## External Anomaly Prevalence Index for Nearshore Fish

Indicator #124

### Overall Assessment

| | |
|---|---|
| Status: | **Poor** |
| Trend: | **Unchanging** |

### Lake-by-Lake Assessment

*Lake Superior, Lake Huron and Lake Michigan were unstudied for this indicator and were categorized with a* not assessed *status and an* undetermined *trend*.

**Lake Erie**
Status: Poor
Trend: Unchanging

**Lake Ontario**
Status: Poor
Trend: Unchanging

### Purpose

- To assess select external anomalies in nearshore fish
- To identify nearshore areas that have populations of benthic fish exposed to contaminated sediments
- To help assess the recovery of Areas of Concern (AOCs) following remedial activities

### Ecosystem Objective

The objective is to help restoration and protection of beneficial uses in Areas of Concern or in open Great Lakes waters, including beneficial use (iv) *Fish tumors or other deformities* (Great Lakes Water Quality Agreement (GLWQA), Annex 2). This indicator also supports Annex 12 of the GLWQA (United States and Canada 1987).

### State of the Ecosystem

The presence of contaminated sediments at AOCs has been correlated with an increased incidence of external and internal anomalies in benthic fish species (brown bullhead and white suckers) that may be associated with specific groups of chemicals. Elevated incidence of liver tumors (histopathologically verified pre-neoplastic or neoplastic growths) were frequently identified during the past two decades. These elevated frequencies of liver tumors have been shown to be useful indicators of beneficial use impairment of Great Lakes aquatic habitat. External raised growths (histopathologically verified tumors on the body and lips), such as lip papillomas, have also been useful indicators. Raised growths may not have a single etiology, but they have been produced experimentally by direct application of polynuclear aromatic hydrocarbon (PAH) carcinogens to brown bullhead skin. Field and laboratory studies have correlated verified liver and external raised growths with chemical contaminants found in sediments at some AOCs in Lake Erie, Lake Michigan, Lake Ontario and Lake Huron. Other external anomalies may also be used to assess beneficial use impairment. The external anomaly prevalence index (EAPI) will provide a tool for following trends in fish population health that can be used by resource managers and community-based monitoring programs.

The EAPI has been developed for mature (greater than three years of age) fish as a marker of both contaminant exposure and of internal pathology. Brown bullhead has been used to develop the index. It is the most frequently used benthic indicator species in the southern Great Lakes and has been recommended by the International Joint Commission (IJC) as a key indicator species (IJC 1989). The most common external anomalies found in brown bullhead in Lake Erie over the last twenty years are: 1) abnormal barbels (BA); 2) focal discoloration (FD); and 3) raised growths (RG) - on the body and lips (Figure 1). Initial statistical analysis of sediments and external anomalies at different locations indicates that variations in the chemical mixtures (total, priority and carcinogenic PAHs; DDT metabolites; organochlorine chemicals (OC); and total metals) show a statistically significant relation with a differing prevalence of individual external anomalies (raised growths and barbell abnormalities). Age and external anomalies indicate a positive correlation (Figure 2). Impairment determinations should be based on age comparisons of the prevalence of external anomalies at contaminated sites with the prevalence at “reference” (least impacted) sites (Figure 3). Preliminary data indicate that if the prevalence of raised growths on the body and lip combined is greater than 5%, barbell abnormalities greater

than 10% and focal discoloration (melanistic alterations) greater than 5% in brown bullhead, the population should be considered impaired.

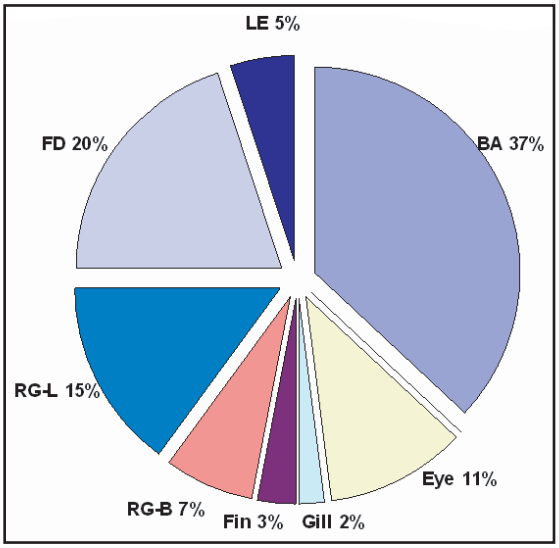


**Figure 1**. External anomalies on brown bullhead collected from Lake Erie from the 1980s through 2000.

BA-barbel abnormalities, RG-raised growth (body and lip), FD-focal discoloration, LE-lesion (total ca. 2400 fish).

Source: Great Lakes Science Center, Ann Arbor, MI

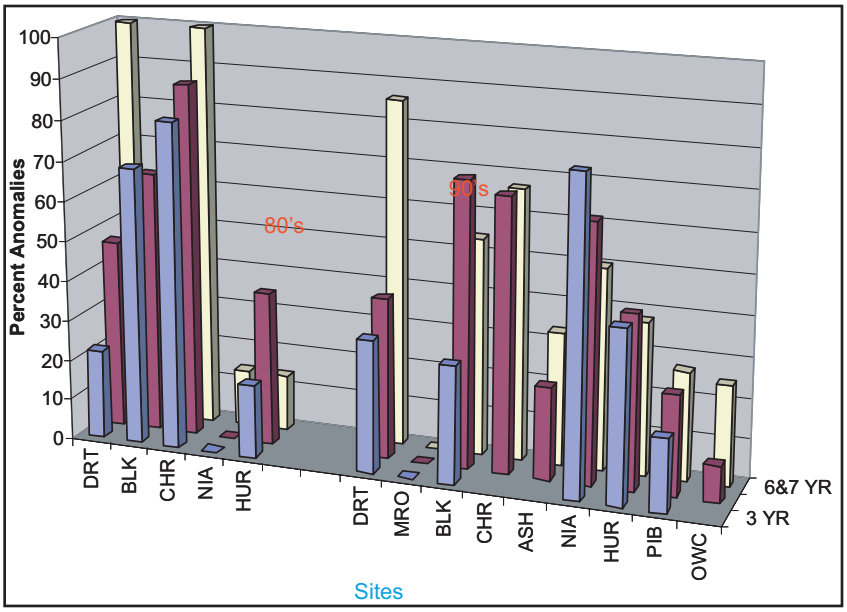


**Figure 2**. Age of brown bullhead at Lake Erie sites from 1986-87 and 1998-2000 collections in relation to combined external anomalies.

Age groups; age 3, ages 4&5, ages 6&7.

Source: S.B. Smith, unpublished data

Surveys conducted in 1999 and 2000 in the Detroit, Ottawa, Black, Cuyahoga, Ashtabula, Buffalo, and Niagara Rivers and at Old Woman Creek in Lake Erie demonstrated that external raised growths are positively associated with both PAH metabolites in bile and in PAH concentrations in sediment. The association with PAH metabolites in bile (Figure 4) is stronger than that with total PAH concentrations in sediments (Figure 5). Bile metabolite concentrations may be a better estimate of potential exposure of PAHs to individual fish than concentrations in sediments. The EAPI indicates the impacts from the exposure to individual fish from the PAHs as well as other compounds in the mixtures of compounds that may be present in sediments. Barbel deformities (Figure 5) also showed a positive correlation with total PAH levels in sediment. In addition to the locations listed above, the Huron River and Presque Isle Bay sites all showed a statistically significant correlation between external raised growths and concentration of heavy metals in sediment (Figure 6).

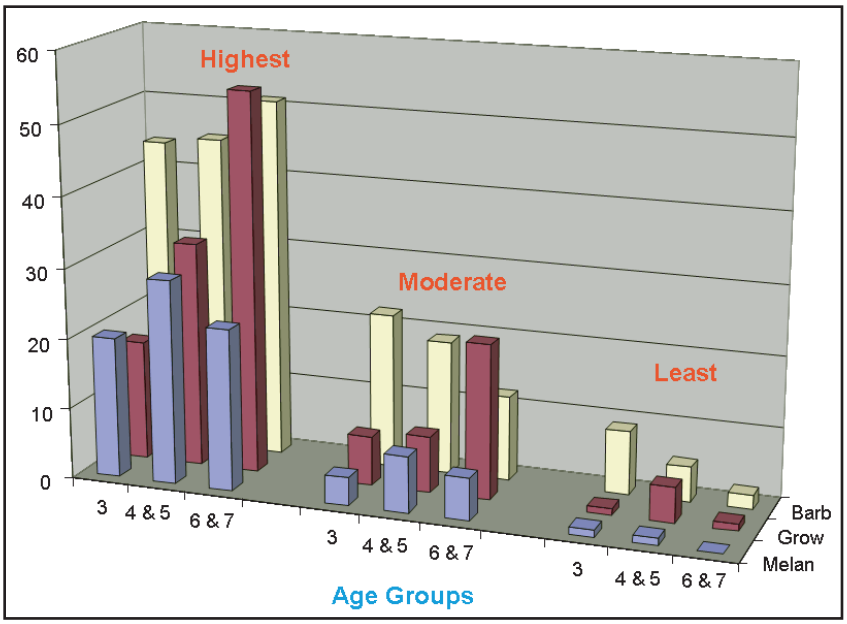


**Figure 3**. External anomalies (Melanoma, Raised Growth on body and lips, and Barbell abnormalities) in relation to sites classified for sediment contaminants and BB morphology from all collections in the 1980s and 1990s.

Source: S. B. Smith, unpublished data

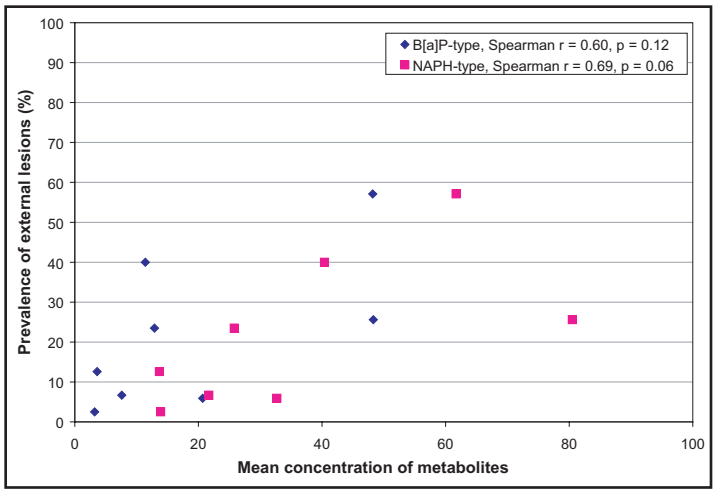


**Figure 4**. Prevalence of external raised growths in brown bullhead from Lake Erie tributaries compared to PAH metabolite concentrations in bile (B[P] and NAPH-type).

Units are µg/mg protein.

Source: Yang and Baumann, unpublished data

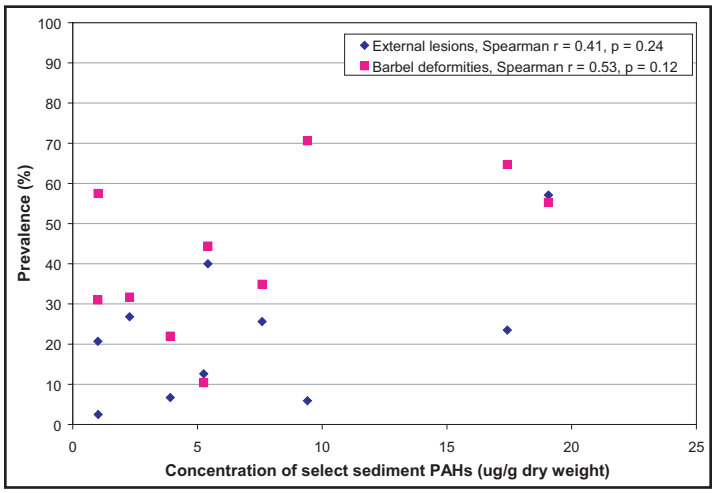


**Figure 5**. Prevalence of external raised growths and barbel deformities in brown bullhead from Lake Erie tributaries compared to PAH concentrations in sediment.

Source: Yang and Baumann, unpublished data

## Pressures

Many Great Lakes AOCs and their tributaries remain in a degraded condition. Exposure of the fish populations to contaminated sediment continues and the elevated evidence of external anomalies still persist. The human population in the Great Lakes basin is expected to increase, and urbanization along Great Lakes tributaries and shorelines will likely expand in the future. Therefore, some locations impacted by land use changes may continue to deteriorate even as control and remediation actions improve conditions at the older contaminated sites. Achieving a low EAPI at an AOC will help the delisting process of the beneficial use impairment for fish tumors and other deformities. A single common data base must be implemented for international brown bullhead data sets to evaluate AOC and reference conditions in each of the Great Lakes.

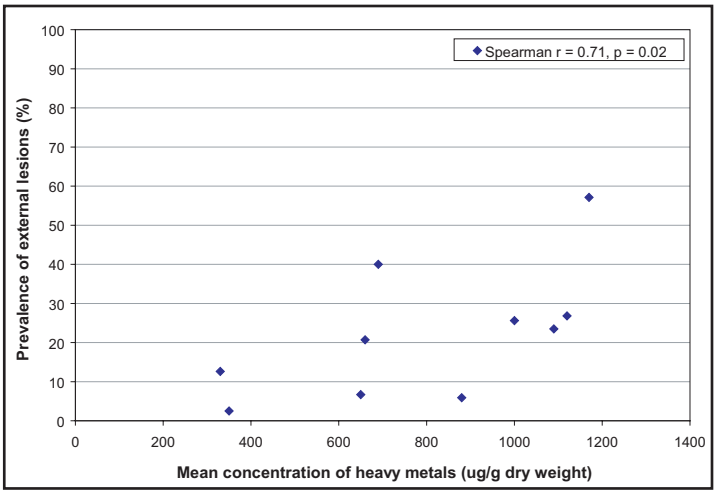


**Figure 6**. Prevalence of external raised growths in brown bullhead from Lake Erie tributaries compared to concentrations of heavy metals in sediment.

Source: Yang and Baumann, unpublished data

## Management Implications

The EAPI provides managers and researchers with a tool to monitor contaminant impacts to the fish populations in Great Lakes AOCs. Additional remediation to clean up contaminated sediments at Great Lakes AOCs will help to reduce rates of external anomalies. The EAPI, particularly for brown bullheads and white suckers and the inclusion of a single common data base will help environmental managers to follow trends in fish population health and to determine the status of AOCs that may be considered for delisting. Delisting principals and guidelines have been adopted by the U.S. Policy Committee (2001).

## Comments from the author(s)

This external anomaly index for benthic species has potential for defining habitats that may or may not be impacted from contaminants. Collaborative U.S. and Canadian studies investigating the etiology and prevalence of external anomalies in benthic fishes over a gradient of polluted to pristine Great Lakes habitats are desperately needed. These studies would create a common

index that could be used as an indicator of ecosystem health. The establishment of a single data base to house all lake wide-data for each Great Lake is necessary to enable managers and decision makers to gain an understanding of the health of individual fish (e.g. brown bullhead) and their populations. Unless this takes place, understanding of health conditions at AOCs compared to the least impacted (reference) sites will remain unknown and the delisting process will not advance.

**Acknowledgments**
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*Dedicated to our friend and collogue Scott Brown, whose untimely passing has saddened all who knew him.

**Sources**
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