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Sexual difference in PCB concentrations of walleyes (*Sander vitreus*) from a pristine lake

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ABSTRACT

We determined polychlorinated biphenyl (PCB) concentrations in 15 adult female walleyes (*Sander vitreus*) and 15 adult male walleyes from South Manistique Lake (Michigan, United States), a relatively pristine lake with no point source inputs of PCBs. By measuring PCB concentration in gonads and in somatic tissue of the South Manistique Lake fish, we also estimated the expected change in PCB concentration due to spawning for both sexes. To determine whether gross growth efficiency differed between the sexes, we applied bioenergetics modeling. Results showed that, on average, adult males were 34% higher in PCB concentration than adult females in South Manistique Lake. Results from the PCB determinations of the gonads and somatic tissues revealed that shedding of the gametes led to 1% and 5% increases in PCB concentration for males and females, respectively. Therefore, shedding of the gametes could not explain the higher PCB concentration in adult male walleyes. Bioenergetics modeling results indicated that the sexual difference in PCB concentrations of South Manistique Lake walleyes was attributable, at least in part, to a sexual difference in gross growth efficiency (GGE). Adult female GGE was estimated to be up to 17% greater than adult male GGE.

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1. Introduction

Based on the results of two unpublished studies conducted in pristine lakes, adult male walleyes (*Sander vitreus*) were about 30% higher in polychlorinated biphenyl (PCB) concentration than adult female walleyes. Here, a pristine lake refers to a lake with no point source inputs of PCBs. The Michigan Department of Environmental Quality (DEQ) sampled 29 mature male walleyes and 11 mature female walleyes from the spring spawning aggregations in South Manistique Lake, located in the Upper Peninsula of Michigan (United States), during 2001–2005 (J. Bohr, Michigan DEQ, Lansing, personal communication). South Manistique Lake has no point sources of PCBs (R. Day, Michigan DEQ, personal communication). Ages of the males ranged from 4 to 12, and ages of the females ranged from 5 to 10. Michigan DEQ results showed that, on average, males were higher in PCB concentration than females by 23%. Additionally, PCB concentrations in skin-on fillets of 48 mature male walleyes and 32 mature female walleyes in five pristine lakes in northwestern Ontario (Canada) have been determined during 1990–1992 (D. C. G. Muir, Environment Canada, Burlington, personal communication); these lakes had no point sources of PCBs (Fee and Hecky, 1992). Ages of the males ranged from 7 to 23, and ages of the females ranged from 8 to 19. Results showed that males were higher in PCB concentration than females by 38%, on the average. To date, no attempt has been made to explain why adult male walleyes in pristine lakes are about 30% greater in PCB concentration than adult female walleyes.

In contrast to findings from pristine lakes, adult male walleyes from the Saginaw Bay population were 151% higher in PCB concentration than adult female walleyes (Madenjian et al., 1998). Saginaw Bay is a large embayment of Lake Huron, one of the five Laurentian Great Lakes. The Saginaw River, the chief tributary to Saginaw Bay, has been heavily contaminated with PCBs released from industries, and a substantial amount of PCBs has been deposited in the sediments at the mouth of the Saginaw River (Giesy et al., 1997). Madenjian et al. (1998) concluded that this sexual difference in PCB concentrations was most likely attributable to males spending substantially more time in the highly contaminated Saginaw River system than females. The mouth of the Saginaw River represents a "hot spot" for PCBs, as PCB concentrations in the sediments at the mouth of the river are several orders of magnitude higher than PCB concentrations in the center of Saginaw Bay (Richardson et al., 1983; Endicott and Kandt, 1994). Consequently, the fish preyed upon by walleyes in the Saginaw River system were higher in PCB concentration than Saginaw Bay prey fish, which in turn were higher in PCB concentration than prey fish from the main basin of Lake Huron (Madenjian et al., 1998). Using mark-recapture data, Madenjian et al. (1998) demonstrated a significant

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difference in habitat use between the two sexes of walleyes from the Saginaw Bay population. Most of the male recaptures were from the Saginaw River and its tributaries, whereas most of the female recaptures were from Saginaw Bay proper. Although only a few PCB determinations of prey fish have been made, these data indicated that prey fish from the Saginaw River and its tributaries were roughly three times higher in PCB concentration than prey fish from Saginaw Bay proper (Madenjian et al., 1998). Thus, walleyes preferring to inhabit the Saginaw River system would be feeding on much more heavily contaminated prey fish than walleyes residing in Saginaw Bay proper. Madenjian et al. (1998) used bioenergetics modeling to show that a sexual difference in gross growth efficiency (GGE) explained only a minor portion of the sexual difference in Saginaw Bay walleye PCB concentrations. Gross growth efficiency is equal to the amount of growth divided by the amount of food consumption needed to produce the growth. All other factors being equal, PCB concentration in fish is inversely proportional to GGE (Madenjian et al., 1994; Jackson and Schindler, 1996).

Larsson et al. (1993) attributed higher PCB concentration in adult male northern pike (*Esox lucius*) compared with adult female northern pike in a Scandanavian lake to a sharp decrease in female whole-body PCB concentration immediately after spawning. These researchers determined that PCB concentration in the ovaries of northern pike was about 100 times higher than the whole-body PCB concentration. Thus, PCB concentration in female northern pike was expected to decrease by nearly 80% immediately after release of eggs.

Understanding the underlying causes for sexual differences in contaminant concentrations should lead to a more efficient sampling design for monitoring contaminant concentrations in fish, and should facilitate the prediction of changes in contaminant concentrations under various environmental scenarios (Sheffy, 1980; Masnado, 1987; Madenjian et al., 1998). In addition, identification of the important factors determining contaminant concentrations in fish is useful in managing a fishery to reduce contaminant exposure to people consuming fish (Stow et al., 1995).

The objectives of this study were to: (1) confirm that male PCB concentration is about 30% higher than female PCB concentration in walleyes from pristine lakes, (2) determine whether a sexual difference in GGE of walleyes from a pristine lake could explain the observed sexual difference in PCB concentrations, and (3) determine whether the release of gametes contributed to the observed sexual difference in PCB concentrations of walleyes from a pristine lake.

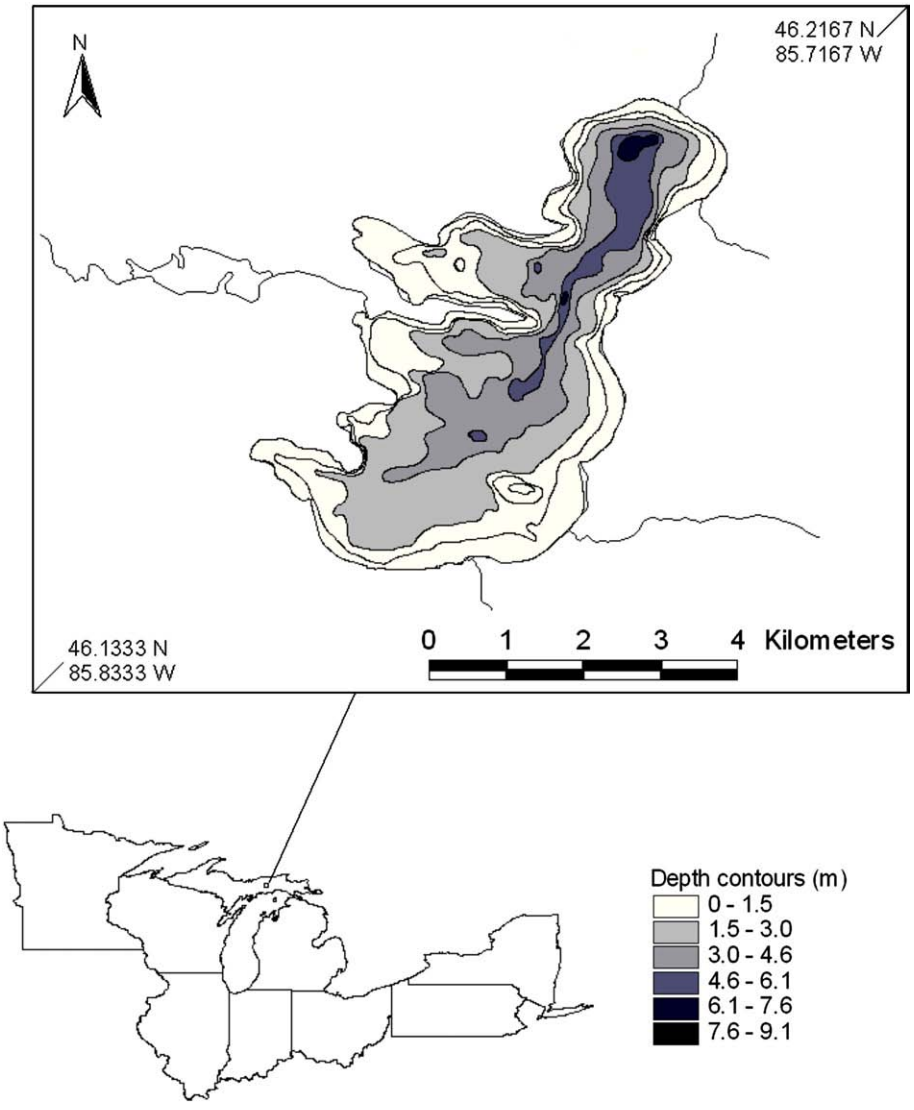

Fig. 1. Bathymetric map for South Manistique Lake, located in the Upper Peninsula of Michigan (United States).