2015 Lake Michigan Lake Trout Working Group Report

This report provides a review on the progression of lake trout rehabilitation towards meeting the Salmonine Fish Community Objectives (FCOs) for Lake Michigan (Eshenroder et. al. 1995) and the interim goal and evaluation objectives articulated in *A Fisheries Management Implementation Strategy for the Rehabilitation of Lake Trout in Lake Michigan* (Dexter et al. 2011); we also include data describing lake trout stocking and mortality to portray the present state of progress towards lake trout rehabilitation.

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Methods: We drew from several data sources in preparing this report. Harvest information was supplied by the Lake Michigan Extraction database. More detailed reporting of harvest and mortality within 1836 Treaty Waters of Lake Michigan was based on stock assessment models for northern and eastern Lake Michigan management units that we used to approximate harvest and mortality in the proximate southern rehabilitation priority areas. Trends in spring catch-per-unit-effort (CPUE) were based on the spring (April – June) lakewide assessment plan (LWAP) gillnet survey that employs 2.5-6.0" graded multifilament mesh at nine nearshore and two offshore locations distributed throughout the lake (Schneeberger et al. 2001; Map 1). We also included spring surveys performed under the modified LWAP design, 1.5-6.0" mesh, used by Michigan DNR and spring surveys following the Fishery Independent Whitefish Survey (FIWS) protocols for the 1836 Treaty waters that employ 2.0-6.0" graded multifilament mesh in locations between Saugatuck and Manistique, Michigan. Fall adult CPUE was determined from the 4.5-6.0" graded multifilament mesh spawner surveys completed at selected reefs during October – November. Estimates of natural reproduction were determined from the proportion of unclipped lake trout from all lake trout sampled within a management unit. Roughly 3% of recently stocked lake trout were released without a fin clip (Hanson et al. 2013), and therefore we infer natural reproduction when unclipped fish exceed 3% of all lake trout recoveries. Data sources for lake trout recoveries included LWAP surveys, lake trout spawner surveys, Great Lakes Mass Marking Program samples of recreationally caught lake trout, and assessment surveys targeting other species that also sampled lake trout. In general, these surveys sampled several hundred lake trout annually in most management units, but we only report data for management units with sample sizes $\geq$ 30 lake trout recoveries.

EVALUATION OF ATTAINMENT OF FISH-COMMUNITY OBJECTIVES
<u>Salmonine (Salmon and Trout) Objectives for Lake Michigan (Eshenroeder et al. 1995)</u>:

> *Establish a diverse Salmonine community capable of sustaining an annual harvest of 2.7 to 6.8 million Kg, of which 20-25% is lake trout.*
>
> *Establish a self-sustaining lake trout population.*

<u>Harvest</u>: In 2015, total salmon and trout (SAT) harvest in Lake Michigan was 2.03 million kg, which is equal to only 75% of the 2.7 million kg specified in the FCO harvest objectives (Figure 1). However, since 2013 the total harvest of lake trout has met the lower-end range, >0.54 million kg, specified for lake trout harvest objectives; this harvest objective for lake trout was previously met from 1985 – 2001, and again recently in 2013 – 2015. Since 2014 lake trout contributed to more than 20% of the SAT harvest, as they had throughout most of the 1990s (Figure 2).

<u>Natural Reproduction</u>: From the 2015 spring and fall gillnet assessment data, 45% of the lake trout captured in Illinois were wild origin (unclipped), 18 - 20% in WM4 and WM5, 7 – 13% in MM5 – MM8 (Figure 3). Wild lake trout recoveries in MM3, Grand Traverse Bay (MM4), and Indiana were near the 3% marking error rate. Similar proportions of wild lake trout were reported within the Great Lakes Mass Marking Program sampling of the recreational fishery where nearly 5,800 lake trout were examined in 2015. Substantial recoveries of wild lake trout were made in WM6 (24.9%), ILL (43.5%), MM8 (23.8%) and Indiana waters (18.0%); in Indiana and WM6 more intensive sampling was available in the recreational fishery than for assessment surveys in these units. Ages for 842 recreationally caught wild lake trout were derived from thin-sectioned otoliths and ranged between 4 and 21 years with a median age of 7 years (Figure 4).

EVALUATION OF ATTAINMENT OF INTERIM STOCKING TARGETS, MORTALITY TARGETS, AND IMPLEMENTATION STRATEGY EVALUATION OBJECTIVES

Fish Stocking: Stocking hatchery reared lake trout to achieve lake trout rehabilitation is the primary feature of the "Fisheries Management Implementation Strategy for the Rehabilitation of Lake Trout in Lake Michigan" (Strategy) approved by the Lake Michigan Committee in January 2011. The maximum stocking target is 3.31 million yearlings and 550,000 fall fingerlings, or 3.53 million yearling equivalents where one fall fingerling = 0.4 yearling equivalents (Elrod et al. 1988). The Lake Michigan Committee adopted an interim stocking target when the strategy was approved not to exceed 2.74 million yearling equivalents until the Federal hatchery production is capable of achieving higher stocking rates and the Lake Committee reaches consensus, informed by decision support tools and information, to increase stocking above 2.74 million equivalents. Nearly 2/3 of the fish stocked are targeted in first priority rehabilitation areas with rehabilitation as the primary objective. The remainder of the fish will be stocked in second priority rehabilitation areas with primary objectives being to support local fishing opportunities in addition to supporting rehabilitation.

Since 2008, lake trout have been stocked in accordance to the Strategy and this has substantially increased the numbers of fish stocked in high priority rehabilitation areas (Figure 5). In 2015, Lake Michigan was stocked with 2.99 million lake trout yearlings and 455,000 fall fingerlings which equates to 3.17 million yearling equivalents; 98.4% of these originated from Federal hatcheries. Lean strains (Lewis Lake, Seneca Lake, and Huron Parry Sound) represented 93% of all lake trout stocked while 206,000 Klondike Reef strain from Lake Superior were stocked at Northeast Reef within the Southern Refuge following a Strategy recommendation to introduce a deep-water morphotype to the underutilized deep-water habitats. Priority rehabilitation areas (Charlevoix, East and West Beaver reef complexes in or near the Northern Refuge and the Southern Refuge reef complex including Julian's Reef) received 64.3% of the lake trout. Over 87% of the Federal lake trout were stocked in offshore waters using the M\V Spencer F. Baird.

Lake Trout Mortality: Tracking mortality experienced by Lake Michigan lake trout stocks is best accomplished by the stock assessment conducted for the sport and commercial fisheries within the 1836 Treaty waters. Mortality estimated by application of stock assessment models is partitioned into natural mortality, lamprey induced mortality, and fishing (both sport and commercial) mortality. The Strategy requires management agencies to "adjust local harvest regulations if appropriate when mortality rates exceed target levels", and the target annual mortality rate has been set equal to 40% (Bronte et al. 2008; Dexter et. al. 2011).

In northern Lake Michigan, total mortality rates for lake trout ages 6-11 have exceeded the maximum targeted annual mortality rate of 40% since 1997 (Figure 6, upper panel; Technical Fisheries Committee: 2000 Consent Decree). Commercial fishing represented the predominant component of mortality rates in the late 1990's though 2002 and more recently from 2011 to present day. By 2000 the Manistique River dam failed as a lamprey barrier and subsequently lamprey numbers increased substantially. As a result, lamprey induced mortality was the primary source of mortality between 2003 and 2010. Since 2003 the Manistique River has been treated seven times which has effectively reduced abundance of lamprey in northern Lake Michigan and the mortality imposed on lake trout to a more manageable level (Figure 7). Lake trout mortality rates in the Southern Refuge priority area have not been estimated, but total annual mortality rates from the proximal waters of MM6\7 have been at or below 40% since 1999 (Figure 6, bottom panel). Prior to 2003, recreational fishing was the main source of mortality in MM6\7, but with the reduction in overall recreational fishing effort since the 1990s, lamprey induced mortality is now substantially greater than fishing mortality in MM6\7.

<u>Evaluation Objective 1 :</u> **Increase the average catch-per-unit-effort (CPUE) to $\geq$25 lake trout 1000 feet of graded mesh gill net (2.5-6.0 inch) over-night set lifted during spring assessments pursuant to the lakewide assessment in MM-3, WM-5, and at Julian's Reef by 2019.**

In 2015, 159 gillnet lifts were completed lakewide to measure spring lake trout abundance. This included at least 6 lifts at each nearshore LWAP site except for Michigan City (n = 3 lifts). Increased effort was directed at the offshore reef complexes with 12 lifts on Northeast Reef in the Southern Refuge reef complex and 34 lifts at 6 reefs (Dahlia Shoal, Fisherman's Island, Gull Is. Shoal, Ile aux Galets, Irishman's Ground, and South Fox Is.) within the Northern Refuge reef complex. About 25% of the lifts stemmed from FIWS sampling that added additional effort to sites between Saugatuck and Manistique (Map 1).

Spring survey CPUEs for the first priority areas including the Northern Refuge reef complex, Southern Refuge reef complex, and Julian's Reef, and second priority regions, all other areas, are shown in Figure 8. In the priority rehabilitation areas, lake trout CPUE remains below the 25 fish per 1000' benchmark. Spring survey CPUEs were at or near their highest values in the time series for the Northern Refuge reef complex (9.8 trout per 1000'), Little Traverse Bay including nearshore reefs of MM3 (12.7), and the northern waters of MM5 near Leland (15.1). All other areas of the lake, including the Southern Refuge (CPUE = 14.2) and Julian's Reef\Waukegan region (CPUE = 11.8), have fluctuating CPUEs that are below the 25 fish benchmark with no strong evidence for any trend upward or downward. Interestingly both first priority areas in southern Lake Michigan had previously been above the benchmark, Julian's Reef in 2005 and the Southern Refuge in 2012-13, yet CPUE in each area subsequently declined for unknown reasons.

<u>Evaluation Objective 2:</u> **Increase the abundance of adults to a minimum catch-per-unit-effort of 50 fish per 1000 feet of graded mesh gill net (4.5-6.0 inch) gill net fished on spawning reefs in MM3, WM5, and at Julian's Reef by 2019.**

In 2015, 54 spawner survey lifts from 9 regions were performed during October-November. Eastern Lake Michigan sites from Saugatuck north to Leland, except for Arcadia, were not surveyed in 2015. Fall CPUE in 2015 was near or above the 50 fish benchmark in all surveyed regions except for the Northern Refuge complex reefs where spawner abundance has been increasing but has remained below the benchmark of 50 lake trout per 1000' (Figure 9). Spawner abundance at Northeast Reef in the Southern Refuge was roughly 3-fold higher (154 per 1000') than that in other regions in the lake.

<u>Evaluation Objective 3:</u> Significant progress should be achieved towards attaining spawning populations that are at least 25% females and contain 10 or more age groups older than age-7 in first priority areas stocked prior to 2007. These milestones should be achieved by 2032 in areas stocked after 2008.

<u>Percent Female:</u> Since 1998, the percentage of females captured during the fall spawner surveys has generally exceeded the 25% benchmark and has reached as high as 45% (Figure 10).

<u>Age Composition:</u> Age compositions were only reported from the Northern Refuge, nearshore MM3 / Little Traverse Bay, Grand Traverse Bay, and Sturgeon Bay sites. Sturgeon Bay met the criteria with 13 age-classes older than age 7, the oldest fish was aged at 23 years, and there were a substantial proportion in the 15+ group, whereas spawning populations in northern sites were predominantly younger fish between 4-8 years (Figure 11). For the Southern Refuge and Julian's Reef, the only age information available was from lake trout tagged with a coded wire tag (CWT). Of the CWT fish caught, 16 age-classes older than age 7 with a maximum age of 26 years were recorded for the Southern Refuge, and 11 age-classes older than age 7 with a maximum age of 30 were recorded for Julian's Reef.

<u>Evaluation Objective 4:</u> Detect a minimum density of 500 viable eggs/m^2 (eggs with thiamine concentrations of >4 nmol/g) in previously stocked first priority areas. This milestone should be achieved by 2025 in newly stocked areas.

<u>Egg Deposition:</u> Egg deposition rates have remained low at the four sites where egg deposition has been measured in northern Lake Michigan during 2000-2015 (Figure 12). Nearly all of the measured densities of lake trout eggs were < 60 eggs/m^2.

<u>Egg Thiamine Concentration:</u> Mean thiamine concentrations for lake trout eggs sampled in fall spawner surveys, 2001 – 2013, show thiamine concentrations exceeded 4 nmol/g in most areas of the lake during 2005-2010 (Figure 13). In 2013, thiamine concentrations fell slightly to at or below the 4 nmol/g threshold in southern and eastern Lake Michigan waters, including reefs near Waukegan (ILL), Michigan City (IND), Milwaukee (WM5), and Portage Point and Ludington (MM6).

<u>Conclusions</u>: Since 2013, lake trout harvest from Lake Michigan has partly met the specified Fish-Community Objectives, as lake trout annual harvest has exceeded 0.54 million kg. The majority of the lake trout harvest has been from northern Lake Michigan, where lake trout annual mortality still exceeds the 40% target level. Since 2013, fishing mortality, largely attributable to commercial fishing, has been the predominant component of lake trout mortality in northern Lake Michigan. In the Southern Refuge and at Julian's Reef, the Strategy evaluation objectives have largely been met, as lake trout populations in these areas are characterized by high spawner densities, a diverse age structure including older age-classes, and an increasing trend in the proportion of wild fish. However these populations are not considered self-sustaining yet as they are still stocked and comprised of $\geq$ 50% hatchery fish. Among northern populations, higher stocking rates in the northern priority area have resulted in increasing lake trout density. Recently, sea lamprey induced mortality rates in this northern priority area have declined as a result of intensive lamprey eradication efforts on the Manistique River since 2003.

Progress toward lake trout rehabilitation in this northern priority area can be accelerated by a reduction in fishing mortality such that the mortality target level is attained.

Fall spawner densities in the southern priority areas and western sites at Sturgeon Bay, Sheboygan, and Milwaukee have generally met or exceeded the 50 fish per 1000 feet benchmark since 2007, and recent natural reproduction is evident in each of the corresponding management units to varying degrees. Spawner densities at Arcadia (MM5) have also consistently exceeded the fall benchmark though evidence of natural reproduction is marginal with Great Lakes Mass Marking Program recoveries of wild fish just slightly above the 3% rate of marking error. Sites in northern Lake Michigan, including Grand Traverse Bay, the Northern Refuge, Little Traverse Bay, and nearshore MM3 reefs, have shown increasing spawner densities, but to date these populations are relatively young and substantial production of wild fish has yet to be observed.

The apparent onset of detectable and sustained natural reproduction by lake trout in Lake Michigan, as documented by Hanson et al. (2013) and Illinois DNR survey data (S. Robillard, unpublished data), also coincided with reduced alewife abundance. A substantial increase in lake trout natural reproduction appeared to begin around 2004. Alewife abundance in Lake Michigan in 2004 was at a reduced level, and abundance has continued to decline to the present time (Madenjian et al. 2016). Reduced densities of alewives can facilitate natural reproduction by lake trout through decreased potential for alewife predation on lake trout larvae (Krueger et al. 1995). Continued declines in alewife densities since 2004 were also weakly correlated with an increase in mean thiamine content within lake trout eggs (Riley et al. 2011), although by 2013 egg thiamine concentrations have dropped below 4 nmol\g at selected sites in eastern and southern Lake Michigan.

In summary, widespread recruitment of wild fish is now occurring in the southern priority rehabilitation area where evaluation objectives for spawner abundance, spawner age composition, percent spawning females, target mortality, and thiamine egg concentrations (in most years) have been achieved but not for spring abundance. Recruitment of wild fish, at a lesser scale, is now evident in mid-latitude management units, particularly on the western shore. We have shown that managing lake trout stocks to achieve the evaluation objectives provided in the Implementation Strategy remains an appropriate strategy to achieve progress toward lake trout rehabilitation in Lake Michigan.

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Map 1. Reporting of spring and fall graded mesh gill net data has been aggregated into the 11 LWAP sites and 3 supplemental sites. Generally each reported lift is within 18 km of the site numerical label. Statistical district boundaries are outlined and shading is used to outline the Northern and Southern Refuges.

Data Reporting Stations for Spring and Fall Graded Mesh Gillnet Surveys

LWAP sites:

1. Manistique
2. Northern Refuge
3. Washington Island
4. Leland
5. Sturgeon Bay
6. Arcadia
7. Sheboygan
8. Southern Refuge
9. Saugatuck
10. Julian's Reef \ Waukegan
11. Michigan City

Supplemental sites:

12. Little Traverse Bay
13. Grand Traverse Bay
14. Milwaukee

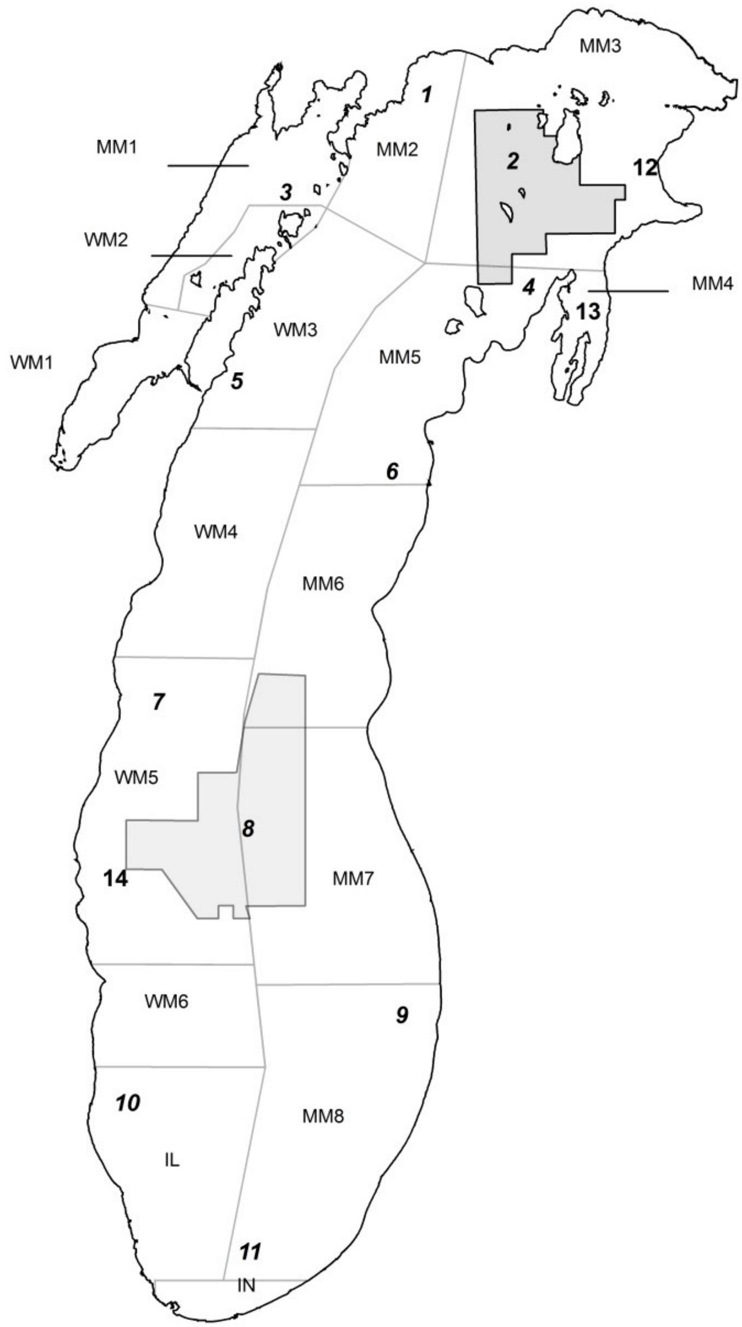

Figure 1. Lake Michigan total harvest (1985 – 2015) of for lake trout and all species of salmon and trout (SAT); green-shading depicts the range of SAT harvest in the FCO while blue-shading depicts the 20-25% range of SAT harvest reserved for lake trout.

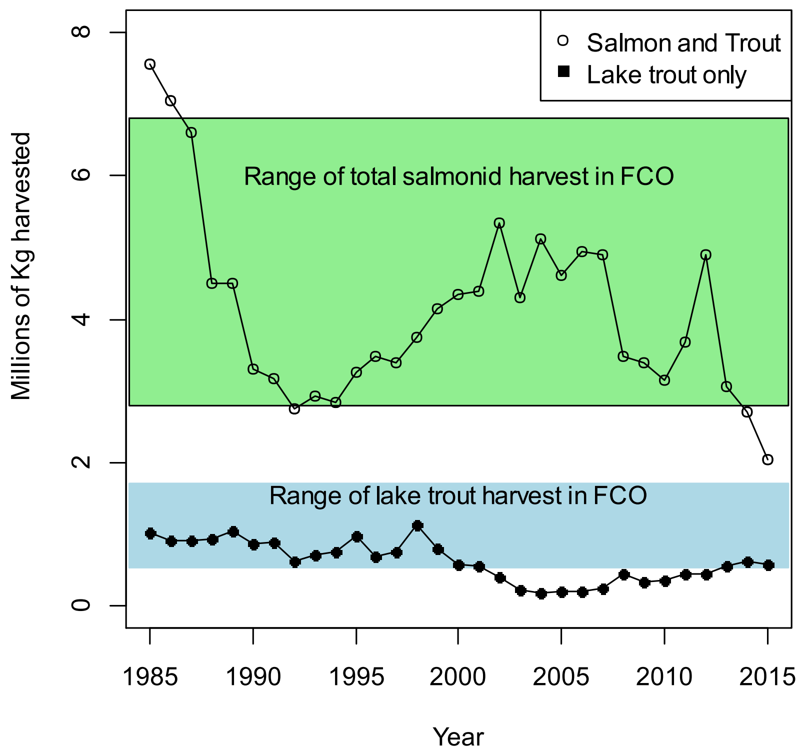

Figure 2. The percentage of SAT harvest comprised of lake trout; the horizontal gray line represents the upper range 25% specified in the FCO.

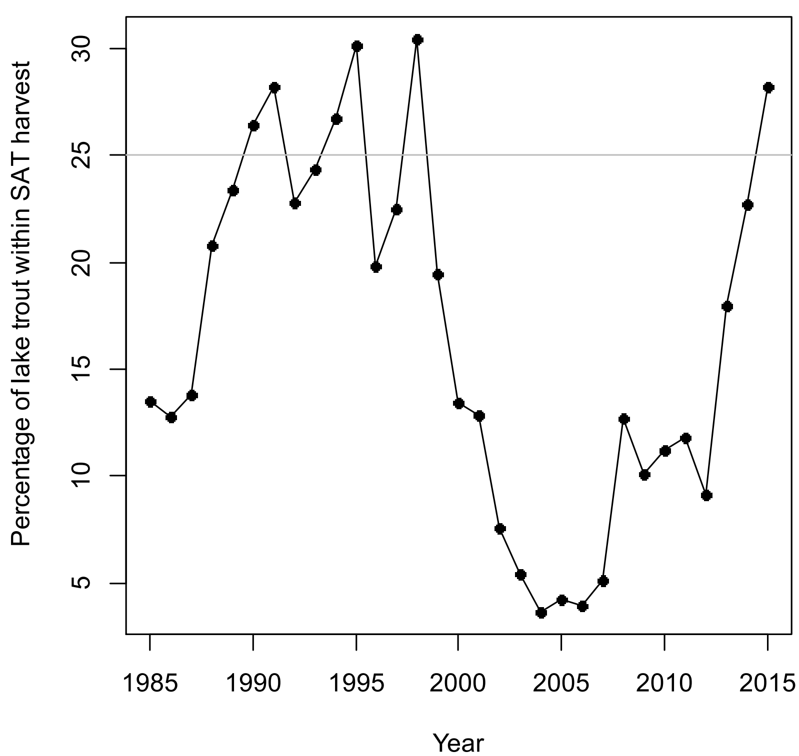

Figure 3. The proportion of unclipped lake trout captured in spring and fall assessment surveys from each statistical district (black lines). Data points are only included when at least 30 lake trout per year were examined. Red boxes show the proportions of unclipped lake trout examined from the Great Lakes Mass Marking Program sampling in 2014 and 2015. The gray line represents 3% marking error, e.g. hatchery origin fish that were stocked with no fin clip.

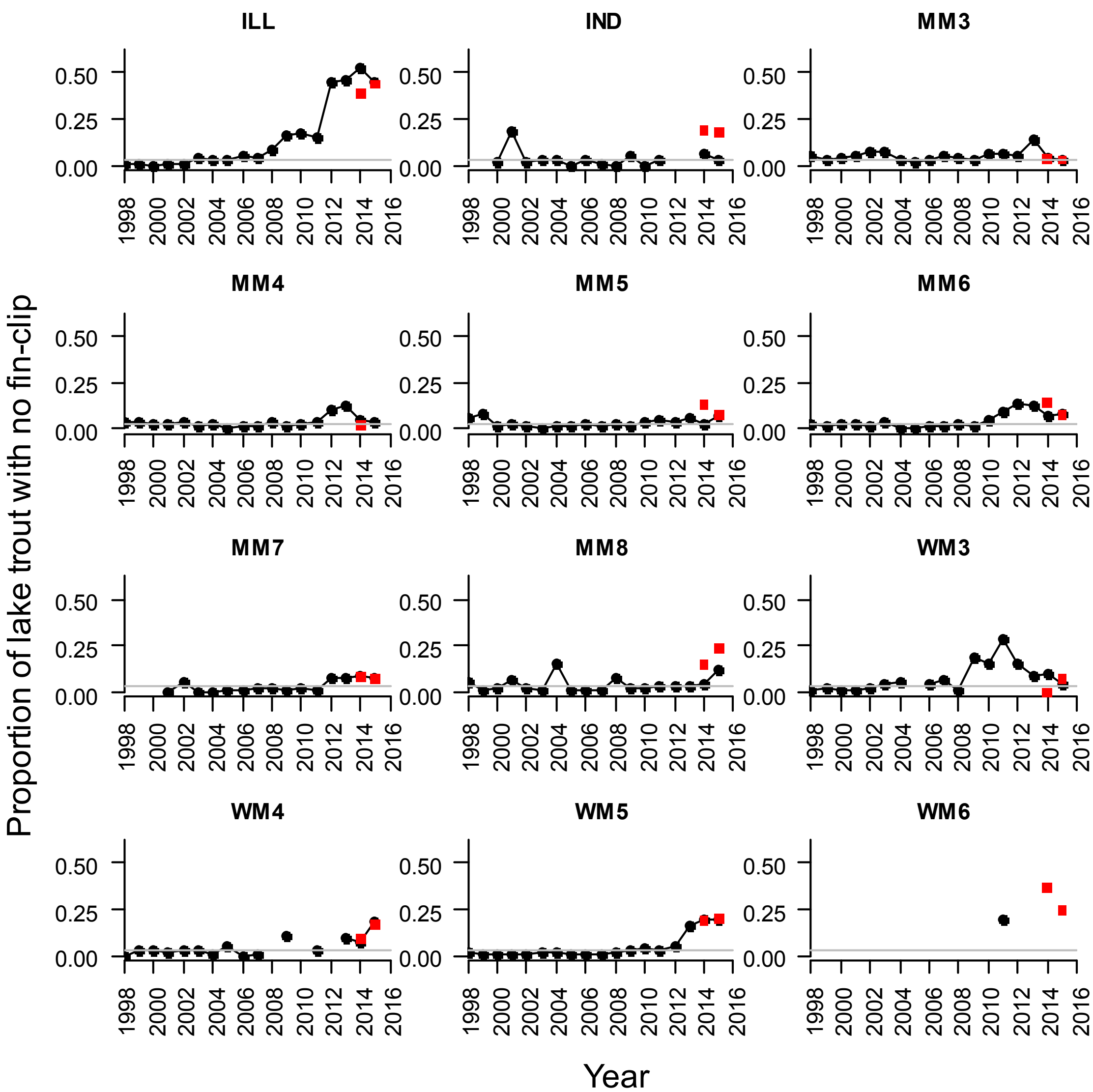

Figure 4. Histogram of the age-classes present among Great Lakes Mass Marking Program sampling of unclipped lake trout caught in the recreational fishery. A total of 842 of the 5,794 unclipped lake trout sampled in 2015 were aged from thin-sectioned otoliths.

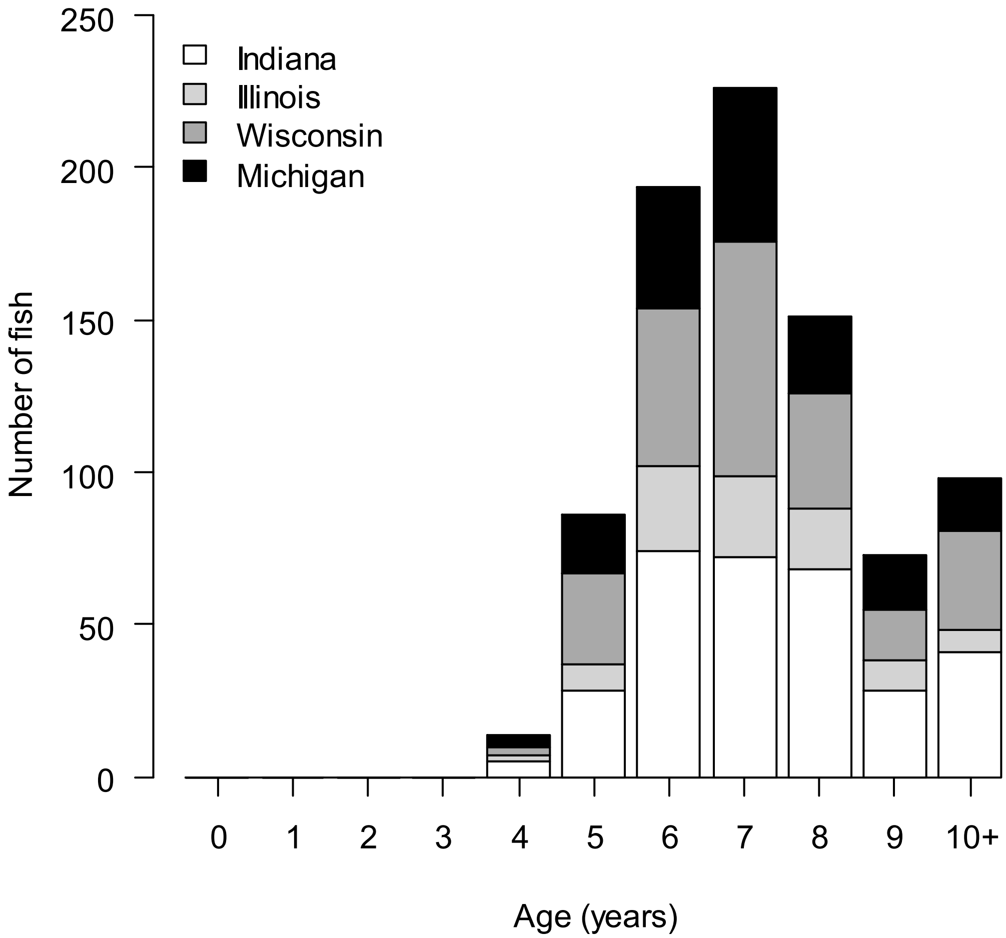

Figure 5. Number of lake trout (yearling equivalents) stocked in Lake Michigan by region, 1995 – 2015. In the "lakewide" panel, the black line represents the 3.53 million maximum stocking target prescribed in the Strategy while the red line represents the 2.74 million interim target the Lake Committee is currently managing for.

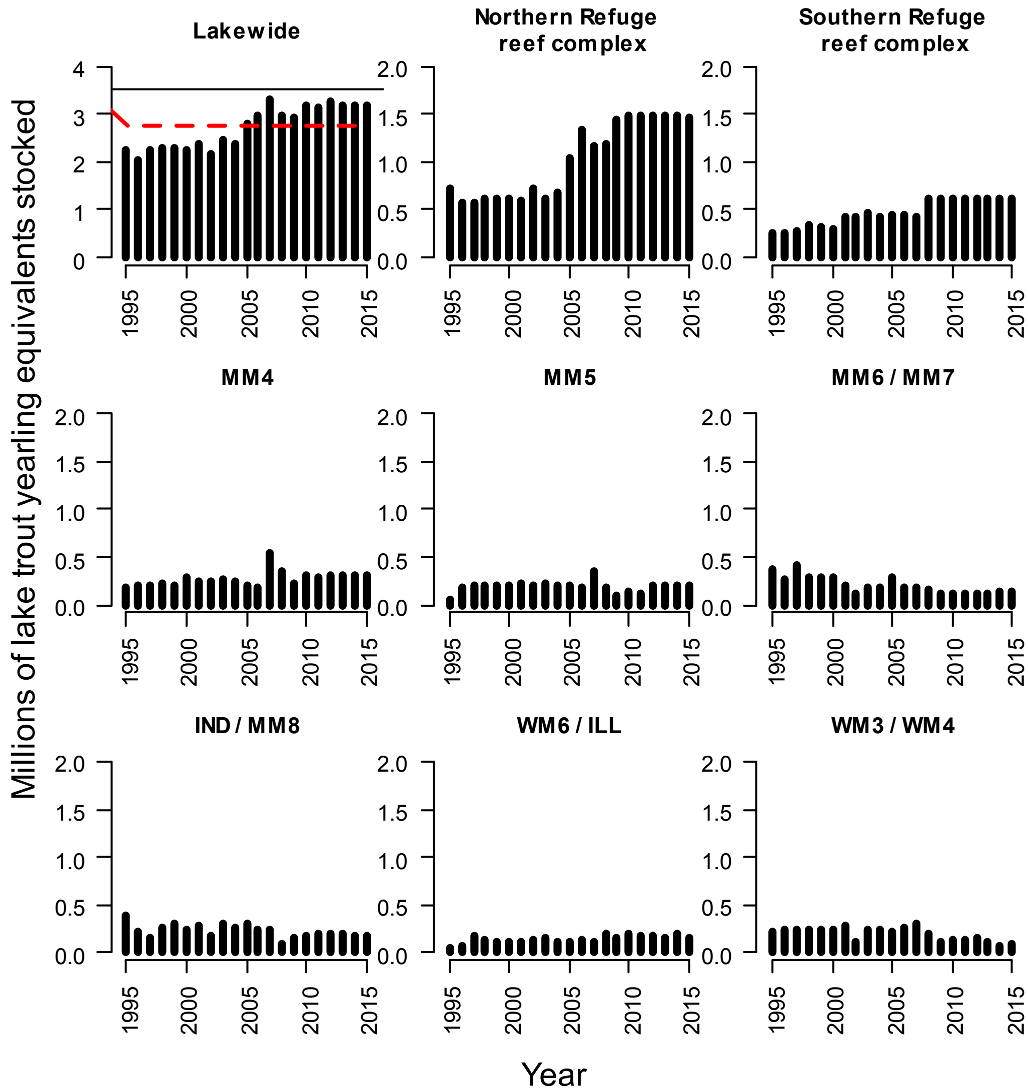

Figure 6. Instantaneous mortality rates for lake trout ages 6-11 in northern Lake Michigan and in MM6\7 waters proximal to the Southern Refuge. The black dashed line represents an instantaneous mortality rate of 0.51 that is equivalent to a 40% annual mortality rate.

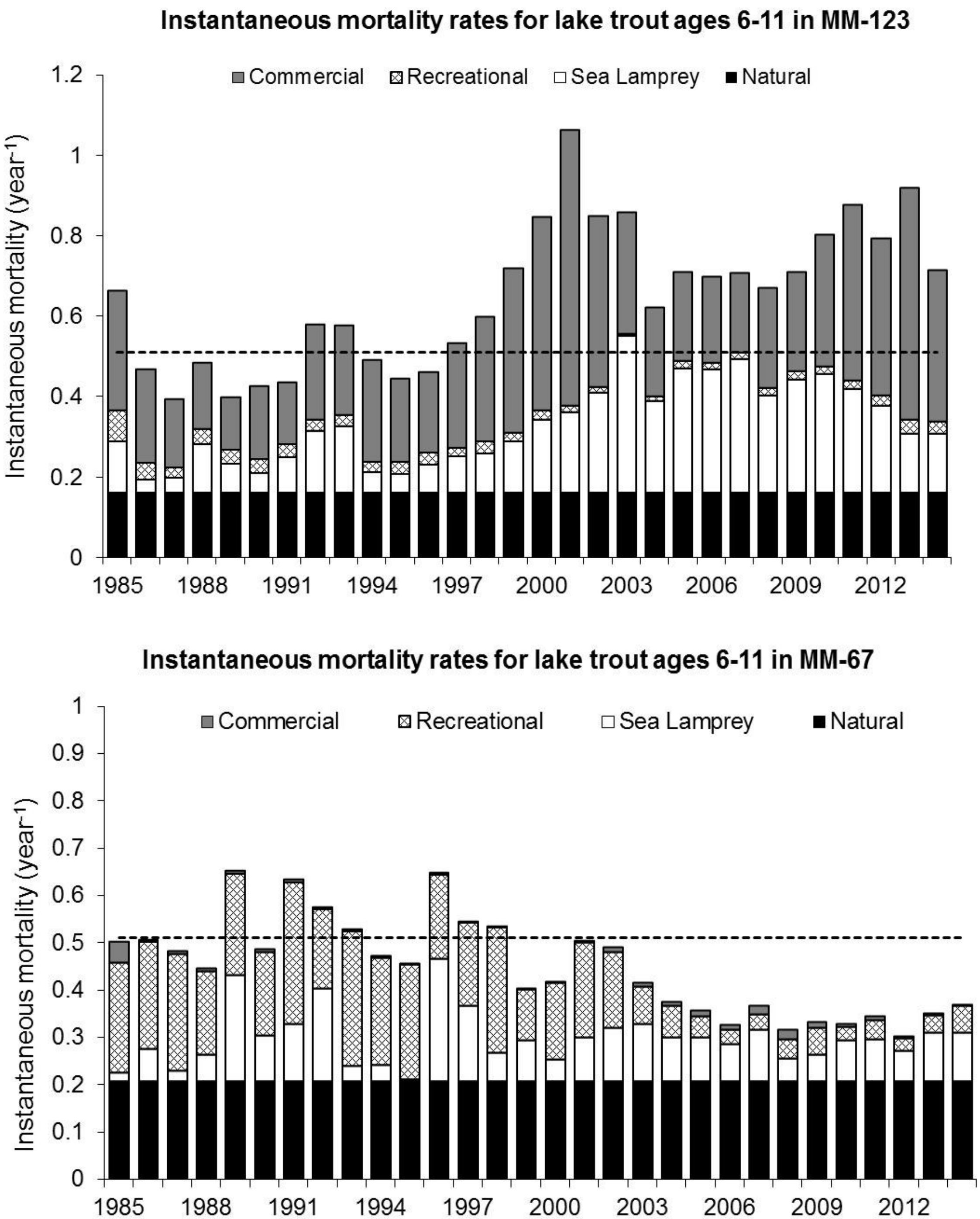

Figure 7. Sea lamprey-induced mortality on lake trout ages 6-11 for Lake Michigan management units MM3 and MM6\7.

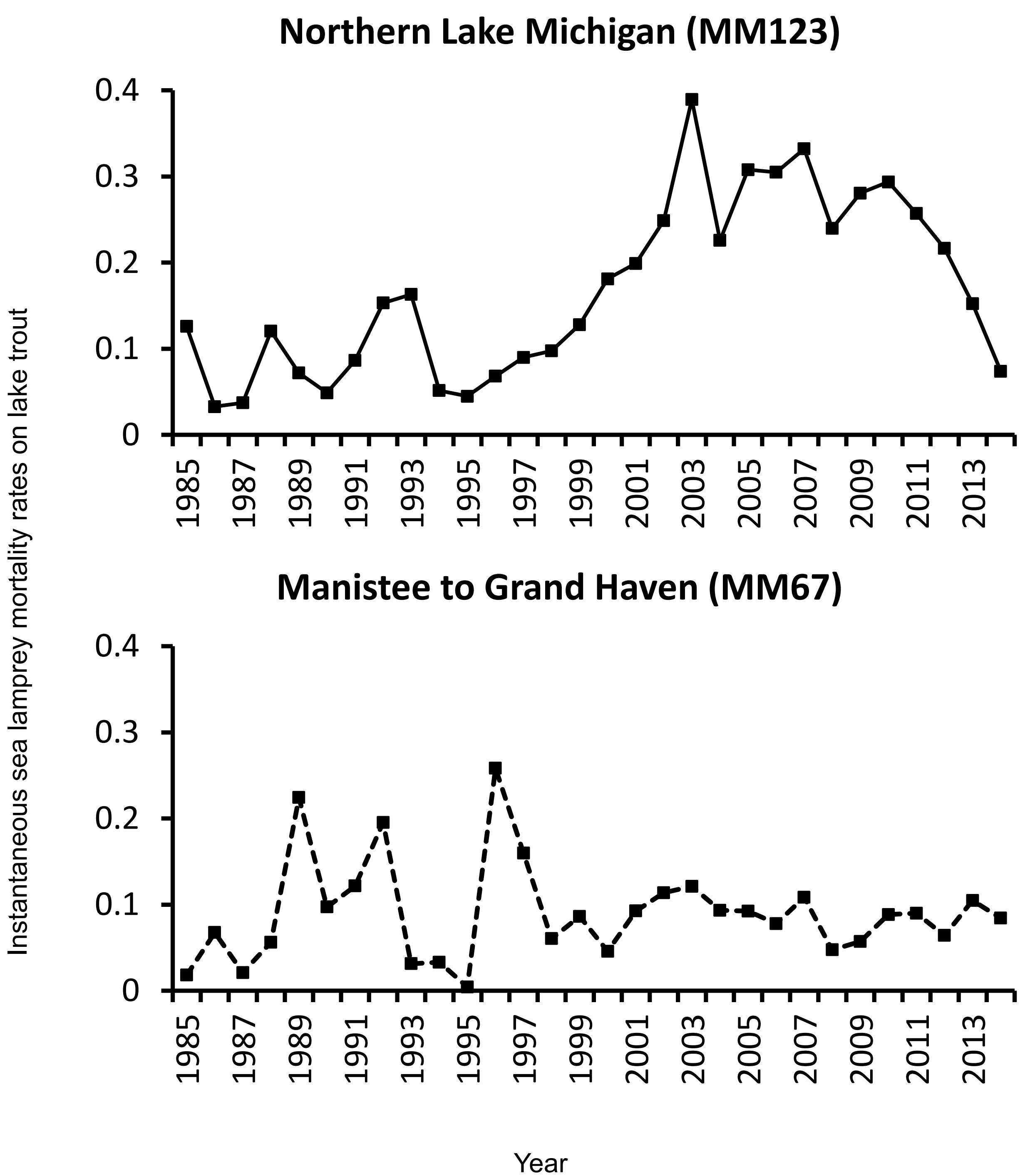

Figure 8. Time series of spring survey lake trout catch per effort (mean number of fish/1000 ft of graded mesh gill net) for the 11 LWAP sites plus 2 supplemental sites with comparable data (Grand Traverse Bay, Little Traverse Bay including near shore MM3 waters). Vertical bars represent ± 2 SE and the horizontal gray line shows the spring CPE benchmark of 25 fish per 1000'.

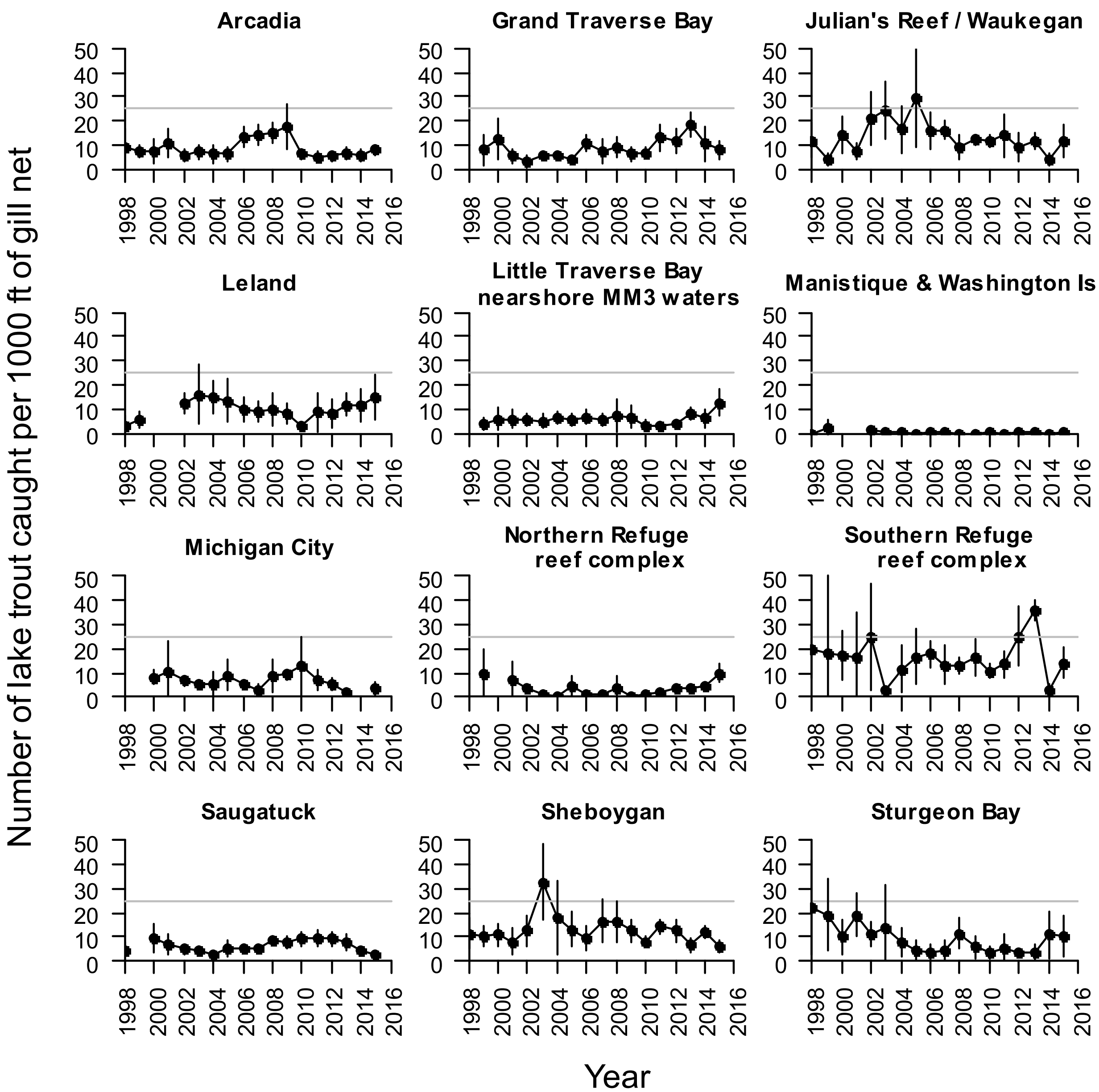

Figure 9. Time series of fall lake trout spawner survey catch per effort (mean number of fish/1000 ft of graded mesh gill net) for reefs within or near the spring LWAP stations. Vertical bars represent ± 2 SE and the horizontal gray line shows the fall CPE benchmark of 50 fish per 1000'.

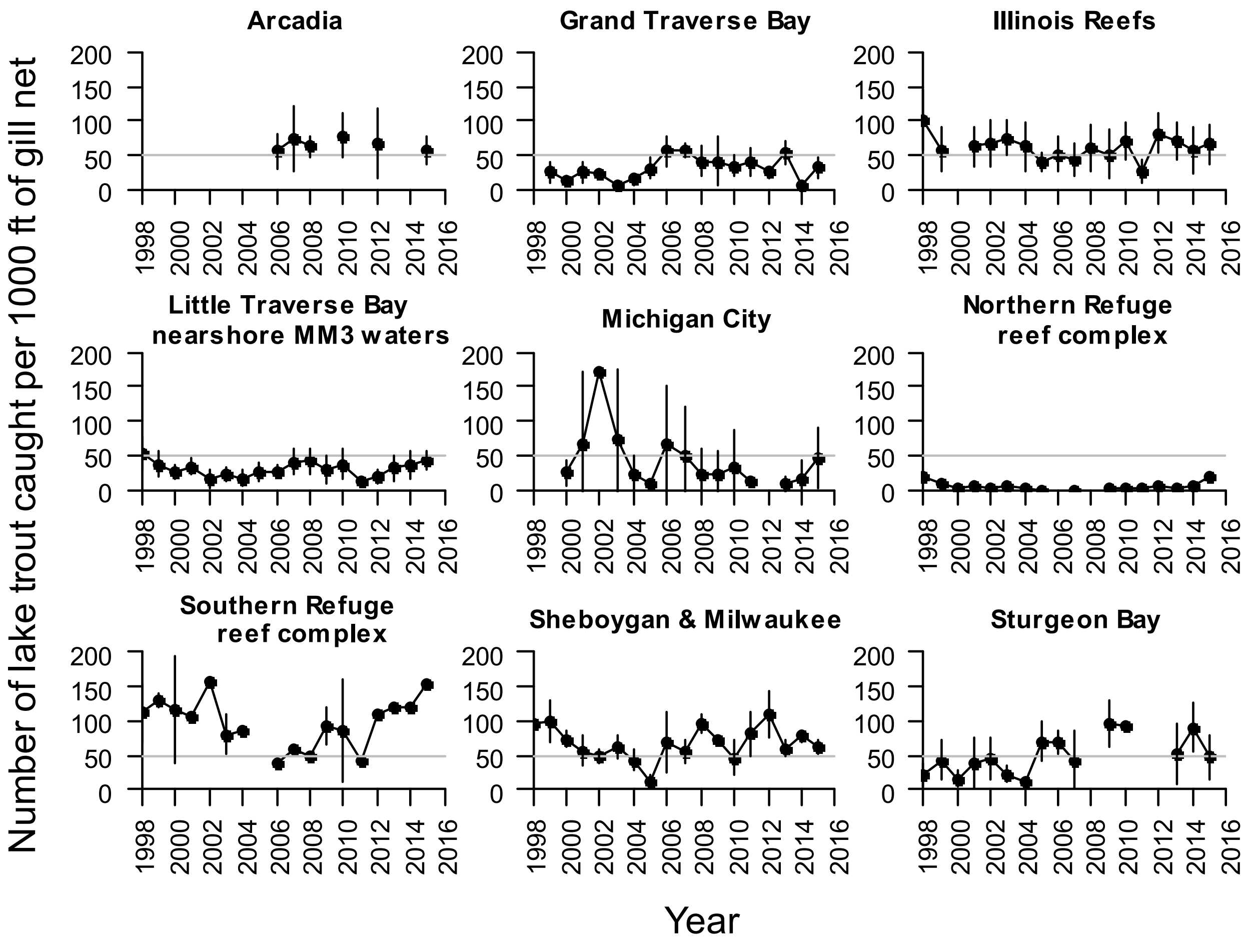

Figure 10. Proportion of females in fall spawner survey catches; the horizontal gray line portrays the Strategy evaluation objective of 25% females.

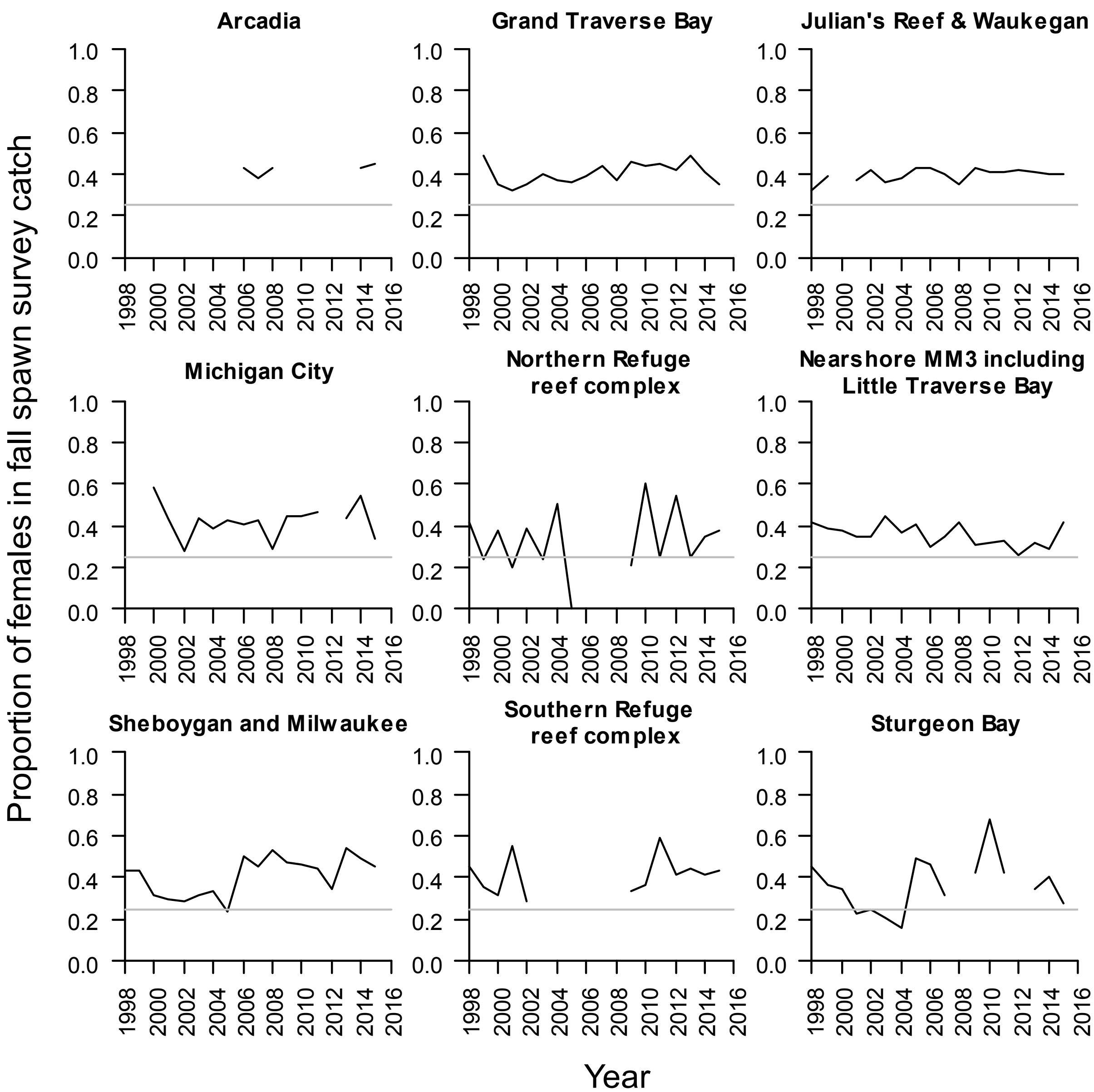

Figure 11. Number of lake trout captured during 2015 spawner surveys by age-class and origin.

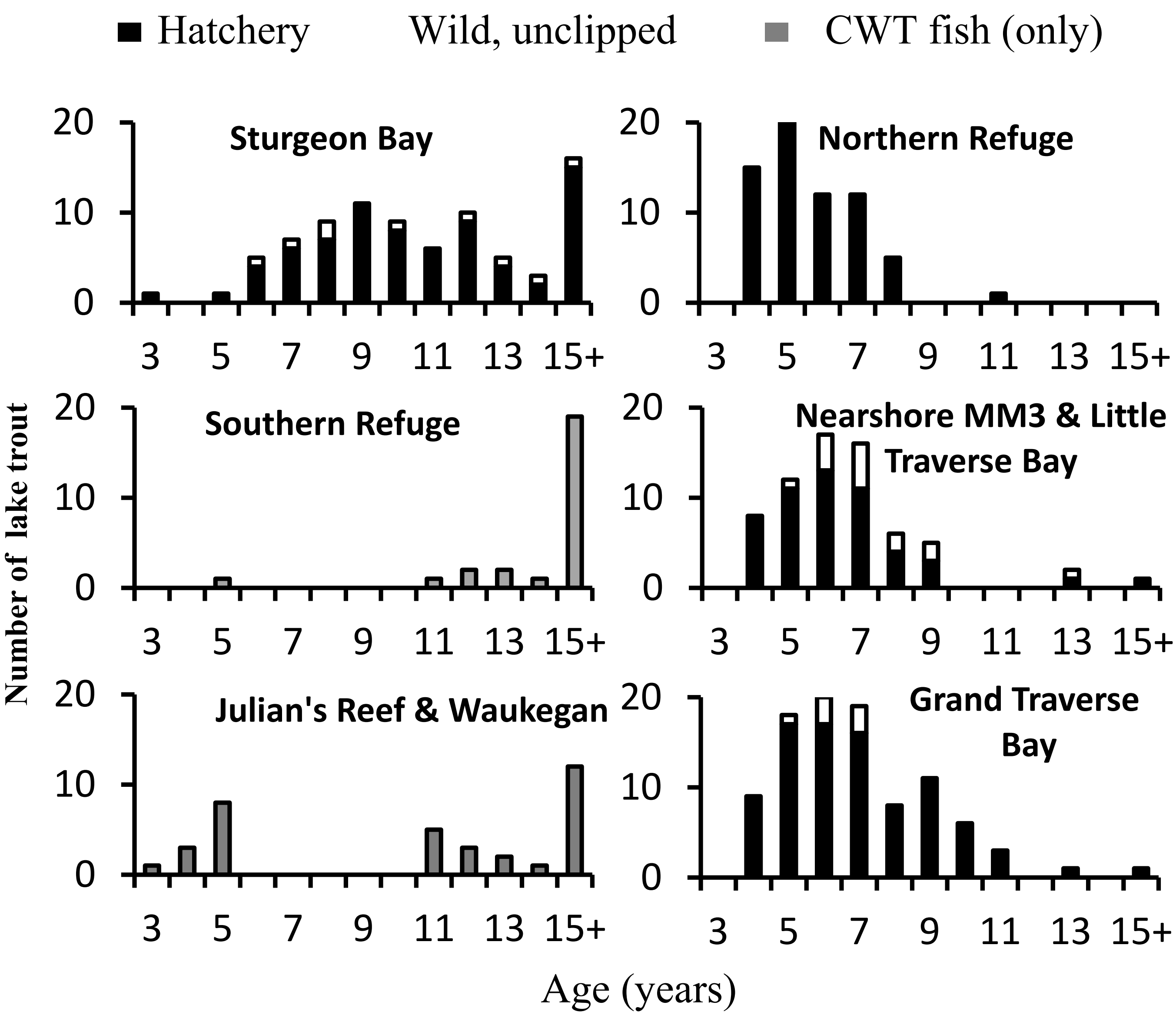

Figure 12. Numbers of lake trout eggs observed per square meter in northern Lake Michigan fall egg deposition surveys, 2000-2015. Egg deposition was measured using standard egg bag methodologies (Jonas et al.2005).

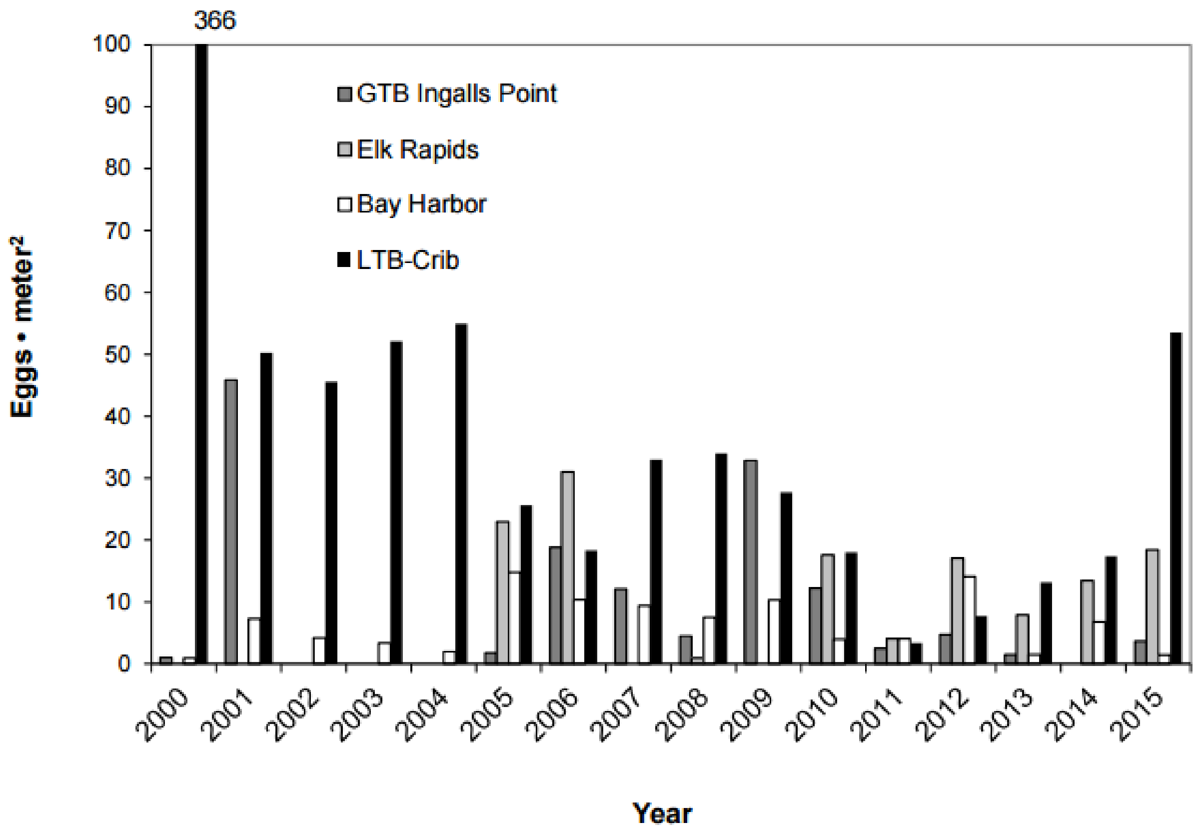

Figure 13. Mean egg thiamine concentrations (nmol/g) for ovulated lake trout females sampled in Lake Michigan fall spawner surveys, 2001 – 2013. Larvae produced from eggs with thiamine concentrations ≤ 4 nmol/g are often correlated with observations of early mortality syndrome (EMS).