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Are Brook Trout Stocking Programs Increasing the Risks of Mercury Poisoning to Wildlife in Ontario?

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While threats of mercury poisoning to indigenous wildlife from aquatic organisms is receiving substantial national and international attention, there has been less focus on the role of government fish stocking programs and their potential to increase or decrease such risks. For example, the Ontario Government typically stocks more than 650 lakes annually with brook trout, even though results from the Ontario Sport Fish Monitoring Program indicate that mercury accumulates in many brook trout in Ontario waters to levels which exceed the Canadian Tissue Residue Guideline for the protection of mink - by up to a factor of ten. Stocked brook trout are particularly prone to predation by mink and others during spawning periods when they emigrate to small creeks to spawn - and it is these larger brook trout that contain the most mercury. Based on the precautionary principle, governments may wish to evaluate the risks of their stocking programs to wildlife, as their stocking policies may be contributing to adverse effects on wildlife. Trout stocked at larger sizes would reduce risks of mercury poisoning as mercury concentrations in brook trout reared in aquaculture settings are substantially less than for those fish grown in the wild. Risks would also be reduced if sterile stock were utilized, as these fish are not as vulnerable to predation during spawning periods and from bioenergetic modelling considerations should accumulate less mercury than their sexually mature counterparts.

Introduction

The potential for aquatic food webs to contaminate and possibly harm fish consuming wildlife through ingestion of mercury enriched prey has and continues to receive substantial public and scientific attention. Methylmercury is the form of mercury that is of most concern as methylmercury is a potent neurotoxin. It is the form most prevalent in fish and crayfish muscle.

The degree of impairment to birds and wildlife from mercury exposure and the exact extent of this impairment is not easy to ascertain. There are difficulties in measuring and ascertaining wild population effects to mercury poisoning per se when mortality may well be the result of multiple stressors, of which mercury is only one.

Environment Canada (2003) has noted that *mercury exists in Canada at levels that are causing deleterious impacts on wildlife*. Further, *mercury levels in fish are high enough to put wildlife such as loons, kingfishers, herons, osprey and mink at risk of adverse health effects*. Some of these risks were identified for Ontario. (Kent et al. 1998).

Reproduction of loons in Ontario appears at risk. Concentrations in prey in a significant number of Ontario lakes likely have mercury concentrations above the threshold for reproductive impairment (Scheuhammer and Blancher 1994)

Otters may be at risk to reduced survivorship in Ontario. Mierle et al. (2000) observed that otter survivorship appeared to decrease as mercury levels in their hair – which reflect dietary exposure- increased. The mean age of otters in low mercury townships was nearly twice that observed for otters in high mercury townships. Later work by Klenavic (2004) also shows that there are no long lived otters and mink with high mercury levels in brains. This work also suggests possible adverse population impacts of these animals to exposure to methylmercury.

Assessing Risk of Mercury Poisoning to Wildlife

The risk of mercury poisoning to birds and wildlife from consuming aquatic organisms with elevated levels of methylmercury was assessed by Environment Canada (2002) in their document “Canadian Tissue Residue Guidelines for the Protection of Consumers of Aquatic Life: Methylmercury” This report establishes species specific upper limits for mercury levels in the diet of various consumers of aquatic organisms based upon the ecotoxicology of methylmercury (MeHg) to the animal or bird in question. The goal of the Canadian Tissue Residue Guidelines (CTRG) values is to determine a concentration of methylmercury when consumed by wildlife that will not result in adverse effects.

The report recommends:

To protect Canadian wildlife that consume fish or shellfish from any toxilogical effects of MeHg, aquatic biota should contain no more than 33 ug/kg (0.033 ppm) *MeHg on a wet weight basis".*

This guideline of 0.033 ppm is designed to protect the most sensitive species in Canada, the Wilson's storm petrel. As this bird does not commonly inhabit Ontario, guidelines for more appropriate species should be viewed and diet guidelines for these species are slightly less restrictive.

For birds and animals common to Ontario, such as the common tern, concentrations in aquatic prey organisms should not exceed 0.051 ppm, for the Belted Kingfisher, 0.062 ppm; for the female Wood Duck, 0.089 ppm; for the female Herring Gull, 0.107 ppm; for the female Common Merganser, 0.115 ppm; for the Common Loon, 0.172 ppm; for the Bald Eagle, 0.282 ppm; for the Osprey, 0.155 ppm; for the female Great Blue Heron, 0.141 ppm; for female Mink it is 0.092 ppm and for the River Otter, 0.220 ppm. The criterion is different for each species owing to differences in metabolism, diet, and vulnerably to mercury poisoning.

The vast majority of waters in Ontario have not been monitored for mercury concentrations in prey. There are many places, however where mercury concentrations in prey fish such as perch or other aquatic food items such as crayfish exceed the Canadian Tissue Residue Guidelines for sensitive wildlife by up to ten times or more (Allard and Stokes 1989, Suns and Hitchin 1990, Parks et al. 1991, Swanson et al. 2003).

Brook trout can be a prey item for many wildlife including kingfishers, mergansers, loons, herons, mink and otters. Insights into the potential for brook trout in Ontario waters to pose risks of mercury poisoning to these fish consuming wildlife can be gained by comparing concentrations of mercury in brook trout in Ontario with Environment Canada (2002) Canadian Tissue Residue Guidelines.

Mercury concentrations in brook trout were obtained for over 70 sites (Figure 1) from the Ontario Sport Fish monitoring program conducted by the Ontario Ministry of the Environment This database is perhaps the best in North America. It contains over 150,000 records from over 1300 water bodies, and has had rigorous QA/QC protocols for mercury measurements from its inception.

Mercury concentrations for over 1250 brook trout from across Ontario ranged from 0.01 to 1.2 ppm with higher concentrations in larger fish (Figure 2). While there is relatively little data for the smaller size trout which would make up most of the prey items for most wildlife (<15-20 cm), the available data do indicate that mercury levels in trout in Ontario can exceed Canadian Tissue Residue Guidelines and thus pose risks to wildlife (Figures 3,4).

Levels of mercury in bigger trout may have relevance to otters and mink which are fully capable of killing and consuming 30-40 cm trout if they are vulnerable to capture. Concentrations of mercury in these larger brook trout can exceed 1 ppm, a level shown to be lethal in toxilogicol studies with mink. (Wren et al. 1987).

The results for brook trout (Figures 2-4) may contain data for stocked lakes, but no attempt has been made here to identify results for stocked versus indigenous fish, merely to show that mercury levels can accumulate to levels in trout that pose a risk to fish consuming wildlife. It would not be surprising if these results did include some stocked fish as the Ministry of Natural Resources stock over 650 lakes a year with brook trout (S.J. Kerr, Ontario Ministry of Natural Resources, pers.comm.) These stocked trout range in size from fry to adult brood stock that is no longer needed by the Ministry of Natural Resources.

Why Stocking Programs May Contribute to Risks of Mercury Poisoning to Wildlife

When stocked, brook trout likely cause little risk to wildlife consumers, independent of the size at which they are stocked because mercury concentrations in trout in hatchery or aquaculture operations typically have low concentrations of mercury - even in larger fish. Damsa grew brook trout in a hatchery in excess of 50 cm that had mercury concentrations less than 0.033 ppm, the lowest criterion established by Environment Canada to protect all wildlife consumers. These results are consistent with those released by the Ontario Ministry of Agriculture and Food (OMAF) for a study on farm raised fish in Ontario. For 59 samples of rainbow trout, mercury concentrations were typically less than the 0.010 ppm with a range of < 0.01 – 0.07 ppm (Casssidy et al 2003).

However the longer the trout survive in stocked waters, the more their body burdens will reflect exposure to methylmercury in the ambient environment. Fry will respond most quickly; when they grow to the size of prey for most predators – they will reflect over 90% of the concentrations of indigenous trout. Large brood stock, on the other hand, will respond the slowest and may not attain substantial increases in mercury concentrations before they are angled or die from natural factors. Other sizes stocked will fall somewhere in between.

Although mercury levels in fish in Ontario are amongst some of the highest in the country (Environment Canada 2002), the elevated tissue levels are not necessarily associated with point source or historical loadings of mercury into the aquatic environment. Many of these fisheries are associated with biogeochemical and/or hydrological conditions that enhance mercury bioaccumulation in fish independent of mercury loadings. Lakes with the potential for biota to accumulate high mercury concentrations have certain characteristics including low pH, high dissolved organic carbon concentrations and low productivity (Evers 2005).

Brook trout are particularly adaptable to these same waters as they have a high tolerance to acid conditions. They also prefer cooler waters which are enhanced by elevated dissolved organic carbon concentrations. Dissolved organic carbon effectively limits the depths to which light penetrates and warms, thereby increasing the depth of the hypolimnion and the quantity of cooler water available for trout habitat during summer (Schindler and Gunn 2004)). Brook trout also prefer low productivity systems as it is productivity that frequently limit over winter survival by lowering the dissolved oxygen levels to lethal conditions. For these reasons it would not be surprising to find brook trout stocked in some of these ecosystems that have a known propensity to produce biota with high mercury concentrations.

Some stocked brook trout will become vulnerable to predation at much larger sizes than normally considered for prey. They are particularly vulnerable at larger sizes during spawning periods. Brook trout stocked in Ontario typically do not successfully reproduce as there are poor no suitable spawning locations in majority of the lakes in which they are stocked. During spawning periods in these lakes it is not unusual for stocked fish to emigrate to spawn in lake outflows. The number of brook trout fish emigrating to spawn in these kinds of lakes can frequently run 50% of the sexually mature fish with certain years as high as 90% depending upon hydrological conditions (Warrilow et al.1997).

These outflows are usually quite small, reflective of small headwater systems that provide much if not most brook trout habitat in lakes in Ontario and most often lake levels are beaver dam controlled. Trout emigrating to spawn in such small creeks are particularly vulnerable to predation; even more so when they are unable to return to the lake after spawning due to obstruction by the beaver dam. These larger sexually mature brook trout are usually predated within two to three weeks (D. C. Josephson pers. comm.). Both otter and mink are capable of capturing and killing sexually mature trout in the 30 - 40 cm size range or larger as many fish farmers will attest - provided that the predators can access the trout. Thus in vulnerable spawning conditions these larger trout with the highest mercury concentrations can also be prey to otters and mink.

Future Considerations

The available evidence suggests that brook trout in Ontario waters have mercury concentrations that can be of concern to wildlife consumers and further that stocked fish may be contributing to these concerns. As the province ascribes to the precautionary principle, the regulatory agencies may wish to further assess the risk of mercury poisoning to wildlife, as they may, at present, be deliberately – though inadvertently – creating additional risks through their stocking programs Such assessments could include the collection of additional data on mercury levels in stocked brook trout lakes, particularly those lakes with biogeochemical characteristics that have a known potential to create high mercury fisheries.

Should high risks be identified, steps could be undertaken to reduce such risks through modifications to size of fish at stocking, stocking rates, and the possible inclusion of sterile fish. According to bioenergetic modeling considerations, sterile trout would accumulate lower levels of mercury than their sexually mature counterparts (Rodgers 1994). Additionally such fish would be less vulnerable to predation during spawning periods as they do not emigrate to spawn (Warrilow et al. . 1997).

Other adjustments to the ecosystem to reduce mercury bioaccumulation could include increasing productivity, or other biogeochemical alterations that reduce levels of methylmercury to which fish, aquatic organisms – and ultimately wildlife -are exposed.

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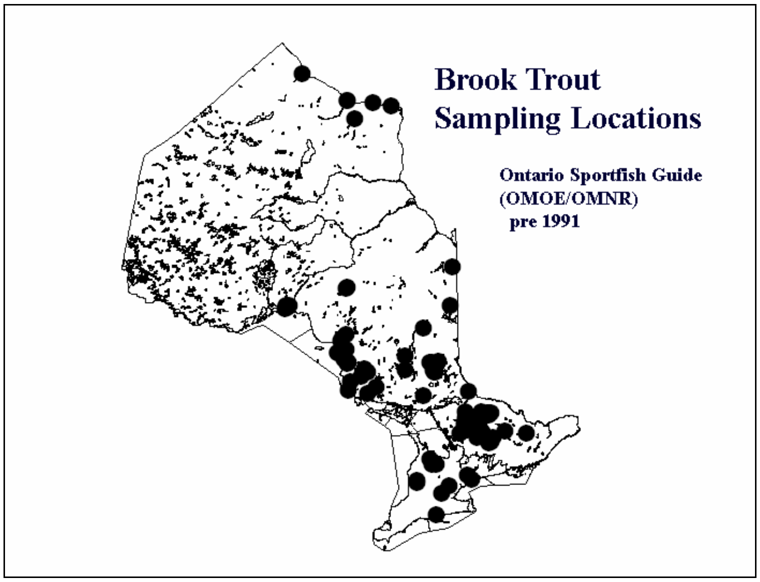

Figure 1. Brook trout sampling locations for the Ontario Sport Fish monitoring program.

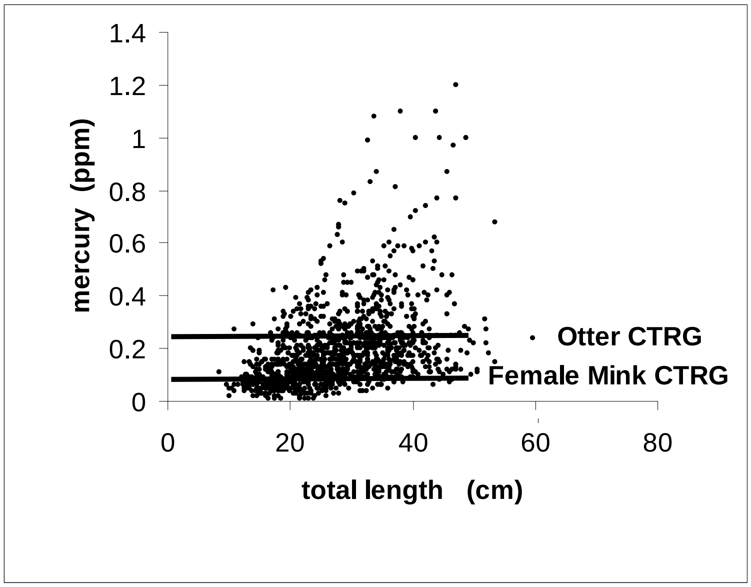

Figure 2. Mercury concentrations in brook trout (n=1281) in Ontario waters, with Canadian Tissue Residue Guidelines (CTRG) for otter and female mink.

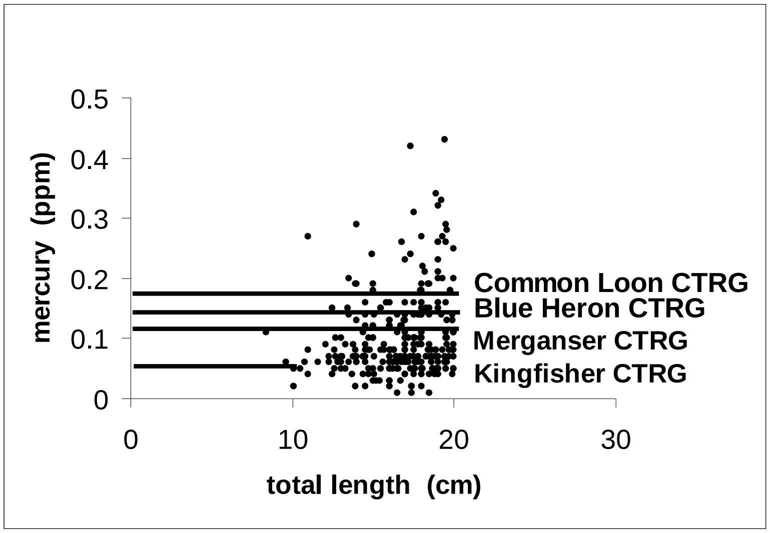

Figure 3 Mercury concentrations in brook trout (< 20 cm) in Ontario waters with Canadian Tissue Residue Guidelines (CTRG) for selected birds.

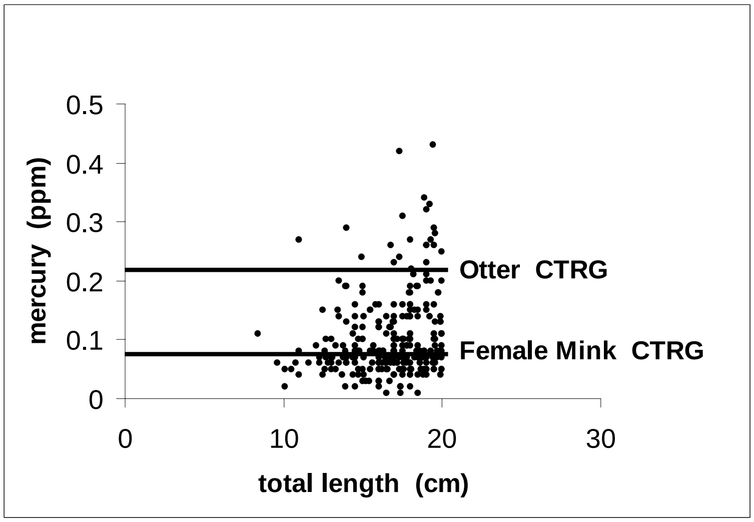

Figure 4 Mercury concentrations in brook trout (< 20 cm) in Ontario waters with Canadian Tissue Residue Guidelines (CTRG) for selected mammals.