Assessment of wildlife status and trends within the St. Clair River and Detroit River Areas of Concern Using Bird Studies Canada Data

Final Report

Left: Detroit River AOC; Right: St. Clair River AOC; photos by U.S. Environmental Protection Agency

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ÉTUDES D'OISEAUX

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Executive Summary

Birds and frogs are excellent indicators of environmental quality due in part to their habitat requirements and ease of detection. As a result, the presence, diversity, or reproductive success of these groups of animals is often used to assess the status of wildlife beneficial use impairments in Areas of Concern (AOCs). In cases where the status and trend of wildlife within the AOC is as good as or better than the surrounding region, a case can be made for lifting beneficial use impairments.

This report summarizes previous analyses of bird, frog, and mammal data for the St. Clair River and Detroit River AOCs by Bird Studies Canada (BSC), a non-government charitable organization dedicated to conservation of wild birds and their habitats in Canada. It also supplements these previous analyses by illustrating basic information such as sampling locations, monitoring effort, and statistics. This basic information, which is typically omitted from more-technical reports due to space limitations or other reasons, is useful for interpreting statistical analyses. For example, the sophisticated statistics calculated for various datasets from the St. Clair River AOC by Rankin (2011), such as pair-wise community dissimilarity indices, Poisson generalized additive mixed models, and non-metric multi-dimensional scaling, are required and appropriate, but are challenging for many readers. Thus, the bulk of this report supplements these previous assessments by providing more-user-friendly illustrations of the data, to help digest the more-complicated analyses. They should not be interpreted as an additional separate analysis of the same data.

Overall in the St. Clair River AOC, the status and/or trend of marsh-breeding birds and frogs, other groups of aquatic breeding birds (but not waterbirds or fish-eating birds), mink and muskrat, and spring and autumn-staging dabbling and diving ducks is as good as or better within or adjacent to the AOC than in the surrounding region (Table 1). Overall in the Detroit River AOC, the status and/or trend of marsh-breeding birds and frogs and all groups of aquatic breeding birds is worse than in the surrounding region; by contrast, visual inspection of plots of data suggest that spring and autumn-staging dabbling and diving ducks and reproductive success of Bald Eagles is as good as or better within or adjacent to the Detroit River AOC than in the surrounding region (Table 1).

The diversity of most groups of aquatic wildlife, particularly marsh-breeding birds and frogs, increases as wetland area increases and the amount of urban land use in the surrounding region decreases. Thus, the more positive status and trend of aquatic wildlife in the St. Clair River AOC compared to the Detroit River AOC is likely at least partly due to the existence of more and larger wetlands (at the mouth of the St. Clair River) and predominantly agricultural rather than urban land use in the surrounding region. Differences in water quality between the AOCs may also be a factor.

Reliable assessment of the status and trend of wildlife within AOCs requires that surveys be representative of the entire AOC. It may be possible to improve the coverage of some of the datasets analyzed in this report, for example, by ensuring, to the extent possible, that all marsh sizes and types within the AOC are sampled using the Marsh Monitoring Program bird and amphibian protocols.

Table 1. Summary of the status and/or trend of wildlife in the St. Clair River and Detroit River AOCs.

Metric	St. Clair River AOC	Detroit River AOC
Marsh breeding birds and frogs	*Fair / no apparent impairment*	*Poor / impaired*
Aquatic breeding birds	*Poor / impaired* to *Fair / no apparent impairment*	*Poor / impaired*
Mink and muskrat	*Good / no impairment*	Not assessed
Spring and autumn-staging migratory waterfowl	*Fair / no apparent impairment* to *Good / no impairment*	*Fair / no apparent impairment* to *Good / no impairment*
Bald Eagle reproductive success	Not assessed	*Fair / no apparent impairment*

Preamble

Bird Studies Canada (BSC) was contracted by Environment Canada (EC) in December 2011 to produce the following general deliverables for the St. Clair River and Detroit River Areas of Concern (AOCs):

1. Assess and review all available amphibian and bird data from wildlife monitoring programs administered by BSC within the St. Clair River and Detroit River AOCs and suggest to EC which data sets are recommended for use as per the objective of the project.

2. Compile all agreed upon wildlife data sets (minimum of amphibians and birds) for the St. Clair River and Detroit River AOCs and:

    - Produce maps of all data collection/survey sites along with the data corresponding to each site within each AOC. Also include sites that are adjacent/close to the AOC boundary.

    - Use appropriate and creative graphs and charts to illustrate wildlife abundance and changes in diversity over time within each AOC.

    - Summarize the data collection methodologies and summarize the number of surveys conducted, the number of sites, level of survey effort and degree of accuracy.

3. Provide insight/interpretation of data and make recommendations if appropriate on how to improve survey/data coverage within each AOC.

Item 1 above is presented in Datasets and Definitions. Items 2 and 3 above are presented separately for the St. Clair River AOC and the Detroit River AOC in the two main sections thereafter. The AOC sections can be read in isolation, although some definitions common to each are given in Datasets and Definitions. The AOCs are discussed separately to make the report more accessible to people interested in one AOC or the other.

In the past BSC has analyzed data from its own monitoring programs and those of other agencies to assess the health of the St. Clair River and Detroit River AOCs. This information is briefly summarized at the beginning of each AOC section.

In many cases, the data presented in this report have already been analyzed in other ways in previous AOC-related reports by BSC (data from Great Lakes Marsh Monitoring Program, Ontario Breeding Bird Atlas, and Canadian Wildlife Service Waterfowl Survey). Often, however, the previous reports do not illustrate basic information such as sampling locations, monitoring effort, or basic statistics, such as changes in species richness and abundance over time, within and adjacent to the AOC versus the surrounding region. Having illustrations of these basic data are useful for interpreting more-complex statistical tests, but are usually omitted from reports due to space limitations or other reasons. This report attempts to remedy this for the St. Clair River and Detroit River AOCs. In other cases, the information has not, to our knowledge, been analyzed in an AOC-context elsewhere, by BSC or otherwise (data from Southern Ontario Bald Eagle Monitoring Program for the Detroit River AOC, but see Best and Wilke 1987; data from Canadian Wildlife Service Waterfowl Survey for the Detroit River AOC, but see Dennis et al. 1985). In cases where the data have been analyzed previously, this report is meant to supplement the previous assessments by providing more user-friendly illustrations of the data, and should not be interpreted as an additional separate analysis of the same data.

Appendices containing detailed site-level summaries of the data appear at the end of the report.

Definitions and Datasets

Definition of Status and Trend

In this report *status* indicates whether the abundance or species richness of a particular group within or adjacent to the AOC is higher (not impaired, good), the same (no apparent impairment, fair), or lower (impaired, poor) than that in the surrounding region during a certain time period. *Trend* indicates whether the change in abundance or species richness of a particular group within the AOC is increasing more than (not impaired, good), the same as (no apparent impairment, fair), or decreasing more than (impaired, poor) the surrounding region during a certain time period.

Appropriate Datasets

AOCs are designated and assessed using a set of 14 beneficial use impairments (BUIs) described in the Canada-U.S. Great Lakes Water Quality Agreement. Given that the Agreement addresses aquatic systems and life forms, it is our opinion that the datasets that are the most appropriate for assessing the health and recovery of AOCs are those which track attributes of species or groups of species that are expected to be negatively affected by poor water quality (e.g., diet comes predominantly from lakes, rivers, or wetlands within the AOC or life history requires lake, river, or wetland habitat within the AOC). As well, the dataset should allow for an assessment of status and trend according to the definitions above. Thus, the dataset should include comparable information from (ideally healthy) reference sites within the surrounding region, to put the data from within the AOC in context. Data from only within the AOC are of limited value for assessing health and recovery without this comparative context.

Using this approach, the following BSC programs yield data that are appropriate for assessing the health and status of wildlife within most AOCs:

- Great Lakes Marsh Monitoring Program
- Ontario Breeding Bird Atlas
- Southern Ontario Bald Eagle Monitoring Program
- Christmas Bird Count

In this report we analyze or summarize data from the first 3 of these 4 programs. We do not analyze data from the Christmas Bird Count because in the case of the St. Clair River and Detroit River AOCs, there is much more extensive information, both temporally and spatially, from aerial surveys for suitable indicator species (waterfowl).

St. Clair River Area of Concern

Note: *Status* and *trend* are used often throughout this report; definitions can be found on p. 3.

Summary of Previous Assessments

Great Lakes Marsh Monitoring Program

Using various biologically-meaningful groupings of species chosen as indicators by experts, including rails, bitterns, grebes, and widespread frog species, the status of the bird and amphibian community has been assessed as *no apparent impairment* based on data from 1995 to1996 (Chabot et al. 1998), *no apparent impairment* based on data from 1995 to 2002 (Timmermans et al. 2004), and *no apparent impairment* based on data from 2002 to 2006 (Archer et al. 2006).

Using a less subjective statistical technique that chooses groupings of indicator species in a way that minimizes redundancy, Rankin (2011) assessed the status of the bird and amphibian community as *good* and *fair*, respectively, and the trend of the bird community as *fair*; a trend assessment for the amphibian community was not attempted due to sparseness of data.

Together, the assessments suggest that the status and trend of the bird and amphibian community within and adjacent to the St. Clair River AOC is *fair* or has *no apparent impairment*.

Breeding Bird Atlases

Crewe et al. (2007) assessed trends in species richness of 20 taxonomic, habitat, and foraging guilds between the first (1981 to 1985) and second (2001 to 2005) atlases within or adjacent to the AOC compared to the surrounding ecoregion. Trends of most guilds were similar within or adjacent to the AOC compared to the surrounding ecoregion. Of the aquatic guilds, waterbirds and piscivores declined significantly more within or adjacent to the AOC than within the surrounding ecoregion. By contrast, there was no significant difference in the trend within or adjacent to the AOC versus the surrounding ecoregion for waterfowl, marsh-nesting species, and area-sensitive marsh-nesting species.

The same dataset was analyzed by Rankin (2011), but compared to the approach taken by Crewe et al. (2007), he reduced the number of guilds to 9 rather than 20 to avoid redundancy; applied spatial autocorrelation statistics to determine the extent of the surrounding “region” rather than using the surrounding pre-defined ecoregion; and used data from 8 rather than 10 atlas squares within or adjacent to the AOC. Like Crewe et al. (2007), Rankin (2011) assessed waterbirds as *poor*, waterfowl as *fair*, and marsh-nesting species as *fair*; he did not analyze piscivores or area-sensitive marsh-nesting species.

Together, the assessments suggest that the trend in species richness of aquatic bird guilds within and adjacent to the St. Clair River AOC is between *poor* / *impaired* and *fair* / *no apparent impairment*.

Furbearer Harvests

Using trapping data for Mink and Muskrat with appropriate covariates to control for trapping effort and prices of pelts, Rankin (2011) found that harvests within the AOC increased significantly between the mid-1990s and 2010 compared to declining harvests in surrounding counties. He assessed the trend of both of these species within the St. Clair River AOC as *good*; a status assessment was not attempted.

Canadian Wildlife Service Waterfowl Survey

Using a statistical technique that chooses groupings of indicator species in a way that minimizes redundancy, Rankin (2011) reported that dabblers and divers increased in the spring and decreased in the autumn both within the AOC and within the surrounding region. There was weak statistically non-significant evidence that increases in dabblers and divers in spring were more positive within the AOC than within the surrounding region and that decreases in dabblers and divers in autumn were more

negative within the AOC than within the surrounding region. He assessed the trends in the waterfowl community within the St. Clair River AOC as *fair* to *good* but stressed numerous limitations of comparing these waterfowl data from within the AOC to the surrounding region; a status assessment was not attempted.

Further Analysis of Previous Assessments

The previous section summarizes past reports that analyzed data within or adjacent to the St. Clair River AOC compared to the surrounding region. This section builds on some of these previous reports by providing supplementary background information and illustrations of basic statistics.

Great Lakes Marsh Monitoring Program

Birds

There were 28 routes containing 120 stations within the remedial action plan (RAP)-defined AOC boundary or mostly (>90%) within a few kilometres and within up to ~20 km of the RAP-defined AOC boundary (hereafter adjacent), where bird data was collected for 1 or more years between 1995 and 2011 (Fig. 1). Bird data were collected at 4.1 ± 2.1 routes (mean ± SD) and 14.4 ± 10.6 stations per year within or adjacent to the AOC between 1995 and 2011 (Fig. 2), indicating that most routes were not surveyed in all of the years. Volunteers visited routes containing 1-8 stations in emergent wetlands during the morning or evening on the same day two or three times per breeding season, targeting early and late-season breeding species. Conditions were calm, warm, and dry during 15-minute surveys and call broadcasts were used to increase detections of secretive species.

To illustrate the status and trend of marsh birds in the AOC, we plotted the mean number of marsh-nesting and marsh indicator species observed per station per season over time between 1995 and 2011 for stations within or adjacent to the AOC and 1041 stations within the Lake Erie basin, although not all of the 1041 stations were surveyed in all of the years. We included 95% confidence intervals on these plots to illustrate the amount of uncertainty around each annual mean; only in years when the intervals around the mean for the AOC do not overlap those for the Lake Erie basin should the difference between the means be considered with confidence. Marsh-nesting species consisted of 48 species that are known to nest in wetlands, although many of them also nest in uplands. Marsh indicator species were a subset of the marsh-nesters, consisting of rails and bitterns plus Black Tern, Blue-winged Teal, Marsh Wren, and Wilson's Snipe; out of all of the marsh-nesting species, the marsh indicator species are the most dependent on wetlands for breeding.

The mean number of marsh-nesting and marsh indicator species observed per station within and adjacent to the AOC was as high as or higher than the mean number within the Lake Erie basin until 2003, after which the values became more variable and in some years were much lower or much higher than the mean number within the Lake Erie basin (Fig. 3). The increased variability after 2003 may be partly due to a decrease in the number of stations surveyed per year in most years during that time period (Fig. 2). Compared to mean values for the Lake Erie basin, the mean number of marsh-nesters within or adjacent to the AOC was clearly less (i.e., confidence intervals did not overlap) in only 3 of 17 (18%) years and the mean number of marsh indicators within or adjacent to the AOC was clearly less in only 2 of 17 (12%) years.

These results illustrate the conclusions made by others using parts of the same dataset, that the status and trend of marsh birds within and adjacent to the St. Clair River AOC is somewhere between *fair* / *no apparent impairment* and *good / not impaired*, (Chabot et al. 1998, Timmermans et al. 2004, Archer et al. 2006, Rankin 2011).

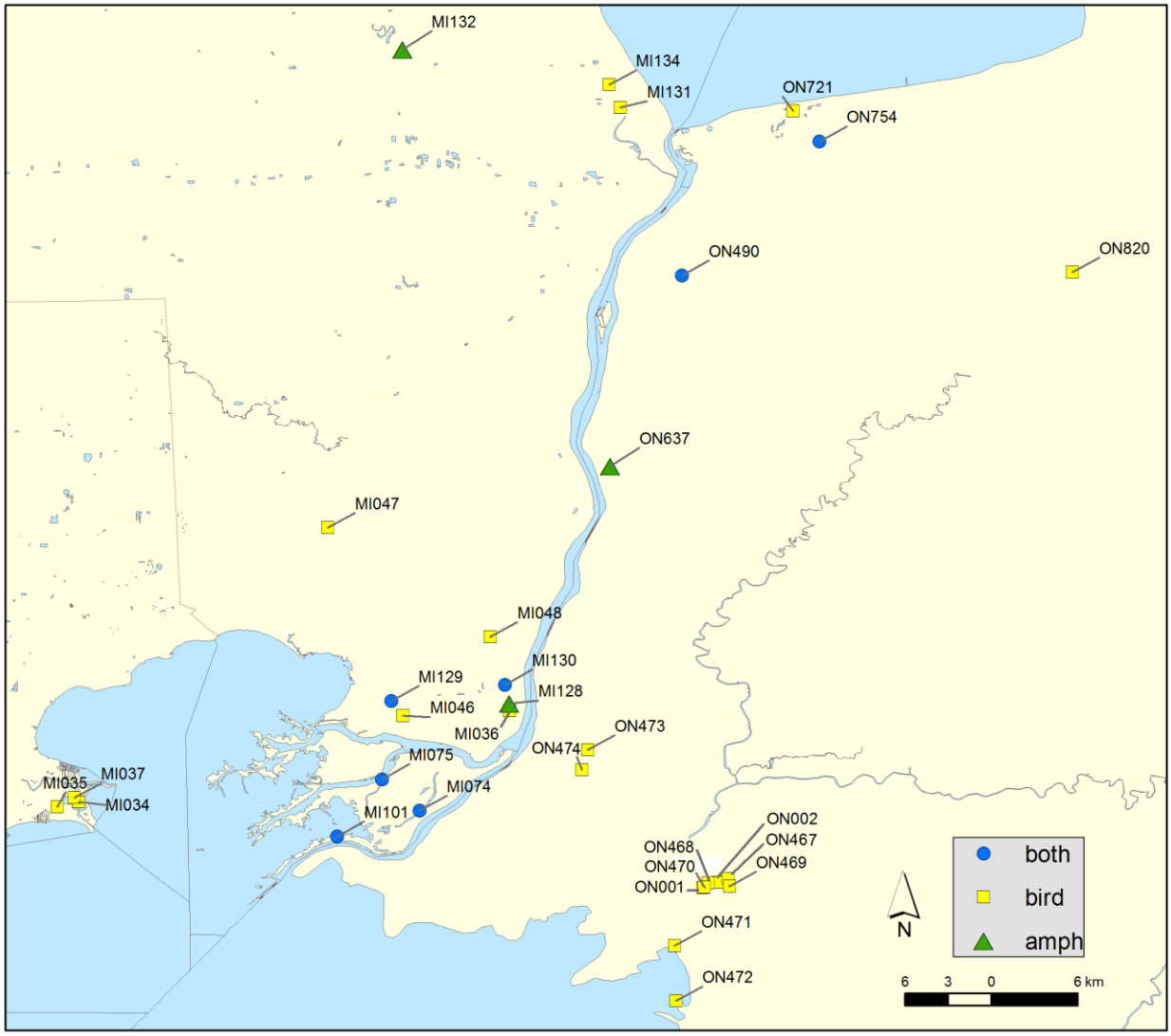

Fig. 1. Locations of Great Lakes Marsh Monitoring Program routes within or adjacent to the St. Clair River AOC. Routes monitored for at least 1 year for birds (bird), amphibians (amph), or both birds and amphibians (both) are shown with different symbols.

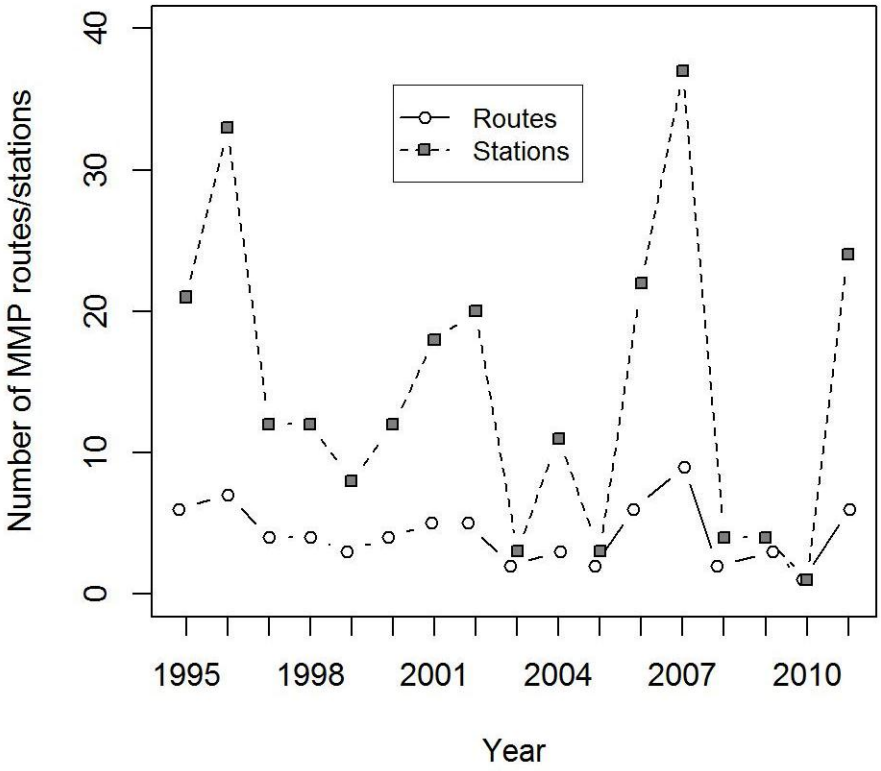

Fig. 2. Number of active Great Lakes Marsh Monitoring Program bird routes and stations per year within or adjacent to the St. Clair River AOC between 1995 and 2011.

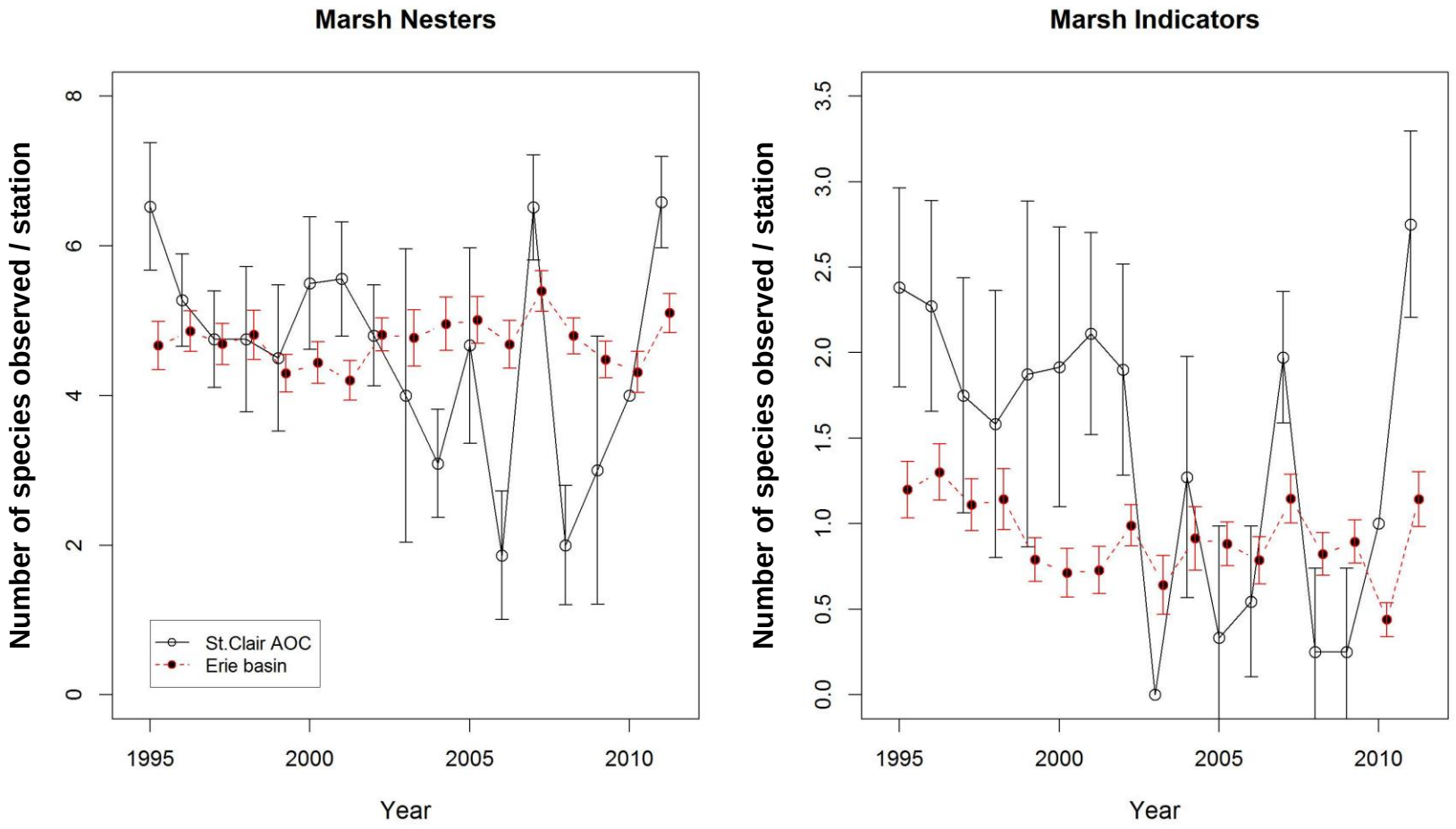

Fig. 3. Mean (±95% CIs) number of marsh-nesting and marsh indicator bird species observed per station within and adjacent to the St. Clair River AOC and within the Lake Erie basin between 1995 and 2011.

Amphibians

There were 10 routes containing 49 stations within the remedial action plan (RAP)-defined AOC boundary or mostly (>90%) within a few kilometres and within up to ~20 km of the RAP-defined AOC boundary (hereafter adjacent), where amphibian data were collected for 1 or more years between 1995 and 2011 (Fig. 1). Amphibian data were collected at 1.8 ± 1.1 routes (mean ± SD) and 7.5 ± 4.5 stations per year within or adjacent to the AOC between 1995 and 2011 (Fig. 4), indicating that most routes were not surveyed in all of the years. Volunteers visited routes containing 1-8 stations in emergent wetlands within 4 hours after sunset on the same day three times per breeding season, targeting early, mid, and late-season breeding species. Wind was calm with little or no precipitation during 3-minute surveys.

To illustrate the status and trend of marsh-breeding amphibians in the AOC, we plotted the mean number of amphibian and amphibian indicator species observed per station per season over time between 1995 and 2011 for stations within or adjacent to the AOC and 1009 stations within the Lake Erie basin, although not all of the 1009 stations were surveyed in all of the years. We included 95% confidence intervals on these plots to illustrate the amount of uncertainty around each annual mean; only in years when the intervals around the mean for the AOC do not overlap those for the Lake Erie basin should the difference between the means be considered with confidence. Indicator species were Chorus Frog, Northern Leopard Frog, and Spring Peeper, chosen for the following reasons: sufficiently common to make detection likely, dependent on marshes for breeding, and require habitats with few invasive species and low toxin levels (Chabot et al. 1998).

The mean number of all amphibian species and amphibian indicator species observed per station within or adjacent to the AOC was the same as or lower than the mean number in the Lake Erie basin in all years except one between 1995 and 2011 (Fig. 5). In 2005 the mean number of all amphibian species and amphibian indicator species appeared to spike well above the mean for the Lake Erie basin, but this result is likely biased upwards and unrepresentative of the AOC because only one station was surveyed that year, the lowest number per year of any year between 1995 and 2011 when surveys occurred somewhere within or adjacent to the AOC (Fig. 4). Compared to mean values for the Lake Erie basin, the mean number of all amphibian species within or adjacent to the AOC was clearly less (i.e., confidence intervals did not overlap) in only 1 of 8 (13%) years and the mean number of amphibian indicators within or adjacent to the AOC was clearly less in only 2 of 8 (25%) years.

These results illustrate the conclusions made by others using parts of the same dataset, that the status of marsh amphibians within and adjacent to the St. Clair River AOC is somewhere between *poor / impaired* and *fair* / *no apparent impairment* (Chabot et al. 1998, Timmermans et al. 2004, Archer et al. 2006, Rankin 2011).

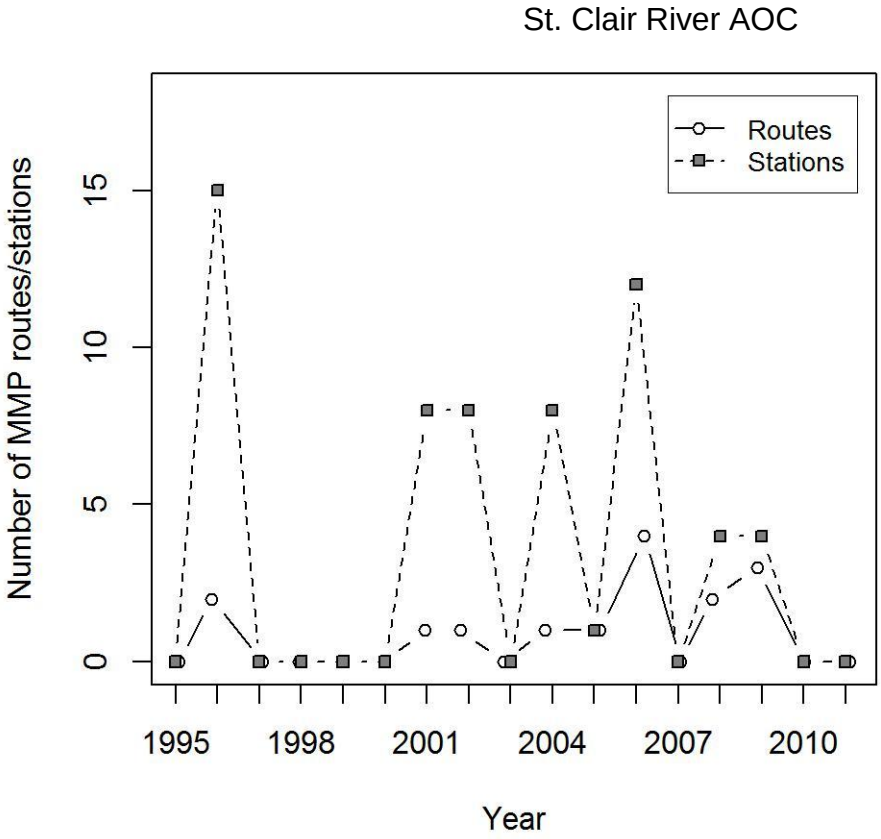

Fig. 4. Number of active Great Lakes Marsh Monitoring Program amphibian routes and stations per year within or adjacent to the St. Clair River AOC between 1995 and 2011.

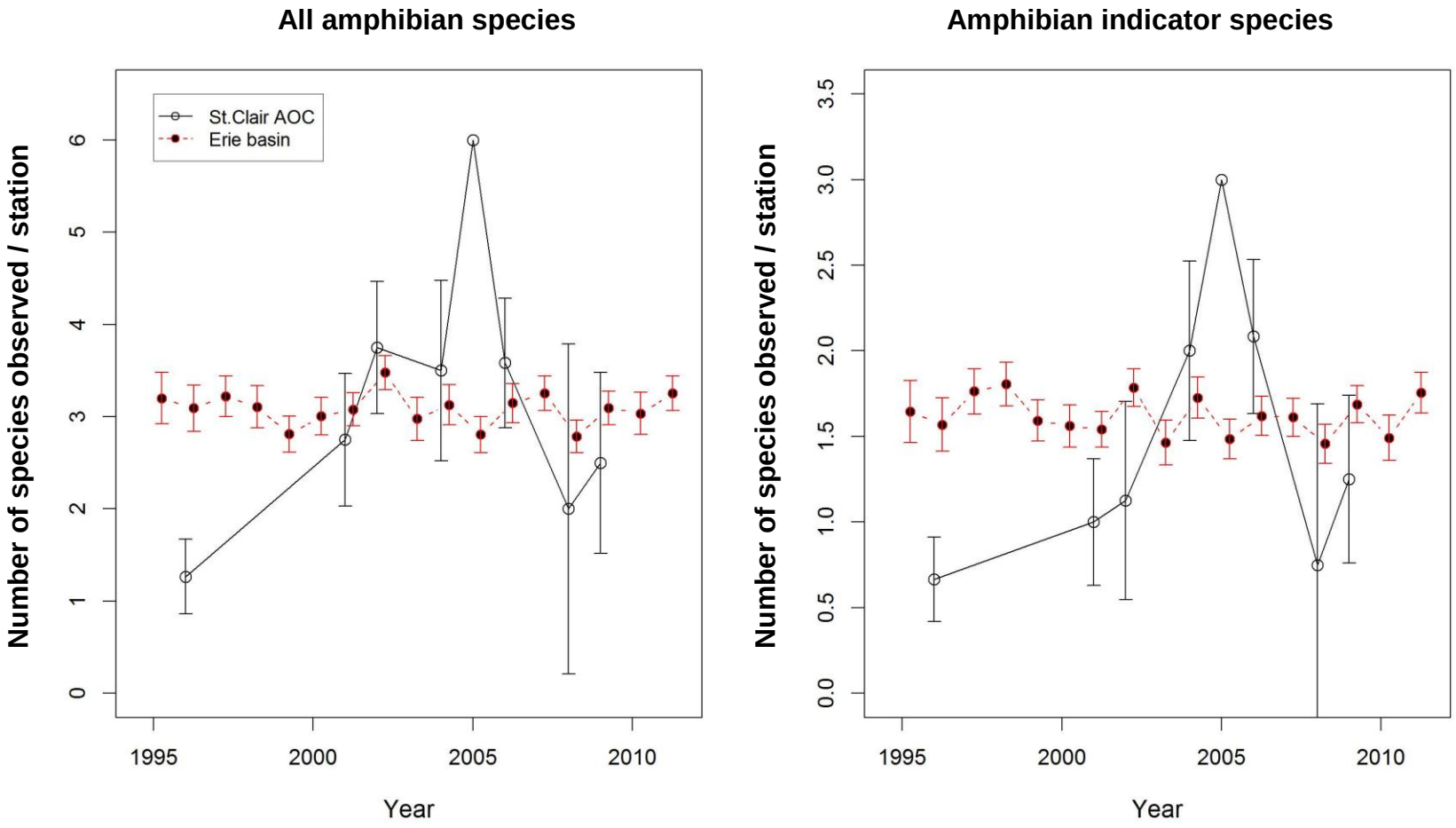

Fig. 5. Mean (±95% CIs) number of all amphibian species and amphibian indicator species observed per station per season within and adjacent to the St. Clair River AOC and within the Lake Erie basin between 1995 and 2011.

Canadian Wildlife Service Waterfowl Survey

There was 1 survey sector located within the AOC and 6 sectors chosen within the surrounding region, 2 located on the southern shore of Lake St. Clair and 4 located in the Long Point area (Fig. 6). The sectors within the surrounding region were the same sectors chosen as a regional reference by Rankin (2011), being areas close enough to the St. Clair River AOC to harbour similar waterfowl communities (according to tests of spatial autocorrelation) but known to be highly-used staging areas by waterfowl (Dennis et al. 1985). Using aircraft, all waterfowl within each sector were tallied 2–6 times in the spring and 2–6 times in the autumn about once each decade between 1969 and 2003; more-recent data were not available.

To illustrate the status and trend of spring and autumn waterfowl use within the AOC and within the surrounding region, we followed Rankin (2011) by averaging the number of dabbler and diving duck use days between the first and the last survey within each season in each survey year. Then, to standardize effort, we divided the averages by the number of days between the first and last visit and by the number of kilometres of shoreline within the sector. This produced a spring and autumn index of dabbler and diver use for each sector for each survey year. We then plotted the index within the AOC and the mean of the indices of the sectors within two surrounding regions separately over time for spring and autumn. We plotted data from the surrounding region for Lake St. Clair and the Long Point area separately because the abundances often differed greatly between the two, and we felt that an aggregated value might be misleading. We included 95% confidence intervals (CIs) for the two surrounding regions on these plots to illustrate the amount of uncertainty around each mean. By contrast, there are no 95% CIs for the AOC because there is only one sector within the AOC. However, in years when the index within the AOC lies beyond the 95% CIs for a surrounding region, the difference can be considered with confidence. Survey years when only one flight occurred in the spring or autumn were omitted from analysis.

The number of dabblers and divers within the AOC was the same as or higher than the mean number in each of the surrounding regions in most years between 1969 and 2003, although variability around the means in the surrounding regions makes patterns difficult to interpret (Fig. 7). Dabblers and divers generally increased in the spring and decreased in the fall within the AOC and within the surrounding regions (Fig. 7). It is possible that dabblers and divers increase more in spring within the AOC than in the surrounding region (Fig. 7).

These results illustrate the conclusions made by others using parts of the same dataset, that the trend of staging waterfowl in spring and autumn within the St. Clair River AOC is somewhere between *fair / no apparent impairment* and *good / not impaired* (Rankin 2011). Crewe et al. (2007) also found no differences in the status or trend of the number of species of breeding waterfowl within or adjacent to the AOC compared to the surrounding region.

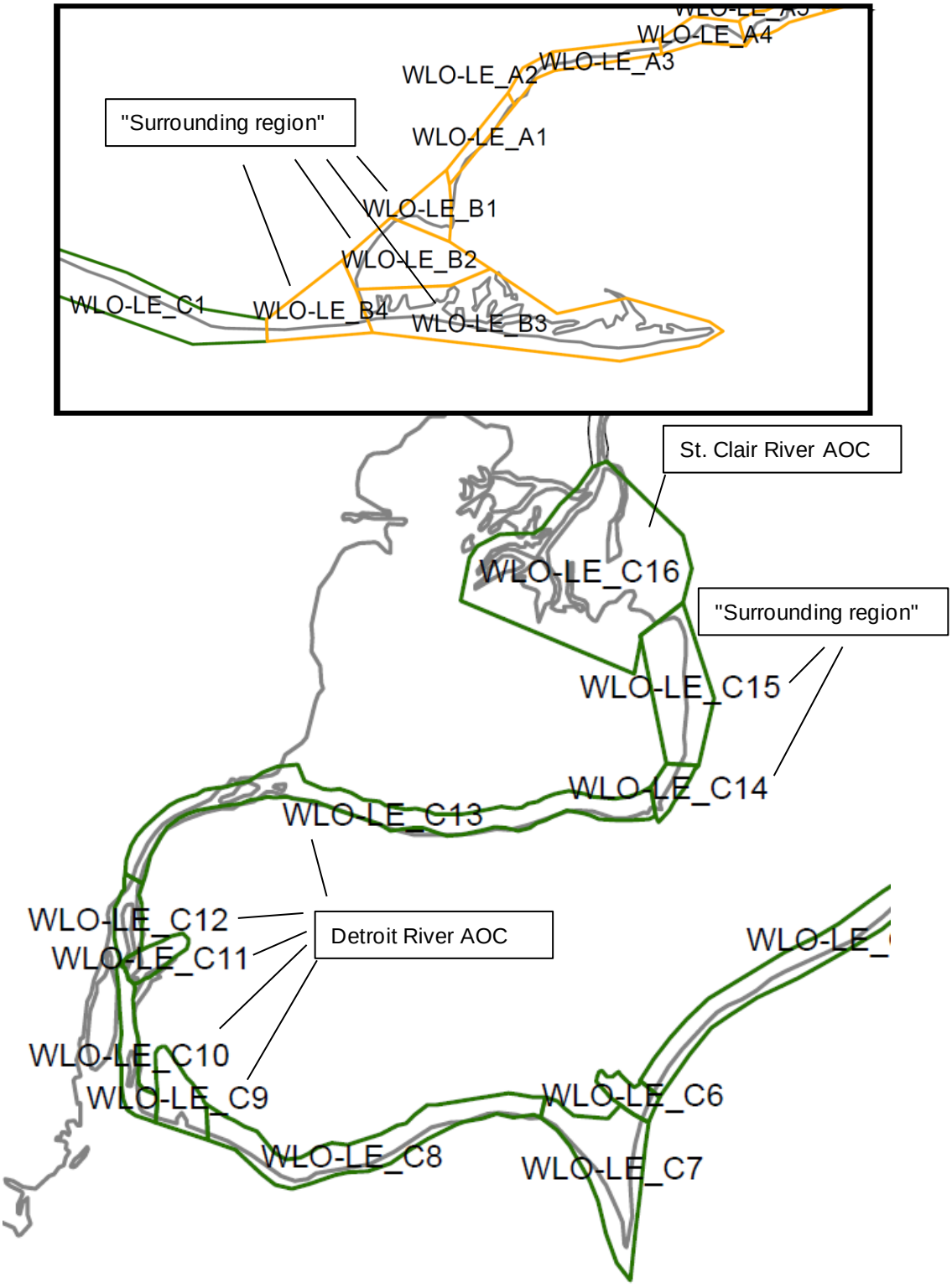

Fig. 6. Locations of Canadian Wildlife Service Waterfowl Survey sectors within the St. Clair River AOC (1 sector), the Detroit River AOC (5 sectors), and the surrounding region (2 sectors on the south shore of Lake St. Clair and 4 sectors at Long Point [shown within the inset at the top]).

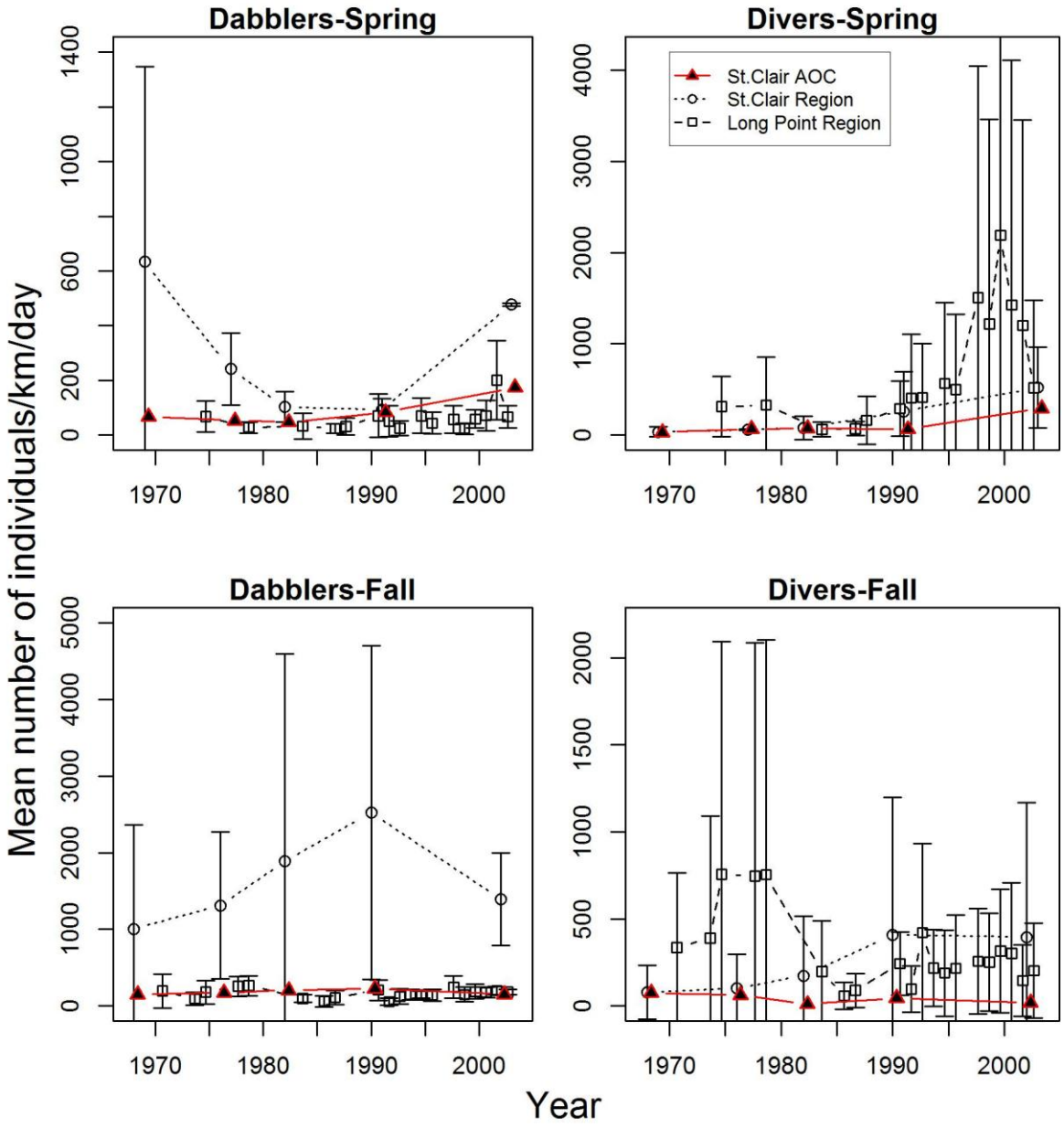

Fig. 7. Mean number of dabbler and diving ducks (±95% CIs) per kilometre of shoreline per day within the St. Clair River AOC and within sectors within two surrounding regions, the southern shore of Lake St. Clair and the Long Point area.

Interpretation and recommendations

In the St. Clair River AOC, the status and/or trend of marsh-breeding birds and frogs, most other groups of aquatic breeding birds, mink and muskrat, and spring and autumn-staging dabbling and diving ducks is as good as or better than in the surrounding region. By contrast, waterbirds and fish-eating birds are worse within and adjacent to the AOC than in the surrounding region. A summary of these findings appears in Table 1 on p. 1.

The diversity of most groups of aquatic wildlife, particularly marsh-breeding birds and frogs, increases as wetland area increases (e.g., birds: Riffel et al. 2001; frogs: Findlay and Houlahan 1997) and the amount of urban land use in the surrounding region decreases (e.g., birds: Smith and Chow-Fraser 2010; frogs: Gague and Fahrig 2007). There are >100 km^2 of wetlands in the St. Clair River AOC (St. Clair River Remedial Action Plan team 1991), nearly all of which are at the St. Clair River mouth, which is almost 1.5x more wetland than the current total aerial extent of wetlands throughout adjacent Lambton and Kent counties (Ducks Unlimited Canada 2010). Most (~>80%) of the watershed surrounding the St. Clair River AOC is used for agriculture and very little of the remainder is urban; only 170,000 people live in the AOC's watershed, at relatively low population densities compared to many other locations in southwestern Ontario (St. Clair River Remedial Action Plan team 1991). Thus, the positive status and trend of aquatic wildlife in the St. Clair River AOC is likely at least partly due to the existence of extensive large wetlands (at the mouth of the St. Clair River) and predominantly agricultural rather than urban land use in the surrounding region. Additional factors may also be contributing to the positive status and trend.

The reality may be, however, that the wildlife communities within the St. Clair River AOC are some of the best among a collection of species-impaired declining communities within a highly environmentally-degraded region (i.e., the Lake Erie basin; Hartig et al. 2009). It may also be that the positive picture illustrated here for the St. Clair River AOC is largely driven by the data being partly from the extensive wetlands located at the mouth of the St. Clair River and may not be representative of the smaller isolated wetlands in the rest of the St. Clair River AOC.

Reliable assessment of the status and trend of wildlife within the St. Clair River AOC requires that surveys be representative of the entire AOC. This was likely achieved for breeding bird atlas and Canadian Wildlife Service waterfowl data because coverage was nearly complete; it may not have been as successfully achieved for the mink/muskrat or Marsh Monitoring Program data. For these programs representative coverage could be achieved by placing sampling points within each wetland within the AOC, an approach suggested previously (Weeber et al. 1997) but unrealistic with available resources. With limited resources, the best coverage is probably achieved by placing replicated sampling points within replicated randomly-chosen wetlands within each of the wetland size x wetland type combinations within the AOC (e.g., large, medium, small cattail; large, medium, small grass-sedge; etc.). The coverage of wetland sizes and types within the St. Clair AOC was not assessed for the surveys illustrated here, and coverage may have fallen short of these guidelines. Ideally survey coverage within the AOC should fulfill these guidelines.

Detroit River Area of Concern

Note: *Status* and *trend* are used often throughout this report; definitions can be found on p. 3.

Summary of Previous Assessments

Great Lakes Marsh Monitoring Program

Using various biologically-meaningful groupings of species chosen as indicators by experts, including rails, bitterns, grebes, and widespread frog species, the status of the bird and amphibian community has been assessed as *impaired* based on data from 1995 to1996 (Chabot et al. 1998) and *impaired* based on data from 1995 to 2002 (Timmermans et al. 2004); Archer et al. (2006) did not analyze data for the Detroit River AOC.

Together, the assessments suggest that the status of the bird and amphibian community within and adjacent to the Detroit River AOC is *poor* or *impaired*.

Breeding Bird Atlases

Crewe et al. (2007) assessed trends in species richness of 20 taxonomic, habitat, and foraging guilds between the first (1981 to 1985) and second (2001 to 2005) atlases within the AOC and its surrounding ecoregion. Trends of most guilds were similar within the AOC compared to the surrounding ecoregion. Of the aquatic guilds, waterbirds, waterfowl, marsh-nesters, area-sensitive marsh-nesters, and piscivores declined more within the AOC than within the surrounding ecoregion. The assessment suggests that the trend in species richness of aquatic guilds within and adjacent to the Detroit River AOC is *poor* or *impaired*.

Further Analysis of Previous Assessments

The previous section summarizes past reports that analyzed data within or adjacent to the Detroit River AOC compared to the surrounding region. This section builds on some of these previous reports by providing supplementary background information and illustrations of basic statistics.

Great Lakes Marsh Monitoring Program

Birds

There were 24 routes containing 55 stations within the remedial action plan (RAP)-defined AOC boundary or mostly (>90%) within a few kilometres and within up to ~20 km of the RAP-defined AOC boundary (hereafter adjacent), where bird data was collected for 1 or more years between 1995 and 2011 (Fig. 8). Bird data were collected at 3.5 ± 4.4 routes (mean ± SD) and 7.7 ± 8.4 stations per year within or adjacent to the AOC between 1995 and 2011 (Fig. 9), indicating that most routes were not surveyed in all of the years. Volunteers visited routes containing 1-8 stations in emergent wetlands during the morning or evening on the same day two or three times per breeding season, targeting early and late-season breeding species. Conditions were calm, warm, and dry during 15-minute surveys and call broadcasts were used to increase detections of secretive species.

To illustrate the status and trend of marsh birds in the AOC, we plotted the mean number of marsh-nesting and marsh indicator species observed per station per season over time between 1995 and 2011 for stations within or adjacent to the AOC and 1041 stations within the Lake Erie basin, although not all of the 1041 stations were surveyed in all of the years. We also plotted the mean number of Black-crowned Night Herons in this manner because this species was listed as an indicator species in the Detroit River Canadian Remedial Action Plan Stage 2 Report (Green et al. 2010). We included 95% confidence intervals on these plots to illustrate the amount of uncertainty around each annual mean; only in years when the intervals around the mean for the AOC do not overlap those for the Lake Erie basin should the difference between the means be considered with confidence. Marsh-nesting species consisted of 48 species that are known to nest in wetlands, although many of them also nest in uplands. Marsh indicator species were a subset of the marsh-nesters, consisting of rails and bitterns

plus Black Tern, Blue-winged Teal, Marsh Wren, and Wilson's Snipe; out of all of the marsh-nesting species, the marsh indicator species are the most dependent on wetlands for breeding.

The mean number of marsh-nesting and marsh indicator species observed per station per season within and adjacent to the AOC was the same as or lower than the mean number within the Lake Erie basin between 1995 and 2011 (Fig. 10). The mean number of marsh-nesting species appears to rise from 2002 onwards, although there is no corresponding rise in marsh indicators during the same period (Fig. 10). This pattern may be partly the result of an increase in the number of bird routes and stations surveyed per year during that period (Fig. 9). The Black-crowned Night Heron was observed on only 18 of the 228 (8%) surveys within or adjacent to the AOC between 1995 and 2011, too few to make any meaningful conclusions about their status or trend (Fig. 10). Compared to mean values for the Lake Erie basin, the mean number of marsh-nesters within or adjacent to the AOC was clearly less (i.e., confidence intervals did not overlap) in 13 of 17 (76%) years and the mean number of marsh indicators within or adjacent to the AOC was clearly less in 10 of 17 (59%) years.

These results illustrate the conclusions made by others using parts of the same dataset, that the status and trend of marsh birds within the Detroit River AOC is *poor / impaired* (Chabot et al. 1998, Timmermans et al. 2004).

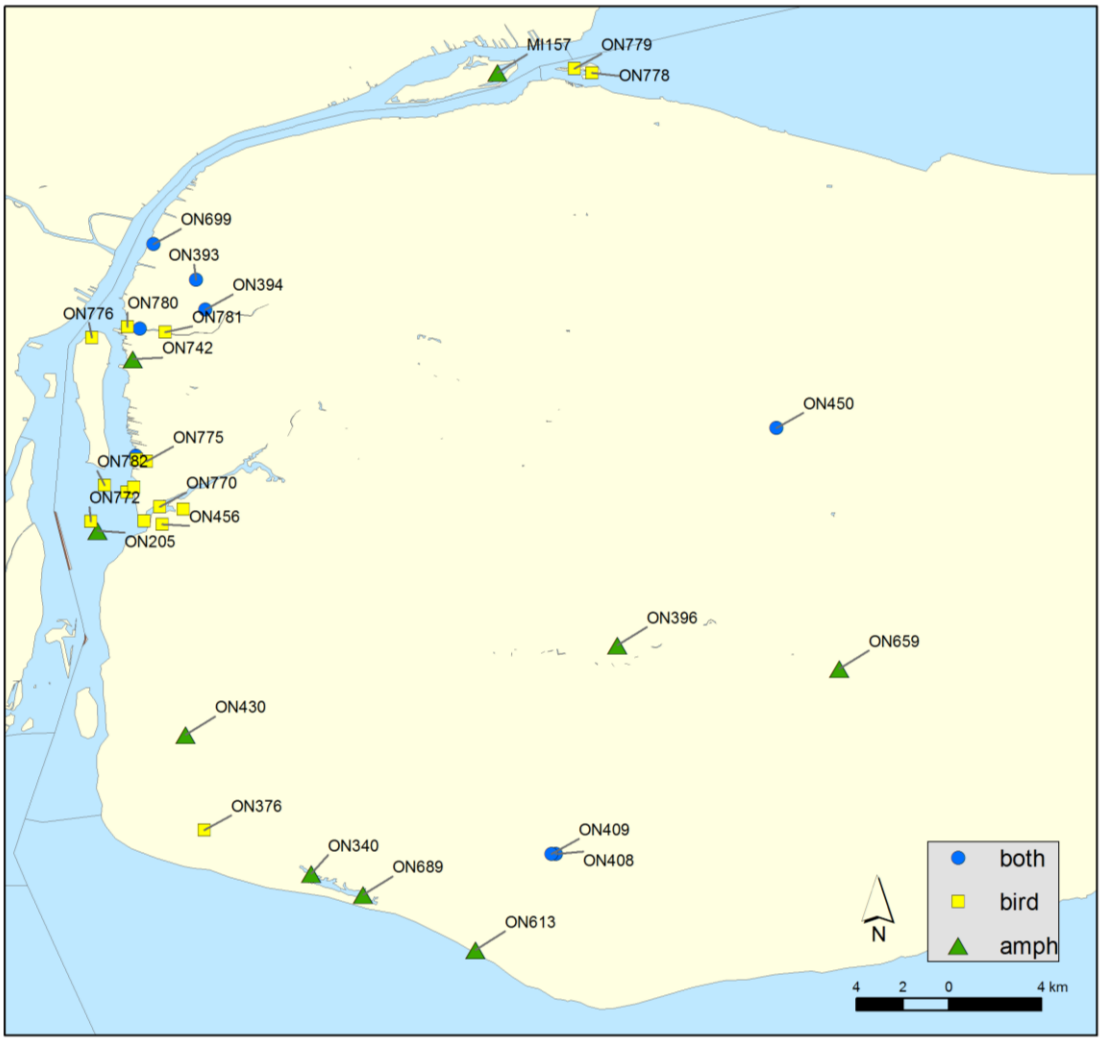

Fig. 8. Locations of Great Lakes Marsh Monitoring Program routes within and adjacent to the Detroit River AOC. Routes monitored for at least 1 year for birds (bird), amphibians (amph), or both birds and amphibians (both) are shown with different symbols.

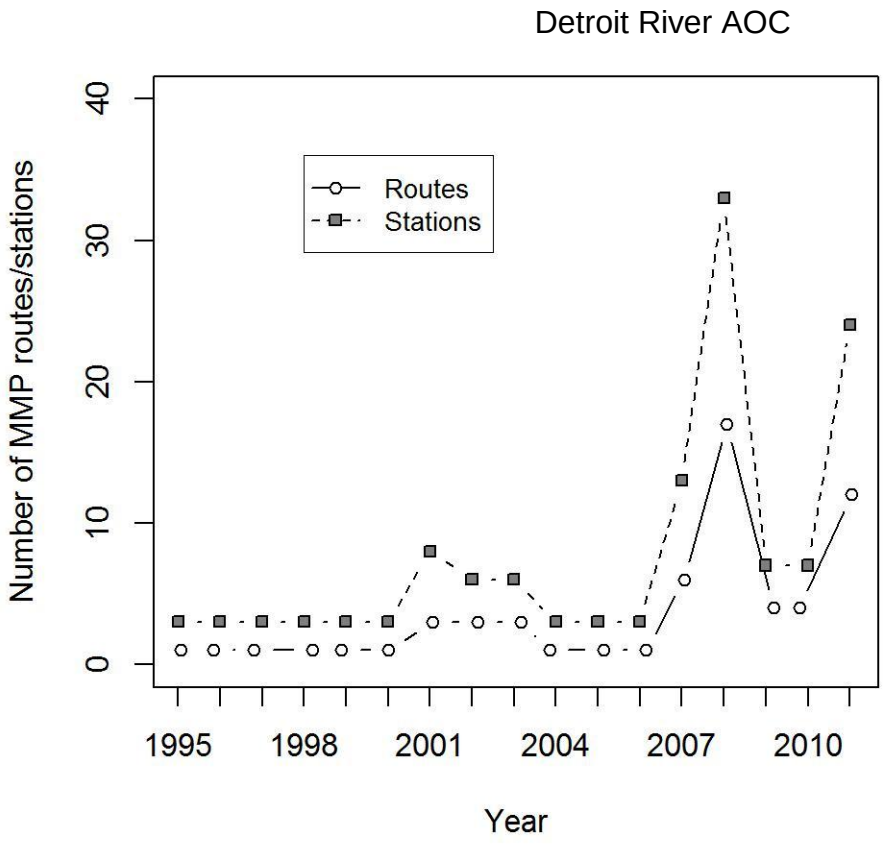

Fig. 9. Number of active Great Lakes Marsh Monitoring Program bird routes and stations per year within or adjacent to the Detroit River AOC between 1995 and 2011.

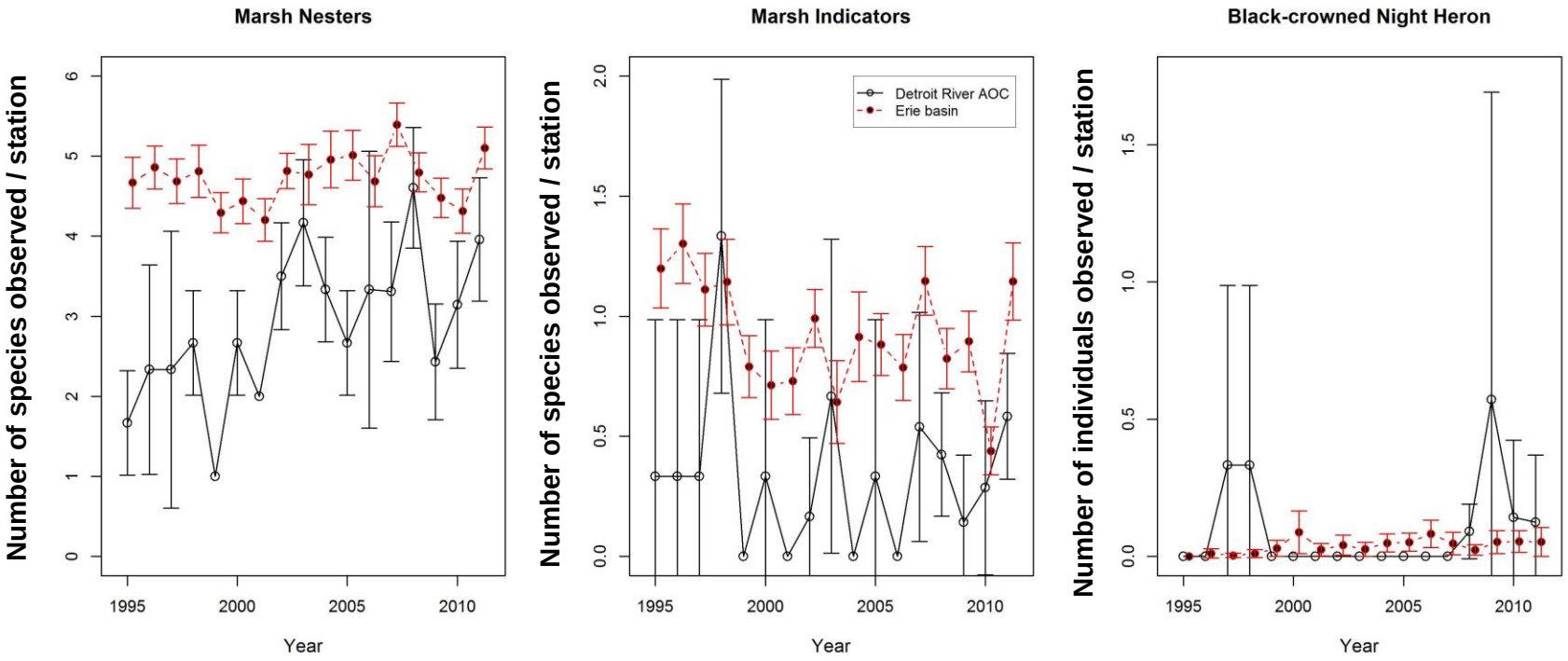

Fig. 10. Mean (±95% CIs) number of marsh-nesting and marsh indicator bird species and mean number of Black-crowned Night Herons observed per station per season within and adjacent to the Detroit River AOC and within the Lake Erie basin between 1995 and 2011.

Amphibians

There were 18 routes containing 39 stations within the remedial action plan (RAP)-defined AOC boundary or mostly (>90%) within a few kilometres and within up to ~20 km of the RAP-defined AOC boundary (hereafter adjacent), where amphibian data were collected for 1 or more years between 1995 and 2011 (Fig. 8). Amphibian data were collected at 3.6 ± 2.6 routes (mean ± SD) and 8.1 ± 6.2 stations per year within or adjacent to the AOC between 1995 and 2011 (Fig. 11), indicating that most routes were not surveyed in all of the years. Volunteers visited routes containing 1-8 stations in emergent wetlands within 4 hours after sunset on the same day three times per breeding season, targeting early, mid, and late-season breeding species. Wind was calm with little or no precipitation during 3-minute surveys.

To illustrate the status and trend of marsh-breeding amphibians in the AOC, we plotted the mean number of amphibian and amphibian indicator species observed per station per season over time between 1995 and 2011 for stations within or adjacent to the AOC and 1009 stations within the Lake Erie basin, although not all of the 1009 stations were surveyed in all of the years. We also plotted the mean proportion of stations occupied by Northern Leopard Frogs in this manner because this species is noted as an indicator species in the Detroit River Canadian Remedial Action Plan Stage 2 Report (Green et al. 2010). We included 95% confidence intervals on these plots to illustrate the amount of uncertainty around each annual mean; only in years when the intervals around the mean for the AOC do not overlap those for the Lake Erie basin should the difference between the means be considered with confidence. Indicator species were Chorus Frog, Northern Leopard Frog, and Spring Peeper, chosen for the following reasons: sufficiently common to make detection likely, dependent on marshes for breeding, and require habitats with few invasive species and low toxin levels (Chabot et al. 1998).

The mean number of all amphibian species and amphibian indicator species observed per station within or adjacent to the AOC was the same as or lower than the mean number in the Lake Erie basin in most years between 1995 and 2011 (Fig. 12). The mean proportion of stations occupied by Northern Leopard Frogs was also the same as or lower than the mean proportion in the Lake Erie basin in most years between 1995 and 2011 (Fig. 12). In all cases, variability was greater prior to 2007 and less after (Fig. 12), which was probably partly related to the increase in routes and stations from 2007 onwards (Fig. 11). Compared to mean values for the Lake Erie basin, the mean number of all amphibian species within or adjacent to the AOC was clearly less (i.e., confidence intervals did not overlap) in 7 of 13 (54%) years and the mean number of amphibian indicator species within or adjacent to the AOC was clearly less in 8 of 13 (62%) years.

These results illustrate the conclusions made by others using parts of the same dataset, that the status and trend of marsh amphibians within and adjacent to the Detroit River AOC is somewhere between *poor / impaired* and *fair* / *no apparent impairment* (Chabot et al. 1998, Timmermans et al. 2004).

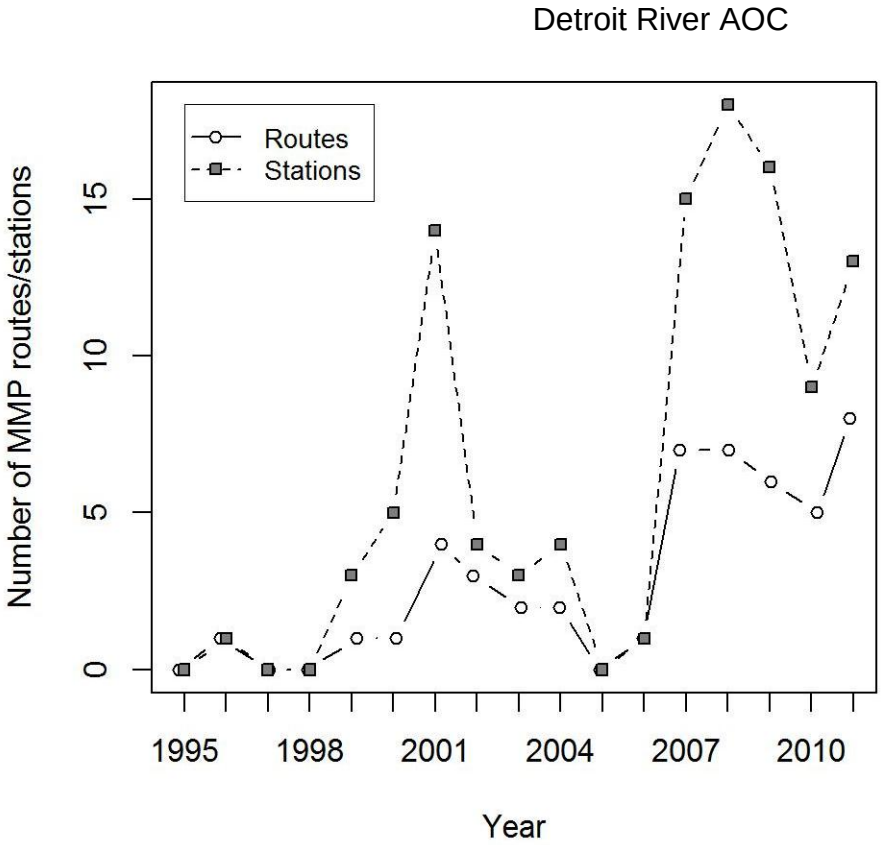

Fig. 11. Number of active Great Lakes Marsh Monitoring Program amphibian routes and stations per year within or adjacent to the Detroit River AOC between 1995 and 2011.

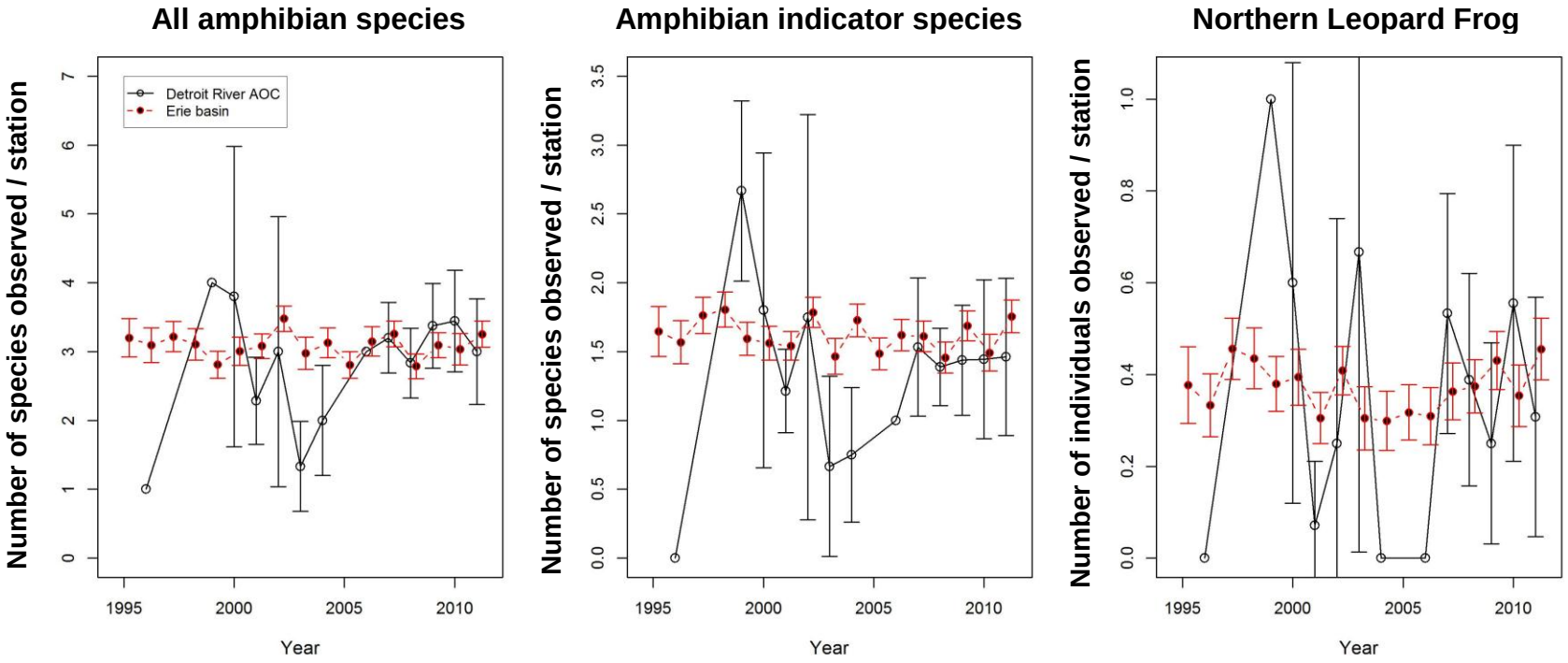

Fig. 12. Mean (±95% CIs) number of all amphibian and amphibian indicator species observed per station per season within and adjacent to the Detroit River AOC and within the Lake Erie basin between 1995 and 2011.

Canadian Wildlife Service Waterfowl Survey

There were 5 survey sectors located within the AOC and 6 sectors chosen within the surrounding region, 2 located on the southern shore of Lake St. Clair and 4 located on the northern shore of Lake Erie around Long Point (Fig. 6). The sectors within the surrounding region were the same sectors chosen as a regional reference by Rankin (2011), being areas close enough to the St. Clair River AOC to harbour similar waterfowl communities (according to tests of spatial autocorrelation) but known to be highly-used staging areas by waterfowl (Dennis et al. 1985). Using aircraft, all waterfowl within each sector were tallied 2–6 times in the spring and 2–6 times in the autumn about once each decade between 1969 and 2003 in the surrounding regions and between 1992 and 2003 within the AOC; more-recent data were not available.

To illustrate the status and trend of spring and autumn waterfowl use within the AOC and within the surrounding region, we followed Rankin (2011) by averaging the number of dabbler and diving duck use days between the first and the last survey within each season in each survey year. Then, to standardize effort, we divided the averages by the number of days between the first and last visit and by the number of kilometres of shoreline in the sector. This produced a spring and autumn index of dabbler and diver use for each sector for each survey year. We then plotted the means of the indices of the sectors within the AOC and the means of the indices of the sectors within the surrounding region separately over time for spring and autumn. We included 95% confidence intervals (CIs) on these plots to illustrate the amount of uncertainty around each mean; only in years when the intervals around the mean for the AOC do not overlap those for the surrounding region should the difference between the means be considered with confidence. Survey years when only one flight occurred in the spring or autumn were omitted from analysis.

The mean number of dabblers and divers in spring and autumn within the AOC was the same as or lower than the mean number in each of the surrounding regions in 1992 and 2003, although variability around the means in the surrounding regions made patterns difficult to interpret (Fig. 13). Dabblers and divers appeared to increase in the spring within the AOC and within the surrounding regions, perhaps increasing more so within the AOC than in the surrounding region, whereas in autumn they appeared to remain stable within the AOC and within the surrounding regions, or they may have slightly decreased within the AOC compared to the surrounding region (Fig. 13).

These results suggest that the status and trend of staging waterfowl in spring and autumn within the Detroit River AOC is somewhere between *fair* / *no apparent impairment* and *good / not impaired*. A more sophisticated analysis, like that done by Rankin (2011) for waterfowl within the St. Clair River AOC, might lend further support to this conclusion; although the amount of variability evident in Fig. 13 suggests that any statistical test will have low power for detecting differences, which was the case with the similar St. Clair data (Rankin 2011). Crewe et al. (2007) found that species richness of breeding waterfowl declined significantly more within and adjacent to the Detroit River AOC than within the surrounding ecoregion, but that analysis did not assess abundance of species or groups of species nor did it examine migratory individuals in spring and autumn, as is the case here.

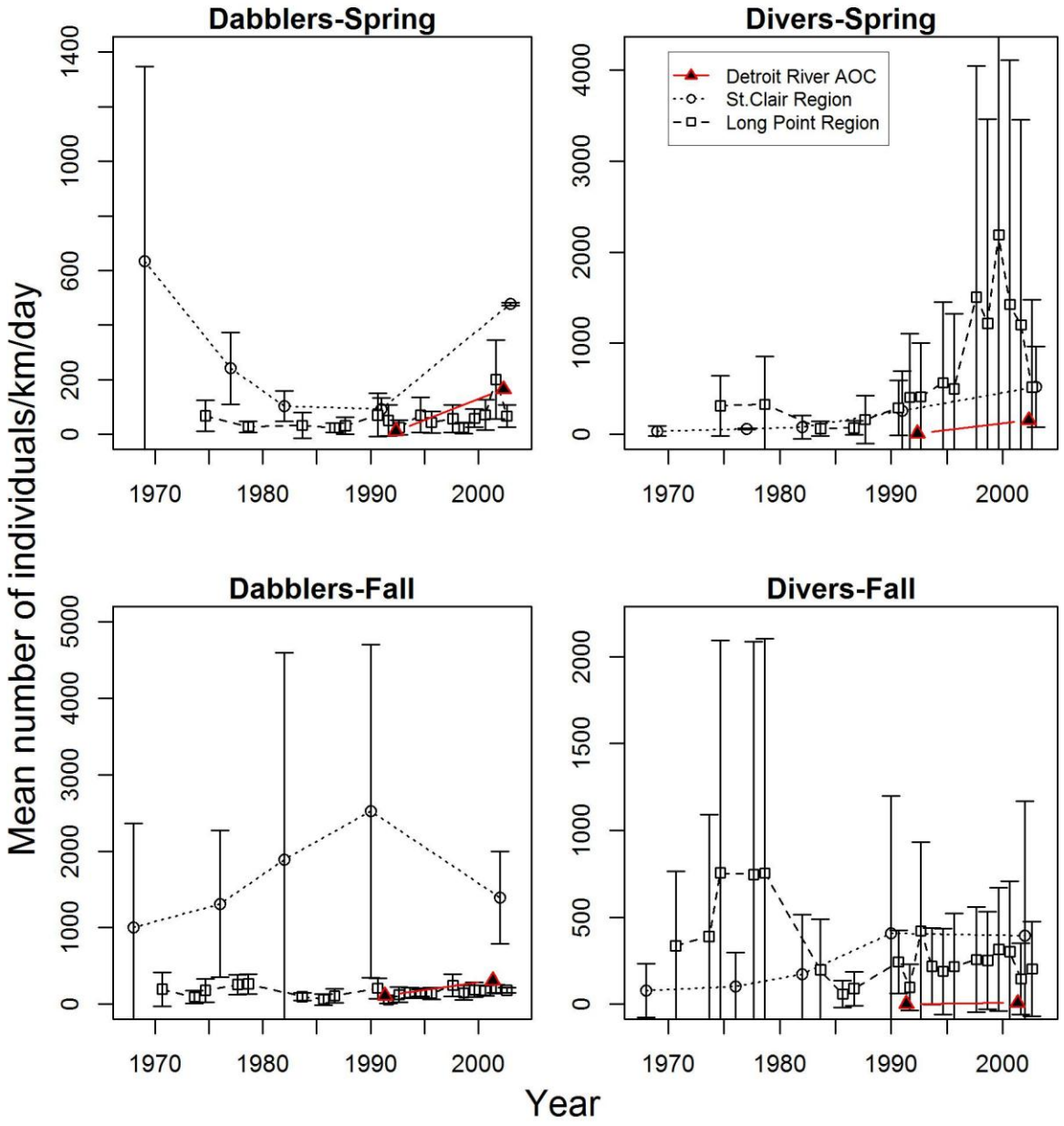

Fig. 13. Mean number of dabbler and diving ducks (±95% CIs) per kilometre of shoreline per day within the Detroit River AOC and within sectors within two surrounding regions, the southern shore of Lake St. Clair and the Long Point area.

Southern Ontario Bald Eagle Monitoring Program

There were 5 territories within the AOC and 8 territories within the surrounding region where at least one nesting attempt took place between 1980 and 2010 (Fig. 14). Attempts were made to determine if nesting occurred in each territory within the region in each year. Attempts were also made to determine the number of chicks fledged from each active nest in each year.

To illustrate the status and trend of breeding Bald Eagles within the AOC and within the surrounding region, we plotted the number of breeding territories within the AOC and within the surrounding region between 1980 and 2010 and the mean number of chicks fledged within the AOC and within the surrounding region between 1992 and 2010. Data prior to 1992 was too sparse to make meaningful comparisons for the mean number of chicks fledged. We included 95% confidence intervals on the fledgling plots to illustrate the amount of uncertainty around each annual mean; only in years when the intervals around the mean for the AOC do not overlap those for the surrounding region should the difference between the means be considered with confidence.

The number of active territories was essentially the same (±1) within the AOC and the surrounding region between 1980 and 2010 (Fig. 15). There was a drop in active territories in the surrounding region in 2008 to 2009 but this recovered in 2010 with the addition of new territories (Fig. 15). The average number of chicks fledged per nesting attempt was the same within the AOC and within the surrounding region between 1992 and 2010 (Fig. 16). There was a drop in the number of chicks fledged in the surrounding region in 2009 and 2010 (Fig. 16), although it is unclear whether the drop was real or a result of old territories going fallow and new ones becoming occupied, given that pairs on new territories often have low productivity at the beginning of their tenure. The drop is also partly attributable to high winds associated with storms, which caused chick mortality at a large proportion of nests in the surrounding region in 2010 (Allair 2011). The average number of chicks fledged per nesting attempt within the Detroit River AOC was >1 in 17 of the 19 (89%) years between 1992 and 2010. Others suggest that >1 fledgling per nesting attempt by Bald Eagles is enough to maintain a stable or growing population (Sprunt 1973, Grier et al. 1983), although the value to maintain a stable or growing population for the Detroit River AOC may be higher considering that adult survival (Laing and Badzinski 2006) and possibly other rates (e.g., juvenile survivorship) may be lower within the AOC than across most of the rest of the species' range.

These results illustrate the conclusions made by others using parts of the same dataset, that the status and trend of the number of breeding territories and the reproductive success of Bald Eagles within the Detroit River AOC is *fair* / *no apparent impairment* (Best and Wilke 2007).

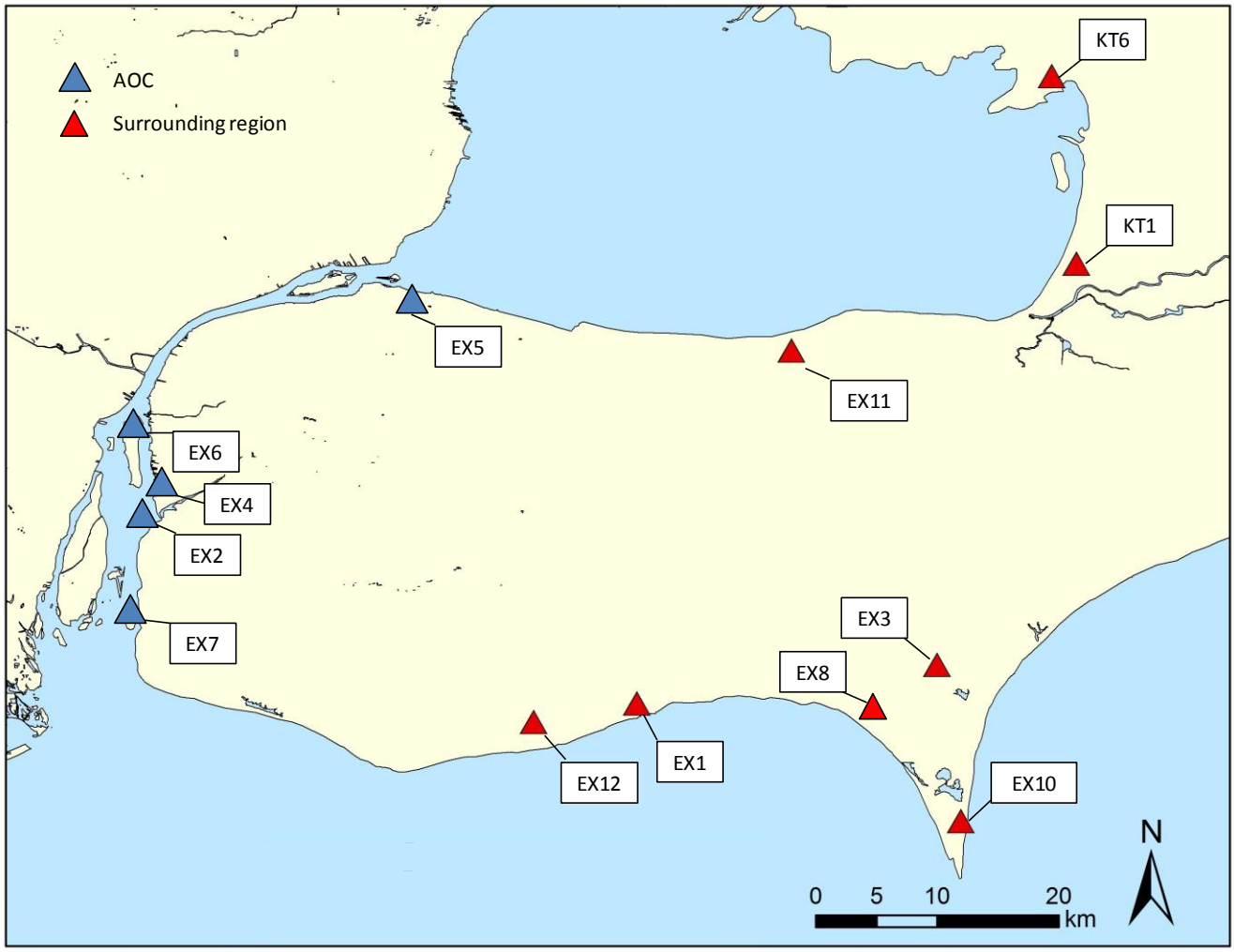

Fig. 14. Locations of active nesting territories monitored by the Southern Ontario Bald Eagle Monitoring Program between 1980 and 2010.

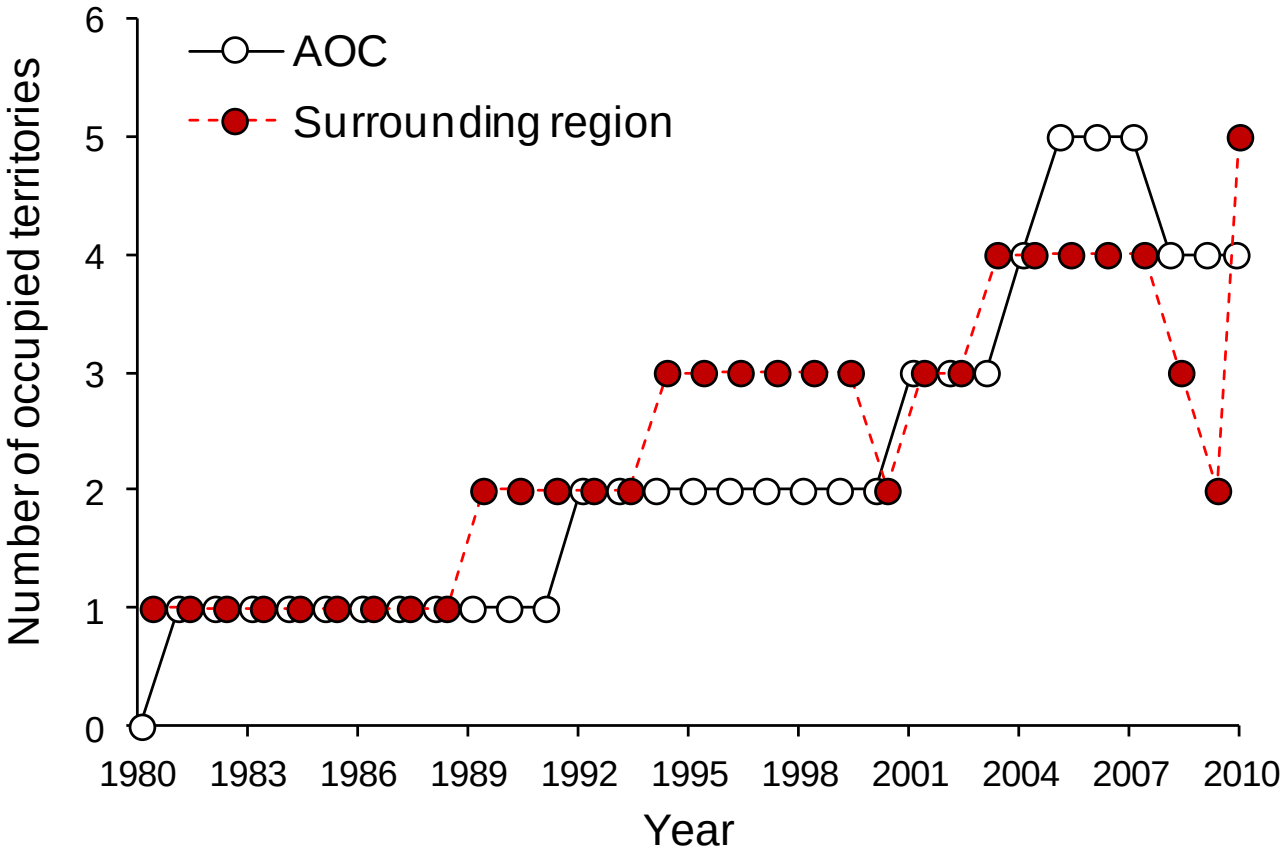

Fig. 15. Number of occupied Bald Eagle territories within the Detroit River AOC and within the surrounding region between 1980 and 2010.

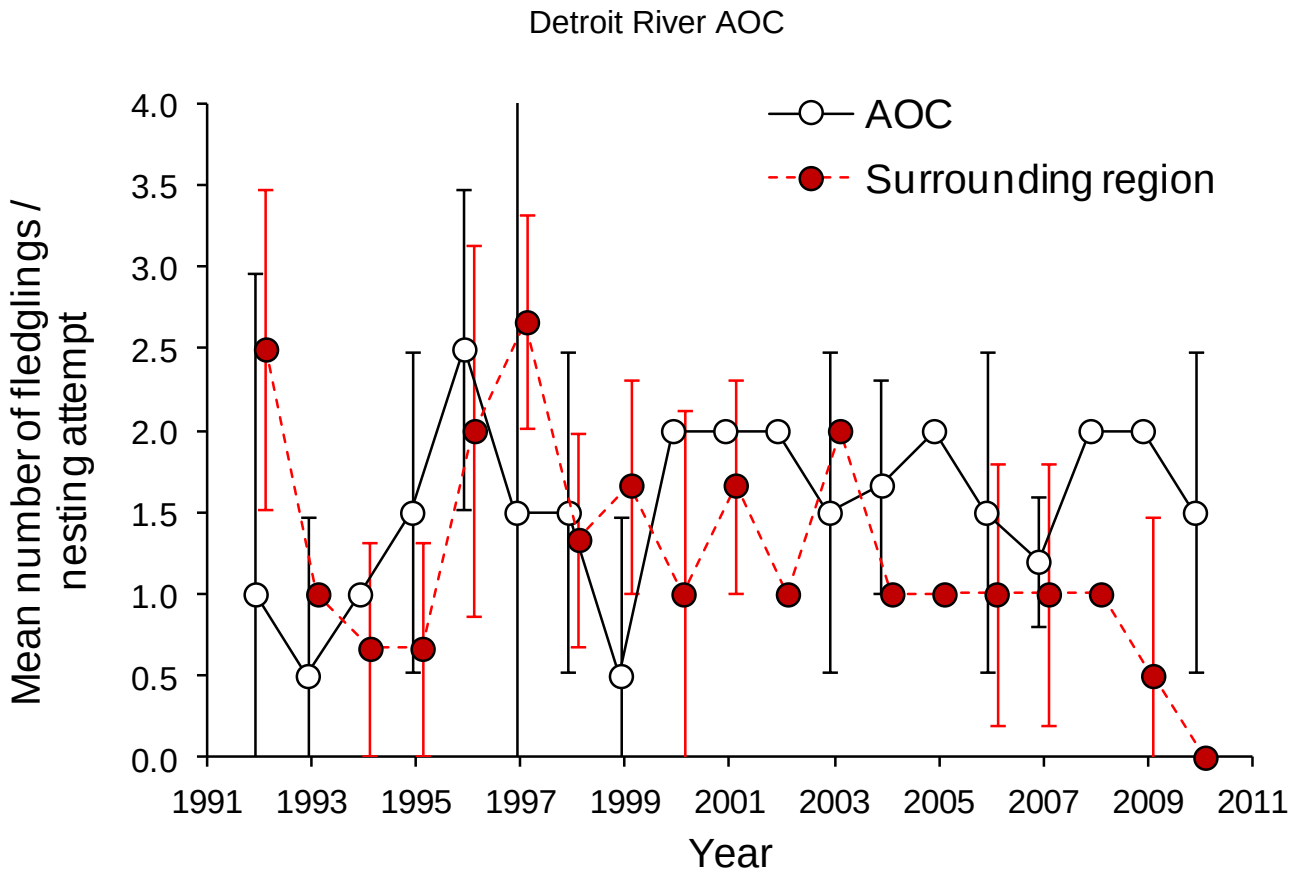

Fig. 16. Mean (±95% CIs) number of fledglings produced per nesting attempt by Bald Eagles within the Detroit River AOC and within the surrounding region between 1992 and 2010.

Interpretation and recommendations

In the Detroit River AOC, the status and/or trend of marsh-breeding birds and frogs and all groups of aquatic breeding birds is worse than in the surrounding region; by contrast, visual inspection of plots of data suggest that spring and autumn-staging dabbling and diving ducks and reproductive success of Bald Eagles within or adjacent to the Detroit River AOC are as good as the surrounding region. A summary of these findings appears in Table 1 on p. 1.

The diversity of most groups of aquatic wildlife, particularly marsh-breeding birds and frogs, increases as wetland area increases (e.g., birds: Riffel et al. 2001; frogs: Findlay and Houlahan 1997) and the amount of urban land use in the surrounding region decreases (e.g., birds: Smith and Chow-Fraser 2010; frogs: Gague and Fahrig 2007). There are only ~13 km^2 of wetlands in the Detroit River AOC, most of which exist as small isolated fragments <50 ha in size (Manny et al. 1988). Most (50% on average) of the watershed surrounding the Detroit River AOC is categorized as urban, where ~ 5 million people live at extremely high density; not surprisingly then, the land use immediately adjacent to most of the wetlands within the AOC is also highly urbanized (Green et al. 2010). Thus, the negative status and trend of aquatic wildlife, particularly marsh-dependent wildlife, in the Detroit River AOC is likely at least partly due to an absence of large wetlands and predominantly urban land use surrounding the few remaining wetlands. Additional factors may also be contributing to the negative status and trend.

The reality may be that the aquatic wildlife communities within the Detroit River AOC are some of the poorest and most impaired within a highly environmentally-degraded region (i.e., the Lake Erie basin; Hartig et al. 2009). As such, they may be as good as they will ever realistically get because existing wetlands are isolated within an urban setting and land use within and adjacent to the AOC largely prevents creating new wetlands or expanding or connecting existing ones on any appreciable scale.

Two groups of wildlife within the Detroit River AOC, breeding Bald Eagles and migratory waterfowl, appear to be fair or unimpaired. These two groups may be less-affected by the limited existence of wetlands within the AOC than other aquatic wildlife because their diet and/or breeding do not depend entirely on wetlands, although their diet and/or breeding may be enhanced by wetlands. For instance, certain staging dabbling and diving ducks feed on submerged aquatic plants or zebra and quagga mussels found within and outside wetlands at widespread locations throughout the AOC; and Bald Eagles mainly scavenge fish and birds, which are also available throughout the AOC.

Reliable assessment of the status and trend of wildlife within the Detroit River AOC requires that surveys be representative of the entire AOC. This was likely achieved for breeding bird atlas and Canadian Wildlife Service waterfowl data because coverage was nearly complete; it may not have been as successfully achieved for the Marsh Monitoring Program data. For this program representative coverage could be achieved by placing sampling points within each wetland within the AOC, an approach suggested previously (Weeber et al. 1997) but unrealistic with available resources. With limited resources, the best coverage is probably achieved by placing replicated sampling points within replicated randomly-chosen wetlands within each of the wetland size x wetland type combinations within the AOC (e.g., large, medium, small cattail; large, medium, small grass-sedge). The coverage of wetland sizes and types within the Detroit River AOC was not assessed for the surveys illustrated here, and coverage may have fallen short of these guidelines. Ideally survey coverage within the AOC should fulfill these guidelines.

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Appendices Appendix 1. Route locations and the number of years that routes were actively surveyed for birds or amphibians between 1995 and 2011 in the St. Clair River and Detroit River AOC.

Route	AOC	No. years surveyed		Route Name	Latitude	Longitude
		Birds	Amphibians			
MI034	St. Clair	1	0	Metrobeach - North Marsh 2	42.5828	-82.7928
MI035	St. Clair	1	0	Metrobeach - South Marsh	42.5798	-82.806
MI036	St. Clair	1	0	Algonac State Park - Channel	42.6398	-82.5236
MI037	St. Clair	1	0	Metrobeach - North Marsh 1	42.5855	-82.7955
MI046	St. Clair	1	0	St. John's East End	42.6369	-82.5901
MI047	St. Clair	11	0	Casco Section 23/ Adair	42.75444	-82.63694
MI048	St. Clair	11	0	Cottrellville	42.68619	-82.53556
MI074	St. Clair	1	1	Harsen's Island Marsh South- Route 1	42.5773	-82.5798
MI075	St. Clair	1	1	Harsen's Island Marsh North - Route 2	42.597	-82.6033
MI101	St. Clair	3	3	Harsen's Island	42.5612	-82.6314
MI128	St. Clair	0	1	Algonac State Park South	42.6444	-82.5239
MI129	St. Clair	2	1	St. John's Marsh Central	42.6458	-82.5975
MI130	St. Clair	1	1	Algonac State Park - NORTH	42.6561	-82.5265
MI131	St. Clair	1	0	Baker field	43.0169	-82.4544
MI132	St. Clair	0	1	Walker's Flats	43.0533	-82.5905
MI134	St. Clair	1	0	Howe Drain	43.0311	-82.4613
MI157	Detroit	0	1	Belle Isle_Blue Heron Lagoon	42.345162	-82.960906
ON001	St. Clair	8	0	St. Clair NWA - Bear Creek A	42.5292	-82.4028
ON002	St. Clair	7	0	St. Clair NWA - Bear Creek B	42.5325	-82.3928
ON064	Detroit	1	0	General Chemical	42.175	-83.0833
ON078	Detroit	5	0	Ruwe Marsh - Bird Route	42.1817	-83.1053
ON205	Detroit	0	1	Ruwe Amphibians	42.1667	-83.1166
ON340	Detroit	0	3	Holiday Beach Amphibian Route	42.0333	-83.0334
ON376	Detroit	12	0	Big Creek Marsh & Holiday Beach	42.050233	-83.075097
ON393	Detroit	1	2	Ojibway Nature Center Marsh	42.2644	-83.0783
ON394	Detroit	1	3	Ojibway Prairie Marsh_Prov Nat Res	42.2528	-83.0747
ON396	Detroit	0	6	Canard River Drainage System	42.1221	-82.9142
ON408	Detroit	2	2	Harrow Sewage Lagoon - east cell	42.0408	-82.9383
ON409	Detroit	2	2	Harrow Sewage Lagoon - centre and West cells	42.0408	-82.9399

Route	AOC	No. years surveyed		Route Name	Latitude	Longitude
		Birds	Amphibians			
ON430	Detroit	0	1	Big Creek at Lowe's side Road	42.08737	-83.08237
ON450	Detroit	5	5	Kennette Wetland	42.20666	-82.85245
ON456	Detroit	2	0	Canard river Mouth	42.16919	-83.09153
ON467	St. Clair	2	0	Bear Creek East (BCE 2 - 5)	42.535134	-82.386931
ON468	St. Clair	2	0	Bear Creek North (BCN 1-4)	42.532354	-82.399604
ON469	St. Clair	1	0	Bear Creek South (BCS 2 - 5)	42.530319	-82.386169
ON470	St. Clair	1	0	Bear Creek West (BCW 2 - 5)	42.529504	-82.401904
ON471	St. Clair	2	0	Mitchell's Bay (MTB 14_15_17_19_21_24)	42.493077	-82.420552
ON472	St. Clair	2	0	Moon Cove - Tic Tac Point (MCT 1 - 5)	42.458525	-82.419724
ON473	St. Clair	1	0	Roberta Steward Wetland north (RSW 1)	42.615445	-82.47476
ON474	St. Clair	2	0	Snye River Marsh (SCR 1 - 3; ne. Channel Ecarte)	42.602937	-82.47843
ON489	Detroit	4	3	Petite Cote Conservation Area	42.19587	-83.101896
ON490	St. Clair	1	2	The Dow Wetlands	42.911798	-82.416032
ON613	Detroit	0	1	Lypps Marsh	42.00362	-82.969445
ON637	St. Clair	0	2	Lambton Generating Station Marsh	42.79288	-82.46075
ON659	Detroit	0	6	Narrow Acres	42.11293	-82.82775
ON689	Detroit	0	3	Holiday Beach near country club	42.02505	-83.01323
ON698	Detroit	2	2	Turkey Creek	42.2453	-83.10028
ON699	Detroit	5	5	Brighton Beach Power Pond 3 wetland	42.2783	-83.09489
ON721	St. Clair	1	0	Logan Pond	43.014667	-82.34633
ON742	Detroit	0	1	Marsh at 230 Front Road Lasalle	42.233502	-83.102938
ON754	St. Clair	2	2	Wawanosh Wetlands West	42.995631	-82.329883
ON770	Detroit	2	0	CWS Canard River Route 1	42.175946	-83.092545
ON771	Detroit	1	0	CWS Canard River Route 2	42.170593	-83.098523
ON772	Detroit	1	0	CWS Canard River Mouth Marsh	42.170277	-83.119377
ON773	Detroit	2	0	CWS Detroid River Wetlands Route 1	42.183731	-83.102612
ON774	Detroit	2	0	CWS- Detroit River Wetlands Route 2	42.194452	-83.101429
ON775	Detroit	1	0	CWS Detroit River Wetlands Route 3	42.19372	-83.097683
ON776	Detroit	1	0	CWS Fighting Island Dike Route 1	42.241985	-83.118973
ON778	Detroit	2	0	CWS Peche Island Route 1	42.345001	-82.924103
ON779	Detroit	2	0	CWS Peche Island Route 2	42.34664	-82.931053

Route	AOC	No. years surveyed		Route Name	Latitude	Longitude
		Birds	Amphibians			
ON780	Detroit	2	0	CWS Turkey Creek Marsh Route 1	42.246056	-83.10506
ON781	Detroit	2	1	CWS Turkey Creek Marsh 2	42.2439722	-83.090407
ON782	Detroit	1	0	CWS Turkey Island	42.18434	-83.114034
ON820	St. Clair	3	0	Marthaville Habitat Management Area (SCRA)	42.914041	-82.171812

Appendix 2. Mean number of individuals per Great Lakes Marsh Monitoring Program bird station, averaged across all years between 1995 and 2011, within or adjacent to the St. Clair River AOC. Species columns are arranged alphabetically. See Appendix 6 for description of 4-letter species codes.

Route	AMBI	AMCO	AMCR	AMGO	AMRE	AMRO	BANS	BAOR	BARS	BCCH	BCNH	BEKI	BHCO	BLJA
MI034	-	1.0	-	-	-	0.3	-	0.3	1.0	-	-	-	-	-
MI035	-	-	-	-	-	0.5	-	-	-	-	-	-	-	-
MI036	-	-	-	-	-	-	-	-	1.7	-	-	-	-	0.3
MI037	-	0.3	-	-	-	-	-	-	0.8	-	-	-	-	-
MI046	-	-	-	0.4	0.2	1.6	-	0.2	11.4	-	-	0.2	-	-
MI047	-	-	-	1.5	-	1.3	-	0.4	3.1	-	-	-	2.5	-
MI048	-	-	-	0.4	-	0.2	-	0.0	6.4	-	-	0.1	0.2	-
MI074	-	0.6	-	-	-	-	-	-	3.0	-	-	-	-	-
MI075	0.1	3.0	-	-	-	-	-	-	0.6	-	-	-	-	-
MI101	0.2	0.2	-	0.2	-	0.2	-	-	0.3	-	-	-	-	-
MI129	-	-	-	2.0	-	0.1	2.7	-	1.1	-	0.2	0.2	-	-
MI130	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MI131	-	-	-	-	-	-	-	-	-	0.3	-	-	-	-
MI134	-	-	-	-	-	0.5	-	-	-	0.3	-	-	0.5	-
ON001	0.1	-	-	-	-	0.1	-	0.1	0.4	-	-	-	-	-
ON002	0.1	-	-	-	-	0.1	0.1	-	1.2	-	-	-	-	-
ON467	0.1	1.7	-	-	-	-	-	-	0.3	-	-	0.1	-	-
ON468	0.1	-	-	-	-	0.1	-	-	0.6	-	-	-	-	-
ON469	-	-	-	0.8	-	-	-	-	1.3	-	-	-	-	-
ON470	-	-	-	-	-	-	0.5	-	-	-	-	-	-	-
ON471	0.1	0.4	-	0.1	-	-	-	-	0.1	-	-	-	-	-
ON472	-	1.1	-	-	-	-	-	-	-	-	0.5	-	-	-
ON473	-	-	-	-	-	1.0	-	-	1.0	-	-	-	-	-
ON474	-	-	-	-	-	-	0.5	-	1.3	-	-	-	-	-
ON490	-	-	-	-	-	-	-	-	-	-	-	1.0	-	-
ON721	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-
ON754	-	-	-	-	-	1.8	-	-	0.3	-	-	-	-	-
ON820	-	-	-	0.3	-	-	-	-	1.0	-	-	-	-	-

Route	BLTE	CAGO	CANV	CATE	CEDW	CHSP	CHSW	CLSW	COGR	COHA	COMO	CONI	COTE	COYE	DCCO
MI034	0.3	-	-	-	-	-	-	-	1.7	-	-	-	1.7	-	-
MI035	-	-	-	-	-	-	-	-	1.0	-	2.5	-	-	-	-
MI036	-	-	-	-	-	-	-	-	1.3	-	-	-	0.3	2.0	-
MI037	-	-	-	-	-	-	-	-	-	-	1.0	-	0.3	-	-
MI046	-	-	-	-	3.4	-	1.4	-	-	-	-	-	-	0.4	-
MI047	-	-	-	-	3.4	-	0.6	-	4.5	0.1	-	-	-	0.7	-
MI048	-	-	-	-	2.0	-	0.2	0.2	2.6	-	-	-	-	0.7	-
MI074	5.0	-	0.3	0.6	-	-	-	-	0.4	-	0.8	-	0.3	-	-
MI075	4.3	0.5	-	0.1	-	-	-	-	-	-	0.9	-	0.6	0.1	-
MI101	-	0.4	-	-	-	-	-	-	0.0	-	-	0.2	2.5	0.4	-
MI129	0.2	1.3	-	-	0.2	-	-	0.3	0.4	-	0.1	-	1.3	-	-
MI130	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MI131	-	-	-	-	-	0.8	-	-	-	-	-	-	-	-	-
MI134	-	-	-	-	-	0.8	-	-	-	-	-	-	-	0.3	-
ON001	0.5	-	-	-	0.1	-	-	-	1.1	-	0.5	-	-	0.7	-
ON002	0.2	0.1	-	-	-	-	-	-	0.7	-	0.8	-	-	0.6	-
ON467	-	0.3	-	-	-	-	-	-	0.1	-	2.6	-	-	0.6	-
ON468	-	0.9	-	-	-	-	-	-	0.4	-	-	-	-	1.7	-
ON469	-	0.3	-	-	-	-	-	-	1.0	-	-	-	-	1.8	-
ON470	-	0.3	-	-	-	-	-	-	-	-	-	-	-	3.0	-
ON471	0.2	5.5	-	-	-	-	-	-	0.2	-	1.1	-	-	1.1	0.1
ON472	-	0.5	-	0.2	-	-	-	-	0.9	-	2.0	-	-	0.3	-
ON473	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ON474	-	-	-	-	-	-	-	-	0.3	-	-	-	-	1.0	-
ON490	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ON721	-	37.5	-	-	-	-	-	-	-	-	-	-	-	-	-
ON754	-	4.8	-	0.5	0.5	-	-	-	-	-	-	-	-	-	-
ON820	-	-	-	-	-	-	-	-	0.3	-	-	-	-	0.3	-

Route	DOWO	EABL	EAKI	EUST	FOTE	GADW	GBHE	GRCA	GREG	GRHE	HOFI	HOSP	HOWR	KILL	LEBI
MI034	-	-	-	55.3	1.0	-	0.3	-	-	-	-	-	-	-	-
MI035	-	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-
MI036	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MI037	-	-	-	0.5	1.3	-	-	-	-	-	-	-	-	-	-
MI046	-	-	0.2	-	0.2	-	-	1.0	-	-	-	-	-	-	-
MI047	0.1	0.2	0.5	3.0	-	-	-	0.2	-	0.1	0.8	2.5	0.3	0.5	-
MI048	-	-	0.2	0.2	0.1	-	0.1	0.3	-	0.4	-	-	-	-	-
MI074	-	-	-	-	-	-	0.3	-	-	-	-	-	-	-	-
MI075	-	-	0.1	-	-	-	0.3	0.1	-	-	-	-	-	-	0.1
MI101	-	-	-	0.1	-	-	0.1	-	-	-	-	-	-	0.3	-
MI129	-	-	-	0.8	-	-	1.0	-	-	0.2	-	-	0.1	0.9	-
MI130	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MI131	-	-	-	0.3	-	-	-	-	-	-	-	-	-	0.3	-
MI134	-	-	-	-	-	-	-	-	-	-	-	-	0.3	-	-
ON001	-	-	0.0	-	0.3	-	-	-	-	0.0	-	-	-	-	0.2
ON002	-	-	0.0	-	0.5	-	0.0	-	0.0	0.0	-	-	-	-	0.3
ON467	-	-	0.1	-	0.7	0.1	0.1	-	-	-	-	-	-	-	0.4
ON468	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1
ON469	-	-	-	-	0.3	-	-	-	-	-	-	-	-	-	-
ON470	-	-	-	-	0.3	-	-	-	-	-	-	-	-	-	-
ON471	-	-	0.1	-	0.6	0.3	0.1	-	-	0.2	-	-	-	-	0.4
ON472	-	-	-	-	22.4	-	0.2	-	-	0.5	-	-	-	-	0.2
ON473	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0	-
ON474	-	-	-	-	1.3	-	0.2	-	-	-	-	-	-	-	-
ON490	-	-	-	-	-	-	1.0	-	-	-	-	-	-	-	-
ON721	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ON754	-	-	-	-	-	-	0.8	-	-	-	-	-	-	-	-
ON820	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Route	MALL	MAWR	MODO	MOOT	MUSW	NOBO	NOCA	NOFL	NOPI	NRWS	PBGR	PUMA	RBGR	RBGU	RTHA
MI034	1.3	3.0	-	-	1.0	-	-	-	-	0.3	0.3	0.7	-	-	-
MI035	0.5	4.0	-	-	-	-	-	-	-	-	-	-	-	-	-
MI036	-	1.0	0.3	-	-	-	-	-	-	-	-	-	-	-	-
MI037	-	6.5	-	-	-	-	-	-	-	-	0.5	0.3	-	-	-
MI046	0.4	-	-	-	-	-	0.2	-	-	-	-	0.8	-	-	-
MI047	0.2	-	2.8	-	-	0.1	0.4	-	-	-	-	-	0.3	-	-
MI048	0.2	0.0	0.3	-	-	-	0.3	0.0	-	0.5	0.1	0.7	0.1	-	0.0
MI074	1.6	2.1	-	-	-	-	-	-	0.1	-	0.8	0.4	-	0.3	-
MI075	2.3	2.5	-	1.0	0.3	-	-	-	-	-	1.9	-	-	-	-
MI101	0.5	2.4	0.2	-	0.1	-	0.0	-	-	-	0.8	2.5	-	0.0	-
MI129	0.8	2.3	1.1	0.8	0.5	-	-	-	-	-	0.8	4.1	-	-	-
MI130	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MI131	-	-	-	-	-	-	0.3	-	-	-	-	-	-	-	-
MI134	-	-	0.3	-	-	-	0.3	-	-	0.5	-	-	-	-	-
ON001	0.1	2.5	0.0	0.1	-	-	-	-	-	-	0.1	-	-	-	0.0
ON002	0.2	4.0	-	0.0	-	-	-	-	-	-	0.3	-	-	-	-
ON467	0.9	3.3	-	0.4	-	-	-	-	-	-	0.7	-	-	-	-
ON468	-	0.7	0.1	-	-	-	-	-	-	0.3	-	-	-	-	-
ON469	-	-	-	-	-	-	-	-	-	0.3	-	-	-	-	-
ON470	0.3	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-
ON471	0.8	3.4	-	0.1	1.1	-	0.1	-	-	0.1	0.4	0.1	-	-	-
ON472	14.9	2.4	-	0.4	0.4	-	-	-	-	-	0.2	0.1	-	11.4	-
ON473	2.0	-	-	-	2.0	-	-	-	-	-	2.0	-	-	-	-
ON474	0.8	2.0	-	-	0.7	-	0.2	-	-	-	1.0	0.3	-	-	-
ON490	-	-	-	-	-	-	-	1.0	-	-	-	-	-	-	-
ON721	8.5	3.5	-	-	-	-	-	-	-	-	-	-	-	-	-
ON754	3.3	-	-	0.3	-	-	1.0	-	-	-	-	-	-	-	-
ON820	0.3	-	-	-	-	-	-	-	-	-	0.3	-	-	-	0.7

Route	RUBL	RUDU	RWBL	SACR	SAVS	SEOW	SORA	SOSP	SPSA	SWSP	TRES	VIRA	WAVI	WIFL	WISN
MI034	-	-	16.7	-	-	-	-	0.7	-	1.3	2.0	-	-	-	-
MI035	-	-	15.5	-	-	-	-	-	-	5.0	3.5	0.5	-	-	-
MI036	-	-	11.0	-	-	-	-	0.3	-	2.0	3.0	-	-	-	-
MI037	-	-	16.3	-	-	-	-	0.3	-	1.0	1.0	0.5	-	-	-
MI046	-	-	3.2	-	-	-	-	2.6	-	1.4	15.4	-	-	-	-
MI047	-	-	5.4	-	-	-	-	2.4	-	0.4	12.2	-	-	-	0.1
MI048	-	-	4.3	-	-	-	0.1	0.8	-	1.1	8.5	0.1	-	0.0	-
MI074	-	-	6.3	-	-	-	-	-	-	-	10.0	-	-	-	-
MI075	-	-	6.6	-	-	-	-	-	-	0.3	13.6	-	-	-	-
MI101	-	-	5.4	-	-	-	-	0.1	-	-	0.6	-	-	-	-
MI129	-	-	10.2	-	-	-	-	-	-	-	5.9	-	-	-	-
MI130	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MI131	-	-	0.8	-	-	-	-	0.3	-	-	2.0	-	-	-	-
MI134	-	-	0.3	-	-	-	-	0.3	-	0.5	-	-	-	-	-
ON001	-	-	7.2	-	-	-	0.0	0.0	-	0.7	0.4	0.7	0.2	-	-
ON002	-	-	6.1	-	-	-	0.1	0.1	-	0.6	1.1	0.6	-	-	-
ON467	-	-	8.9	-	-	-	-	-	0.3	0.3	0.6	-	-	-	-
ON468	-	-	7.6	-	-	-	-	-	-	2.7	0.4	0.1	0.1	0.3	-
ON469	-	-	11.0	-	-	1.0	-	0.3	-	4.3	1.8	0.3	-	-	-
ON470	-	-	14.3	-	-	-	0.5	0.5	-	2.3	1.0	1.0	-	-	-
ON471	-	0.1	6.5	0.1	-	-	0.3	0.2	-	1.3	0.3	0.3	0.1	-	0.1
ON472	-	-	7.9	-	-	-	-	0.3	-	0.6	-	0.2	-	0.1	-
ON473	-	-	12.0	-	-	-	2.0	-	-	-	1.0	-	-	-	-
ON474	-	-	6.5	-	-	-	-	-	-	1.2	1.7	-	-	0.5	-
ON490	-	-	2.0	-	-	-	-	1.0	-	-	8.0	-	-	-	-
ON721	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-	-
ON754	0.3	-	6.0	-	-	-	-	0.3	-	-	7.8	-	-	-	-
ON820	-	-	3.7	-	-	-	0.3	-	1.0	-	3.7	-	-	-	-

Route	WODU	YHBL	YWAR
MI034	-	-	0.3
MI035	-	-	0.5
MI036	0.7	-	1.3
MI037	-	-	0.3
MI046	-	-	2.0
MI047	-	-	1.5
MI048	0.1	-	1.1
MI074	0.4	-	-
MI075	-	-	0.3
MI101	0.1	-	0.1
MI129	0.1	-	-
MI130	-	-	-
MI131	-	-	-
MI134	-	-	-
ON001	0.1	-	0.2
ON002	0.2	-	0.0
ON467	0.4	-	-
ON468	-	-	0.9
ON469	0.3	-	0.5
ON470	-	-	1.0
ON471	0.1	-	0.3
ON472	-	1.2	0.1
ON473	-	-	-
ON474	-	-	-
ON490	-	-	-
ON721	-	-	-
ON754	0.3	-	-
ON820	-	-	0.3

Appendix 3. Mean calling code (1 = low abundance, 2 = middle abundance, 3 = high abundance) per Great Lakes Marsh Monitoring Program amphibian station, averaged across all years between 1995 and 2011, within or adjacent to the St. Clair River AOC. Species columns are arranged alphabetically. See Appendix 6 for description of 4-letter species codes.

Route	AMTO	BULL	CHFR	GRFR	GRTR	NLFR	PIFR	SPPE	WOFR
MI074	0.1	0.3	-	0.4	-	-	-	0.1	-
MI075	-	0.9	-	0.6	-	-	-	-	-
MI101	0.8	0.7	0.3	0.8	0.4	0.5	0.2	-	-
MI128	1.0	-	-	1.0	1.0	-	-	1.0	-
MI129	0.8	-	2.8	0.3	-	2.0	-	3.0	-
MI130	0.6	-	1.8	0.8	-	-	-	1.4	-
MI132	-	-	3.0	2.0	3.0	-	0.5	2.0	1.5
ON490	1.5	-	-	2.5	-	1.5	-	1.5	-
ON637	1.0	-	2.0	1.5	1.5	0.5	-	3.0	-

Appendix 4. Mean number of individuals per Great Lakes Marsh Monitoring Program bird station, averaged across all years between 1995 and 2011, within or adjacent to the Detroit River AOC. Species columns are arranged alphabetically. See Appendix 6 for description of 4-letter species codes.

Route	AMBI	AMCO	AMCR	AMGO	AMRO	BANS	BAOR	BARS	BCNH	BEKI	BHCO	BOBO	BWTE	CAGO
ON064	0.5	-	0.3	-	0.3	-	-	-	-	-	-	-	-	-
ON078	-	-	-	-	-	-	-	-	0.1	0.1	-	-	-	-
ON376	-	-	-	0.1	0.2	-	0.1	1.2	0.1	0.0	-	-	-	0.3
ON393	-	-	-	-	3.0	-	-	8.0	-	1.0	-	-	-	-
ON394	-	-	-	0.7	4.0	-	1.0	-	-	-	-	-	-	-
ON408	-	-	-	-	-	-	-	2.0	-	-	-	1.0	-	-
ON409	-	-	-	-	-	-	-	-	-	-	-	0.5	0.5	1.5
ON450	-	-	-	-	0.4	-	-	1.2	-	-	-	-	-	1.4
ON456	-	0.3	-	0.3	0.3	0.5	-	1.3	0.2	-	-	-	-	-
ON489	-	-	-	-	0.1	-	-	5.5	-	-	-	-	-	0.1
ON698	-	-	-	-	0.5	4.5	-	1.5	-	-	-	-	-	-
ON699	-	-	-	-	0.8	1.0	-	5.0	-	-	-	-	-	1.8
ON770	-	-	-	0.1	0.3	-	-	0.6	-	-	0.1	-	-	0.1
ON771	-	-	-	1.0	-	-	-	-	-	-	0.5	-	-	-
ON772	-	2.5	-	-	-	1.0	1.0	2.0	-	-	-	-	-	-
ON773	-	-	-	0.5	-	-	-	-	-	-	-	-	-	2.0
ON774	-	-	-	0.4	0.7	-	0.3	1.0	-	-	0.3	-	-	2.1
ON775	-	-	-	-	-	-	-	2.0	-	-	-	-	-	-
ON776	-	-	-	0.2	0.5	-	0.2	1.2	0.2	0.3	-	-	-	-
ON778	-	-	-	0.5	1.0	-	1.5	-	-	-	-	-	-	2.0
ON779	-	-	-	0.5	0.5	1.0	2.0	-	1.5	-	-	-	-	7.0
ON780	-	-	-	-	-	-	0.5	1.5	-	-	0.5	-	-	2.0
ON781	-	-	-	-	2.3	-	0.3	0.3	-	-	-	-	-	-
ON782	-	-	-	-	-	-	1.0	1.0	1.0	-	-	-	-	52.0

Route	CARW	CATE	CEDW	CHSW	CLSW	COGR	COMO	COYE	CSWA	DOWO	DUNL	EAKI	EAPH	EAWP	EUST
ON064	-	-	-	-	-	-	-	1.5	0.5	-	-	-	-	-	-
ON078	-	-	-	-	-	-	-	0.1	-	-	-	0.1	-	-	-
ON376	-	-	-	0.1	-	0.5	0.0	0.2	-	-	-	0.1	-	-	-
ON393	-	-	-	-	-	3.0	-	-	-	-	-	-	-	-	-
ON394	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ON408	-	-	-	-	-	5.0	-	-	-	-	4.5	-	0.5	-	-
ON409	-	-	-	-	-	1.8	-	-	-	-	2.0	0.3	-	-	-
ON450	-	-	-	-	-	-	-	-	-	-	-	0.2	-	-	0.2
ON456	-	-	-	-	3.0	-	-	0.2	-	-	-	-	-	0.2	-
ON489	-	0.1	-	-	-	-	-	0.6	-	-	-	0.1	-	-	-
ON698	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ON699	-	-	-	-	-	1.2	-	-	-	-	-	-	-	-	3.8
ON770	-	-	0.2	-	-	0.6	-	1.3	-	-	-	0.1	-	-	2.2
ON771	-	-	-	-	0.5	-	-	1.5	-	0.5	-	1.0	-	-	0.5
ON772	-	-	-	-	-	0.5	-	0.5	-	-	-	0.5	-	-	-
ON773	0.5	-	0.5	-	-	-	-	2.0	-	-	-	-	-	-	-
ON774	0.1	-	0.1	-	0.1	1.7	-	0.6	-	0.1	-	0.1	-	-	1.3
ON775	-	-	-	-	-	1.0	-	2.0	-	-	-	-	-	-	-
ON776	-	-	-	-	-	2.0	-	1.7	-	-	-	-	-	-	0.8
ON778	-	-	2.0	-	-	4.0	-	-	-	0.5	-	-	-	-	0.5
ON779	0.5	-	1.0	-	-	3.5	-	1.0	-	-	-	-	-	-	1.5
ON780	-	-	-	-	-	0.5	-	1.0	-	0.5	-	-	-	-	1.0
ON781	-	-	-	0.7	-	2.3	-	1.3	-	-	-	-	-	-	2.0
ON782	-	-	-	-	-	10.0	-	-	-	-	-	-	-	-	-

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Route	FOTE	GBHE	GCFL	GRCA	GREG	GRHE	HERG	HOSP	HOWR	KILL	LEBI	LESA	MALL	MAWR	MODO
ON064	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ON078	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-
ON376	-	0.0	-	-	0.3	-	-	-	-	0.1	-	-	0.3	0.1	-
ON393	-	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-
ON394	-	-	-	-	-	-	-	-	-	-	-	-	1.3	-	-
ON408	-	-	-	-	-	-	-	-	-	-	-	2.5	1.0	-	-
ON409	-	-	-	-	-	-	-	-	-	1.8	-	1.0	4.0	1.0	-
ON450	-	0.8	-	-	-	-	-	0.4	-	0.2	-	-	1.2	-	-
ON456	-	0.2	-	0.2	-	-	-	-	-	-	-	-	-	0.2	0.3
ON489	-	0.1	-	-	-	-	-	-	-	-	-	-	0.3	-	-
ON698	-	0.5	-	-	-	1.5	-	-	-	-	-	-	1.0	-	-
ON699	-	0.4	-	-	-	-	-	-	-	1.4	-	-	0.8	-	0.6
ON770	-	-	-	-	-	-	-	-	-	-	0.1	-	-	0.6	-
ON771	0.5	-	-	0.5	-	-	-	-	-	-	-	-	-	0.5	-
ON772	1.0	-	-	0.5	-	-	-	-	-	-	-	-	-	1.0	-
ON773	-	-	-	-	-	-	-	-	0.5	-	-	-	-	1.0	-
ON774	-	0.1	0.1	0.1	0.3	-	-	0.1	0.1	-	-	-	0.6	0.7	-
ON775	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0
ON776	-	-	-	0.3	-	0.3	-	-	0.2	-	-	-	-	0.3	-
ON778	-	0.5	-	-	-	-	-	-	0.5	-	-	-	-	-	-
ON779	-	0.5	-	1.0	-	-	-	-	-	-	-	-	-	-	-
ON780	-	-	-	0.5	-	-	-	-	-	-	-	-	-	1.5	-
ON781	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-
ON782	-	-	-	-	-	-	20.0	-	1.0	-	-	-	-	-	1.0

Route	MOOT	MUSW	NOCA	NOFL	NOMO	NRWS	PBGR	PUMA	RBGU	REVI	RUDU	RWBL	SBDO	SEPL	SESA
ON064	-	-	-	-	-	-	-	-	-	-	-	0.3	-	-	-
ON078	0.1	-	-	-	-	-	0.3	0.1	-	-	-	2.6	-	-	-
ON376	-	0.1	0.0	-	-	0.0	0.3	0.3	-	-	-	2.9	-	-	-
ON393	-	-	-	-	-	-	-	-	0.5	-	-	4.5	-	-	-
ON394	-	-	-	-	-	-	-	-	1.7	-	-	5.3	-	-	-
ON408	-	-	-	-	-	-	-	-	2.0	-	2.0	9.0	1.0	-	2.5
ON409	-	-	-	-	-	1.0	-	-	-	-	1.8	6.0	-	0.5	1.8
ON450	-	-	-	-	-	-	-	-	-	-	-	4.4	-	-	-
ON456	-	0.8	0.2	-	-	4.2	0.2	-	-	-	-	3.5	-	-	-
ON489	-	0.1	-	-	-	-	0.3	-	-	-	-	2.8	-	-	-
ON698	-	-	-	-	-	-	-	-	-	-	-	4.0	-	-	-
ON699	-	-	-	-	-	-	-	-	-	-	-	3.6	-	-	-
ON770	-	-	0.3	-	-	0.3	-	-	-	-	-	4.8	-	-	-
ON771	-	-	-	-	-	2.0	-	-	-	-	-	4.0	-	-	-
ON772	0.5	100.0	0.5	-	-	-	1.0	-	-	-	-	5.0	-	-	-
ON773	-	-	-	-	0.5	-	0.5	-	-	-	-	5.5	-	-	-
ON774	-	0.6	0.4	-	-	0.4	0.1	-	2.1	-	-	5.9	-	-	-
ON775	-	-	-	-	-	2.0	-	-	-	-	-	8.0	-	-	-
ON776	-	-	0.5	-	-	3.0	-	-	-	-	-	5.8	-	-	-
ON778	-	-	1.0	0.5	-	-	-	-	-	0.5	-	19.5	-	-	-
ON779	-	-	0.5	-	-	-	-	-	-	-	-	7.5	-	-	-
ON780	-	-	0.5	-	-	0.5	-	-	-	-	-	3.5	-	-	-
ON781	-	-	1.0	-	-	-	-	-	0.7	-	-	6.7	-	-	-
ON782	-	-	-	-	-	-	-	-	2000.0	-	-	3.0	-	-	-

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Route	SORA	SOSP	SPSA	SWSP	TRES	VEER	VIRA	WAVI	WBNU	WIFL	WISN	WODU	YBCU	YWAR
ON064	-	1.3	-	2.5	-	0.3	-	-	-	1.0	-	-	-	1.0
ON078	-	0.1	0.1	0.1	7.3	-	-	-	-	-	-	0.7	-	0.1
ON376	0.0	0.0	-	0.2	4.6	-	-	-	-	-	-	0.2	-	0.3
ON393	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ON394	-	-	-	-	0.3	-	-	-	-	-	-	-	-	-
ON408	-	1.5	-	-	1.5	-	-	-	-	-	-	-	-	-
ON409	-	1.0	0.8	-	0.5	-	-	-	-	-	-	0.5	-	-
ON450	-	0.8	0.6	-	6.4	-	0.2	-	-	-	-	0.8	-	-
ON456	-	0.7	0.3	-	3.0	-	-	0.2	-	-	0.2	-	-	0.5
ON489	-	-	-	-	3.6	-	-	-	-	-	-	-	-	-
ON698	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ON699	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ON770	-	1.0	-	0.4	5.4	-	-	-	-	0.3	-	0.8	-	0.9
ON771	-	0.5	-	-	1.0	-	-	0.5	-	-	-	-	-	1.5
ON772	-	0.5	-	-	3.5	-	-	1.5	-	-	-	-	-	2.0
ON773	-	0.5	-	1.0	1.5	-	-	-	-	-	-	-	-	1.0
ON774	0.1	0.6	-	0.7	1.6	-	-	0.4	-	0.3	-	-	-	1.6
ON775	-	1.0	-	-	1.0	-	-	1.0	-	-	-	-	-	1.0
ON776	-	1.0	0.2	-	8.5	-	0.2	-	0.2	-	-	0.3	-	0.8
ON778	-	-	-	-	1.5	-	-	0.5	-	-	-	-	0.5	3.5
ON779	-	0.5	-	-	1.0	-	-	0.5	-	-	-	1.0	-	2.5
ON780	0.5	1.0	-	-	1.5	-	-	-	-	1.0	-	-	-	0.5
ON781	-	0.3	-	-	-	-	-	0.3	-	-	-	-	-	0.3
ON782	-	1.0	-	-	2.0	-	-	1.0	-	-	-	-	-	2.0

Appendix 5. Mean calling code (1 = low abundance, 2 = middle abundance, 3 = high abundance) per Great Lakes Marsh Monitoring Program amphibian station, averaged across all years between 1995 and 2011, within or adjacent to the Detroit River AOC. Species columns are arranged alphabetically. See Appendix 6 for description of 4-letter species codes.

Route	AMTO	BULL	CHFR	GRFR	GRTR	NLFR	PIFR	SPPE	WOFR
MI157	-	-	-	-	-	-	-	-	-
ON205	-	-	-	1.0	-	-	-	-	-
ON340	1.6	0.9	1.3	1.0	-	0.7	-	0.1	0.2
ON393	-	1.0	0.3	0.5	0.5	-	-	-	-
ON394	0.6	0.7	1.1	0.6	-	0.1	-	-	-
ON396	1.7	0.1	2.3	1.6	-	0.1	0.1	-	-
ON408	-	-	-	1.0	-	-	-	0.5	-
ON409	-	-	-	1.3	-	0.5	-	0.8	-
ON430	1.0	-	-	-	-	1.0	-	-	-
ON450	3.0	-	3.0	3.0	-	0.8	-	-	-
ON489	0.3	-	-	0.7	-	0.7	-	-	-
ON613	1.0	1.0	2.0	1.0	-	2.0	-	3.0	-
ON659	0.9	0.8	2.4	1.1	-	0.5	-	0.2	0.2
ON689	0.6	1.0	-	1.0	-	0.7	-	0.2	0.1
ON698	-	-	-	1.0	-	-	-	-	-
ON699	2.2	0.2	-	1.6	-	-	-	-	-
ON742	-	-	3.0	0.5	-	-	-	-	-
ON781	1.0	-	1.0	-	-	-	-	1.0	-

Appendix 6. Four-letter species codes used in Appendices 1–4.

Code	Common Name	Code	Common Name	Code	Common Name
AMBI	American Bittern	COTE	Common Tern	NOPI	Northern Pintail
AMCO	American Coot	COYE	Common Yellowthroat	NRWS	Northern Rough-winged Swallow
AMCR	American Crow	DCCO	Double-crested Cormorant	PBGR	Pied-billed Grebe
AMGO	American Goldfinch	DOWO	Downy Woodpecker	PIFR	Pickeral Frog
AMRE	American Redstart	EABL	Eastern Bluebird	PUMA	Purple Martin
AMRO	American Robin	EAKI	Eastern Kingbird	RBGR	Rose-breasted Grosbeak
AMTO	American Toad	EUST	European Starling	RBGU	Ring-billed Gull
BANS	Bank Swallow	FOTE	Forster's Tern	RTHA	Red-tailed Hawk
BAOR	Baltimore Oriole	GADW	Gadwall	RUBL	Rusty Blackbird
BARS	Barn Swallow	GBHE	Great Blue Heron	RUDU	Ruddy Duck
BCCH	Black-capped Chickadee	GRCA	Gray Catbird	RWBL	Red-winged Blackbird
BCNH	Black-crowned Night-Heron	GREG	Great Egret	SACR	Sandhill Crane
BEKI	Belted Kingfisher	GRFR	Green Frog	SAVS	Savannah Sparrow
BHCO	Brown-headed Cowbird	GRHE	Green Heron	SEOW	Short-eared Owl
BLJA	Blue Jay	GRTR	Gray Treefrog	SORA	Sora
BLTE	Black Tern	HOFI	House Finch	SOSP	Song Sparrow
BULL	Bullfrog	HOSP	House Sparrow	SPPE	Spring Peeper
CAGO	Canada Goose	HOWR	House Wren	SPSA	Spotted Sandpiper
CANV	Canvasback	KILL	Killdeer	SWSP	Swamp Sparrow
CATE	Caspian Tern	LEBI	Least Bittern	TRES	Tree Swallow
CEDW	Cedar Waxwing	MALL	Mallard	VIRA	Virginia Rail
CHFR	Chorus Frog	MAWR	Marsh Wren	WAVI	Warbling Vireo
CHSP	Chipping Sparrow	MODO	Mourning Dove	WIFL	Willow Flycatcher
CHSW	Chimney Swift	MOOT	Am. Coot/C. Moorhen	WISN	Wilson's Snipe
CLSW	Cliff Swallow	MUSW	Mute Swan	WODU	Wood Duck
COGR	Common Grackle	NLFR	Northern Leopard Frog	WOFR	Wood Frog
COHA	Cooper's Hawk	NOBO	Northern Bobwhite	YHBL	Yellow-headed Blackbird
COMO	Common Gallinule	NOCA	Northern Cardinal	YWAR	Yellow Warbler
CONI	Common Nighthawk	NOFL	Northern Flicker		

Appendix 7. Mean number of waterfowl per km per day in various survey sectors within the St. Clair River and Detroit River AOC. Species columns are arranged alphabetically. See Appendix 8 for description of 4-letter species codes.

Sector	AOC	Season	ABDU	AMWI	BLSC	BWTE	BUFF	CAGO	CANV	COGO	COME	DABB	DIVE	GADW
WLO-LE_C9	Detroit	Fall	8769	294	0	458	0	1584	0	22	2	64174	1232	1290
WLO-LE_C9	Detroit	Spring	4167	1075	0	0	0	9176	415	734	2527	19311	17583	1469
WLO-LE_C10	Detroit	Fall	1012	28	825	0	11	6103	6601	0	3	2374	7743	21
WLO-LE_C10	Detroit	Spring	139	5	0	0	217	1629	2564	9	78	714	13616	0
WLO-LE_C11	Detroit	Fall	5126	4053	0	77	36	528	27665	18	2	31209	40950	633
WLO-LE_C11	Detroit	Spring	512	63	0	0	43	1969	25158	661	975	7369	31872	4247
WLO-LE_C12	Detroit	Fall	38	283	0	0	0	392	30	0	27	773	104	0
WLO-LE_C12	Detroit	Spring	390	161	0	0	63	939	6147	46	267	3482	11957	0
WLO-LE_C13	Detroit	Fall	1795	177	0	64	1430	17942	18185	495	1453	12560	25044	19
WLO-LE_C13	Detroit	Spring	2193	4	0	0	190	5792	4256	198	1676	7493	22838	0
WLO-LE_C16	St. Clair	Fall	66555	23739	0	677	108	21616	18267	240	1233	257751	54606	1253
WLO-LE_C16	St. Clair	Spring	16497	16316	0	181	3011	6940	27875	5440	15253	108236	140384	1734
Sector	AOC	Season	GRSC	GWTE	HOME	LESC	LTDU	MALL	MUSW	NOPI	NSHO	RBME	REDH	RNDU
WLO-LE_C9	Detroit	Fall	0	4379	0	0	0	48371	62	124	0	0	0	144
WLO-LE_C9	Detroit	Spring	0	379	0	0	0	11683	292	444	0	103	605	9419
WLO-LE_C10	Detroit	Fall	0	0	0	0	0	1312	22	0	0	0	56	0
WLO-LE_C10	Detroit	Spring	0	0	0	0	0	570	39	0	0	54	2998	0
WLO-LE_C11	Detroit	Fall	0	98	0	0	0	20625	5530	531	0	0	5620	3614
WLO-LE_C11	Detroit	Spring	0	59	0	0	0	2454	1050	34	0	3	4032	0
WLO-LE_C12	Detroit	Fall	0	0	0	0	0	452	535	0	0	0	32	0
WLO-LE_C12	Detroit	Spring	0	0	0	0	0	2906	915	25	0	0	4206	313
WLO-LE_C13	Detroit	Fall	0	40	0	0	0	10434	77	17	0	523	301	21
WLO-LE_C13	Detroit	Spring	0	3	0	0	0	5293	87	0	0	198	4597	8
WLO-LE_C16	St. Clair	Fall	1012	3703	41	2	4	159763	1146	2044	0	19	15881	17490
WLO-LE_C16	St. Clair	Spring	18123	6888	247	15	172	57108	1291	9341	159	141	42380	15069

Sector	AOC	Season	RUDU	SNGO	TUSW	WWSC	WODU
WLO-LE_C9	Detroit	Fall	2845	0	0	0	489
WLO-LE_C9	Detroit	Spring	15	3	788	0	94
WLO-LE_C10	Detroit	Fall	0	0	509	0	0
WLO-LE_C10	Detroit	Spring	0	0	45	0	0
WLO-LE_C11	Detroit	Fall	11	0	2098	0	67
WLO-LE_C11	Detroit	Spring	4	0	857	0	0
WLO-LE_C12	Detroit	Fall	0	0	213	0	0
WLO-LE_C12	Detroit	Spring	0	0	328	0	0
WLO-LE_C13	Detroit	Fall	190	1	11110	2	15
WLO-LE_C13	Detroit	Spring	0	0	4102	0	0
WLO-LE_C16	St. Clair	Fall	1990	37	1797	0	18
WLO-LE_C16	St. Clair	Spring	892	117	20661	0	12

Appendix 8. Four-letter species codes used in Appendix 7.

Code	Common Name	Code	Common Name
ABDU	American Black Duck	LESC	Lesser Scaup
AMWI	American Wigeon	LTDU	Long-tailed Duck
BLSC	Black Scoter	MALL	Mallard
BWTE	Blue-winged Teal	MUSW	Mute Swan
BUFF	Bufflehead	NOPI	Northern Pintail
CAGO	Canada Goose	NSHO	Northern Shoveler
CANV	Canvasback	RBME	Red-breasted Merganser
COGO	Common Goldeneye	REDH	Redhead
COME	Common Merganser	RNDU	Ring-necked Duck
DABB	Dabbler spp.	RUDU	Ruddy Duck
DIVE	Diver spp.	SNGO	Snow Goose
GADW	Gadwall	TRUS	Trumpeter Swan
GRSC	Greater Scaup	WWSC	White-winged Scoter
GWTE	Green-winged Teal	WODU	Wood Duck
HOME	Hooded Merganser		

Appendix 9. Occupancy of Bald Eagle breeding territories within the Detroit River AOC between 1980 and 2010.

Territory	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
EX7																		
EX6																		
EX2		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
EX5																		
EX4													1	1	1	1	1	1
Territory	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010					
EX7								1	1	1	1	1	1					
EX6							1	1	1	1	1	1	1					
EX2	1	1	1	1	1	1	1	1	1	1	1	1	1					
EX5				1	1	1	1	1	1	1	1	1	1					
EX4	1	1	1	1	1	1	1	1	1	1								

Appendix 10. Number of chicks fledged from Bald Eagle territories within the Detroit River AOC between 1992 and 2010.

Territory	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
EX7														2	2	1	2	2
EX6													2	2	0	1		2
EX2	2	1	1	2	3	0	2	0	2	2			2	2	2	2	2	2
EX5												2	1			1	2	2
EX4	0	0	1	1	2	3	1	1	2	2	2	1			2	1		
Territory	2010																	
EX7																		
EX6	2																	
EX2																		
EX5	1																	
EX4																		