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DEPARTMENT OF NATURAL RESOURCES

FR14 October 2016

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FISHERIES DIVISION
FISHERIES REPORT 14

Suggested Citation Format

He, Ji X., and J. E. Johnson. 2016. Revisit the three milestones measures of Lake Trout rehabilitation, based on status of Lake Trout stock and fisheries in the main basin of Lake Huron, 2011. Michigan Department of Natural Resources, Fisheries Report 14, Lansing.

For information or assistance on this publication, contact:

MICHIGAN DEPARTMENT OF NATURAL RESOURCES,
Fisheries Division
PO BOX 30446
LANSING, MI 48909
517-373-1280

TTY/TDD: 711 (Michigan Relay Center)

Michigan Department of Natural Resources
Fisheries Report 14, 2016

Revisit the Three Milestones Measures of Lake Trout Rehabilitation, Based on Status of Lake Trout Stock and Fisheries in the Main Basin of Lake Huron, 2011

Ji X. He and James E. Johnson

Michigan Department of Natural Resources, Alpena Fisheries Research Station,
160 E. Fletcher St. Alpena, Michigan 49707

Introduction

One major fish-community objective for the main basin of Lake Huron is to restore a self-sustaining Lake Trout *Salvelinus namaycush* population (DesJardine et al. 1995; Bence and Mohr 2008). The rehabilitation process can be marked by three milestones (Ebener 1998). The first has been recently achieved and our measure is that the reestablished spawning stock has produced pervasive wild recruitment over more than ten consecutive years (Riley et al. 2007; He et al. 2012). In the near future wild adults may exceed 50% of the spawning biomass, which is our measure of the second milestone that the stock starts to be self-sustaining. In comparison with Lake Superior when that lake was experiencing a successful transition from a hatchery-stocked population to a wild fish population, the current spawning biomass in Lake Huron is still very low (Sitar and He 2006). If the abundance of top predators is below a minimum required level (Walters and Kitchell 2001), the prey-fish community always has a potential to reach the undesirable status that nonnative prey species either heavily feed on Lake Trout egg and fry or even lead to unbalanced nutritional status of adult Lake Trout and reproduction failures. Our measure of the third milestone of the rehabilitation process is to have sufficient and sustained top-down influence on the dynamically changing food web by Lake Trout, together with Walleye *Sander vitreus* and other top predators to stabilize and diversify the prey-fish community.

Toward those large goals for the main basin of Lake Huron, the purpose of this Lake Trout stock assessment is to provide essential measures of the primary Lake Trout management strategies and thereby inform management decisions. In the future these management decisions will include the following: (1) continuation or termination of Lake Trout stocking; (2) protection of spawning stock and wild recruitment through fishery regulation and the control of Sea Lamprey *Petromyzon marinus* abundance; and (3) fishing opportunity improvements for recreational anglers.

Stocking

Through 2011, hatchery-stocked Lake Trout still dominated the Lake Trout population in the main basin of Lake Huron, and annual stocking of Lake Trout yearlings was continued. With all fall fingerlings converted to yearlings based on an average survival of 40% (Elrod et al. 1993), the total annual stocking of yearling-equivalent Lake Trout has been stable in the main basin, ranging between 1.4 and 1.8 million since 1991 (Figure 1). On average, 0.28 million of the stocking per year was from the Ontario side of the main basin during 2005–2011. Canadian stocking has emphasized areas of Lake Huron other than the main basin, including average annual stocking of 1.5 million in Georgian Bay and average annual stocking of 0.36 million in North Channel. The annual stocking allocation among northern, north-central, and southern main basin of Lake Huron has been similar since 2003.

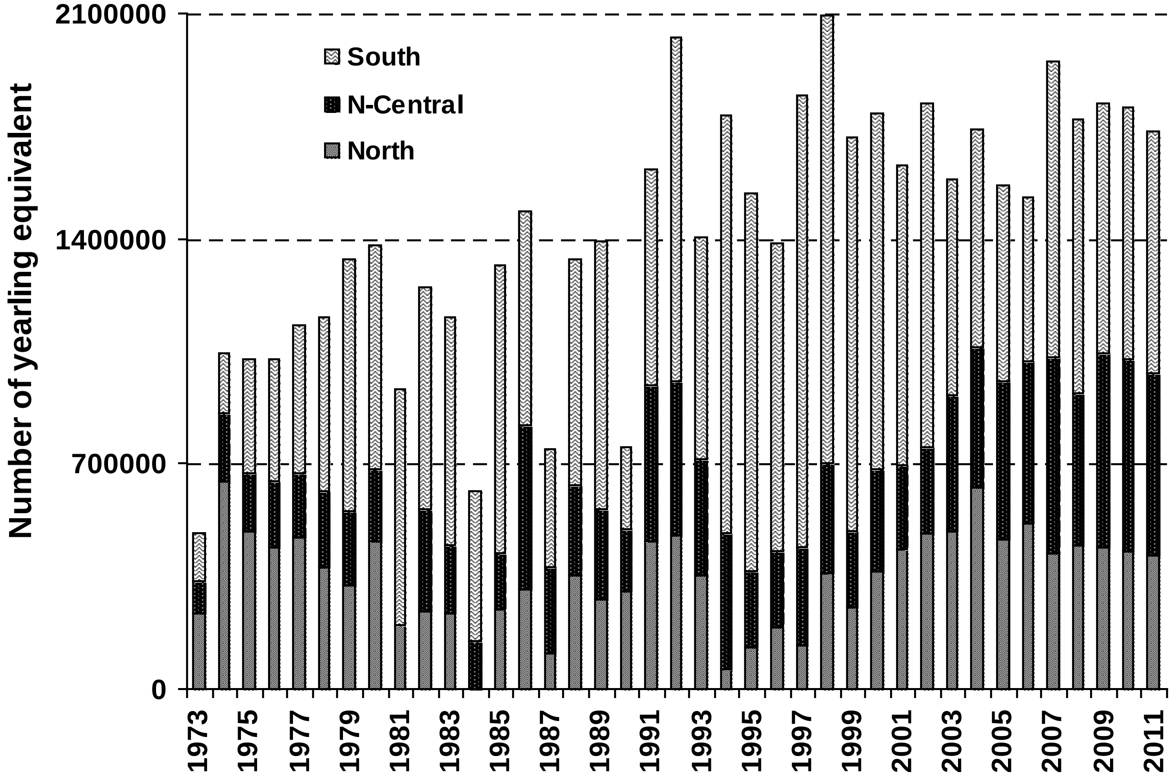

Figure 1.–Total annual stocking of yearling-equivalent Lake Trout allocated among northern, north-central, and southern main basin of Lake Huron.

Post Stocking Survival

Prior to 2005, stocking success was measured as age-5 Lake Trout caught per 1,000 ft of gill net per million of yearling equivalents stocked (Wilberg et al. 2002; Johnson et al. 2004). This measure of stocking success is called catch per effort per recruit (CPE/R). The age-5 CPE/R has decreased steadily from the highest value of 2.1 for the 1995 year class to almost zero recently. Meanwhile, for the 1990–2001 year classes, age-7 CPE/R remained relatively high and stable (Figure 2). The stable age-7 CPE/R and the decline in age-5 CPE/R indicates a delay in recruitment from age 5 to age 7. This delay in recruitment is also evident in the increases in age composition from recreational and commercial harvests. Both a decline in growth and changes in spatial distribution must be used to explain the delay, as our survey gill nets have always included smaller graded mesh sizes and small fish are captured by the gear deployed. However, for the last three year classes indexed by the 2011 sampling (year classes 2002–2004), age-7 CPE/R also became very low, indicating that the post-stocking survival was poor. These three consecutive weak year classes made the peak in age composition unclear and thus the age at full recruitment more difficult to interpret (Figure 4). The effectiveness of stocking should be questioned if the survival index continues to be at this low level. These last three year classes were stocked during 2003–2005, and corresponded in time with the dramatic food-web change and the collapse of Alewives *Alosa psedoharengus* (Riley et al. 2008). The performance of more recent hatchery year classes after the event of Alewife collapse will be one major focus of the near future assessments.

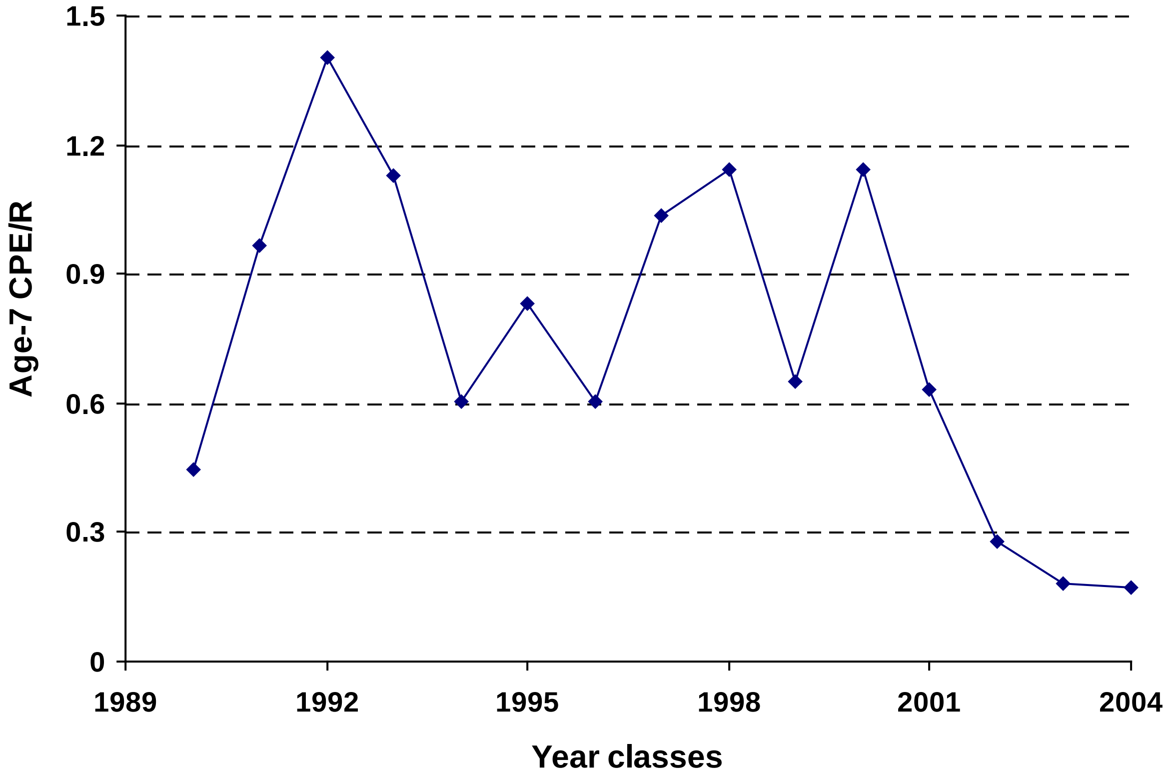

Figure 2.–Age-7 hatchery-stocked Lake Trout caught per 1,000 feet of gill net per million Lake Trout stocked as yearling equivalents, based on annual lake-wide spring gillnetting survey in U.S. waters of Lake Huron.

Relative Abundance

Lake Trout survey catch has changed substantially from being dominated by juveniles to being dominated by adults. The highest total catch per thousand feet (CPE) was 16 in 1996, but only about 4 in 2010. Since 1996, however, the CPE for Lake Trout longer than 21 inches has been stable, ranging between 4 and 8 fish per 1,000 ft, in comparison with 2–4 before 1996 (Figure 3). The adult percentage in the total catch has increased from less than 30% in 1995 to more than 90% by 2010. The stable adult CPE and the decline in total CPE or juvenile CPE since 1996 is another clear indication of the major delay in recruitment to adult size and age. Future assessments are likely to reflect mostly the relative abundance of adults and spawning stock. For those age groups too small to be fully recruited to our nets (e.g., age 6 and younger Lake Trout), the life-history measurements of individual fish will be very important for understanding their prerecruitment status and more informative than the unreliable estimation of their relative abundance.

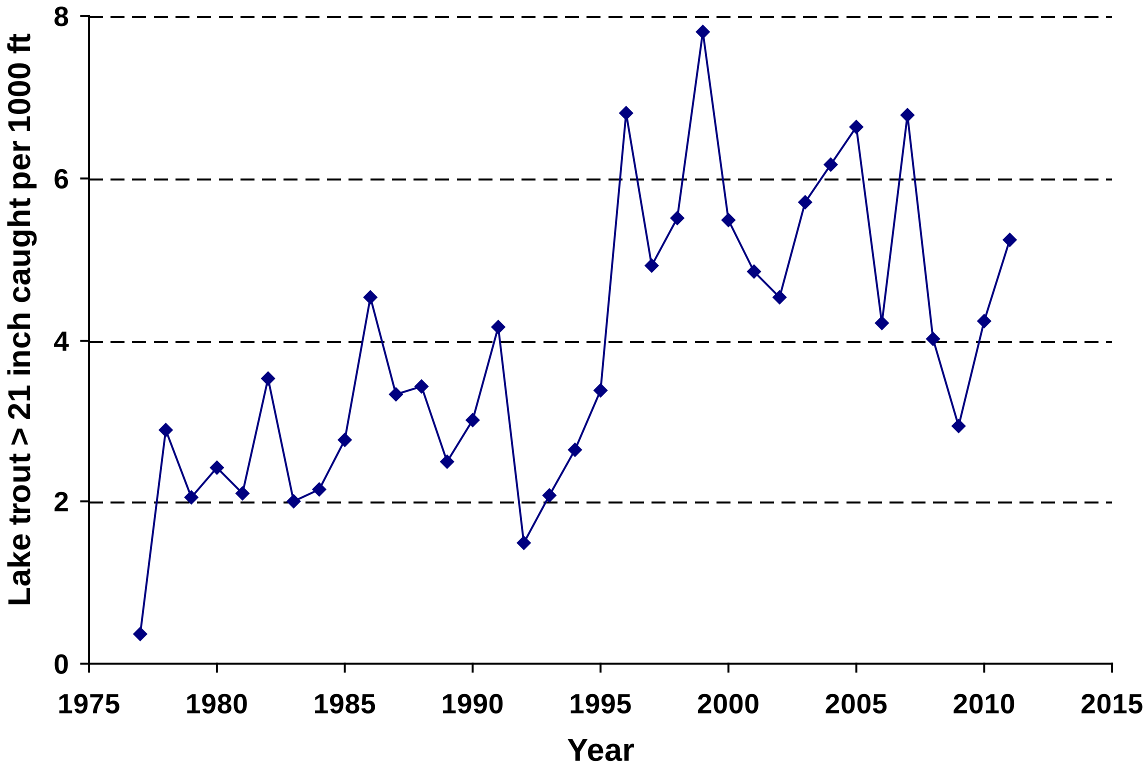

Figure 3.–Geometric mean gillnetting CPE for Lake Trout larger than 21 inches, based on annual lake-wide spring gillnetting surveys in U.S. waters of Lake Huron.

Recruitment of Wild Lake Trout

Before 1995, when adult relative abundance was below 4 fish per 1,000 ft, reports of natural reproduction were limited to the detection of age-0 wild Lake Trout in a few local areas, such as Thunder Bay and the mid-lake offshore reef (Nester and Poe 1984; Johnson and VanAmberg 1995; Desorcie and Bowen 2003), and it was very rare to see wild recruitment to the gillnetting surveys and fisheries. The increase in wild recruitment started in the mid 1990s, and was correlated with the increases in relative abundance of adults (He et al. 2012). A more recent major increase was after 2001, and corresponded with the decline and collapse of Alewives and the increase in thiamine concentration in Lake Trout eggs (Riley et al. 2007, 2012). By 2011 (Figure 4), wild Lake Trout consistently made up 18% of Lake Trout sampled from the annual spring gillnetting surveys conducted by Michigan Department of Natural Resources (MDNR), summer gillnetting surveys conducted by Chippewa Ottawa Resource Authority (CORA) and U.S. Fish and Wildlife Service (USFWS), and tribal commercial fisheries in northern Lake Huron (CORA), but 33% from the recreational fisheries in Michigan waters (MDNR), and 60% from the commercial fisheries in Ontario waters based on biological monitoring conducted by Ontario Ministry of Natural Resources (OMNR). Furthermore, wild Lake Trout are now an increasing component of the spawning stock and will be more effective than hatchery-stocked fish in using suitable spawning habitats and contributing to an even higher level of wild recruitment. Future development of the stock will include further expansion of older and mature age groups, and gradual replacement of hatchery-stocked Lake Trout by wild Lake Trout. Our assessment of the stock will use otoliths to provide more adequate age assignment for old fish, as a rotation of fin clips will be much less useful for ageing hatchery-stocked older Lake Trout. The assessment will also closely monitor the increases in wild recruitment and wild adults, and cooperate with university and federal laboratories to identify the temporal and spatial patterns of the genetic makeup of wild Lake Trout.

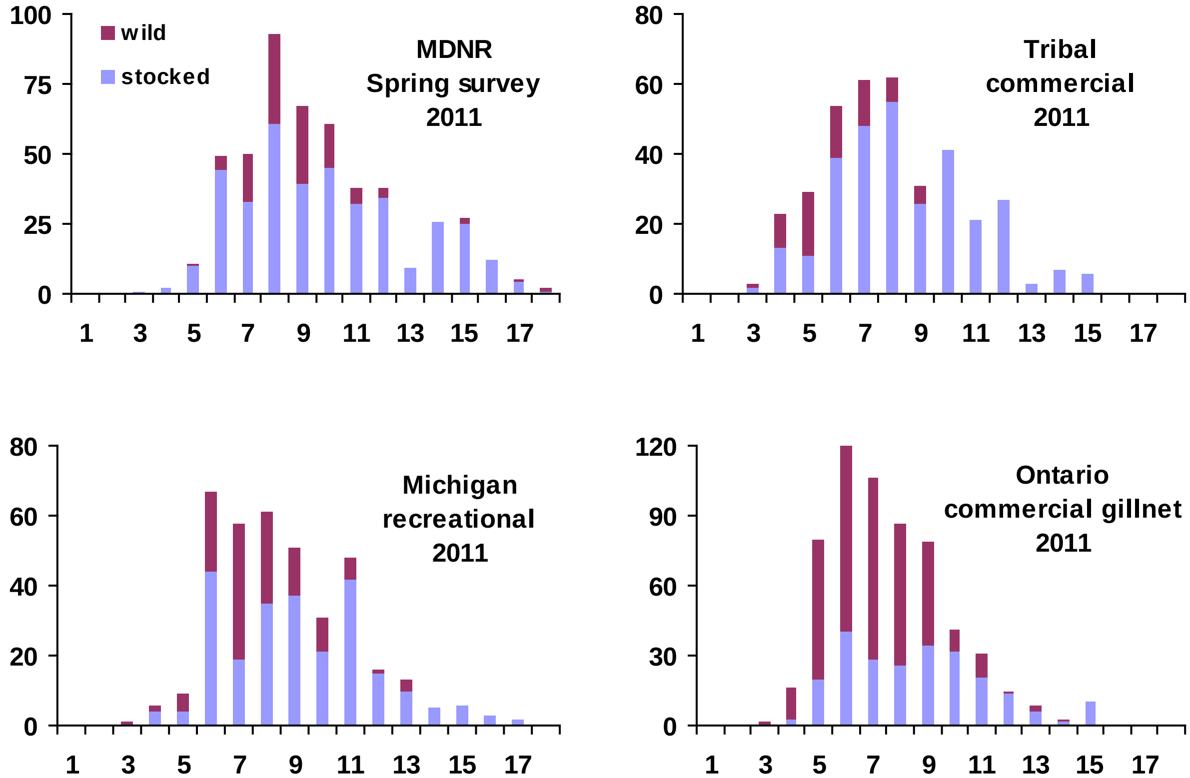

Figure 4.–Wild and hatchery-stock Lake Trout samples from Lake Huron distributed among ages, and compared among the surveys, and commercial and recreational fisheries.

Spawning Stock Biomass

Based on the catch-at-age statistics of the fishery-independent surveys and recreational and commercial harvests (He et al. 2011; He and Cottrill 2011), and size at age and body condition of the fish (He and Bence 2007; He et al. 2008), the estimated biomass of age-7 and older Lake Trout in the main basin has been remarkably stable between 1.2 and 1.4 million kg since 2004 (Figure 5). Biomass of age-10 and older has increased from 0.23 million kg in 2004 to 0.60 in 2011, while biomass of ages 7–9 has decreased from 1.0 million kg in 2004 to 0.66 in 2011. The increase in biomass of age-10 and older Lake Trout indicates that adult mortality is generally below the maximum limit of 40% (see also Madenjian et al. 2004, 2008). The decline in biomass of ages 7–9 is consistent with the observation that age-7 CPE/R was very low for the year classes of 2002–2004 (Figure 2). In the past, the rehabilitation efforts by multiple agencies have largely relied on stocking success and management actions to reduce mortality, particularly Sea Lamprey predation induced mortality (Eshenroder et al. 1995; Reid et al. 2001). To sustain the rehabilitation process, effective control of Sea Lamprey abundance and adequate fishery regulations are still essential. An adequate protection of spawning stock and wild recruitment will also require sufficient consideration of the increased recruitment uncertainty which in part is related to the delay in recruitment to adult size and age and the annual variation to be expected in annual reproduction success as wild fish replace hatchery recruits, the latter of which were stocked in nearly static numbers since 1990 (Figure 1).

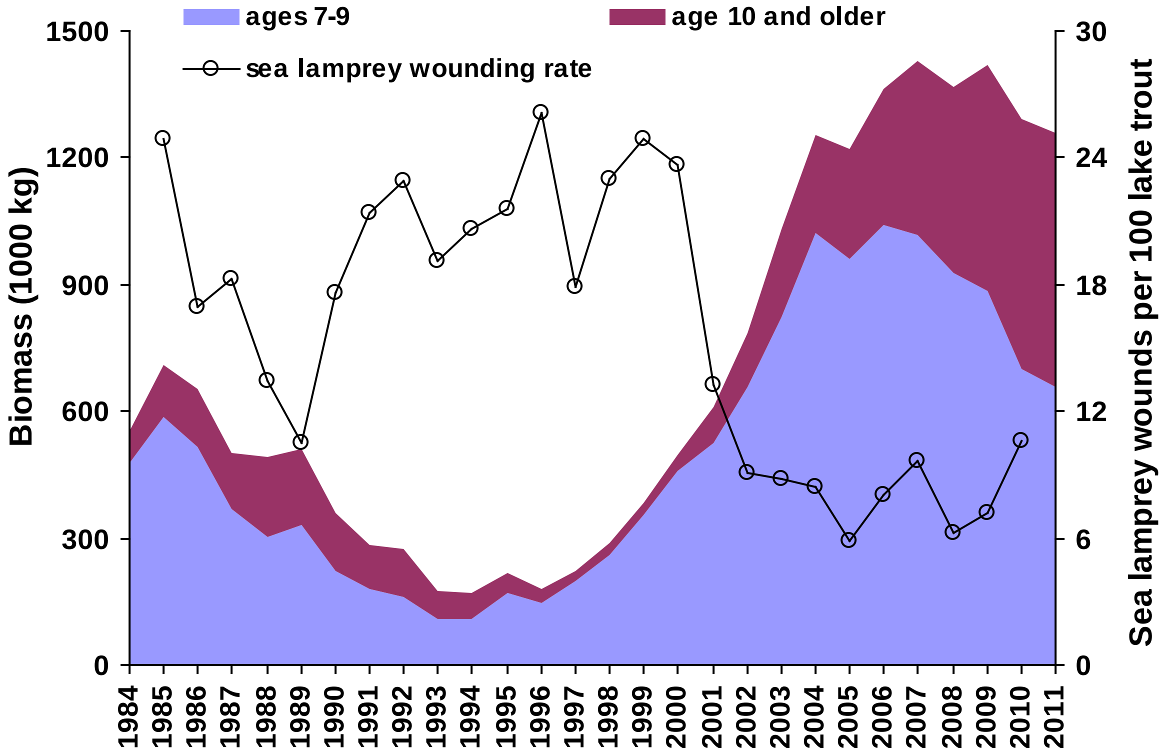

Figure 5.–Biomass estimated for age-7 and older Lake Trout in the main basin of Lake Huron, and Sea Lamprey wounding rate estimated as the year effect in additional to the effects of seasons, regions, and size groups (He et al. 2012)

Fishery Harvests

The reported total fishery harvest has been relatively stable since the mid 1990s (Figure 6). There was a sharp increase during 2000–2004, which is due to the rapid increase in the stock biomass (Figure 5). The total harvest has decreased from 0.58 million kg in 2004 to 0.26 million kg in 2011 and this decrease is largely due to the declines in Ontario commercial fishing effort targeting Lake Whitefish *Coregonus clupeaformis* and the recreational fishing efforts targeting Chinook Salmon *Oncorhynchus tshawytscha* in the north-central and southern Michigan waters. The current total fishery yield is similar to the late 1990s, but the harvest composition has changed. During the 1990s, both the recreational and commercial fisheries relied on strong and predictable recruitment from hatchery stocking, the overall harvest was dominated by ages 4 and 5 fish, and the age structure was truncated at age 6. Now the mean age of harvests is far above 6.5 (Figure 4), which is the mean age at first maturity. Currently, pre-recruitment status of the stock is not reflected by the fishery harvest, and the total harvest is essentially a proportion of the established spawning stock. Commercial harvests have continued to dominate the total yield, on average making up more than 80% since 2005. As long as the total spawning stock is maintained or further increases, the circumstances that require the use of very restrictive recreational size limits should become rare.

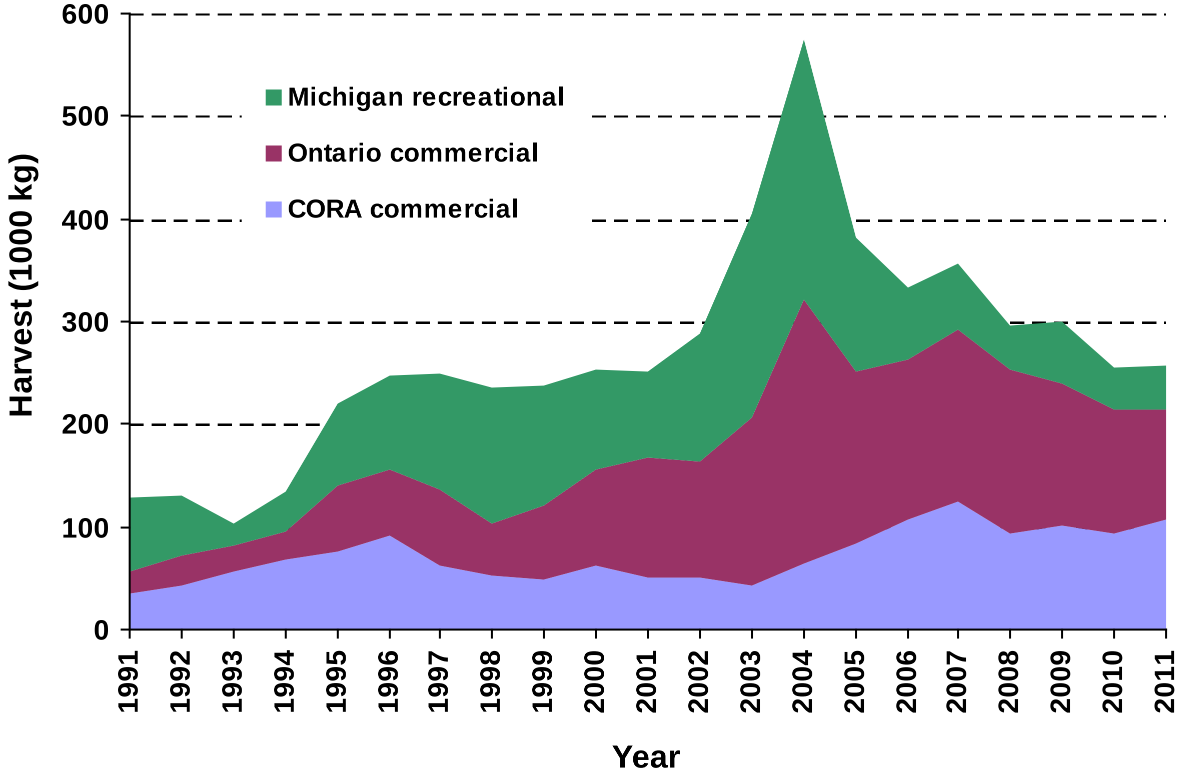

Figure 6.–Total Lake Trout yield produced by the tribal, Ontario and Michigan fisheries.

Acknowledgements

This study was funded in part by the U.S. Fish and Wildlife Service, Federal Aid in Sport Fish Restoration Project F-81-R, Study 230451. The crew of R/V Chinook collected the baseline data. The Great Lakes Fishery Commission, Lake Huron Committee, Lake Trout Task Group provided additional data and technical guidance. Tammy Newcomb reviewed the manuscript. The layout and final proofs were prepared by Ellen Grove.

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