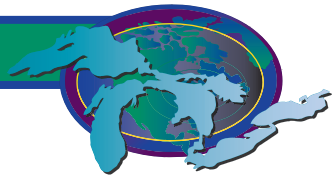

Contaminants in Colonial Nesting Waterbirds

Indicator #115

Overall Assessment

Status: **Mixed**
Trend: **Improving**
Rationale: **Overall, most contaminants have declined substantially (greater than 90%) since first measured. Spatially, some sites in 2 to 3 of the lakes were much more contaminated than others. Temporally, more than 70% of all contaminant concentrations at all colonies (105 total) were currently declining as fast or faster than they did in the past.**

Lake-by-Lake Assessment

Lake Superior

Status: Good
Trend: Improving
Rationale: For 6 contaminants that have been measured since the program started in 1974 (PCBs, DDE, HCB, HE, mirex and dieldrin), the two herring gull egg monitoring sites in Lake Superior showed declines of 93.9% to 99.8% between then and 2005. Both sites ranked among the lowest for concentrations of 7 major compounds (the above 6 contaminants + TCDD) among the 15 monitoring sites. The temporal pattern at the two sites showed 71% of colony-contaminant comparisons declining as fast or faster than previously.

Lake Michigan

Status: Mixed
Trend: Improving
Rationale: For 6 contaminants that have been measured since the program began, the two herring gull egg monitoring sites showed declines of 91.8% to 99.1% between then and 2005. Eggs from one of the Lake Michigan sites ranked as the 3rd most contaminated among the 15 monitoring sites. Eggs from the other site ranked much lower (9th). The temporal pattern for the two sites showed 86% of the colony-contaminant comparisons declining as fast or faster than previously.

Lake Huron

Status: Mixed
Trend: Improving
Rationale: Herring gull eggs from two of three monitoring sites in Lake Huron were relatively clean. The third site, in Saginaw Bay, had the most contaminated gull eggs among all sites tested and reduced the overall status of this indicator in Lake Huron. The three sites showed contaminant declines of 68.9% to 99.7% in gull eggs in 2005. Two of three sites ranked among the lowest for concentrations for 7 major compounds among 15 sites. The temporal pattern at the three sites showed 86% of colony-contaminant comparisons declining as fast or faster than previously.

Lake Erie

Status: Mixed
Trend: Improving
Rationale: Of the two monitoring sites in Lake Erie, the most easterly, at Port Colborne, had the cleanest gull eggs of all 15 sites tested. Eggs from Middle Island, in the Western Basin, were considerably more contaminated. The two sites showed contaminant declines of 80.2% to 99.3% in gull eggs in 2005. Eggs from Middle Island were in the mid-range and those from Port Colborne were the lowest for contaminants. The temporal pattern at the two sites showed 93% of colony-contaminant comparisons declining as fast or faster than previously.

Lake Ontario

Status: Poor
Trend: Improving
Rationale: Eggs from the three Lake Ontario herring gull monitoring sites showed declines of 88.6% to 99.0% in 2005. The three sites ranked among the top 8 for concentrations of contaminants in gull eggs. Temporally, 76% of colony-contaminant comparisons were declining as fast or faster than previously.

Purpose

- To assess current chemical concentrations and trends in representative colonial waterbirds (gulls, terns, cormorants and/or herons) on the Great Lakes
- To assess ecological and physiological endpoints in representative colonial waterbirds (gulls, terns, cormorants and/or herons) on the Great Lakes
- To infer and measure the impact of contaminants on the health, i.e. the physiology and breeding characteristics, of the waterbird populations

Ecosystem Objective

One of the objectives of monitoring colonial waterbirds on the Great Lakes is to track progress toward an environmental condition in which there is no difference in contaminant levels and related biological endpoints between birds on and off the Great Lakes. Other objectives include determining temporal and spatial trends in contaminant levels in colonial waterbirds and detecting changes in their population levels on the Great Lakes. This includes monitoring contaminant levels in herring gull eggs to ensure that the levels continue to decline and utilizing these data to promote continued reductions of contaminants in the Great Lakes basin.

State of the Ecosystem

Background

This indicator is important because colonial waterbirds are one of the top aquatic food web predators in the Great Lakes ecosystem and they are very visible and well-known to the public. They bioaccumulate contaminants to the greatest concentration of any trophic level organism and they breed on all the Great Lakes. Thus, they are a very cost efficient monitoring system and allow easy inter-lake comparisons. The current Herring Gull Egg Monitoring Program (HGEMP) is the longest continuously running annual wildlife contaminants monitoring program in the world (since 1974). It determines concentrations of up to 20 organochlorines, 65 polychlorinated biphenyls (PCB) congeners and 53 polychlorinated dibenzo-p-dioxin (PCDD) and polychlorinated dibenzo furan (PCDF) congeners, as well as 16 brominated diphenyl ethers BDEs) congeners (Braune *et al*. 2003).

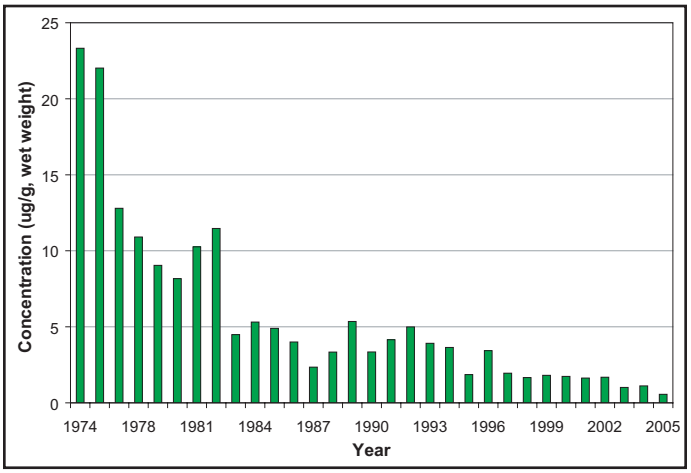

Figure 1. Annual concentration of DDE in Herring Gull eggs, Toronto Harbour, 1974-2005.

Source: Environment Canada, Herring Gull Monitoring Program

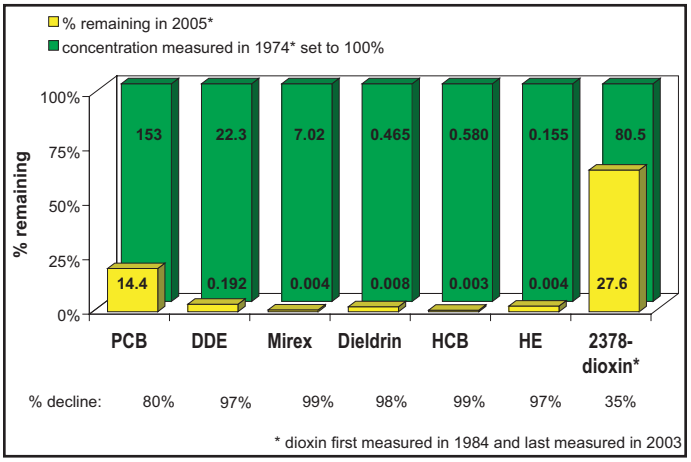

Figure 2. Mean contaminant concentrations and percent decline of 7 contaminants in Herring Gull eggs from year of first analysis to present, Middle Island, Lake Erie.

Concentrations in µg/g wet weight except for dioxin in ρg/g wet weight.

Source: Environment Canada, Herring Gull Monitoring Program

The primary factors used to assess the status and trends of contaminants in herring gull eggs were: 1) the change in contaminant concentrations in herring gull eggs between when they were first measured (usually 1974) and currently, in 2005 (Jermyn-Gee *et al*. 2005; Canadian Wildlife Service (CWS) unpublished); 2) the overall ranking of contaminant concentrations at the 15 Great Lakes herring gull egg monitoring sites (Weseloh *et al*. 2006); and 3) the direction and relative slope of the change-point regression line calculated for each compound at each site (Pekarik and Weseloh 1998, Weseloh *et al*. 2003, 2005; CWS unpublished).

Status of Contaminants in Colonial Waterbirds

The HGEMP has provided researchers and managers with a powerful tool (a 30-year database) to evaluate changes in contaminant concentrations in Great Lakes wildlife (e.g., see Figure 1). The extreme longevity of the egg database makes it possible to calculate temporal trends in contaminant concentrations in wildlife and to look for significant changes within those trends. The database shows that most contaminants in gull eggs have declined 90% or more since the program began in 1974 (Figure 2). In 2005, PCBs, hexachlorobenzene (HCB), dichlorodiphenyl-dichloroethene (DDE), heptachlor epoxide (HE), dieldrin, mirex and 2,3,7,8-

tetrachlorodibenzo-p-dioxin(TCDD) levels measured in eggs from the 15 Annual Monitoring Colonies (Figure 3) were analyzed for temporal trends (total of 105 comparisons). Analysis showed that in 83.8% of cases (88 of the 105), the contaminants were decreasing as fast as or faster in recent years than they had in the past. This was interpreted as a positive sign. In 9.5% of cases (10/105), contaminants were decreasing more slowly than they had in the past (calculated from Bishop *et al*. 1992, Pettit *et al*.1994, Pekarik *et al*.1998 and Jermyn-Gee *et al*. 2005, as per Pekarik and Weseloh 1998). This is viewed as a negative sign. PCBs showed the most frequent reduction in their rates of decline. The decline in contaminant concentrations in gull eggs, however, may not be due wholly to a decrease in contaminants in the environment. Changes in food web dynamics may be playing a role in some of these declines, that is, contaminant exposure at some colonies may have lessened because the birds are now feeding on lower trophic level prey.

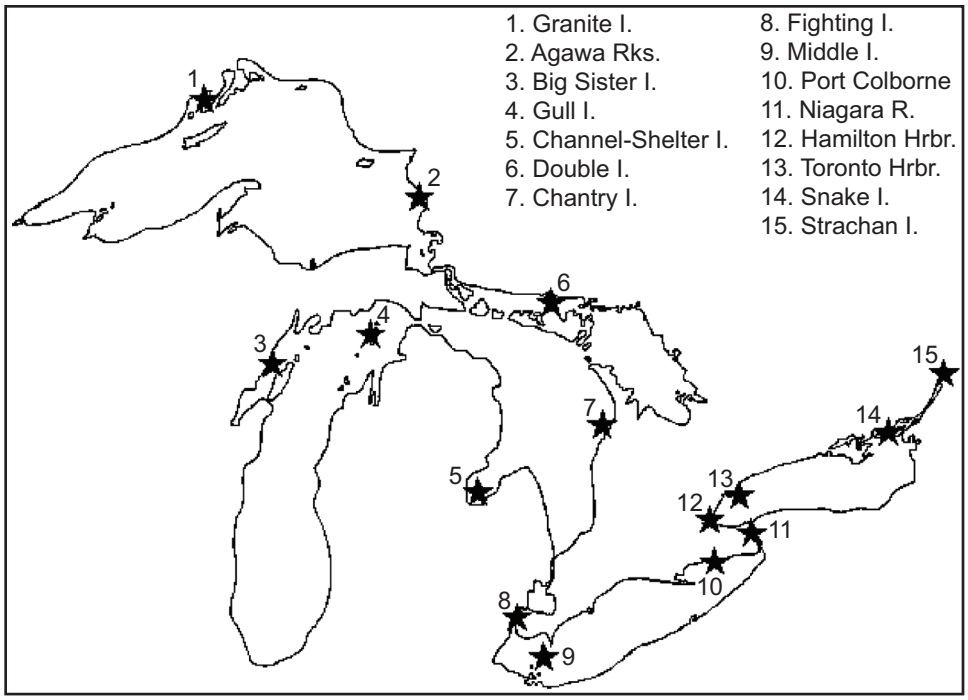

Figure 3. The distribution and locations of the 15 Herring Gull Annual Monitoring Colonies.

Source: Environment Canada, Herring Gull Monitoring Program and Canadian Wildlife Service

The sole exception to these declining herring gull egg contaminant concentrations appears to be brominated diphenyl ethers (BDEs). These compounds, which are used as fire retardants in plastics, furniture cushions, etc., increased dramatically in gull eggs during 1981-2000 (Norstrom *et al*. 2002). Recent data showed a combined 3.9% decline for the 15 monitoring sites from 2000 to 2003 but a 25.3% increase from 2000 to 2005 (CWS, unpubl. data).

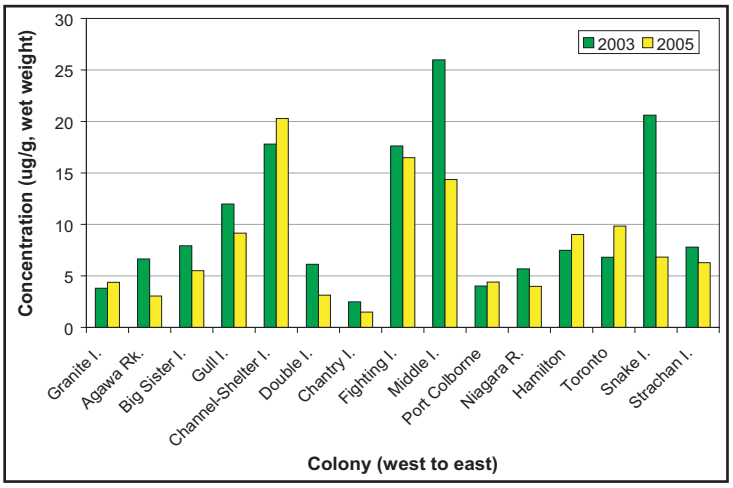

Figure 4. A comparison of PCB concentrations at all sites for 2003 and 2005.

Note the between-year differences as well as the variation among sites.

Source: Environment Canada, Herring Gull Monitoring Program and Canadian Wildlife Service

A comparison of concentrations of six contaminants (PCBs, HCB, DDE, HE, dieldrin and mirex) at the 15 sites in 2003 and 2005 (total of 90 comparisons) was made to show the variability in a short-term (two year) assessment. TCDD was last measured in 2003. Therefore, for this short-term assessment, 2001 and 2003 data were used for an additional 15 comparisons. Of the total 105 comparisons, 89 (84.8%) decreased; only 16 (15.2%) increased. TCDD and PCBs were the most frequently increasing contaminants (CWS unpublished data). This is illustrated for a single contaminant, PCBs, in Figure 4. Annual fluctuations like these, including both short-term increases and decreases, are part of current contaminant patterns (Figures 1 and 4).

In terms of gross ecological effects of contaminants on colonial waterbirds, e.g., eggshell thinning, failed reproductive success and population declines, most species appear to have recovered. Populations of most species have increased over the past 25-30 years, e.g., see Figure 5 (Blokpoel and Tessier 1993-1998, Austen *et al*. 1996,

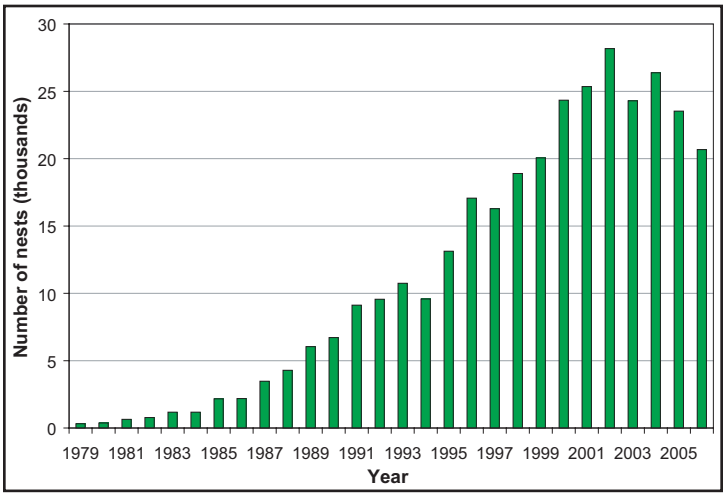

Figure 5. Double-crested Cormorant nests (breeding pairs) on Lake Ontario, 1979-2005.
Source: Environment Canada, Canadian Wildlife Service

Scharf and Shugart 1998, Cuthbert *et al*. 2001, Weseloh *et al*. 2002, Morris *et al*. 2003, Havelka and Weseloh in review, Hebert *et al*. in press, CWS unpublished data). Although the gross effects appear to have subsided (but see Custer *et al*. 1999), there are many other subtle, mostly physiological and genetic endpoints that are being measured now that were not measured in earlier years (Fox *et al*. 1988, Fox 1993, Grasman *et al*. 1996, Yauk *et al*. 2000). A recent and ongoing study, the Fish and Wildlife Health Effects and Exposure Study, is assessing whether there are fish and wildlife health effects in Canadian Areas of Concern (AOCs) similar to those reported for the human population (Environment Canada 2003). To date, the following abnormalities have been found in herring gulls in one or more Canadian AOCs on the lower Great Lakes: a male-biased sex ratio in hatchlings, elevated levels of embryonic mortality, indications of feminization in more than 10% of adult males, a reduced or suppressed ability to combat stress, an enlarged thyroid with reduced hormone production and a suppressed immune system. Although there is little question that herring gulls and colonial waterbirds on the Great Lakes are healthier now than they were 30 years ago, these findings show that they are in a poorer state of health than are birds from clean reference sites in the Maritimes (Environment Canada 2003).

Pressures

Future pressures for this indicator include all sources of contaminants which reach the Great Lakes. These include those sources that are already well-known, e.g., point sources, re-suspension of sediments, and atmospheric inputs, as well as lesser known ones such as underground leaks from landfill sites. There are also other, non-contaminant factors that regulate the stability of populations, e.g., habitat modification (in the Detroit River), food availability (Lake Superior), interspecific competition at breeding colonies (Lake Ontario) and predation (western Lake Erie). Many of these factors pose much more tangible threats to researchers' ability to collect eggs from these colonies in the future.

Management Implications

Data from the HGEMP suggest that, for the most part, contaminant levels in wildlife are continuing to decline at a constant rate. However, even at current contaminant levels, more physiological abnormalities in herring gulls occur at Great Lakes sites than at cleaner, reference sites away from the Great Lakes basin. Also, with the noted increase in concentrations of polybrominated diphenyl ethers (PBDEs), steps should be taken to identify and reduce sources of this compound to the Great Lakes. In short, although almost all contaminants are decreasing and many biological impacts have lessened, we do not yet know the full health implications of the subtle effects and of newly monitored contaminants.

Future Activities

The annual collection and analysis of herring gull eggs from 15 sites on both sides of the Great Lakes and the assessment of this species' reproductive success is a permanent part of the CWS Great Lakes surveillance activities. Likewise, so is the regular monitoring of population levels of most of the colonial waterbird species. The plan is to continue these procedures. Research on improving and expanding the HGEMP is done on a more opportunistic, less predictable basis. A lake-by-lake intensive study of possible biological impacts to herring gulls is currently underway in the lower lakes. Recently, ecological tracers (stable isotopes and fatty acids) have been generated from archival eggs as part of the program, and they provide insights into how food webs in the Great Lakes ecosystem are changing. This information broadens the utility of the program from just examining contaminants to providing insights into ecosystem change. Ecological tracer data are also directly relevant to the interpretation of contaminant monitoring data.

Comments from the author(s)

We have learned much about interpreting the herring gull egg contaminants data from associated research studies. However, much of this work is conducted on an opportunistic basis, when funds are available. Several research activities should be incorporated

into routine monitoring, e.g., tracking of porphyria, vitamin A deficiencies, and evaluation of the avian immune system. Likewise, more research should focus on new areas, e.g., the impact of endocrine disrupting substances, factors regulating chemically induced genetic mutations and ecological tracers.

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