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Algonquin's silver lake trout: highlighting the history, habitat, and concerns for a unique biodiversity element

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ABSTRACT

Kingscote Lake in southern Algonquin Park is home to a unique population of silver-coloured lake trout. These lake trout have a uniform body colour without spots or vermiculations that are more typical of lake trout in eastern Canada. Despite historically high exploitation rates and six decades of supplemental stocking from allopatric sources, this population has retained its native ancestry. Persistence of this non-dominant colouration trait provides evidence of local adaptation and wild fitness. Captive breeding trials and the heritability of its unique appearance (colour phenotype) have provided further evidence for local adaptation and greater fitness of native versus non-native hatchery stocks. These findings also support genetic model predictions and fisheries management policies designed to protect biological diversity. Limited cold-water habitat volume and extreme seasonal oxygen depletion in Kingscote Lake highlight the vulnerability of this and other native lake trout, and underscores the urgent need to conserve rare and valuable biodiversity elements.

RÉSUMÉ

Le lac Kingscote, situé dans le sud du parc Algonquin, abrite une population exclusive de touladis de couleur grise. La couleur du corps de ces touladis est uniforme, sans taches ni vermiculures qui sont plus typiques des touladis de l'Est du Canada. Malgré des taux d'exploitation historique élevés et six décennies d'empoissonnement supplémentaire de sources allopatriques, cette population a conservé son origine indigène. La longévité de ce trait de coloration non dominant fournit la preuve de l'adaptation locale et de la santé de la faune. Les essais de reproduction en captivité et l'héritabilité de son aspect exclusif (phénotype de couleur) ont fourni d'autres preuves de l'adaptation locale et de la santé plus grande des productions d'élevage indigènes par rapport à celles non indigènes. Ces constatations appuient également les prédictions du modèle génétique et les politiques de gestion des pêches conçues en vue de protéger la diversité biologique. Le volume limité de l'habitat en eaux froides et l'extrême épuisement saisonnier d'oxygène dans le lac Kingscote mettent en lumière la vulnérabilité de ce touladi et d'autres touladis indigènes, et soulignent le besoin urgent de conserver les éléments rares et inestimables de la biodiversité.

Lake trout are one of Ontario's most valued fish species, and are uniquely vulnerable to human activities and changing ecological conditions. This is particularly true for populations in southern Ontario, which represent close to ten percent of all lake trout populations in Canada and are subjected to substantial ecological pressures from species invasions and expansions, warming climate, and increasing human development. The ecological and genetic variation among these populations represents a significant component of Ontario's aquatic resources and biodiversity, and reflects thousands of years of isolation and local adaptation in inland lakes as well as the raw material for future adaptation.

Kingscote Lake at the southern tip of Algonquin Park (Figure 1) holds a unique population of lake trout. These small-bodied lake trout differ from the typical spotting pattern for lake trout in having no spotting or vermiculations at all, instead having a uniform silver or chrome-like appearance (Figure 2). This difference in colour and patterning variation is parallel to how aurora trout (*Salvelinus fontinalis timagamiensis*) differ from regular brook trout, and the Kingscote lake trout are at least as unique. Although historical accounts refer to "grey trout" and "salmon trout" in the Algonquin Park to Pembroke region (Addison 1973; Quinn 2002; T. Haxton, OMNR, pers. comm.), evidence of this phenotype in other lake trout populations has so far only been confirmed from Barker Lake in Bancroft district (S. Lawrence, OMNR, pers. comm.). Other colour variants have been reported for lake trout, although none so extreme (Wilson and Mandrak 2004). Although lake trout with large vermiculations have been reported from populations where lake trout are known to hybridize with arctic charr, and are hypothesised to result from differential expression of a developmental gene controlling timing of chromatophore expression (Wilson and Hebert 1993), no evidence of ancestral hybridization exists for the Kingscote Lake population (Yott 2000).

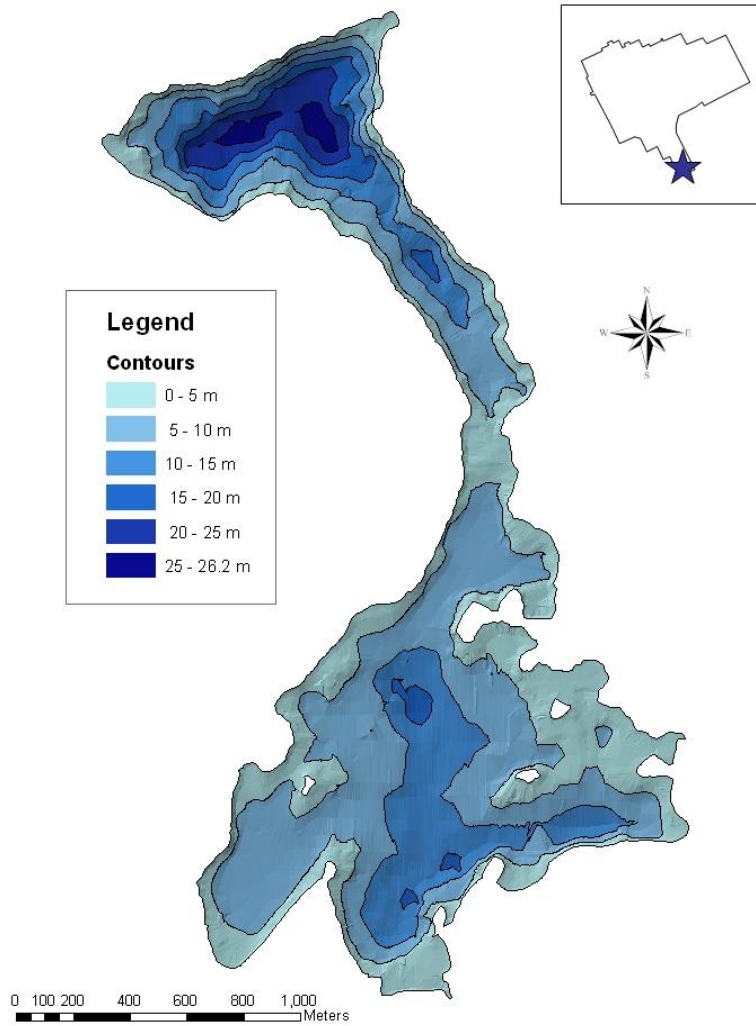


Figure 1: Map of Kingscote Lake, showing bathymetric contours and location within Algonquin Park. The lake is the access point for the southern portion of Algonquin Park.



Figure 2: photograph of "silver" lake trout from Kingscote Lake, showing the absence of typical phenotypic markings. This difference in appearance has caused confusion among anglers and misinterpretation of harvest regulations in the past.

The unique colour phenotype of the Kingscote Lake trout is more than an evolutionary novelty, and provides evidence that the Kingscote population is locally adapted and has higher local fitness than introduced hatchery fish. During the first decades of the 20th century, the population was reduced to the point that supplemental stocking was initiated using outside sources (OMNR and OMOE 1993). Beginning in 1925, thousands of lake trout were stocked, continuing after the incorporation of Bruton Township into Algonquin Park and ending in 1985 with the establishment of park policy to end stocking from outside sources onto self-sustaining trout populations in the Park (OMNR 1998; Yott 2000). According to local knowledge and angler diaries, the relative abundance of silver lake trout compared with normal-appearance lake trout in Kingscote Lake substantially increased over this time interval, from a low of less than 10% of the population in the mid-1920s to approximately 50% in the early 1960s (C. Cowan, Haliburton, pers. comm). Intensive sampling since 1999 has shown that the silver lake trout now make up approximately 95% of the population (Yott 2000; OMNR unpubl. data). The persistence and significant recovery of the silver lake trout, after a long history of stocking with non-native lake trout, suggests that this stock is probably uniquely adapted to the local conditions in Kingscote Lake.

The colour phenotype of the Kingscote population provides key evidence that this increased abundance of silver lake trout reflects local adaptation and superior local fitness of native fish. If the silver phenotype was a dominant heritable trait, the increase of the silver lake trout would merely represent interbreeding of stocked and native fish and the subsequent spread of a dominant phenotype. Heritability studies of crosses between Kingscote and unrelated (Killala strain) lake trout at the Codrington research hatchery, however, have shown that the silver phenotype is not a dominant trait, and appears to be governed by more than one gene. The observed increase over time in silver versus normal or “wild type” lake trout phenotypes cannot therefore be explained by spread of the dominant trait, and appears to reflect increased reproductive success and superior fitness of the native population. Genetic investigation of the silver morphotype based on microsatellite DNA also confirmed the genetic uniqueness of this population, despite decades of intensive stocking (Yott 2000). As such, the Kingscote lake trout appear to provide a model example of the long-held view that isolated native stocks of salmonid fishes represent locally adapted units within species (MacLean and Evans 1981). The combined data provide substantial evidence of local adaptation in this population, and suggest that other southern inland populations may similarly be locally adapted.

Preliminary investigations into the reproductive health of the Kingscote population have shown that females collected prior to spawning had comparable fecundity (1541 eggs·kg body mass⁻¹; n=16; Murphy et al., unpublished) to values observed for other lake trout populations (mean from 54 lakes = 1506 eggs·kg body mass⁻¹; Shuter et al. 1998). Average condition of fish [calculated using 10⁵(weight/length³)] was 1.16 ± 0.02, and all fish were in good condition with values over 1 (Murphy et al., unpublished). These preliminary data suggest that the females in Kingscote Lake are in good health with adequate nutrition (C. Murphy, University of Toronto, pers. comm.). Other studies are in progress to estimate age structure and overall lipid content of the sampled females, which will contribute to a more detailed understanding of the reproductive health of the Kingscote population.

In the past, because of confusion over whether the silver fish were lake trout or “salmon”, anglers were able to catch and retain up to five fish per day, in keeping with Algonquin Park catch limits for combined salmon and trout (OMNR 1998). Although the Kingscote fish were known to be lake trout (Quinn 2002), this was not widely accepted by anglers, and their appearance made enforcement difficult. At the Park’s request, therefore, the species identity of the population was confirmed as lake trout using genetic markers (allozymes and DNA), and a poster informing anglers that the fish are indeed lake trout and highlighting conservation concerns and relevant harvest regulations has been posted at the lake’s boat launch access (Figure 3).

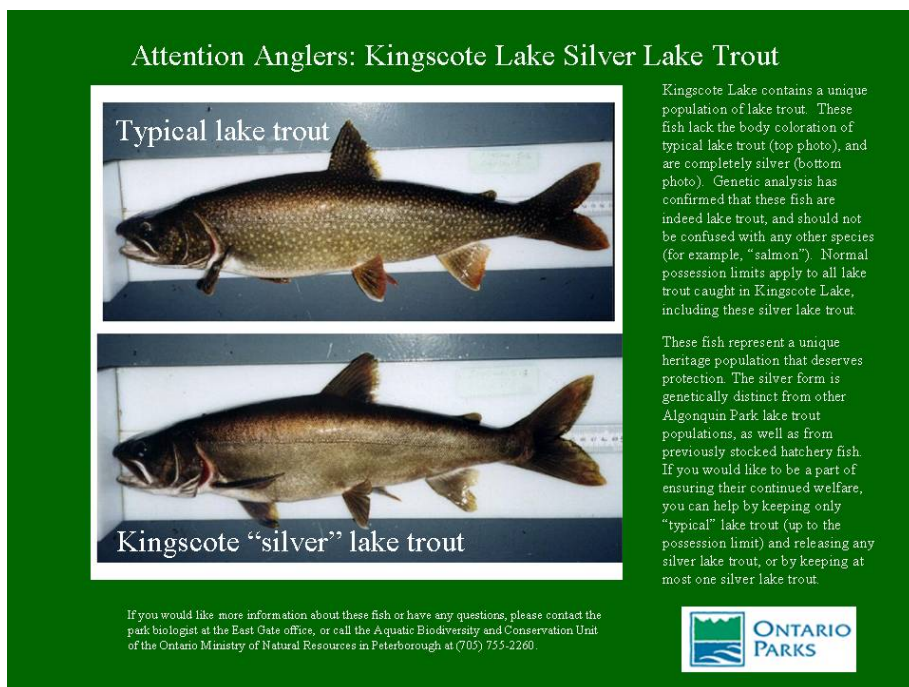


Figure 3: Public information poster at the Kingscote Lake boat launch, informing anglers about silver lake trout and applicable harvest regulations.

Despite these management measures, the population is still vulnerable to a number of anthropogenic and biotic stressors. Despite Park regulations prohibiting the use of baitfish, rock bass have been introduced into Kingscote Lake and are now firmly established. Although the effects of rock bass on the Kingscote Lake population have not been assessed, it is expected that population and reproductive declines similar to those observed by Vander Zanden et al. (1999) are imminent. The lake's bathymetry also limits suitable habitat for lake trout, with its north and south basins becoming functionally isolated once stratification occurs (Figure 1). The maximum depth of the south basin is only 16.5m; the north basin is substantially deeper, but is limited to a maximum depth of 26.2m.

Figure 4 shows seasonal oxygen depletion curves for the north and south basins of the lake for 2006. In the south basin the mean volume weighted dissolved oxygen content of the hypolimnion (MVWHDO) reached the incipient lethal threshold [$3 \text{ mg}\cdot\text{L}^{-1}$] by July 15, eliminating the south basin as juvenile habitat and seriously constraining the adult summer habitat as well. In the north basin, MVWHDO approached the avoidance threshold for lake trout [$4 \text{ mg}\cdot\text{L}^{-1}$; (Evans 2007)] by September 30 (Figure 4). Combined with the limited size of the lake's northern basin (Figure 1), these data highlight the habitat vulnerability for this unique lake trout population. The current limiting summer habitat conditions also make this population particularly vulnerable to other stressors such as angling pressure, introductions, water level variation, and climatic factors. For example, climate warming may result in greater thermocline depth and extended duration of thermal stratification, reducing habitat volume and causing greater depletion of dissolved oxygen levels during late summer, respectively. Water level declines would further aggravate both of these processes, which would have serious consequences for survival of juvenile lake trout either singly or in combination (Evans 2007). Angling pressure and species introductions are expected to increase with promotion of the Park's southern access and nearby development.

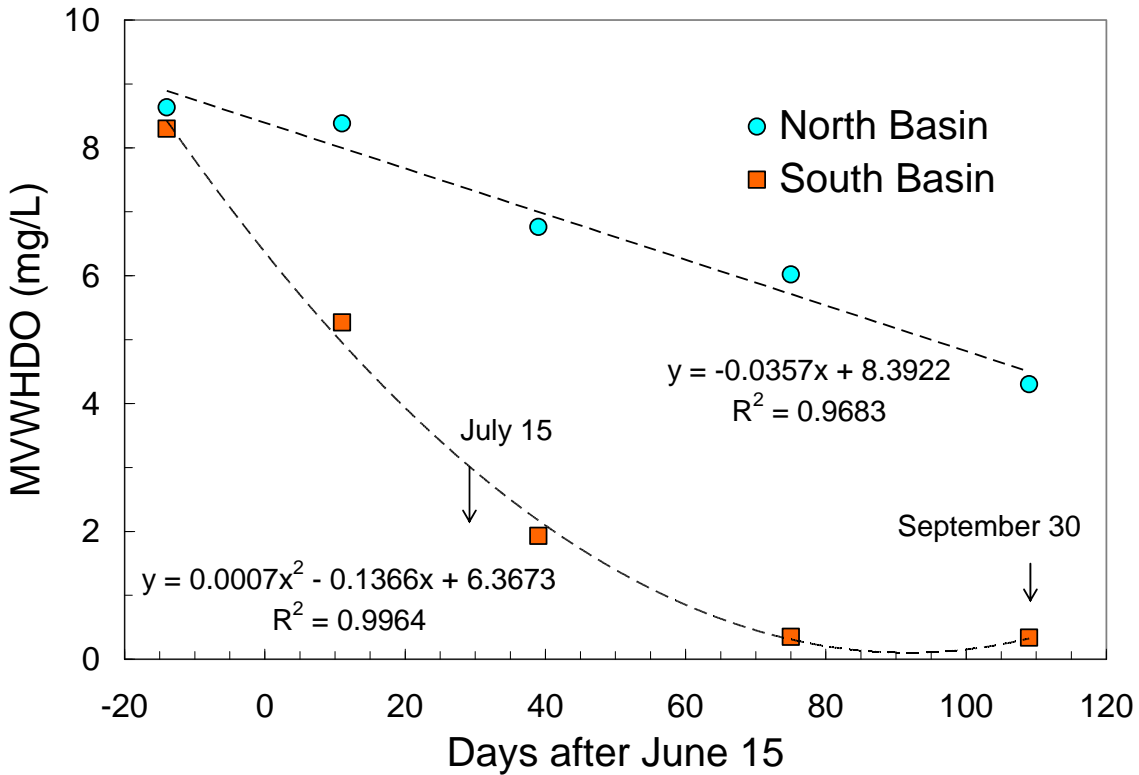


Figure 4: Oxygen depletion of the hypolimnion in the north and south basins of Kingscote Lake during the summer of 2006.

As well as their evolutionary uniqueness, the silver lake trout of Kingscote Lake exemplify the vulnerability and precariousness of southern lake trout populations in general. Given the unique nature of this population both in Algonquin Park and in North America, special measures should be taken to ensure its viability and sustainable management. Wild egg collections from Kingscote Lake and hatchery rearing have been used for rehabilitative stocking and to establish allopatric satellite populations within and outside Algonquin Park. One such experimental introduction is underway in nearby Percy Lake, which is located 11 km northwest of Kingscote Lake. As well as using native fish to foster rehabilitation and introduction events, it is hoped that these efforts and ongoing monitoring will help ensure that this unique biodiversity element of a highly valued species will not be lost.

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