Lake Michigan Salmonine Stocking Strategy

Lake Michigan Committee July 2014

Background

Lake Michigan is a dynamic ecosystem that has been significantly altered by the introduction of invasive and exotic species. Introduced Pacific salmon (coho and Chinook salmon) in the 1960s provided top-down predatory control for the invasive alewife, and established an extensive recreational fishery. At that time, predator-prey dynamics were most influenced by top-down mechanisms. As managers increased Chinook salmon stocking throughout the 1980s, angler catch and harvest likewise increased. Eventually, the amount of stocked Chinook salmon exceeded the available prey and the Chinook salmon population became stressed. Intensive culture of Chinook salmon that carried the Bacterial Kidney Disease (BKD) pathogen resulted in a disease outbreak in the stressed lake population. The first concerted effort to bring the predator-prey relationship into balance, resulting in a 25% lakewide reduction in Chinook salmon stocking, occurred in 1999.

More recently, the invasive *Dreissenid* mussels (quagga and zebra mussels) have shifted most of the productivity to the bottom of the lake thereby reducing the amount of food available for pelagic preyfish. In addition, establishment of planktivorous zooplankton (i.e., fishhook and spiny water fleas) appear to be causing additional intermediary impacts at lower trophic levels. There currently exists debate among the Lake Michigan researcher community as to the greatest contributing factor to an imbalance between predators and prey resources, however it is generally agreed that bottom-up mechanisms now exist.

As Lake Michigan’s productivity continued to decrease through the 2000s, fishery managers continued to see signs of low prey biomass and over-abundance of predators. Chinook salmon stocking was reduced lakewide by 25% again in 2006. While the actual cause for decreased productivity has yet to be established, it is apparent that top-down management of the prey resource is no longer a simplistic mechanism. The shift in productivity has contributed to reduced and sporadic prey fish production, which then has resulted in variable growth and survival of predator salmon and trout.

It is widely acknowledged that the most sensitive species in this predator-prey relationship are the Chinook salmon (predator) and alewife (prey). It was also apparent by a 2005 lakewide public meeting with anglers that natural reproduction of Chinook salmon in Lake Michigan was contributing a significant portion to the predator population. An important outcome of the 2005 meeting was strong public and manager support for a lakewide study of Chinook salmon natural reproduction to better estimate the abundance of predators. Treatment of hatchery-stocked Chinook salmon with oxytetracycline (OTC) in 2006-2010 provided estimates of approximately 50-55% natural reproduction for Chinook salmon in Lake Michigan. In addition to natural Chinook salmon recruits from Lake Michigan, recent studies using coded-wire tags indicate that hatchery-reared and naturally produced Chinook from Lake Huron are also found in Lake Michigan further creating an imbalance between predator demand and prey resources.

The Lake Michigan Committee (LMC) consulted with angling groups, the general public, and federal agencies to develop stocking reductions in 1999 and 2006. The continued decline in prey abundance coupled with information from the OTC study led managers again in 2010 to suggest that reductions in predator stocking were necessary to bring predators and prey closer to balance.

During 2011, fishery managers met with constituents representing sport fishing clubs, charter boat organizations, and the general angling public through a series of comprehensive and interactive workshops to develop more proactive management strategies for stocked salmonines. The resultant strategies were presented at a lakewide public meeting held in April 2012. Following the public meeting, and with input from the public, the Lake Michigan Committee adopted a salmon stocking strategy to be implemented in 2013.

Goals and Objectives

At the initial workshops, both fisheries managers and constituent anglers defined specific goals and objectives for the fishery. In general, there were similarities between those developed by the fishery managers and anglers.

Fishery Management Goals and Objectives

- Maintain acceptable catch rates (8-12 fish/100 hrs)
- Maintain a diverse fishery (>50% Chinook; >25% other species)
- Maintain good salmon growth (Age 3 Chinook > 7 kg [15.4 lbs] in late summer)
- Maintain alewife below undesirable levels
- Maintain adequate spawning stock biomass for lake trout

Constituent Goals and Objectives

- Maintain ecosystem balance
- Maximize harvest and catch rates (catch per effort)
- Maximize sport fish potential
- Maximize sustainable benefits
- Protect forage biomass
- Minimize collapse of the forage base (alewives)
- Avoid loss of native species
- Provide larger Chinook (16-18 lbs range for age 3+)
- Maintain a stable fishery
- Maintain a diverse fishery

Model description and changes from previous models

The Lake Michigan Technical Committee's Red Flags Analysis was utilized in 1999-2010 to identify imbalance in the predator-prey ratio and was critical for determining when a change in management strategy was justified. Previous changes to stocking levels were also guided by the CONNECT model and a salmon stocking model developed by Drs. Michael Jones and Jim Bence, both currently with the Quantitative Fisheries Center at Michigan State University. Following the 2005 meeting, the Lake Michigan Committee decided that a re-development and expansion of the salmon stocking model would be beneficial in guiding future stocking changes. The redeveloped salmon decision model includes catch-at-age model components for estimation of alewife biomass and standing stock of Chinook salmon predators. The model was run for several scenarios (e.g., status quo or 25% reduction in Chinook stocking) and model outputs were used in evaluation of risks associated with different management actions.

Stocking options and model outputs

Four strategic stocking options were presented to the public in April 2012 (Table 1). Two options, one of which employed a feedback mechanism, included reductions in strictly Chinook salmon. Two other options included reductions in Chinook salmon and other species. It was decided that an option of "status quo", included in the previous two stocking reductions, was not warranted at this time due to historically low alewife abundances, new information regarding natural recruitment and immigration of Chinook salmon, and constituent and fishery managers' discomfort with risk associated with that option.

Table 1. Risk (number of occurrences in 100 model simulations) associated with four measures of predator-prey balance from stocking options presented at a 2012 public meeting.

Stocking options	Alewife biomass < 100kt	Age-3 Chinook salmon < 13 lb	Chinook salmon harvest < 200,000	< 8 Chinook salmon / 100 hours
Option 1	14	23	21	19
Option 2	12	20	21	19
Option 3	4	12	10	9
Option 4	3	11	7	6

Option 1 – 50% reduction in Chinook salmon stocking; evaluate after 5 years

Option 2 – 50% reduction in Chinook salmon stocking; alter stocking based on Chinook salmon weight feedback mechanism; 3 year evaluation

Option 3 – 30% reduction in Chinook salmon stocking and 10% other salmonines (excluding lake trout); alter stocking based on Chinook salmon weight feedback mechanism; 3 year evaluation

Option 4 – 30% reduction in Chinook salmon stocking and 10% other salmonines; alter stocking based on Chinook salmon weight feedback mechanism; 3 year evaluation

Option 2 was generally preferred by fishery managers and constituents. This option provided for more immediate reaction to predator-prey imbalance than Option 1 (3-year vs 5-year) and resulted in lower risk associated with low alewife biomass, decreased Chinook salmon weights, decreased Chinook salmon harvest, and decreased Chinook salmon CPUE (Table 1). There was slightly higher risk associated with Option 2 compared to Options 3 and 4, however, Option 2 was limited to reductions in Chinook salmon stocking and did not affect stocking of other salmonine species.

The remainder of this document provides a framework by which Lake Michigan fishery managers may alter stocking strategies to ensure continued fisheries and better balance predator demand with prey availability.

Salmonine Stocking Strategy

The LMC adopted a modified version of Option 2 (50% Chinook salmon reduction and implementation of a feedback policy) to be implemented with stocking in spring of 2013. The modification results from LMC agreement that WI and MI may utilize species equivalence numbers to substitute reductions in other species in place of a portion of Chinook salmon to achieve a 50% lakewide reduction in Chinook salmon. A feedback policy would be used to determine when additional changes to the stocking policy were necessary rather than a fixed timeframe. Overall reductions are drawn from the 2012 stocking target numbers in state management plans.

2012 stocking target numbers

State fishery agencies submitted state stocking plans for Lake Michigan and these plan numbers were adopted by the LMC as the 2012 stocking baseline (Appendix A). Approximately 12.9 million salmon and trout, comprised of fall fingerlings, spring fingerlings, and yearlings, were designated for stocking in state management plans. LMC agreed that the 2012 stocking plan numbers will be used as the baseline for the 2013 reduction and when developing future reductions or additions of stocked fish.

Species equivalence

Fishery biologists commonly agree that not all species are equivalent in terms of diet requirements, overlap with specific prey fish, annual consumption, or consumption over lifespan. "Chinook salmon equivalents" were developed in the 1980s for Lake Michigan salmonines as a way to compare prey fish consumption rates among species. These equivalence values have been updated through time when additional studies were completed. The LMC adopted the latest version (Table 2) of these values for use in this stocking strategy. In addition, a previously proposed equivalence rate for lake trout of 1.0 fall fingerling = 0.4 yearling lake trout was adopted.

Table 2. Number of each species equivalent to one stocked Chinook salmon.

Species	Number of fish equivalent to one (1) Chinook salmon
Chinook salmon	1.00
Coho salmon	3.20
Lake trout (yearling)	2.30
Lake trout (fall fingerling)	5.75
Rainbow trout	2.40
Brown trout	2.20

Per LMC agreement, agencies can account for hatchery shortages by stocking more of a particular species (except Chinook salmon) by using these species equivalences such that the number of Chinook salmon equivalences stays relatively the same (e.g. replace a 24,000 rainbow trout shortfall with 32,000 coho salmon).

2013 stocking targets

Approximately 3.3M Chinook salmon were included in the 2012 stocking plans. A 50% lakewide reduction in Chinook salmon stocking will be accomplished through state-specific reductions (Table 3).

Table 3. 2012 Chinook salmon plan numbers and 2013 target numbers.

	2012 Plan	2013 Target	Reduction
Illinois	250,000	230,000	8.0%
Indiana	225,000	200,000	11.1%
Michigan	1,688,500	558,500	66.9%
Wisconsin	1,164,000	724,000 [a]	37.8%
Total	3,327,500	1,712,500	48.6%

[a] see note on equivalence

State-specific allocations of the lakewide 50% Chinook salmon reduction were determined using a variety of criteria including prevalence of natural reproduction, lakewide contribution to total Chinook stocking, and concerns regarding maintenance of fall fisheries.

Wisconsin proposed, and LMC agreed, that Wisconsin could achieve its overall stocking reduction target by incorporating non-Chinook salmon predators (e.g. lake trout) into its stocking reduction plans. Per LMC agreement, Wisconsin may utilize species equivalence values to offset any Chinook salmon reduction beyond 30% (i.e., up to 7.8% of total 37.8% reduction by Wisconsin may be species other than Chinook salmon). Thus, Wisconsin would be limited to stocking a maximum of 814,800 Chinook salmon (30% reduction) and will reduce other species in the amount of 90,800 "Chinook salmon equivalents" to achieve a 37.8% reduction of Chinook equivalents (Table 3).

Lake trout rehabilitation and changes to stocking

LMC reaffirmed its interest in lake trout rehabilitation for Lake Michigan. Stocking of lake trout fall fingerlings is included in *A Fisheries Management Implementation Strategy for the Rehabilitation of Lake Trout in Lake Michigan* (Implementation Strategy) in predominantly shoreline locations (i.e., secondary rehabilitation sites). LMC agreed that lake trout fall fingerlings may be utilized by Wisconsin in achieving its Chinook salmon reduction target. U.S. Fish and Wildlife Service should be notified of any changes to the numbers specified in the Implementation Strategy, and the LMC acknowledges: 1) when changes to lake trout stocking numbers are requested, fish already in the hatchery system should be used for stocking; 2) there is a lag between development of fish for stocking and potential requests for stocked fish; and, 3) changes to numbers of lake trout requested per the Implementation Strategy (e.g., requests for less fall fingerling lake trout) may become permanent if USFWS reduces its fingerling production capacity to coincide with LMC requests for lake trout.

Planned and actual numbers

It is commonly accepted that actual hatchery stocking numbers are often +/- 10% of target production numbers. LMC has agreed to limit overages in actual stocking numbers to 5% of target production numbers. This will require communication between LMC members and their respective state hatchery managers. In addition, USFWS should be notified regarding changes to target lake trout production numbers, as lake trout should also be limited to 5% overages.

Feedback Policy

Previous lakewide changes to stocking in 1999 and 2006 were brought about by multiple information sources including public feedback, predator weights and alewife abundance estimates, and the LMTC Red Flags analysis results. These information sources were beneficial for monitoring predator-prey balance, but a methodology for determining appropriate actions and the magnitude of those actions was lacking. Under this salmon stocking strategy, LMC will utilize a feedback mechanism to identify when an imbalance exists between predator demand and prey abundance, and to determine when a change in the salmon stocking strategy is appropriate. The intentions of including a feedback policy were to: 1) allow for more timely modifications to the stocking strategy than the historically-used, 5-year evaluation period; 2) streamline the evaluation process (i.e., remove the ambiguity of using multiple indicators); and, 3) reduce the subjectivity of the decision. Option 2, as presented at the April 2012 lakewide stocking conference, included weight of age-3+ female Chinook salmon at the Strawberry Creek weir (WI) as the indicator of predator-prey balance.

Feedback indicator and frequency of evaluation

In the absence of a better indicator, LMC adopted weight of age-3+ female Chinook salmon at the Strawberry Creek weir (WI) as the feedback indicator to evaluate the predator-prey balance. Age-3+ fish are those fish that have completed four summers in the lake. For example, a Chinook salmon stocked in spring 2013 would be classified age-0+ in fall 2013, age-1+ in fall 2014, age-2+ in fall 2015, and age-3+ in fall 2016, having spent the summers of 2013, 2014, 2015, and 2016 in the lake. While a long-standing historic record exists for the condition (weight) of fish returning to the Strawberry Creek weir and that it typically reflects relative condition of the Chinook salmon population in the lake as a whole, it is acknowledged that the measure is not without issues. Namely, flows in Strawberry Creek are highly dependent on rainfall and low flows may impede or delay movement of mature fish to the weir (Legler, personal communication.) Thus, the average weight of Chinook salmon at Strawberry Creek weir may be lower in some years relative to the lake when egg collection operations cease before the run is complete. Given the potential for differences between condition values obtained at Strawberry Creek and the lake, LMC agreed that a more consistent and perhaps better indicator of predator-prey balance should be explored for the future.

LMC adopted 7 kg and 9 kg as the weights at which a change in management strategy may be warranted. Following model runs of the Salmon Decision Analysis model, instances where the three-year average weight of age-3+ female Chinook salmon is below 7 kg indicate that predator-prey imbalance exists in favor of predators and a change in stocking strategy is appropriate (e.g., reduce stocking). Conversely, predator-prey imbalance exists in favor of prey when the weight of Chinook salmon is above 9 kg and a change in stocking strategy also is appropriate (e.g., increase stocking). In instances where the growth indicator (three-year average) is between 7 and 9 kg, no change in the stocking strategy is anticipated.

Following a change in stocking levels (e.g., 2013 reduction), it is unlikely to see immediate effects and an evaluation period is required to determine the impact of the change. LMC agreed that a more proactive approach to predator-prey management could be achieved if the 3-year average began with the year of decision to change the stocking strategy, rather than the year of implementation of a new stocking strategy. Thus, the status of the predator-prey relationship following the 2013 reduction will be evaluated by the 3-year average weight of Chinook salmon measured in 2012 (year of decision), 2013 (year of implementation), and 2014 (one year post-implementation). Egg take in 2015 would allow for adjustment of predator stocking numbers in 2016.

If no change to the stocking strategy is warranted in 2015 (year of decision), then the 3-year average for 2013, 2014, and 2015 will be used to evaluate the predator-prey balance in 2016 (next year of decision) for a potential change to the stocking strategy in 2017. Thus, when no changes in stocking policy occur, the 3-year average will be treated like a rolling average and annually the LMC will review the average weight from the previous three years. It will be incumbent upon Wisconsin DNR to have Strawberry Creek weir data available to the LMC by the end of each year to potentially affect stocking the following spring. It is generally agreed that reductions to fish in the hatchery must occur at the egg or fry stages. In addition, increases to state allocations will be difficult if sufficient eggs are not collected to allow increases in stocking allocations the following spring.

Changes to 2013 numbers and subsequent changes to stocking numbers

It would be most efficient to annually adjust stocking numbers relative to a feedback mechanism through a linear relationship. Hatcheries however do not have the capability to adjust rearing operations on a less than raceway measure. In addition, changes to stocking numbers may have less effect than expected due to significant contributions of natural or immigrating fish. For example, the 50% lakewide reduction of stocked Chinook salmon in 2013 was at most a 25% reduction in Chinook salmon inputs due to equivalent numbers of Chinook entering the system by other means (i.e., natural recruitment and immigration).

LMC decided that having established step-wise changes for lakewide stocking, based on a feedback measure, were more appropriate. Changes to stocking numbers would therefore shift up or down to established stocking levels based on the feedback measure (Table 4). For example, an average weight of 9.1 kg (2012, 2013 and 2014) calculated in 2015 would result in a shift from level 3 to level 2 (30% increase) for 2016. Conversely, an average weight of 6.8 kg (2012, 2013 and 2014) calculated in 2015 would result in a shift from level 3 to level 4 (30% decrease).

Table 4. Lakewide Chinook salmon stocking numbers and percentages of 2012 plan totals.

Stocking level	Number of Chinook salmon	Percentage of 2012 plan
1	3,327,500	100
2	2,662,000	80
3	1,712,500	50
4	665,500	20

When a change in the stocking strategy occurs, the three-year average is reset and evaluation of the predator-prey balance begins again with the year-of-decision to alter the stocking strategy. Thus, the minimum interval for any change in stocking strategy is three years. LMC has agreed however that changes to the stocking strategy may be implemented within the three-year evaluation period, if significant annual changes to the feedback measure occur or other indicators of ecosystem health (e.g., alewife biomass as reported by USGS) indicate severe imbalance between predators and prey.

This stocking strategy does not address situations where the feedback indicator suggests stocking increases above 2012 levels (100%) or stocking decreases below 20% of 2012 levels (Table 4).

Adopted by Lake Michigan Committee July 2014

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Appendix A. Wisconsin (WI), Illinois (IL), Indiana (IN), and Michigan (MI) 2012 stocking plans for Lake Michigan. BRT = brown trout, CHS = Chinook salmon, COS = coho salmon, RBT = rainbow trout, STT = steelhead rainbow trout, LAT = lake trout, YR = yearling, FF = fall fingerling.

							MI	FWS	FWS
	BRT	**CHS**	**COS**	**RBT**	**STT**	**STT-YR**	**LAT - YR**	**LAT - YR**	**LAT - FF**
WI	672,000	1,164,000	500,000	120,000	510,000	0	0	0	0
IL	100,000	250,000	300,000	50,000	50,000	0	0	0	0
IN	35,000	225,000	240,000	0	250,000	331,000	0	0	0
MI	600,000	1,688,500	1,570,000	0	540,000	0	80,000	0	0
TOTALS	**1,407,000**	**3,327,500**	**2,610,000**	**170,000**	**1,350,000**	**331,000**	**80,000**	**3,030,000**	**550,000**