Chironomid Abundance and Deformities

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Background

Chironomids, commonly known as midges, are mosquito-like insects whose larvae live in the sediments of all types of aquatic habitats. They are abundant throughout the Great Lakes, including Lake Erie and the Detroit River. Swarms of adult midges emerge in the spring and summer. They are often seen flying around lights on warm summer nights. After mating, females deposit their eggs on the water surface where they sink to the bottom and then hatch to become larvae. There are over a thousand species of chironomids in Canada. Some species can complete their life cycle in just a few weeks. The larvae of other species of chironomids can spend up to a year feeding on organic matter in the sediments. Chironomids are an important food source for fish and waterfowl (Ciborowski and Corkum, 2003). The adults provide food for amphibians, bats and insect-feeding birds such as purple martins and swallows (Smits et al., 2004; Beck et al., 2013).

Chironomids can be an important freshwater quality indicator. The larvae of some species are sensitive to specific forms of pollution whereas others are quite tolerant. Because the larvae often feed on the debris in aquatic sediments, they are exposed to contaminants contained in the organic matter. The fact that chironomids live in such a wide variety of habitats makes them especially useful indicators. Large numbers of pollution-tolerant chironomids are often indicative of poor water quality conditions. These species have a substance similar to haemoglobin in their blood, which allows them to survive in places where the oxygen has become depleted. Excellent water quality conditions (characterized by high dissolved oxygen and low nutrient concentrations) are often characterized by relatively low densities and high species diversity (50% or more of the species being chironomids). Chironomid species diversity and their sensitivity to eutrophic conditions have been used to create trophic status classifications of lakes (oligotrophic, mesotrophic and eutrophic; e.g., Saether, 1975; Winnell and White, 1985; Langton et al., 2006).

The value of chironomids as an indicator pertains to more than just their abundance. Correlations have been found between larval mouthpart and antennae abnormalities and exposure to heavy metals and pesticides such as DDT, DDE, dieldrin and hexacholorobenzene (Warwick, 1985; Dermott, 1989; Hudson and Ciborowski, 1996a; Doherty et al., 1999; Zhang, 2008). Deformities in chironomids are relatively rare (although much more common than in other types of organisms), so detecting an increase above the baseline level of deformities may require looking at over 100 larvae per site (Hudson and Ciborowski, 1996a; Burt et al., 2003). Midge larvae can metabolize organic contaminants such as PAHs (Harkey et al., 1994), but the breakdown products may also be responsible for morphological abnormalities. Research has also shown that sediments contaminated with trace metals and other pollutants harbour chironomids whose chromosomal activity levels are reduced, which could reflect lowered metabolic activity and inhibited RNA synthesis (Hudson and Ciborowski 1996b). The important role that chironomids play in the food web is also significant for representing the possible transfer of some contaminants (Ciborowski and Corkum, 2003; Smits et al., 2005).

Status and Trends

<u>Abundance</u>

In western Lake Erie, between 1930 and 1961 increasing eutrophication was evidenced by a fourfold increase in chironomid density (Carr and Hiltunen, 1965). In 1961, the three most abundant and widely distributed groups of organisms were chironomid larvae, oligochaetes and fingernail clams.

Chironomids made up 5% (355 larvae/m^2) of the total zoobenthic abundance and were evenly distributed at all sites across western Lake Erie (Carr and Hiltunen, 1965). There was no correlation with the number of oligochaete worms found, so chironomid larvae represent an independent indicator of environmental condition. Water conditions improved in Lake Erie through the 1980s and into the early 1990s. The benthic community slowly recovered as the western basin of Lake Erie returned from a eutrophic state to mesotrophic status. Doherty et al. (1999) examined the chironomid larvae in samples collected from western Lake Erie by the US Geological Survey in 1982 and 1993. Between those periods of time, mean density declined whereas diversity (number of genera) rose (Figure 1).

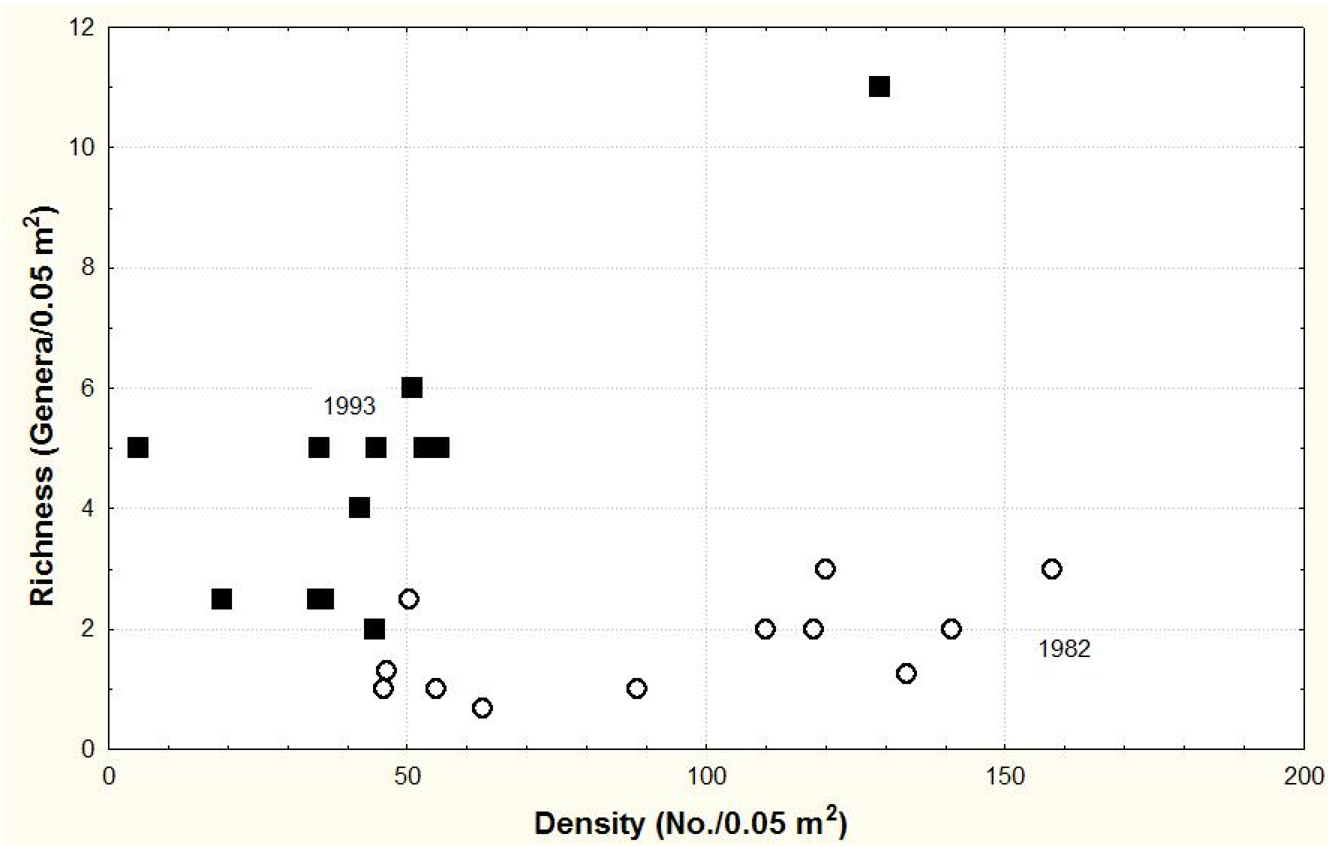

Figure 1. Comparison of number of genera and density of chironomid larvae collected from western Lake Erie locations in 1982 (open circles) and 1993 (filled squares). Data of Doherty et al. (1998) analysed from samples provided by D.W. Schloesser, Great Lakes Science Center, USGS.

In the Detroit River, the overall abundance of chironomids has increased steadily from 1968 – 2004 (Figure 2). No comprehensive, reliable zoobenthic surveys have been conducted since that time.

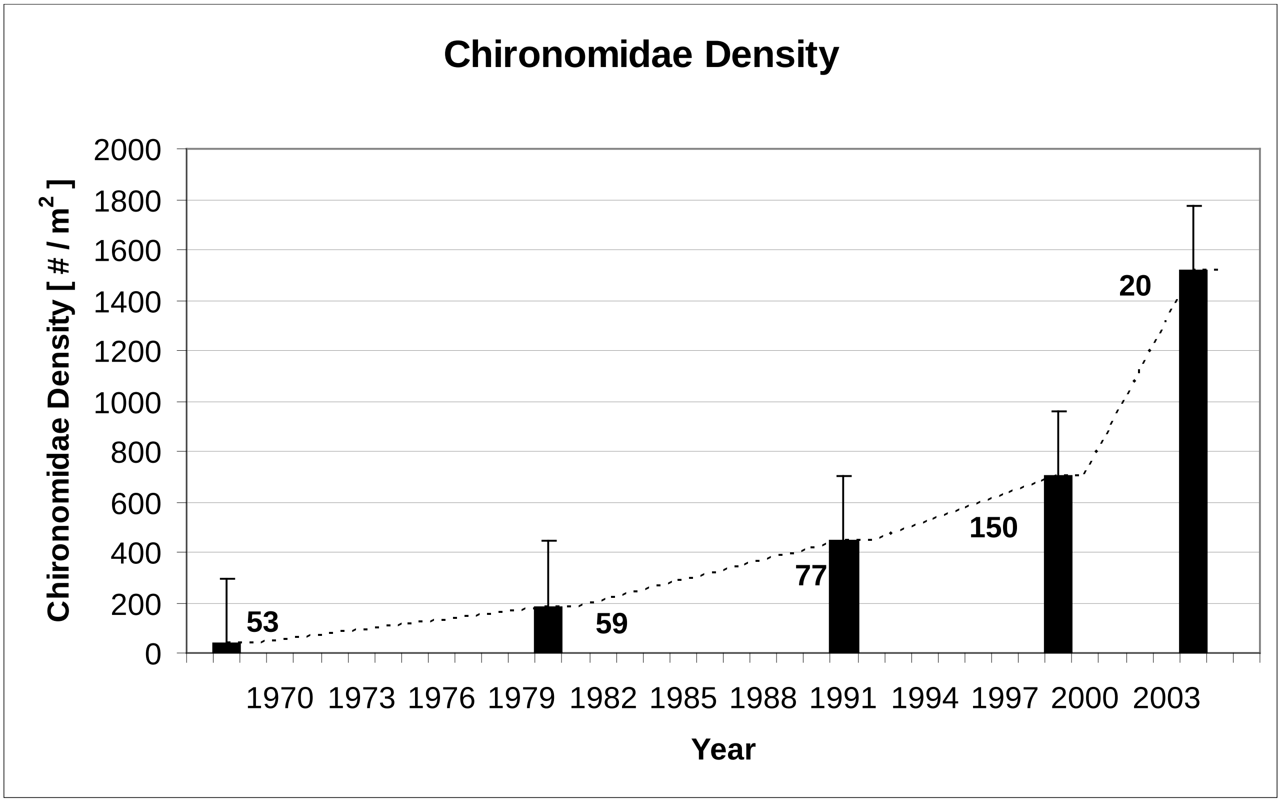

Figure 2. Mean ±SE density of larvae of Chironomidae in the Detroit River between 1968 and 2004. The number of sites sampled each year is indicated. Data compiled from Thornley and Hamdy (1984), Farara and Burt (1993), Wood (2004), and Zhang (2008).

<u>Deformities</u>:

The overall incidence of mouthpart deformities in two genera (*Procladius* and *Coelotanypus*) decreased from the 1980s to the 1990s (Doherty et al., 1999; Figure 3). Hudson and Ciborowski (1996a) studied the frequency of deformities in chironomids collected from 5 locations in the Huron-Erie Corridor in 1992 and 1993. Deformities were most commonly found at the head of the Detroit River near Peche Island. They were surprisingly rare at a location in the Trenton Channel, possibly because the larvae that could survive in Trenton Channel sediments were especially resistant to pollutants. Midge larvae reared in Trenton Channel sediments in the laboratory were much more prone to deformities than those reared in reference sediments (Hudson and Ciborowski, 1996b). The incidence of deformities in chironomids collected in the Detroit River in 2004 (Zhang, 2008) was lower than that observed in 1992/1993 (Hudson and Ciborowski, 1996a).

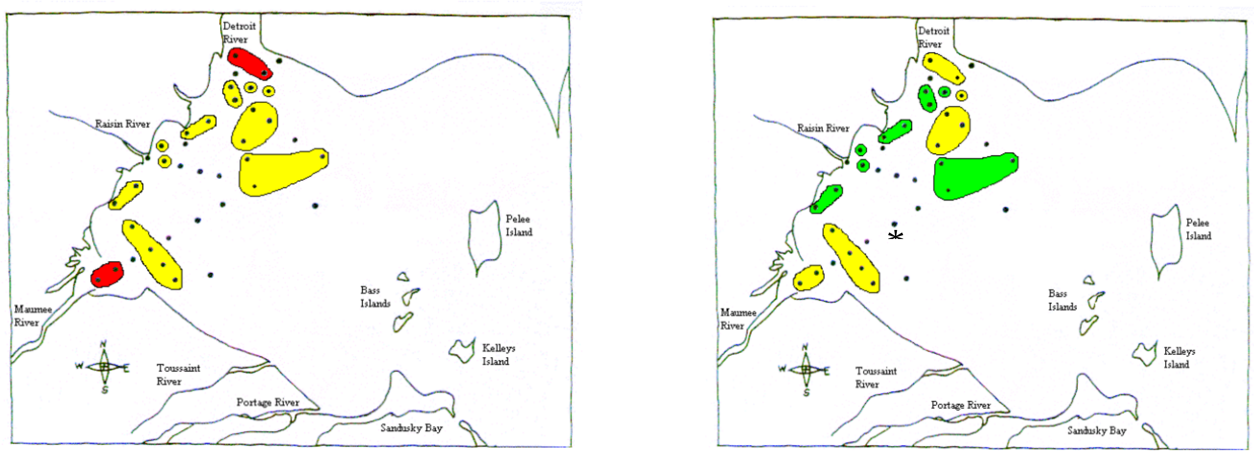

Figure 3. Incidence of mouthpart deformities in larvae of *Procladius* midges in western Lake Erie in 1982 (left) and 1993 (right). Coloured areas enclose sampling sites (points) from which 75 or more larvae could be examined for deformities. Red areas - >6.0%; yellow areas – 1.6-6.0%; green areas <1.6%. Across the entire Great Lakes, approximately 2.3% of *Procladius* larvae have deformed mouthparts (Burt et al. 2003). Data analysed by Doherty et al. (1998) from samples provided by D.W. Schloesser, Great Lakes Science Center, USGS.

Management Next Steps

The relative abundance, community composition and morphological condition of chironomids larvae are all useful indicators of the condition of water and sediments in the Detroit River and western Lake Erie. Time trends suggest that concentrations of deformity-inducing contaminants in Detroit River sediments declined meaningfully between the 1980s and the early 1990s and remained relatively low through the mid 2000s. This reflects the concerted cleanup efforts that were undertaken at that time. We do not have current data to determine whether the continuing efforts to remediate sediment contamination in the Detroit River have resulted in further reduction in the incidence of deformities. Increases in midge larval biodiversity (number of genera) also suggest improving water quality in western Lake Erie between the 1980s and 1990s. The trend of increasing mean density of larvae in the Detroit River up to 2004 could imply either improving water quality conditions (improved survival) or declining sediment quality (enriched sediments, which sustain more larvae). This uncertainty could be resolved by examining community composition using a genus index of pollution (e.g., Winnell and White's (1985) or by examining temporal trends in sediment contamination and its risk to chironomids as assessed by a newly developed Hazard Score Metric (McPhedran et al., 2017).

Research/Monitoring Needs

Chironomids are a dominant part of the benthic community of the Detroit River and western Lake Erie. Because they can be found year-round and live in all types of aquatic habitats, the timing of benthic sampling is not as critical for these organisms as it is for other zoobenthic indicators such as *Hexagenia* mayflies and caddisflies. However, assessment of deformities requires that adequate numbers of larvae be collected at each location. Consequently, multiple replicate samples should be collected during surveys to assure the availability of enough specimens. Community composition assessment can be a valuable tool, permitting use of richness or pollution indices to assess changes in water quality or local conditions. Genus level identification requires that larvae be mounted on microscope slides and examined by an expert. However, samples that are properly preserved and stored can be examined and identified many years after they have been collected.

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