# Lake Trout Biology and Productivity

# Haliburton Gold

### Glacial Relict Lake Trout of the Haliburton Highlands

### Status of the Stock, Precious Futures, Maintaining the Lustre, Minimizing the Tarnish

**John M. Casselman, July 1999**

In the province of Ontario, there are approximately 2,200 lake trout lake (>1% of the lakes in the province), representing from 20 to 25% of the entire worldwide habitat of the species.

Naturally self-sustaining reproducing native lake trout stocks are a unique and precious fisheries resource. The species is a highly evolved and specially adapted keystone predator of low productivity, cold, deep, well-oxygenated (oligotrophic) lakes. Genetically unique and productive stocks for many tens of thousands of years. One such groups of stocks are glacial relict fish that are found in lakes of the Haliburton Highlands of central Ontario.

Studies initiated in 1978 to examine the impact of acid rain on lake trout in the Kennisis River and Redstone River lakes in the Haliburton Highlands discovered a genetically unique stock of glacial relict lake trout-the Haliburton lake trout. Anglers reported to the researchers, “These lake trout are different”. This long-held local observation has been proved in science. They are small-bodies fusiform (torpedo-shaped) fish that have produced excellent angling over the years in lakes that have never needed to be stocked, a rare occurrence. This attests to the unique productivity of these fish. Recent genetic studies confirm that these Haliburton Highlands glacial relict lake trout have remained distinct from all other lake trout, possibly for 100,00 years, and survived the last glaciations in the Mississippi Refugium. They reside in a chain of lakes that is related to a large glacial river system that flowed out of this region in glacial times. They may have evolved as riverine lake trout, even being river spawners. Indeed, there is some evidence that the entire Gull River system has related stocks.

Studies of these glacial relict lake trout in Macdonald and Clear lakes (approx. 375-acre lakes) in the Haliburton Forest and Wild Life Reserve provide insights into the biology of lake trout. Although they are genetically distinct, their biology and the factors that affect their productivity are generally typical of the species. Females of this stock do, however, mature younger (age 5) than most Ontario lake trout populations (age 7-8). Intensive creel censuses were conducted in the early 1980s, when the lakes were heavily angled and extremely productive. In an intensive cooperation program, the anglers provided their catches so that they could be cleaned to obtain biological data. The fisheries and harvest were equally distributed during summer and winter. Over 1,000 lake trout were caught in Macdonald Lake in 1983-84. Harvest was seasonal, being high in January and May, lowest in April, but also low from midsummer to the end of the angling season, in September (closed to angling October and December). Slightly more than 5% of the fish were harvested after July 1, but fish caught at that time of year were distinctly different. The majority were mature females vulnerable to angling because they were feeding heavily to build eggs for subsequent spawning in October. Disproportionately more mature females were harvested in late summer; up to 70% of the catch, compared with an annual average of 13.6% (see selected summary points below-1 and conclusions for this study-2). Reducing the selective harvest of maturing female fish from midsummer onward would increase the reproductive capacity of the spawning population.

Studies on the spawning grounds on Macdonald and Clear lakes indicated that when the population was low, very few mature females were present. The entire egg production may come from as few as 20 to 30 females. Protecting these fish from over-exploitation and selective harvest is extremely important. In 1986, angling success in Macdonald Lake was very low. The mature population was as few as 300 fish (<1/acre). After consultation and presentation of population and biological data, the anglers voluntarily implemented, in cooperation with the Ontario Ministry of Natural Resources (OMNR) and the Haliburton Forest and Wild Life Reserve, a maximum size limit of 15 inches (38 cm). This meant that all females over the size at first maturity were released. The mature population of lake trout increased and in 1988 was almost three times larger than 2 years earlier. The results were obvious, and anglers perceived that their efforts were successful and resumed harvesting some of the larger fish. Mandatory slot size limits were implemented in 1996 and changed to a maximum size limit in 1997; these resulted in an increase in the size of the spawning stock. These changes in regulation and associated fishing pressure are superimposed on natural changes in productivity and year-class strength. The sporadic production of year-classes is common, not always coinciding with a strong spawning population. Extremely strong year-classes were produced in Macdonald and Clear lakes in 1969, 1975, 1978, 1979, 1982, 1989, 1992 and 1993. Consecutively strong year-classes produced strong cohorts over the years. Some of these cohorts are strong in all the lakes under study, and indeed, in other lakes in the Haliburton Highlands. Studies of year-class strength in Nelson Lake near Sudbury confirm that the 1969 and 1975 year-classes were also universally dominant, suggesting the importance of global climate in lake trout year-class and cohort production.

Studies on the development of lake trout eggs and fry in Lake Ontario explain the importance of global climate; more specifically, fall temperatures, as well as spawning time, on the winter survival of eggs and fry and the appropriate timing of hatch in the spring. Spawning at low temperature, either lake in the season or during cold falls, produces stronger year-classes of lake trout. If spawning occurs late in the season or at low temperatures because the fall and winter are abnormally cold, there is great fry survival to swim-up stage in the spring. A study in Lake Ontario revealed that if the temperature at spawning time were 2C lower (that's only 9 days later in the average year), survival and production of fry on May 1 (at swim-u0p) would almost double (from 10 to 19%) (see below-3). This is explained by the accumulation of heat units. In very warm falls, a large number of heat units would be accumulated at a greater rate, accelerating the development of the fry, creating premature hatch under the ice (in some cases, as early as December), whereas low temperatures and the slow accumulation of heat units would retard development, resulting in a more appropriate synchrony involving spring hatch (see below—4). This explains the old adage, often espoused by old, experienced fishermen, that the strongest year-classes of lake trout and whitefish (fall spawners) came from the "coldest falls and hardest winters" (see below—5).

Research into midsummer depth distribution of lake trout in lakes of the Haliburton Highlands has revealed important insights into the unique habitat requirements of young juvenile lake trout. Juvenile lake trout during their first few years of life live below the adults in a deep-water hypolimnetic nursery. Large lake trout are strong piscivorous and can be cannibalistic. Natural selection has resulted in the small juveniles living below the adults to avoid predation. Under average summer conditions in the lakes in the Haliburton Highlands, young juveniles are usually found at a depth of 88 to 165 feet (27-50 m), whereas older juveniles and adults are found shallower, in 60 to 90 feet (18 -28m) of water. Depth distribution of these juveniles is inversely related to the size of the adult population, but when the adult population is large, juveniles are forced into this deep-water refugium, where they feed on zooplankton and are relatively inactive and live at temperatures well below their optimum (4 C as opposed to 10 C). This unique behavioural trait constrains productivity, since the young lake trout reside in this restricted deep-water refugium for up to 2 to 4 years, depending upon growth rate, at least until they reach approximately 8 to 10 inches (20-25 cm). It appears that when they move into shallow water, they move inshore (in close association with the bottom), just above the larger adults. Midsummer depth distribution of larger fish is related to the thermocline; the very largest fish appear to live deeper. Indeed, surveys indicate that some of the largest lake trout spend some time in very deep water, as deep as the young juveniles. Some of these big lake trout are white-fleshed, indicating that they are fish-eaters, possibly cannibalistic. The productivity of naturally recruiting lake trout stocks is directly affected by the quantity and quality of this habitat, which is naturally limited by lake morphology (see below—7). On the average, this deep-water nursery habitat is restricted by depth to only 1.4% of the total volume of the lake (inland lakes).

This deep-water lake trout nursery refugium is critical habitat. If it is limited, production will naturally be limited, and if it becomes degraded through oxygen depletion, this will force the juveniles to move shallower and be directly vulnerable to predation by the large juveniles and adults in the population. Stocking of hatchery fish can directly affect the natural recruitment of juveniles in this restricted nursery habitat. Hatchery fish, which are much faster growing than native fish, could out-compete the natural recruits and even prey directly on them, reducing and possibly even eliminating natural reproduction.

Lake trout production is directly related to primary and secondary productivity and especially to the production and abundance of prey fish. Studies conducted with Lucian Marcogliese, through a graduate student program at Trent University, demonstrate the importance of white suckers to lake trout growth and production. Consecutive sampling of the sucker population at spawning time over a number of years by OMNR confirmed that a bimodal distribution in suckers (more abundant large and small fish) was not related to acid rain stress or dwarfism, but was the direct result of the introduction and increased abundance of large lake trout (>20 inches, 50 cm). The lack of medium-size suckers was directly related to lake trout predation. During the summer, medium-size suckers move deeper, into the habitat occupied by the medium to large lake trout. This makes them vulnerable to size-selective lake trout predation (see below—8). All things considered, rather than suckers affecting lake trout populations, lake trout appear to depend upon and affect sucker populations.

Studies conducted with David Brown, through a graduate student program at Trent University, are demonstrating the negative effects of the introduction and establishment of rock bass, near-shore predators of small fish, which compete with lake trout for the available prey fish, resulting in decreased lake trout growth and production and ultimately angling success and harvest. Lake trout feed heavily on small prey fish after spawning and in early spring (see below—9). Intensive quantitative electrofishing surveys over a 17-year period in lakes in the Haliburton Forest and Wild Life Reserve have demonstrated that the introduction and establishment of rock bass virtually eliminates the near-shore small fish community. The rock bass are competitors for available prey fish and are not utilized by the lake trout. This eliminates important prey fish production and in Macdonald Lake has resulted in lake trout growth (length) decreasing by 15 to 20%. There is an even greater reduction in lake trout weight and biomass. This research is also demonstrating that lake trout are slower growing, are not growing as large, mature at a smaller size, and produce fewer eggs after rock bass has become established. All these results will eventually detrimentally affect harvest and angler success. Over the past two or three decades, rock bass have become established in many lake trout lakes throughout central Ontario. Their negative impact on lake trout is now becoming apparent; this loss in productivity has, I feel, been greatly overlooked. The questions are, How can it be minimized? And Can rock bass be eradicated from lake trout lakes?

Lake trout typically inhabit low-productivity, oligotrophic lakes and have slow growth rate. It takes much longer to produce fish of size than was heretofore thought. New and accurate age determination techniques that have been validated by means of the otoliths, or ear stones, confirm that scales (structures previously and traditionally used for determining age of fish) underestimate the age of old and slow-growing lake trout (see below—10). A 14-pound lake trout from Lake Manitou, Manitoulin Island, which was tagged for 26.5 years, was growing at the Ontario average for the species and was 36 years old when caught. The scales gave an estimate of slightly less than half the known age (16), while age was interpreted from the otoliths to be 35 (an explainable difference). It is not uncommon for lake trout in the 8 to 12 pound range from lakes in central Ontario to be 25 to 35 years old. Now, as a result of precise and accurate age determination techniques, it is apparent that lake trout conservation ethics can be better taught through the age of the fish—how long it took to produce it—rather than its size.

Since otoliths provide the only accurate and reliable way of studying age and growth, attributes critically important in managing lake trout stocks, this requires that the fish be dead to obtain the necessary samples. Managers and researchers are naturally loath to kill fish to assess, manage, and study the population. It is increasingly apparent that fisheries professionals need the assistance of anglers to help collect these important pieces of biological information from the fish that are harvested. A good example exists in the case of muskellunge, where the cleithrum (or shoulder bone), used to determine age and growth, is supplied when the fish are harvested. When lake trout are kept for food or trophy or die during catch and release, it is especially important that otolith samples and biological data be supplied to managers and researchers. It behoves us to take advantage of every opportunity to collect the necessary and best information to study, manage, and sustain natural lake trout populations and fisheries.

These are general factors that are critically important for sustaining lake trout populations and fisheries: habitat and environment; reproduction and recruitment; survival and growth. Naturally reproducing lake trout populations are resilient and can recover from heavy fishing and over-exploitation (see below—11). It is important to protect native lake trout stocks (see below—12). They are a valuable, productive, and self-perpetuating fisheries resource.

**1.**

**MAINTAIN NATURAL REPRODUCTION BY MAXIMIZING REPRODUCTIVE CAPACITY**

Minimize selective harvest of mature females

**2.**

**CONCLUSIONS**

1) Mature female lake trout are selectively vulnerable from mid-to late summer. Energy demands associated with ovarian development make mature females selectively vulnerable to angling at this time. These fish are usually the oldest and most experienced spawners and probably contain the highest body burden of contaminants.
2) From midsummer to the end of the angling season (just before spawning), significantly more mature female trout are caught than at any other time of year. On an annual basis, 12-15% of the catch is mature females. However, by the end of September, 50 to 70% of the angled lake trout are maturing females.
3) Less than 5% of the annual harvest occurs after midsummer.
4) Angling pressure is minimal during this time of year.
5) If this selective harvest can be reduced or eliminated or transferred to another time of year, reproductive potential of the lake trout population will be significantly enhanced.
6) Research is required to develop practical techniques that can reduce and quantify handling mortality resulting from catch-and-release angling.

**4.**

**SPAWNING TIME AND TEMPERATURE CAN AFFECT YEAR-CLASS STRENGTH**

Late spawning at low temperature in the fall or abnormally cold falls and winters produce greater egg and fry survival and a larger hatch of fry in the spring.

**5.**

**ENVIRONMENTAL CONDITIONS CAN GREATLY ENHANCE LAKE TROUT PRODUCTIVITY**

Abnormally cold falls and winters, followed by warm springs, can produce exceptionally large year-classes of lake trout, greatly increasing production and subsequent angling success (the La Nina-El Nino effect)

**7.**

**JUVENILE DEEP-WATER NURSERY HABITAT**

The quantity and quality of the deep-water nursery habitat can limit the natural productivity of lake trout populations

**8.**

**LAKE TROUT PRODUCTION IS DIRECTLY AFFECTED BY PREY FISH ABUNDANCE**

Medium-sized white suckers are important prey for large lake trout.  Rather than suckers affecting lake trout populations, lake trout affect sucker populations.

**9.**

**LAKE TROUT PRODUCTION IS INDIRECTLY AFFECTED BY NEAR-SHORE FISH PREDATORS THAT ACT AS COMPETITORS COMPETING FOR AVAILABLE PREY FISH**

Rock bass introductions reduce the abundance of important near-shore small fish prey for lake trout, resulting in reduced lake trout growth and production and decreased ultimate size.

**10.**

**LAKE TROUT LAKES ARE TYPICALLY OLIGOTROPHIC AND HAVE LOW PRIMARY PRODUCTIVITY RESULTING IN SLOW GROWTH RATE**

New and accurate age determination techniques, using ear stones, or otoliths, indicate that it takes a long time to produce large, trophy-size lake trout.  Lake trout conservation ethics can be better taught through how long it takes to produce fish (its age), rather than its size.

**11.**

**NATURALLY REPRODUCING LAKE TROUT POPULATIONS ARE RESILIENT AND CAN RECOVER FROM HEAVY FISHING AND OVER-EXPLOITATION**

1. Deep-water nursery habitat must be abundant and remain well oxygenated.
2. Fishing mortality must be minimized and reproductive capacity must be high.
3. Lake productivity and environmental conditions will affect rate of recovery.
4. Even under ideal conditions, it may take up to two or three generation times for lake trout stocks to recover from over-exploitation.

**12.**

**IMPORTANT FACTORS FOR SUSTAINING NATIVE LAKE TROUT STOCKS**

1. Recognize and protect genetically unique and productive naturally reproducing native stocks—glacial relicts of the Haliburton Highlands
2. Protect deep-water nursery habitat from degradation—habitat limiting natural productivity of lake trout populations
3. Maximize reproductive capacity and manage to maintain a strong spawning stock—minimize the selective harvest of mature females
4. Maintain prey productivity—prevent the introduction of such near-shore predators as rock bass. Once they have become established, can their impact be minimized? Can rock bass be eradicated?
5. Prevent the introduction of open-water predators such as rainbow smelt, which prey directly upon lake trout fry

**13.**

**ACKNOWLEDGEMENTS**

1) Staff and summer students of the Ontario Ministry of Natural Resources who assisted with these lake trout studies
2) David Brown, Chris Robinson, and Lucian Marcogliese of the Watershed Ecosystems Graduate Program, Trent University
3) Anglers of the Haliburton Highlands and the Haliburton Forest and Wild Life Reserve