each Great Lake basin, the St. Lawrence River watershed, and outside the Great Lakes basin, from 1995-2007. The total number of volunteers that contributed survey data for each year and basin/area is shown in brackets.

	Basin														
Year	Ontario		Erie		Huron		Michigan		Superior		St. Lawrence		Outside of Basin		Total # Routes/Year
	Amphibian	Bird	Amphibian	Bird	Amphibian	Bird	Amphibian	Bird	Amphibian	Bird	Amphibian	Bird	Amphibian	Bird	
1995	45 (34)	42 (34)	32 (24)	51 (36)	23 (22)	33 (31)	12 (10)	14 (11)	3 (3)	5 (5)	3 (2)	4 (3)	15 (13)	21 (17)	303 (240)
1996	53 (41)	54 (43)	49 (37)	63 (42)	37 (33)	28 (24)	25 (18)	17 (15)	13 (8)	15 (8)	2 (1)	2 (1)	31 (26)	26 (22)	415 (305)
1997	51 (35)	47 (37)	71 (56)	77 (50)	48 (45)	24 (23)	36 (27)	23 (20)	2 (2)	4 (3)	2 (1)	2 (1)	25 (22)	27 (23)	442 (344)
1998	47 (34)	41 (31)	61 (48)	54 (34)	31 (30)	23 (23)	27 (23)	26 (19)	2 (2)	7 (6)	2 (1)	2 (1)	24 (19)	20 (15)	364 (285)
1999	43 (35)	41 (33)	62 (47)	62 (40)	33 (31)	26 (24)	24 (19)	20 (17)	1 (1)	5 (4)	2 (1)	2 (1)	22 (17)	19 (14)	362 (280)
2000	48 (31)	44 (28)	59 (51)	62 (39)	23 (21)	19 (18)	24 (20)	22 (19)	4 (4)	6 (5)	0	0	20 (15)	17 (14)	348 (262)
2001	37 (33)	37 (30)	63 (54)	63 (44)	37 (32)	22 (20)	26 (19)	18 (14)	3 (3)	6 (5)	1 (1)	0	23 (20)	17 (15)	353 (287)
2002	61 (47)	57 (39)	84 (50)	74 (37)	30 (28)	20 (19)	15 (14)	12 (12)	3 (3)	7 (6)	2 (2)	1 (1)	30 (27)	14 (12)	410 (291)
2003	61 (50)	52 (38)	43 (36)	37 (29)	27 (25)	20 (18)	21 (18)	15 (12)	4 (4)	7 (6)	1 (1)	0	24 (22)	14 (13)	326 (267)
2004	54 (44)	47 (32)	43 (36)	35 (26)	22 (20)	19 (17)	21 (15)	13 (11)	6 (6)	4 (4)	1 (1)	0	22 (20)	12 (10)	299 (234)
2005	70 (58)	85 (47)	59 (54)	57 (45)	23 (21)	20 (18)	22 (17)	16 (14)	4 (4)	7 (6)	3 (3)	0	19 (18)	12 (10)	312 (227)
2006	105(92)	114 (62)	67 (62)	59 (47)	26 (23)	28 (24)	24 (20)	17 (14)	8 (8)	7 (6)	9 (8)	1 (1)	16 (14)	11 (9)	387 (288)
2007	98 (80)	72 (55)	78 (71)	68 (48)	29 (26)	33 (27)	27 (19)	16 (13)	6 (6)	6 (5)	20 (20)	31 (19)	14 (13)	7 (7)	396 (314)
Total # Routes/Group	*250 (230)*	*223 (176)*	*234 (214)*	*222 (162)*	*105 (129)*	*81 (89)*	*80 (73)*	*59 (50)*	*27 (24)*	*27 (21)*	*33 (34)*	*38 (27)*	*70 (73)*	*62 (62)*	*1096 (967)*

Table 2. Number and percentage of MMP amphibian and bird routes surveyed for 1 to 13 years, 1995 through 2007. Years surveyed represents total data history for a route, and may not be consecutive years of survey.

Number of Years Surveyed	Amphibians		Birds	
	No. of Routes	% of Total	No. of Routes	% of Total
1	335	41.9	358	43.4
2	137	17.1	151	18.3
3	69	8.6	82	10.0
4	58	7.3	54	6.6
5	41	5.1	30	3.6
6	37	4.6	34	4.1
7	27	3.4	18	2.2
8	19	2.4	20	2.4
9	16	2.0	15	1.8
10	18	2.3	12	1.5
11	17	2.1	11	1.3
12	17	2.1	24	2.9
13	8	1.0	15	1.8

Birds

Of 43 species commonly recorded (present in at least 0.3% station-years) by MMP observers on Great Lakes routes, 28 are classified as either obligate or general marsh nesters, 8 are classified as aerial foragers above marshes and 7 typically use marshes for foraging in water (water foragers). Included in the water forager classification are several species of waterfowl. Although data are presented for these species, population indices of waterfowl should be interpreted with caution because of the limitations of the current MMP protocol to adequately detect those species. Similarly, population indices for the American Coot and Common Moorhen may be inaccurate because their calls can often be difficult to distinguish. Thus, these species are also summarized as a combined "species" (MOOT) to account for records where MMP volunteers were unable to differentiate between the two species.

Bird Detection Rates and Average Count

Of the aerial foraging species observed, Tree Swallows and Barn Swallows were the most common, and were recorded in 53.7% and 24.9% of station-years, respectively (Table 3). The other six aerial foraging species occurred much less frequently (<10% of station-years). Red-winged Blackbird was the most commonly recorded marsh nesting species, occurring in 90.0% of station-years. Swamp Sparrow was observed in 49.5% of station-years, and four other songbirds (Yellow Warbler, Common Yellowthroat, Song Sparrow and Marsh Wren) were almost as common. Several other marsh nesting species were observed in approximately 10 to 25% of station-years. Of special note among these species are Virginia Rail and undifferentiated Common Moorhen/American Coot, marsh birds not well surveyed by other monitoring programs.

With respect to the average number of individuals recorded at a station among routes where they occurred, Tree Swallow and Red-winged Blackbird occurred in the highest numbers, with slightly greater than five individuals per station for both species. Common Grackle, Moorhen/Coot, Canada Goose, Black Tern, Forster's Tern, Yellow-headed Blackbird, Barn Swallow, Bank Swallow, Purple Martin, Chimney Swift, Mallard and Ruddy Duck each averaged greater than three individuals per station on routes where they occurred. In contrast, American Bittern and Least Bittern tended to be observed individually at a station on routes where they occurred (Table 3).

More marsh nesting and aerial foraging birds were detected at stations in the four lower Great Lakes than on routes in the Lake Superior basin (Table 3). However, several bird species (Swamp Sparrow, Song Sparrow, Canada Goose, Sedge Wren, and Alder Flycatcher) were detected on a relatively high proportion of Lake Superior stations as compared to other basins. Also, water foragers were generally observed at a higher proportion of Lake Superior routes than other basins.

Most species also differed in their frequency of occurrence among lake basins. For example, American Bittern was detected most frequently in the Lake Huron basin, while Least Bittern occurred in similar proportions of station-years across the Erie, Huron and Ontario basins, and less often in the Lake Michigan and Superior basins. Virginia Rail and Sora also differed among basins in their occurrence, with the former detected most often in Lake Huron and Ontario basins and the latter detected at a slightly greater frequency in the Lake Huron and Michigan basins (Table 3). The vast majority of Alder Flycatcher records occurred in the Lake Superior basin, while Willow Flycatcher was detected in similar proportions across the Lake Erie, Michigan and Ontario basins but less so in the Lake Huron and Superior basins. Pied-billed Grebe was also detected across all lake basins, but was detected more often in the Lake Huron basin, and least often in the Lake Superior basin. Black Tern was detected considerably more often in the Lake Huron basin compared to all other basins.

Table 3. Frequency of occurrence and average number of individuals (at routes where they occurred) of marsh nester, aerial forager and water forager bird species detected inside Great Lakes basin MMP stations, 1995 through 2007. Data are presented by group for each lake basin for those species detected on greater than 0.3 % station-years in a minimum of one basin.

		Percent Station-Years Present [1]					
Group	Species	Lake Erie	Lake Huron	Lake Michigan	Lake Ontario	Lake Superior	Basin Average
Marsh Nesters	Red-winged Blackbird	93.3 (5.5)	83.2 (4.0)	90.7 (4.8)	93.6 (5.4)	45.9 (4.7)	90.0 (5.2)
	Swamp Sparrow	46.6 (2.1)	47.7 (2.0)	40.3 (2.0)	55.7 (2.7)	53.8 (1.6)	49.5 (2.3)
	Yellow Warbler	48.8 (1.9)	26.9 (1.6)	47.2 (1.7)	46.7 (1.8)	45.9 (1.7)	44.5 (1.8)
	Common Yellowthroat	50.3 (1.7)	35.3 (1.4)	52.3 (1.8)	37.4 (1.6)	43.6 (1.6)	43.6 (1.6)
	Song Sparrow	47.2 (1.6)	26.1 (1.4)	39.5 (1.7)	34.4 (1.4)	53.0 (2.3)	39.0 (1.6)
	Marsh Wren	35.4 (2.5)	28.5 (2.6)	32.4 (2.1)	41.4 (2.4)	8.3 (3.0)	35.2 (2.4)
	Virginia Rail	13.8 (1.4)	34.4 (1.7)	17.9 (1.7)	27.0 (1.5)	9.8 (1.5)	21.7 (1.6)
	Common Grackle	22.3 (3.0)	12.7 (4.8)	20.8 (2.9)	24.3 (3.4)	5.6 (3.3)	20.9 (3.3)
	Common Moorhen/American Coot	12.7 (3.7)	19.5 (4.2)	7.6 (3.7)	19.4 (4.0)	1.9 (2.4)	15.2 (3.9)
	Eastern Kingbird	16.9 (1.3)	13.8 (1.3)	10.7 (1.4)	9.1 (1.3)	3.4 (1.3)	12.6 (1.3)
	Canada Goose	13.0 (5.1)	9.5 (3.9)	10.9 (5.3)	10.1 (3.8)	20.7 (8.4)	11.5 (4.8)
	Black Tern	7.9 (2.3)	22.1 (5.2)	7.7 (2.9)	6.1 (2.5)	1.5 (1.8)	9.2 (3.5)
	Pied-billed Grebe	9.6 (1.5)	17.6 (1.6)	9.8 (1.5)	7.4 (1.5)	5.6 (2.0)	9.9 (1.5)
	Common Moorhen	5.8 (1.7)	9.8 (2.2)	2.5 (1.6)	15.9 (1.9)	0.0 (0.0)	9.3 (1.9)
	Sora	5.3 (1.2)	12.8 (1.3)	11.8 (1.3)	6.7 (1.2)	9.0 (1.4)	7.7 (1.3)
	Willow Flycatcher	9.2 (1.2)	1.6 (1.1)	7.7 (1.1)	8.9 (1.2)	1.1 (1.3)	7.5 (1.2)
	American Coot	5.6 (2.1)	6.9 (2.1)	4.6 (2.1)	4.3 (1.8)	1.9 (1.2)	5.1 (2.0)
	American Bittern	2.8 (1.1)	10.6 (1.2)	1.6 (1.1)	5.3 (1.1)	3.4 (1.0)	4.7 (1.1)
	Least Bittern	4.9 (1.1)	5.0 (1.2)	2.6 (1.1)	4.4 (1.1)	1.9 (1.0)	4.4 (1.1)
	Alder Flycatcher	2.6 (1.1)	2.2 (1.1)	0.8 (1.0)	2.9 (1.3)	25.6 (2.3)	3.2 (1.5)
	Mute Swan	1.5 (1.9)	0.3 (2.5)	5.7 (4.0)	5.4 (1.7)	0.0 (0.0)	3.1 (2.2)
	Sedge Wren	1.3 (1.3)	2.3 (1.3)	4.0 (1.7)	1.2 (1.6)	10.2 (2.6)	2.0 (1.6)
	Common Snipe	0.4 (1.2)	5.8 (1.2)	1.8 (1.2)	0.8 (1.1)	4.1 (1.3)	1.6 (1.2)
	Forster's Tern	3.6 (3.3)	0.0 (0.0)	0.5 (1.3)	0.0 (0.0)	0.4 (1.0)	1.4 (3.2)
	Sandhill Crane	0.9 (1.9)	2.8 (2.4)	4.8 (1.8)	0.1 (2.0)	0.8 (2.0)	1.3 (2.0)
	Yellow-headed Blackbird	0.2 (2.5)	0.2 (2.5)	6.8 (3.1)	0.1 (1.8)	1.5 (4.0)	0.9 (3.0)
	Northern Harrier	0.3 (1.4)	0.2 (1.0)	0.1 (1.0)	1.5 (1.2)	0.8 (1.5)	0.7 (1.2)
	Ring-necked Duck	0.2 (2.5)	0.9 (1.5)	0.4 (2.0)	0.2 (2.4)	3.4 (3.7)	0.4 (2.4)
Aerial Foragers	Tree Swallow	62.6 (5.7)	45.3 (4.9)	58.7 (5.6)	48.4 (4.7)	31.6 (4.5)	53.7 (5.2)
	Barn Swallow	29.0 (3.3)	9.7 (3.0)	35.6 (3.4)	25.7 (4.1)	6.8 (2.1)	24.9 (3.6)
	Bank Swallow	8.0 (4.4)	2.8 (3.7)	4.4 (3.2)	11.6 (5.4)	2.3 (2.8)	7.9 (4.8)
	Purple Martin	12.8 (3.6)	1.2 (2.3)	4.1 (9.5)	3.3 (4.2)	0.0 (0.0)	6.4 (4.0)
	Northern Rough-winged Swallow	6.1 (3.1)	1.3 (3.2)	6.1 (2.3)	6.2 (2.8)	1.1 (2.0)	5.2 (2.9)
	Chimney Swift	5.5 (3.0)	0.1 (1.0)	3.5 (2.1)	3.4 (3.5)	0.4 (1.0)	3.6 (3.1)
	Cliff Swallow	0.7 (2.0)	0.7 (1.6)	1.2 (2.5)	1.5 (3.1)	1.9 (3.0)	1.1 (2.6)
	Common Nighthawk	0.6 (1.9)	0.7 (1.3)	1.8 (3.7)	1.0 (2.1)	1.1 (1.3)	0.9 (2.3)
Water Foragers	Mallard	18.5 (3.9)	13.1 (2.3)	12.5 (4.0)	18.5 (2.6)	33.8 (6.2)	17.5 (3.4)
	Blue-winged Teal	1.2 (1.6)	5.9 (2.1)	3.7 (2.0)	3.2 (1.7)	7.9 (1.7)	3.1 (1.8)
	Green-winged Teal	0.2 (1.7)	0.1 (2.0)	1.4 (1.3)	0.6 (1.7)	3.4 (5.0)	0.5 (2.3)
	American Black Duck	0.2 (2.1)	1.4 (2.0)	0.0 (0.0)	0.5 (2.8)	4.1 (4.3)	0.6 (2.8)
	Gadwall	0.1 (2.5)	0.1 (1.0)	0.1 (1.0)	1.2 (1.6)	0.4 (2.0)	0.5 (1.6)
	Ruddy Duck	0.4 (3.9)	0.2 (2.0)	0.1 (2.0)	0.1 (1.5)	0.0 (0.0)	0.2 (3.3)
	Northern Shoveler	0.0 (0.0)	0.1 (2.0)	0.0 (0.0)	0.2 (1.2)	3.0 (2.3)	0.2 (1.9)

[1] Value in parentheses represents average count

Bird Abundance Indices and Trends

Abundance indices and trends of marsh birds (i.e., average annual percentage change in abundance index) were analyzed for species that were observed on greater than 10 routes from 1995 through 2007 (Table 4). Species with a significant Great Lakes basin-wide long-term declining trend were American Coot, Barn Swallow, Black Tern, Blue-winged Teal, Canada Goose, Common Grackle, Common Moorhen, Common Nighthawk, Forster's Tern, Least Bittern, undifferentiated Common Moorhen/American Coot, Mute Swan, Northern Harrier, Pied-billed Grebe, Red-winged Blackbird, Sora, Tree Swallow, and Virginia Rail. In contrast, Common Yellowthroat, Great Blue Heron, Northern Rough-winged Swallow, Trumpeter Swan, Wood Duck and Yellow Warbler all showed a significant increasing trend between 1995 and 2007 ($P < 0.05$) (Table 4).

Bird Community-based Indices of Biotic Integrity

A total of 32 Lake Erie and 64 Lake Ontario coastal wetland sites were evaluated using the marsh bird IBI based on MMP data collected between 1995 and 2007 (Tables 5 and 6, respectively). Within the Lake Erie basin, the Black Creek wetland and the Chenal Ecarte (Snye River) marshes ranked highest, with mean IBI scores of 94.3 and 93.1, respectively. While the Black Creek wetland was only monitored for one year, the Chenal Ecarte marshes were monitored for nine years (Table 5). The Turkey Creek Marsh scored lowest, with an IBI of 8.66. Forty-eight percent of Ontario sites achieved a mean IBI of at least 50.0, while 40% of Michigan's sites, and 60% of Ohio's sites achieved a mean IBI of at least 50.0. Pennsylvania's single coastal wetland site achieved a score of 40.76.

Within the Lake Ontario basin, the French Creek marsh ranked highest (mean IBI score of 89.1), followed by Presqu'ille Bay Marsh 4 and Hay Bay Marsh 3 (mean IBI scores of 88.3 and 87.4, respectively) (Table 6). Several of the highest ranking Lake Ontario sites were only monitored for three or fewer years (Table 6), predominantly since 2005. This was due to the extensive wetland assessment work conducted by the Canadian Wildlife Service on Lake Ontario. The Port Britain Wetland scored lowest among evaluated sites, with an IBI of 15.58. Fifty-four percent of Ontario sites and 44% of New York sites achieved a mean IBI of at least 50.0.

Between lake basins, the Lake Erie basin contained two sites that scored mean IBIs of greater than 90.0, while the Lake Ontario basin featured none. Thirteen percent, and 9% of evaluated Lake Erie and Lake Ontario coastal wetlands, respectively, achieved scores of at least 80.0; however, 38% of Lake Ontario wetlands achieved IBI scores of 60.0 or greater, compared to 34% of Lake Erie wetlands.

Table 4. Annual abundance indices and trends in marsh bird populations throughout the Great Lakes basin, 1995-2007*.

	Annual Abundance Indices																	
Species	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	p^1	Trend (%/Yr)	Lower 95% C.I.	Upper 95% C.I.	p^2
ABDU	0.00	0.00	1.18	0.31	3.78	0.25	0.70	0.33	0.25	0.59	0.49	0.80	0.70	**0.0000**	5.4	19.8	-7.3	0.3240
ALFL	0.46	0.62	0.59	0.79	0.79	1.03	0.63	0.76	0.54	0.57	0.52	0.44	0.67	0.6388	-0.9	3.6	-5.1	0.7062
AMBI	0.45	0.68	0.79	0.82	0.31	0.43	0.36	0.41	0.23	0.59	0.48	0.47	0.62	**0.0127**	-3.0	1.8	-7.7	0.2051
AMCO	1.98	4.19	1.82	3.38	0.93	2.32	1.08	2.59	1.84	2.42	1.26	0.99	0.56	**0.0000**	-7.7	-4.0	-11.2	**0.0000**
BANS	5.26	2.76	4.27	3.06	5.38	1.34	4.11	4.01	1.96	3.00	4.02	2.46	7.67	**0.0000**	1.7	6.0	-2.3	0.3801
BARS	4.48	4.92	4.14	4.66	4.71	4.25	4.83	3.99	4.45	3.94	4.13	2.58	3.98	**0.0068**	-2.5	-0.7	-4.3	**0.0054**
BCNH	0.84	1.26	1.33	1.45	0.82	1.21	0.34	1.16	0.82	0.61	0.62	1.33	0.96	0.3665	-1.5	4.6	-7.2	0.6338
BEKI	0.40	0.47	0.43	0.40	0.34	0.44	0.40	0.40	0.60	0.61	0.55	0.41	0.49	0.6771	1.9	5.5	-1.5	0.2694
BLTE	8.07	6.42	4.75	6.66	2.79	2.43	2.97	3.17	2.40	2.19	3.14	2.63	1.72	**0.0000**	-11.4	-8.4	-14.3	**0.0000**
BWTE	1.44	1.17	0.96	1.27	0.64	0.76	0.70	0.44	0.52	0.38	0.66	0.16	0.18	**0.0001**	-13.1	-8.5	-17.5	**0.0000**
CAGO	4.25	4.16	3.74	6.38	5.05	4.14	3.93	4.13	2.74	2.77	4.07	3.05	3.81	**0.0252**	-3.0	0.0	-5.8	**0.0448**
CATE	0.36	1.13	1.66	1.76	0.66	0.93	1.34	1.12	1.37	1.37	1.28	0.36	0.94	**0.0043**	-1.0	4.6	-6.3	0.7243
CHSW	0.92	1.49	1.40	1.84	1.70	2.15	0.76	1.37	1.30	1.14	0.85	1.33	1.09	**0.0298**	-3.0	1.3	-7.1	0.1707
CLSW	0.21	0.20	0.80	2.07	1.61	2.67	0.57	0.08	2.18	0.37	0.23	0.74	1.24	**0.0000**	3.8	11.5	-3.4	0.3551
COGR	1.70	2.17	1.67	6.83	5.99	1.28	2.01	2.72	3.03	1.79	2.64	2.04	2.27	**0.0000**	-3.0	-0.1	-5.9	**0.0207**
COMO	2.68	1.73	2.09	2.17	1.59	1.37	1.51	1.62	1.61	1.71	1.43	1.19	1.29	**0.0327**	-4.5	-1.9	-6.9	**0.0005**
CONI	2.94	5.45	7.72	2.82	2.30	1.03	0.52	1.46	3.36	0.71	1.23	0.31	0.14	**0.0218**	-15.4	-5.3	-24.4	**0.0041**
COSN	0.46	0.24	0.28	0.50	0.58	0.14	0.09	0.28	0.21	0.28	0.50	0.47	1.10	**0.0058**	6.3	14.1	-1.0	0.0696
COYE	2.35	2.70	2.59	2.96	2.88	3.18	2.77	2.94	3.06	3.04	2.57	3.04	3.05	0.0538	1.2	2.4	0.1	**0.0373**
EAKI	1.00	1.33	1.01	1.27	0.92	1.11	1.25	1.02	1.09	0.94	0.91	1.10	1.09	0.4388	-0.7	1.5	-2.9	0.5302
FOTE	0.76	0.67	1.75	1.01	0.18	0.30	0.97	0.35	0.15	0.00	1.16	0.00	0.17	**0.0087**	-11.0	0.4	-21.2	**0.0250**
GADW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0024**	-9.2	1.8	-19.1	0.0756
GBHE	1.34	1.61	1.46	1.40	1.07	1.20	1.57	2.26	1.93	0.99	1.82	2.45	1.81	**0.0000**	4.7	7.4	2.1	**0.0004**
GRHE	0.47	0.98	0.69	0.65	0.65	0.74	0.68	0.53	0.70	0.77	0.54	0.43	0.40	0.3253	-3.3	0.6	-7.0	0.0958
GWTE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0004**	7.7	26.6	-8.5	0.3273
KILL	2.07	1.01	0.92	1.55	1.35	1.10	0.63	1.31	0.36	0.30	1.20	0.58	1.33	**0.0000**	-3.9	0.5	-8.2	0.0697
LEBI	1.13	0.87	0.71	0.88	0.64	0.70	0.57	0.41	0.53	0.29	0.31	0.39	0.21	**0.0003**	-10.6	-6.9	-14.3	**0.0000**
MALL	2.31	1.68	2.11	2.95	3.55	1.99	2.74	3.12	4.38	2.76	2.40	2.92	1.98	**0.0000**	0.8	3.2	-1.5	0.4906
MAWR	4.02	3.47	3.84	4.85	3.94	3.62	2.96	3.01	2.88	3.78	3.94	3.70	3.85	**0.0000**	-1.0	0.4	-2.3	0.1477
MOOT	7.57	6.72	5.71	6.99	3.99	4.97	3.90	5.46	4.71	5.30	3.82	3.09	2.80	**0.0000**	-6.1	-4.1	-8.0	**0.0000**
MUSW	1.80	3.57	1.81	1.68	2.32	1.60	1.74	1.55	2.95	1.35	1.60	1.31	1.76	0.0556	-5.3	-1.0	-9.5	**0.0162**

Table 4. (Continued)

Species	Annual Abundance Indices 1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	*p* [1]	Trend (%/Yr)	Lower 95% C.I.	Upper 95% C.I.	*p* [2]
NOHA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0154**	-18.4	-6.3	-28.9	**0.0017**
NRWS	0.86	0.75	0.51	1.31	1.69	0.90	2.25	1.27	2.02	1.90	1.72	1.58	2.63	**0.0023**	8.7	13.6	4.0	**0.0003**
PBGR	2.69	2.81	2.02	3.01	1.61	1.69	1.15	1.16	1.66	1.80	1.39	1.33	0.91	**0.0000**	-7.1	-4.3	-9.7	**0.0000**
PUMA	6.00	3.51	4.28	2.95	3.58	2.31	4.71	3.98	2.53	3.58	10.38	3.01	1.63	**0.0000**	1.0	5.7	-3.4	0.6274
RNDU	0.00	1.10	0.47	0.00	0.54	0.91	0.22	0.00	0.11	0.92	0.36	0.37	1.00	**0.0416**	7.5	25.9	-8.2	0.2683
RWBL	19.72	23.65	18.73	18.97	18.17	17.32	17.54	15.34	18.34	18.38	18.11	17.50	15.96	**0.0000**	-1.8	-1.0	-2.6	**0.0000**
SACR	0.74	0.69	0.57	0.62	0.21	1.18	1.03	0.78	1.59	1.05	0.77	1.44	0.91	0.5381	5.6	14.0	-2.2	0.1576
SEWR	1.25	1.25	0.61	0.66	0.28	0.72	0.46	0.44	0.25	0.75	0.48	0.42	0.35	0.1144	-6.7	0.3	-13.2	0.0595
SORA	0.71	0.90	1.19	0.87	0.76	0.30	0.46	1.11	0.50	0.74	0.65	0.45	0.54	**0.0000**	-4.9	-2.0	-7.8	**0.0011**
SOSP	2.97	2.48	2.64	2.81	2.65	3.24	2.94	2.85	2.99	2.77	2.86	3.14	2.83	0.3153	0.7	1.9	-0.5	0.2629
SWSP	3.85	3.87	3.93	3.91	4.11	4.07	3.58	3.41	3.80	4.08	3.77	4.55	4.42	**0.0096**	0.8	1.8	-0.2	0.1111
TRES	21.57	18.27	16.89	18.88	12.01	13.18	13.63	13.79	14.26	9.92	11.56	9.16	8.21	**0.0000**	-6.4	-4.8	-7.9	**0.0000**
TRUS	0.00	0.00	0.00	0.20	0.53	0.00	0.92	0.00	0.34	0.00	0.75	0.49	1.07	**0.0010**	22.0	43.2	4.0	**0.0010**
VIRA	2.12	1.79	2.20	2.37	1.75	1.51	1.57	1.83	1.33	1.81	1.91	1.73	1.80	**0.0015**	-1.7	-0.1	-3.2	**0.0389**
WIFL	0.88	0.62	0.90	0.84	1.09	0.98	1.18	0.99	1.04	1.19	1.28	1.00	0.77	0.1805	1.5	4.3	-1.2	0.2697
WODU	3.05	1.48	2.75	3.95	2.38	1.57	2.78	2.01	3.40	3.22	6.22	2.76	2.99	**0.0000**	4.2	7.0	1.5	**0.0015**
YHBL	3.34	5.95	1.61	2.17	1.48	1.13	1.01	2.55	2.66	1.51	2.19	1.42	2.13	0.5729	-1.0	6.3	-7.8	0.7740
YWAR	3.52	4.03	3.24	3.44	3.46	3.66	3.71	4.04	3.82	3.86	3.73	3.82	4.12	0.2095	1.1	2.1	0.0	**0.0457**

* See Appendix 1 for common and latin names associated with each species code.
p [1] - probability that significant year-to-year variation in abundance index occurred.
p [2] - probability that abundance index trend between 1995-2004 differed significantly from zero.
Bold indicates statistical significance at $p < 0.05$.

Table 5. Mean IBI scores of Lake Erie coastal wetland sites surveyed for birds between 1995 and 2007.

Wetland Name	Province/State	No. Survey Years	Mean IBI
Black Creek Area Wetland	Michigan	1	94.31
Chenal Ecarte (Snye River)	Ontario	9	93.15
Lake St. Clair Marshes	Ontario	8	82.84
Canard River Marshes	Ontario	1	80.30
Point Pelee Marsh 2	Ontario	11	79.84
Long Point Wetland 1	Ontario	12	71.62
Rondeau Provincial Park 1	Ontario	13	69.34
Long Point Wetland 2	Ontario	7	68.64
Harsens Island Area Wetland	Michigan	4	67.08
Grand River Mouth Wetlands	Ontario	2	64.34
Long Point Wetland 5	Ontario	7	63.21
Ottawa Wildlife Refuge Wetland	Ohio	9	56.35
Ottawa National Wildlife Refuge	Ohio	8	54.43
Metzger Marsh	Ohio	2	51.10
Long Point Wetland 3	Ontario	7	50.34
Tremblay Beach Marsh	Ontario	1	47.18
Long Point Wetland 4	Ontario	1	46.95
Algonac Wetland	Michigan	1	44.62
Cedar Point National Wildlife Refuge	Ohio	7	44.48
McGeachy Pond	Ontario	2	42.04
Hillman Marsh	Ontario	6	41.91
Long Pond - Presque Isle State Park	Pennsylvania	13	40.76
Long Point Wetland 7	Ontario	1	37.07
Ruscom Shores Marsh	Ontario	13	36.90
Bouvier Bay Wetland	Michigan	2	34.94
Empire Beach Backshore Basin Forest	Ontario	12	33.66
Mentor Marsh	Ohio	4	30.40
Lighthouse Point Nature Reserve	Ontario	1	28.29
Big Creek Marsh	Ontario	8	24.88
Monroe City Area Wetland	Michigan	1	23.95
Canard River Mouth Marsh	Ontario	5	19.07
Turkey Creek Marsh	Ontario	1	8.66

Table 6. Mean IBI scores of Lake Ontario coastal wetland sites surveyed for birds between 1995 and 2007.

Wetland Name	Province/State	No. Survey Years	Mean IBI
French Creek Marsh	Ontario	1	89.11
Presqu'ille Bay Marsh 4	Ontario	2	88.27
Hay Bay Marsh 3	Ontario	2	87.41
Marysville Creek Wetland	Ontario	1	84.81
Blessington Creek Marsh 1	Ontario	2	81.81
Lower Napanee River 4	Ontario	1	81.17
Sawguin Creek Marsh 3	Ontario	1	78.26
Big Sand Bay 2	Ontario	2	77.53
Hucyks Bay 1	Ontario	1	76.88
Bayfield Bay Wetland 1	Ontario	3	75.31
Presqu'ille Bay Marsh 2	Ontario	2	73.88
Braddock Bay Wetland	New York	3	72.79
Oshawa Second Marsh	Ontario	13	72.59
Cranberry Marsh	Ontario	6	71.33
Presqu'ille Bay Marsh 1	Ontario	2	69.97
McLaughlin Bay Wetland 1	Ontario	4	67.87
Buck Pond	New York	12	67.53
West Lake Wetland 5	Ontario	2	67.27
Dead Creek Marsh	Ontario	1	63.61
Sawguin Creek Marsh 1	Ontario	5	63.58
Blessington Creek Marsh 2	Ontario	3	63.09
Hay Bay Marsh 7	Ontario	3	62.89
Buckhorn Island Wetland	New York	3	62.89
Lower Sucker Creek 1	Ontario	1	62.62
Airport Creek Marsh	Ontario	1	61.91
Carrs Marsh (Peters Rock Marsh)	Ontario	7	59.47
Big Island Marsh	Ontario	12	58.95
Round Pond	New York	13	58.82
Sawguin Creek Marsh 7	Ontario	1	57.54
Little Cataraqui Creek Complex	Ontario	10	57.00
Button Bay 2	Ontario	3	56.04
Parrot Bay Wetland 2	Ontario	1	53.73
South Bay Marsh 1	Ontario	3	51.46
Forester's Island	Ontario	1	50.88
Snake Creek Marsh	New York	2	49.56
Irondequoit Bay Wetland	New York	12	49.07
Rouge River Marsh	Ontario	5	46.40
Lynde Creek Marsh	Ontario	6	46.39
Belleville Marsh 2	Ontario	8	44.34
Robinson Cove Marsh	Ontario	6	43.89
Westside Beach Marsh	Ontario	11	42.93
Corbett Creek Mouth Marsh	Ontario	5	41.94
Cootes Paradise 1	Ontario	11	41.34
Carrying Place	Ontario	1	39.96
Rattray Marsh	Ontario	7	39.90
Pumphouse Marsh	Ontario	4	39.59
Lower Sucker Creek 4	Ontario	1	39.59
Port Darlington Marsh	Ontario	5	38.14
Port Newcastle Wetland Complex	Ontario	5	35.75
Duffins Creek Lakeshore Marsh	Ontario	8	35.12
Royal Botanical Gardens-Hendrie Valley	Ontario	12	34.44
Hydro Marsh	Ontario	6	33.82
Pleasant Bay 2	Ontario	1	32.90
Frenchman's Bay Marsh	Ontario	10	31.04
Eight Mile Creek Estuary	Ontario	2	30.85
Solmesville	Ontario	1	28.86
Genesee River Wetland	New York	1	28.18
Van Wagner's Marsh	Ontario	5	27.62
Tuscarora Bay Wetland	New York	3	27.38
Four Mile Creek Estuary	Ontario	2	22.55
Jordan Station Marsh	Ontario	2	21.07
Carruthers Creek Marsh	Ontario	3	19.55
Humber River Marshes	Ontario	5	18.60
Beaver Island State Park	New York	2	16.65
Port Britain Wetland	Ontario	1	15.58

Amphibians

Amphibian Detection Rates and Average Calling Code

MMP surveyors recorded 13 species of calling amphibians from 1995 through 2007. Spring Peeper was the most frequently detected species (68.8% station-years) and was recorded with the highest average calling code (2.7; Table 7). Green Frog was the next most frequently detected species (55.6% station-years), but its average calling code, along with the average calling code of all other detected species, was below 2. This suggests that although the Green Frog was detected frequently, on average a relatively small number of individuals were detected at a given station. Gray Treefrog, American Toad and Northern Leopard Frog were also common and were recorded in greater than 30% of station-years. Chorus Frog, Bullfrog and Wood Frog were detected in 18-30% of station-years, while the remaining five species were detected infrequently by MMP surveyors and were recorded in less than 3% of station-years (Table 7).

The eight amphibian species commonly detected (present in at least 3% of station-years) by MMP surveyors varied to some extent in their frequency of occurrence among lake basins (Table 7). American Toad was detected with similar frequencies among all lake basins. Green Frog occurred in greater frequencies in the Lake Erie, Huron, and Ontario basins. Chorus Frog was much more commonly detected at stations within the Lake Michigan basin than in other basins. Spring Peeper was observed at much higher frequencies within the Lake Huron and Lake Superior basins relative to other basins. Observation frequencies for Bullfrog were highest in the Lakes Erie and Ontario basins. Northern Leopard Frog was recorded least frequently in the Lake Michigan basin.

Amphibian Occurrence Indices and Trends

Long-term (1995-2007) declining trends across the combined Great Lakes basin were identified for American Toad, Chorus Frog, Green Frog, and Northern Leopard Frog (Table 8). These results indicate that four of the eight commonly occurring species within Great Lakes basin are showing significant population decreases. No commonly detected species exhibited significantly positive population trends ($P < 0.05$).

Amphibian Community-based Indices of Biotic Integrity

A total of 25 Lake Erie and 27 Lake Ontario coastal wetland sites were evaluated using the amphibian IBI based on MMP data collected between 1995 and 2007 (Tables 9 and 10, respectively). Within the Lake Erie basin, the Mentor Marsh, Long Point 7, and Turkey Point sites ranked highest, with mean IBI scores above 88.0 for each. However, the Long Point 7 and Turkey Point site means were only based on one and two years of data, respectively (Table 9). The Long Pond wetland of Presque Isle State Park, which was monitored for 11 years, ranked fourth with a mean IBI of 85.1. The Monroe City Area Wetland scored an IBI of 0. Seventy-five percent of Ontario sites achieved a mean IBI of at least 50.0, while only 17% of Ohio sites achieved a mean IBI of at least 50.0. Both Michigan sites scored below 50.0, while Pennsylvania's single coastal wetland site achieved a score of 85.14.

Within the Lake Ontario basin, three sites (Presqu'ile Bay 4, South Bay 1, and Button Bay 2) had mean IBIs above 99.0 for each (Table 10). However, each of these sites was only monitored for one year. Big Island Marsh, which had been monitored for 13 years, was ranked fourth with a mean IBI of 96.0. In total, six Lake Ontario coastal sites achieved an IBI score of above 90.0. Van Wagner's Marsh scored lowest among evaluated sites, with an IBI of 5.81. Fifty-four percent of Ontario sites and 100% of New York sites achieved a mean IBI of at least 50.0.

Between lake basins, the Lake Ontario basin contained six sites that scored mean IBIs of greater than 90.0, while the Lake Erie basin featured none. Twenty-eight percent, and 26% of evaluated Lake Erie and Lake Ontario coastal wetlands, respectively, achieved scores of at least 80.0; 56% and 48% of Lake Erie and Ontario wetlands, respectively, achieved IBI scores of 60.0 or greater.

Table 7. Frequency of occurrence and average calling code for amphibian species detected at Great Lakes basin MMP stations, 1995 through 2007. Species are ordered by decreasing frequency of occurrence.

Species	Percent Station-Years Present[1]					
	Lake Erie	Lake Huron	Lake Michigan	Lake Ontario	Lake Superior	Basin Average
Spring Peeper	67.2 (2.4)	86.2 (2.7)	68.3 (2.3)	59.8 (2.5)	80.4 (2.4)	68.8 (2.5)
Green Frog	60.4 (1.3)	57.9 (1.4)	47 (1.3)	56.1 (1.3)	26.2 (1.1)	55.6 (1.3)
Gray Treefrog	30.9 (1.8)	46 (1.8)	52.3 (1.7)	36.4 (1.9)	27.4 (1.7)	50 (1.8)
American Toad	39.1 (1.5)	35.4 (1.5)	35.8 (1.5)	36.5 (1.5)	42.3 (1.6)	37.2 (1.5)
Northern Leopard Frog	36.9 (1.3)	25.6 (1.4)	15.8 (1.2)	37.7 (1.3)	19 (1.1)	31 (1.3)
Chorus Frog	22.6 (1.7)	18.6 (1.5)	53.6 (1.6)	18.7 (1.8)	20.8 (1.8)	26.5 (1.7)
Bullfrog	39.8 (1.3)	14.3 (1.5)	10.3 (1.1)	27.7 (1.3)	4.8 (1.1)	25.8 (1.3)
Wood Frog	13.9 (1.6)	27.2 (1.6)	20.6 (1.5)	14.9 (1.6)	31 (1.4)	18 (1.6)
Pickerel Frog	2.7 (1.0)	1 (1.0)	3 (1.2)	2.2 (1.1)	7.7 (1.8)	2.4 (1.1)
Fowler's Toad	3.2 (1.4)	0.4 (1.2)	5.4 (1.4)	0 (0)	1.2 (1.0)	2.2 (1.4)
Mink Frog	0.2 (1.1)	2.2 (1.2)	1.3 (1.0)	1.2 (1.1)	7.1 (1.3)	1.2 (1.2)

[1] Value in parentheses represents average calling code

Table 8. Annual occurrence indices and trends in calling amphibian populations throughout the Great Lakes basin, 1995-2007.

	Annual Occurrence Indices																	
Species	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	p^1	Trend (%/Yr)	Lower 95% C.I.	Upper 95% C.I.	p^2
AMTO	55.56	55.80	51.93	51.28	44.87	44.44	46.71	50.41	51.81	37.20	46.01	45.32	40.37	**0.0037**	-0.9	-0.3	-1.5	**0.0018**
BULL	52.44	47.04	45.93	53.67	49.37	34.91	41.58	44.00	31.34	47.55	32.34	42.92	45.10	**0.0007**	-0.8	0.0	-1.5	0.0578
CHFR	73.34	61.08	60.33	58.52	56.00	49.82	52.21	57.55	48.49	51.64	50.94	42.97	43.96	**0.0087**	-1.6	-0.8	-2.4	**0.0000**
FOTO	2.55	15.44	17.62	20.18	16.56	17.28	25.90	26.94	9.14	11.87	4.30	6.51	8.33	**0.0376**	-0.4	0.3	-0.9	0.2702
GRFR	68.86	68.30	71.98	86.39	60.38	57.21	62.92	63.33	58.04	68.13	66.33	65.67	66.28	**0.0000**	-0.6	-0.1	-1.2	**0.0312**
GRTR	58.15	77.68	68.34	66.63	64.89	70.53	66.72	77.41	71.42	74.21	62.46	61.50	54.94	**0.0000**	-0.7	0.1	-1.4	0.0779
MIFR	4.86	6.30	2.83	1.82	4.46	10.57	10.13	2.50	14.64	12.90	6.51	14.51	16.13	0.4264	1.8	3.7	0.0	**0.0416**
NLFR	33.25	47.71	51.64	65.42	40.96	43.66	35.01	31.74	45.94	35.32	39.50	39.64	37.09	**0.0000**	-0.8	-0.1	-1.4	**0.0190**
PIFR	5.33	22.85	22.80	18.92	29.66	42.78	44.00	26.97	12.74	13.71	19.04	15.10	10.96	**0.0081**	-0.5	0.3	-1.3	0.2131
SPPE	68.36	76.44	82.12	88.72	75.83	72.15	77.64	90.30	85.11	89.61	84.77	80.06	70.27	**0.0000**	0.3	1.1	-0.6	0.5432
WOFR	28.70	39.65	26.94	29.61	30.12	23.74	30.79	33.68	25.32	23.50	31.71	26.35	34.77	0.0601	-0.1	0.7	-0.8	0.8260

* See Appendix 2 for common and latin names associated with each species code.

p^1 - probability that significant year-to-year variation in occurrence index occurred.

p^2 - probability that occurrence index trend between 1995-2004 differed significantly from zero.

Bold indicates statistical significance at $p < 0.05$.

Table 9. Mean IBI scores of Lake Erie coastal wetland sites surveyed for calling amphibians between 1995 and 2007.

Wetland Name	Province/State	No. Survey Years	Mean IBI
Mentor Marsh	Ohio	4	89.67
Long Point Wetland 7	Ontario	1	88.80
Turkey Point Wetland	Ontario	2	88.25
Long Pond - Presque Isle State Park	Pennsylvania	11	85.14
Hillman Marsh	Ontario	6	84.57
Long Point Wetland 5	Ontario	1	83.25
Empire Beach Backshore Basin Forest	Ontario	12	82.13
McGeachy Pond	Ontario	2	78.10
Big Creek Marsh	Ontario	3	75.04
Grand River Mouth Wetlands	Ontario	1	73.50
Rondeau Provincial Park 1	Ontario	9	73.10
Point Pelee Marsh 2	Ontario	9	65.09
Long Point Wetland 1	Ontario	12	64.03
Long Point Wetland 3	Ontario	2	60.56
Long Point Wetland 4	Ontario	1	46.22
Cedar Point National Wildlife Refuge	Ohio	9	45.75
Harsens Island Area Wetland	Michigan	4	45.73
Ottawa Wildlife Refuge Wetland	Ohio	1	39.18
Lake St. Clair Marshes	Ontario	9	37.32
Magee Marsh	Ohio	1	36.27
Metzger Marsh	Ohio	4	31.17
Long Point Wetland 2	Ontario	4	29.76
Ottawa National Wildlife Refuge	Ohio	10	26.65
Ruscom Shores Marsh	Ontario	1	21.52
Monroe City Area Wetland	Michigan	1	0.00

Table 10. Mean IBI scores of Lake Ontario coastal wetland sites surveyed for calling amphibians between 1995 and 2007.

Wetland Name	Province/State	No. Survey Years	Mean IBI
Presqu'ille Bay Marsh 4	Ontario	1	99.90
South Bay Marsh 1	Ontario	1	99.90
Button Bay 2	Ontario	1	99.84
Big Island Marsh	Ontario	13	95.99
Bayfield Bay Wetland 1	Ontario	1	94.35
Presqu'ille Bay Marsh 3	Ontario	1	92.45
Hay Bay Marsh 7	Ontario	2	87.85
East Lake Marsh 6	Ontario	7	77.92
Tuscarora Bay Wetland	New York	10	77.29
Braddock Bay Wetland	New York	6	76.66
Port Britain Wetland	Ontario	1	75.80
Little Cataraqui Creek Complex	Ontario	9	75.28
Rattray Marsh	Ontario	7	72.41
Buckhorn Island Wetland	New York	4	53.73
Belleville Marsh 2	Ontario	3	53.73
Cranberry Marsh	Ontario	7	51.72
Cootes Paradise 1	Ontario	9	47.24
Sawguin Creek Marsh 7	Ontario	2	44.36
Royal Botanical Gardens-Hendrie Valley	Ontario	11	38.53
Lynde Creek Marsh	Ontario	6	30.05
Oshawa Second Marsh	Ontario	13	27.98
Hydro Marsh	Ontario	6	19.72
Bronte Creek Marsh	Ontario	3	16.63
Corbett Creek Mouth Marsh	Ontario	6	12.01
Port Darlington Marsh	Ontario	5	9.74
Humber River Marshes	Ontario	5	7.39
Van Wagner's Marsh	Ontario	2	5.81

DISCUSSION AND CONCLUSIONS

Summaries of data presented in this report are intended as an overview of the types of information contributed by MMP volunteers and to demonstrate the breadth of ongoing analyses. Additional years of data will lead to improved resolution of trends for amphibians and birds. Since the release of the MMP's ten-year assessment report (Crewe et al., 2006), an additional three years of MMP volunteer data have been examined. We discuss below species-specific, basin-wide trends and changes that have occurred from 1995 through 2007.

Routes

Route turnover by MMP volunteer surveyors, a problem experienced during earlier years of the MMP, continues, with variation in turnover rates from year to year. In general, a lower proportion of total MMP routes have been surveyed for marsh birds and amphibians for three or fewer years (71.7% and 67.7%, respectively) than when first examined in 1999 (82.1% and 72.7%, respectively). Increased consistency in MMP volunteer route retention (i.e., monitoring through time) will improve the accuracy of population index and habitat association assessments for marsh birds and amphibians throughout the Great Lakes basin.

Fewer MMP routes have been established in the Lake Superior basin than in other basins, and this is due to the relative scarcity of available surveyors in this region, not to the lack of available wetland habitat. The MMP, with partners, is working to address this deficiency and to increase MMP monitoring coverage and volunteer participation in the Lake Superior basin. Initial effort when the program was initiated, and a more recent re-intensification of MMP involvement in surveying Area of Concern wetlands throughout the Great Lakes basin has also driven the spatial pattern of MMP route distribution to some degree. Intensive program promotion and recruitment initiatives that have occurred over the past three years have also driven up the number of participants and routes. However, a consequence of increased volunteer recruitment has been an increase in the number of routes monitored for only one or two years. Continued regular volunteer correspondence from staff, and support for a recently-developed volunteer MMP regional coordinator network, will be necessary to minimize volunteer turnover, particularly among newer participants.

Birds

The number of years of monitoring required to provide adequate resolution on bird relative abundance trends was assessed by Timmermans and Craigie (2002) based on seven years of MMP data collected from 1995 through 2001. The annual trend (i.e., percent change in population index based on counts) that could be detected was calculated assuming that either 100, 200 or 300 routes were monitored over three, five, or ten years (Timmermans and Craigie 2002). Although a standard has not yet been determined, many bird-monitoring specialists consider annual trends equal to or less than 3% as reasonable for adequate resolution of bird trends. Assuming at least 100 routes are surveyed for 10 years, good trend resolution is expected for 22 of 46 species commonly recorded on MMP routes (Table 4). Only 15 MMP routes were surveyed annually for marsh birds for the full 13-year period between 1995 and 2007. Although the net number of routes surveyed each year may appear adequate, the current rate of route turnover may be problematic. Regardless, monitoring data to estimate annual indices of species abundance need not be derived from the same routes if one assumes that the composition of marshes being surveyed each year does not change drastically among years. In fact, results from the previously described power analyses were derived from the MMP dataset, which inherently includes a certain level of route turnover among year-pairs. Thus, although more years of data collection are required to reliably estimate abundance trends of marsh birds with desired precision, there is merit in discussing results from analyses for those species for which sufficient data were available.

With the current 13 years of MMP data, Black Tern, Blue-winged Teal, Least Bittern, Moorhen/Coot, Mute Swan, Pied-billed Grebe, Red-winged Blackbird, Sora, Tree Swallow and Virginia Rail continue to show significant basin-wide declines in abundance indices. Further, since we last reported in September, 2005, American Coot, Barn Swallow, Common Grackle, Common Moorhen, Common Nighthawk and Killdeer have been added to the list of species showing significant negative population trends in the Great Lakes basin. However, American Bittern, Marsh Wren, Canada Goose and Northern Harrier, previously exhibiting significant basin-wide declines, are now showing a more stable trend ($p<0.05$; Table 4) and Purple Martin is now exhibiting a significant positive basin-wide trend compared to our previous report in which it showed a significant declining trend across the Great Lakes basin.

Most of the species experiencing significant declining trends depend upon wetlands for breeding, but because of their virtually exclusive use of marsh habitat, Black Tern, Least Bittern, Pied-billed Grebe, Sora, and Virginia Rail, are particularly dependent on availability of healthy marshes. Although declines in certain wetland dependant species and increases in some wetland edge species (e.g., Common Yellowthroat) and generalist species (e.g., Mallard) suggest a deterioration of wetland habitat conditions, additional years of data and a better developed understanding of species habitat preferences and interactions are required to better explain such patterns.

Of the individual Great Lake basins, Lake Superior generally had the lowest detection frequencies compared to the other basins. For example, Red-winged Blackbird, the most frequently detected marsh bird species in the Great Lakes basin, was detected only about half as often in Lake Superior basin MMP routes. Similarly, Black Tern was detected less frequently on Lake Superior basin MMP routes than in the other basins. Alternatively, Alder Flycatcher and Sedge Wren were detected with a much greater frequency on Lake Superior basin MMP survey routes. This may be attributed to differences in the physiographic and geologic preferences of these species (Chapman and Putnam 1984), and hence to the preference of alternate wetland types compared with other species recorded by the MMP. For example, the Sedge Wren prefers marshes that offer adequate coverage of sedge meadow habitat. Sedge meadow habitats are dominant in Lake Superior marshes monitored by MMP volunteers (Timmermans and Craigie 2002), and likely contribute to the greater abundance of this species in that area.

Upon examining observed differences in the number of individuals observed at a station, we find that behavioural differences between species may play a key role. Species such as Canada Goose, Mallard and Ruddy Duck, which averaged greater than three individuals per station, are colonial and tend to travel in flocks. However, bitterns, which are more secretive in nature, were observed individually at a station.

The ecology of most marsh-dependent species has received relatively little attention and as a result, relatively little is known about rails and other secretive species (Gibbs et al. 1992, Conway 1995, Melvin and Gibbs 1996, Conway and Timmermans 2005). Marsh birds are believed to be sensitive to habitat disturbances, and many scientists and conservationists consider their populations to be at risk due to continued loss and degradation of their habitats. For instance, a substantial proportion of coastal marshes along Lake Ontario's shoreline have become choked with dense monotypic stands of cattail, likely because of reduced amplitude in water level changes (Timmermans 2002). Further, mean annual water levels of the Great Lakes has proven to be an important correlate and may explain much of the variation in many species trends (Timmermans 2002, Craigie *et al.* 2003, Timmermans *et al.* unpublished data). However, marsh bird species occurrence and abundance, and their activity and likelihood of being observed, vary naturally among years and within seasons, much of the latter of which is attributable to latitudinal differences in breeding phenology due to differences in the onset of favourable weather conditions. For these and other reasons, large numbers of observations, collected over many years, and timed to survey during equivalent weather conditions (i.e., peak breeding period), are required to reliably estimate population trends. Additional years of MMP monitoring data, particularly if augmented with intensive studies of individual species, will determine if patterns observed from current MMP data are representative of long term, persistent population trends.

Amphibians

This report focused on the more common amphibian species that occur in the Great Lakes basin, but certain other species (e.g. Fowler's Toad) are quite rare in parts of the Great Lakes basin and subsequently may require more intensive monitoring efforts than those offered by the MMP. Because the relationship between calling codes and numbers of individuals is uncertain, the focus of this report is on amphibian species presence (or occurrence) at monitoring locations through time. Due to seasonal and annual variability in populations and other related factors, trend estimates for amphibians should be utilized and compared with other complimentary data for verification.

The eight amphibian species commonly detected by MMP surveyors (i.e., American Toad, Bullfrog, Chorus Frog, Green Frog, Grey Treefrog, Northern Leopard Frog, Spring Peeper, and Wood Frog) varied in their relative occurrence among lake basins. Because the range of each species extends the breadth of the Great Lakes basin, these patterns are not likely due entirely to range limitations. Differences in habitats, regional population densities, timing of survey visits, breeding phenology or other factors are possible explanations. Basin-wide declining trends in occurrence were detected for American Toad, Bullfrog, Chorus Frog, Green Frog, and Northern Leopard Frog. Although Weeber and Vallianatos (2000) reported declining trends for American Toad and Bullfrog, only the Chorus Frog showed significant declines in the Great Lakes basin at that time. Results with seven additional years of data continue to show general steady declines in Chorus Frog and American Toad station occurrences. Bullfrog, which began to show only lake basin-specific declining trends in September 2005, is again showing a significant Great Lakes basin-wide declining trend.

Timmermans and Craigie (2002) assessed the extent to which additional years of data may be expected to provide adequate resolution on amphibian occupancy trends based on seven years of MMP data collected from 1995 through 2001. The annual trend (i.e., percent change in relative occurrence index based on station occupancy) from 50% occupancy that could be detected was estimated assuming that either 100, 200 or 300 routes were monitored over three, five or ten years (see Timmermans and Craigie 2002; Table 3). They showed that for 100 routes measured for 10 years, the estimated annual change from 50% occupancy that could be detected was about 1% per year or less for all of the eight amphibians commonly recorded on MMP routes. Resolution improved with 200 and 300 routes, respectively. Expected resolution on trends was best for American Toad and Green Frog, followed by Bullfrog, Chorus Frog, Grey Treefrog and Northern Leopard Frog. Resolution was lower for species that were less common (i.e., Wood Frog) or that exhibited large fluctuations in station occupancy (e.g. Bullfrog).

Most hypotheses concerning global declines in amphibian populations relate to anthropogenic disturbances such as pollution (e.g., acid rain, pesticides), habitat destruction (e.g., urbanization, agriculture), global climate change, and predation from introduced species (Hecnar 1997). Concerns about amphibian population declines are heightened by our relatively poor understanding of their biology, particularly population and community ecology (Hecnar 1997). Long-term population losses (1950s to 1990s) of such species as the Chorus Frog have been recorded in the St. Lawrence River valley just outside the Great Lakes basin and, although natural fluctuations in population and regional extinctions occur (Daigle 1997), such trends are cause for concern.

The MMP has a twelve-year history of survey data, a long history for a citizen science program, but still a relatively short timeframe to reliably determine population trends. However, resolution of trend detection was high for most species (i.e., detect annual change of 1% or less). It should be noted that annual fluctuations of amphibian occurrence indices are apparent and many extrinsic factors may be attributed to those fluctuations. Further work is therefore required to test whether the observed population trends are correlated with anthropogenic factors such as urban development and water level stabilization.

RESEARCH NEEDS

Extensive monitoring and broad comparisons of species trends with components of their changing environment are important to maintain conservation efforts and to address questions about how to better direct conservation efforts of wetland ecosystems. Such approaches often benefit from intensive experimentation to determine if observed correlations are due to causal mechanisms. However, continued expansion of monitoring efforts and improving the robustness of sampling design and comparative approaches can greatly improve confidence in correlative approaches. For example, obtaining geo-referenced locations of MMP route stations is greatly aiding our ability to track route and station locations, and assess habitat and landscape level regimes through various mechanisms. Applying rigorous assessment of temporal and spatial patterns both within MMP surveyed marshes, and throughout adjacent landscapes can have marked effects on marsh community dynamics (Riffel et al. 2001).

The best way to ensure that MMP results are representative of the Great Lakes basin is to randomly sample among an inventory of available wetlands across geomorphologic and habitat-based strata. The degree to which the MMP's volunteer-selected marshes are representative of the Great Lakes basin is currently unknown and depends on criteria of interest. For example, the observed species population densities may not be representative of the entire basin if there is geographic variation in marsh density across the basin and the full variation in population density is not sampled, or if sampled marshes are concentrated primarily in certain regions of the basin. Regardless, if selected marshes do adequately convey the full range of variation in population trends, the population trends reported here might be representative of population trends across the entire basin. Due to the volunteer nature of the MMP surveyor-base, complete randomization of the survey is not practically feasible and may not be desirable. However, recent strides have been made to develop, test, and in the near future, begin implementing a random sampling design within target areas of the Great Lakes basin. Assessment of the proposed random sampling design and its application on a large scale will enable us to test hypotheses about the possible causes of observed population changes. A limiting factor in the establishment of this random sampling design is access to an accurate and useable inventory of all marshes in the Great Lakes basin. An inventory of coastal marshes across the Great Lakes basin is currently available (Burton et al. 2008), but is still lacking for many inland marshes in certain areas of the basin.

Trend results for marsh birds and amphibians would benefit from a comparison with results derived from intensive species- and site-specific sampling. Such sampling could experimentally test how year-to-year changes in water level regimes of marshes affect populations by sampling at non-manipulated control sites and comparing results with those from experimental treatments under different degrees of water level control. Some work has been undertaken by Environment Canada in Ontario to begin comparisons among bird and vegetation communities of dyked and un-dyked wetlands. Combining knowledge gained from such results with species-specific habitat associations of marsh-dependent birds and amphibians would greatly compliment our efforts to conserve and restore damaged and degraded wetland ecosystems for the benefit of entire marsh ecosystems throughout the Great Lakes region.

Finally, trend results from the MMP should be compared against results from other monitoring programs in place in the Great Lakes basin and elsewhere. Cross-correlation of results across programs provides correlative evidence and support for validity of the results. Recently, BSC, in partnership with Environment Canada's Ecological Monitoring and Assessment Network (EMAN) undertook a project to evaluate anuran monitoring activities in Ontario. The objectives of the BSC-EMAN project were to: investigate the compatibility and comparability of datasets collected by the various long-term anuran monitoring programs operating in Ontario, and conduct cross-program species-specific data analyses and summaries (Badzinski et al. 2008). This work demonstrated similar population trend results among programs for certain species. For example, all four programs detected significant or apparent declines in Chorus Frog populations in Ontario, validating results derived from the MMP for this species. It is important to enable validation of the merit of the different programs and collectively provide more compelling results. Likewise, MMP results for marsh birds can, and should, be compared with Breeding Bird Survey results from the Great Lakes basin, at least for the most common species detected in both programs.

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APPENDICES

Appendix 1

Species Code	*Species Name*	*Latin*
ABDU	American Black Duck	*Anas rubripes*
ALFL	Alder Flycatcher	*Empidonax alnorum*
AMBI	American Bittern	*Botaurus lentiginosus*
AMCO	American Coot	*Fulica americana*
BANS	Bank Swallow	*Riparia riparia*
BARS	Barn Swallow	*Hirudo rustica*
BCNH	Black-crowned Night-heron	*Nycticorax nycticorax*
BEKI	Belted Kingfisher	*Megaceryle alcyon*
BLTE	Black Tern	*Chilidonias niger*
BWTE	Blue-winged Teal	*Anas discors*
CAGO	Canada Goose	*Branta canadensis*
CHSW	Chimney Swift	*Chaetura pelagica*
CLSW	Cliff Swallow	*Petrochelidon pyrrhonota*
COGR	Common Grackle	*Quiscalus quiscula*
COMO	Common Moorhen	*Gallinula chloropus*
CONI	Common Nighthawk	*Chordeiles minor*
COSN	Common Snipe	*Capella gallinago*
COYE	Common Yellowthroat	*Geothlypis trichas*
EAKI	Eastern Kingbird	*Tyrannus tyrannus*
GADW	Gadwall	*Anas strepera*
GBHE	Great Blue Heron	*Ardea Herodias*
GRHE	Green Heron	*Butorides virescens*
GWTE	Green-winged Teal	*Anas crecca*
LEBI	Least Bittern	*Ixobrychus exilis*
MALL	Mallard	*Anas platyrhynchos*
MAWR	Marsh Wren	*Cistothorus palustris*
MOOT	Undifferentiated Moorhen/Coot	
MUSW	Mute Swan	*Cygnus olor*
NOHA	Northern Harrier	*Circus cyaneus*
NRWS	Northern Rough-winged Swallow	*Stelgidopteryx ruficollis*
PBGR	Pied-billed Grebe	*Podilymbus podiceps*
PUMA	Purple Martin	*Pronge subis*
RWBL	Red-winged Blackbird	*Agelaius phoeniceus*
SACR	Sandhill Crane	*Grus canadensis*
SEWR	Sedge Wren	*Cistothorus palustris*
SORA	Sora	*Porzana carolina*
SOSP	Song Sparrow	*Melospiza melodia*
SWSP	Swamp Sparrow	*Melospiza geogiana*

Appendix 1 (Cont'd)

Species Code	*Species Name*	*Latin*
TRES	Tree Swallow	*Iridoprocne bicolor*
VIRA	Virginia Rail	*Rallus limicola*
WIFL	Willow Flycatcher	*Empidonax trailli*
YWAR	Yellow Warbler	*Dendroica petechia*

Appendix 2

Species Code	*Species Name*	*Latin*
AMTO	American Toad	*Bufo americanus*
BULL	Bullfrog	*Rana catesbeiana*
CGTR	Cope's (Diploid) Grey Treefrog	*Hyla chrysoscelis*
CHFR	Chorus Frog	*Acris crepitans*
FOTO	Fowler’s Toad	*Bufo woohhousei fowleri*
GRFR	Green Frog	*Rana clamitans*
GRTR	Grey (Tetraploid) Treefrog	*Hyla versicolor*
MIFR	Mink Frog	*Rana septentrionalis*
NLFR	Northern Leopard Frog	*Rana pipiens*
PIFR	Pickerel Frog	*Rana palustris*
SPPE	Spring Peeper	*Hyla crucifer*
WOFR	Wood Frog	*Rana sylvatica*