Lake Ontario stocked salmon and trout equivalents

New York and Ontario each stock a variety of salmon and trout species in Lake Ontario and each species consumes different amounts of prey during their lifespan. The amount of prey fish consumed over an average lifespan varies between species due to species level differences in growth and energy conversion. Therefore, one species may have a greater or lesser impact on the prey population than another species. A key objective for Lake Ontario is to maintain a balance between top predators and available prey fish, and understanding how prey fish consumption varies between species is important when making decision to increase or decrease stocking of a given species.

A set of stocked salmon and trout equivalents is needed for Lake Ontario because it provides a standardized measure of the impact on the prey base from the current stocking load and provides a common currency to use when making stocking changes. Stocked salmon and trout equivalents allow an agency to substitute X number of species A for Y number of species B without changing the overall prey consumption by stocked fish. This provides agencies with the flexibility to make substitutions in the number of stocked fish to offset shortfalls in hatchery production within a given year, and/or to make changes in the number of each species they stock to better achieve fisheries management objectives.

This document provides 1) a set of standard stocked fish, 2) conversion factors used to convert early life stages to the standard stocked fish, and 3) a set of stocked salmon and trout equivalents based on Chinook Salmon Smolt Equivalents. Conversion factors and Chinook Salmon Smolt Equivalents are based on the best available information and will be updated if/when new information becomes available. The Lake Ontario Technical Committee will review the standard stocked fish, lifestage conversions factors, and Chinook Salmon Smolt Equivalents at least every five years and make recommendations to the Lake Ontario Committee for changes, however, changes may be made sooner than the five-year period if necessary.

Survival of Stocked Fish

Fishery managers must consider the overall survival of stocked fish when considering predator/prey balance. In general, survival of stocked salmon and trout in Lake Ontario is assumed to be relatively low. For example, survival, from age-0 to age-1, of Chinook salmon stocked in the Salmon River was estimated to be approximately 14% by Murrey et al. (2010). Relatively low survival of stocked fish is normal and is the reason that so many fish are stocked (greater than 3 million salmon and trout stocked in Lake Ontario in 2023). Survival of wild salmon and trout in Lake Ontario is likely to be variable due to environmental factors such as stream flows, temperature, winter severity etc. Survival of stocked fish is also variable but is expected to be less variable than wild fish because of the controlled early life environment in the hatchery. For lake-wide planning purposes, we assume that all standard stocked fish (see below for definition of standard stocked fish) have similar survival each year and that the return to the fishery from stocking is approximately 10% for all species.

Standard stocked fish

To account for differences in survival of fish stocked at different lifestages (e.g., spring yearling vs fall fingerling), all stocked fish are adjusted to a standard stocked fish for each species. We assume

consistent and equal survival between all standard stocked fish. Any fish that are stocked at earlier lifestages are adjusted relative to the standard stocked fish. This creates a common currency of standard stocked fish that can be used to determine stocked salmon and trout equivalents based on Chinook Salmon Smolt Equivalents (Table 1).

Table 1. Standard stocked fish for six species of trout and salmon.

Species	**Lifestage**	**Size**
Atlantic Salmon	Spring Yearling	50-70 g
Brown Trout	Spring Yearling	80-120 g
Pen-reared Chinook Salmon	Spring Fingerling	6-8 g
Coho Salmon	Spring Yearling	25-30 g
Lake Trout	Spring Yearling	30-50 g
Rainbow Trout	Spring Yearling	35-45 g

Life stage conversions

Chinook Salmon are stocked as spring fingerlings (age-0) and most other species of salmon and trout are stocked as spring yearlings (age-1). However, some Coho Salmon and Atlantic Salmon are stocked as spring fingerlings and fall fingerlings in the Province of Ontario, and surplus hatchery production of all species is sometimes stocked as spring fingerlings or fall fingerlings in both New York and Ontario. Coded wire tagging studies have shown that the return on spring yearling Lake Trout is approximately 2.4 times as high as fall fingerling stocking (Elrod et al. 1988) and that spring yearling Coho Salmon have returns 4 to 12 times higher than fall fingerlings (Connerton et al. 2022). Limited data exists on how stocking age-0 spring fingerlings compares to age-1 spring yearling stocking, but for our purposes we assume that spring fingerlings, for all species except Chinook salmon, have relatively low survival.

The standard conversion for fall fingerlings to spring yearlings is 2.4 fall fingerlings to 1 spring yearling for Lake Trout based on Elrod et al. (1998) and is 4 fall fingerlings to 1 spring yearling for all other species based on the highest observed return on Coho Salmon fall fingerlings from Connerton et al. (2022). Age-0 spring fingerlings are assumed to have limited survival and can be converted to spring yearlings at 10 spring fingerlings to 1 spring yearling. Fry stocking rarely occurs in Lake Ontario but this lifestage is assumed to have extremely low survival and is converted to spring yearlings at 100 fry to 1 spring yearling (Table 2).

Table 2. Conversion factors used to convert early lifestages of stocked fish to standard stocked fish.

Life stage	Species	Conversion to standard stocked fish
Fry	Atlantic salmon	0.01 (100:1)
	Brown trout	
	Coho salmon	
	Rainbow trout	
	Chinook salmon	
Spring fingerling	Atlantic salmon	0.1 (10:1)
	Brown trout	
	Coho salmon	
	Rainbow trout	
Direct stocked spring fingerling	Chinook salmon	0.5 (2:1)
Fall fingerling	Atlantic salmon	0.25 (4:1)
	Brown trout	
	Coho salmon	
	Rainbow trout	
Fall fingerling	lake trout	0.42 (2.4:1)

Chinook salmon smolt equivalents

Chinook salmon typically spend four summers in the lake and consume the most prey fish of any other species on an individual basis and at the lake wide population level. Therefore, we adjust all standard stocked fish to Chinook Salmon Smolt Equivalents based on the typical lifetime prey fish consumed. Conversions between species of stocked salmon and trout are then done using Chinook Salmon Smolt Equivalents.

We considered two approaches when developing Chinook Salmon Smolt Equivalents. The first used a modeling approach that incorporated annual survival up to a maximum age, annual changes in conversion efficiency (i.e., how well a species converts consumed prey to growth), diet, and average weight at each age. The second approach was less complex and estimated average lifetime consumption of a fish that reached a specified age using gross conversion efficiency and the average weight at the specified age.

The first approach was found to be extremely sensitive to survival, especially in the first year after stocking. For example, if a species was given a first-year survival of 0.1 the model generated a consumption value that was twice as high compared to a first-year survival of 0.05. Quantitative data on the exact survival values in the first-year post stocking are limited and are assumed to be variable year to year. Due to the sensitivity of the modeled approach and the uncertainty in the estimated survival we choose to use the simpler approach to develop Chinook salmon equivalents and assume equal survival for all species.

The data inputs used to generate Chinook Salmon Smolt Equivalents of standard stocked fish are shown

in Table 3. and the Chinook Salmon Smolt Equivalents are shown in Figure 1. The average weight value is the average weight at age from the New York open lake creel survey from 2018-2022 for Brown Trout, Chinook Salmon and Coho Salmon. The average weight for Rainbow Trout is the average weight at age from the Salmon River Hatchery steelhead broodstock collection. The average weight for Lake Trout is the average weight at age from the New York adult Lake Trout gill net assessment. The age represents the age at which greater than 90% of fish harvested, or collected during surveys, are that age or younger. There were very few weights at age available for Atlantic Salmon from the New York open lake creel survey during 2018-2022, so we used the average weight of all Atlantic salmon weighed in the creel survey from 2010-2022 (n=108). Conversion efficiency values are the average of the year class specific gross conversion efficiency values reported in Tsehaye et al. (2014). Atlantic Salmon are not included in Tsehaye et al. (2014) and the conversion efficiency value for Atlantic Salmon was set the same as Brown Trout. Total prey fish consumption is estimated by dividing the average weight by the gross conversion efficiency. Chinook Salmon Smolt Equivalents are generated by dividing the total consumption of Chinook Salmon by the total consumption of another species.

Table 3. Data inputs used to generate lifetime prey fish demand in support of establishing Chinook salmon equivalents for Lake Ontario salmon and trout.

Species	Age	Average weight (lbs)	Conversion efficiency	Total Consumption (lbs)	Chinook Equivalents
Atlantic Salmon	3	7.9	0.199	39.7	2.6
Brown Trout	3	6.1	0.199	30.7	3.4
Chinook Salmon	3	18.1	0.174	104.0	1.0
Coho Salmon	2	6.6	0.242	27.3	3.8
Lake Trout	11	12.2	0.127	96.1	1.1
Rainbow Trout	4	8.0	0.184	43.5	2.4

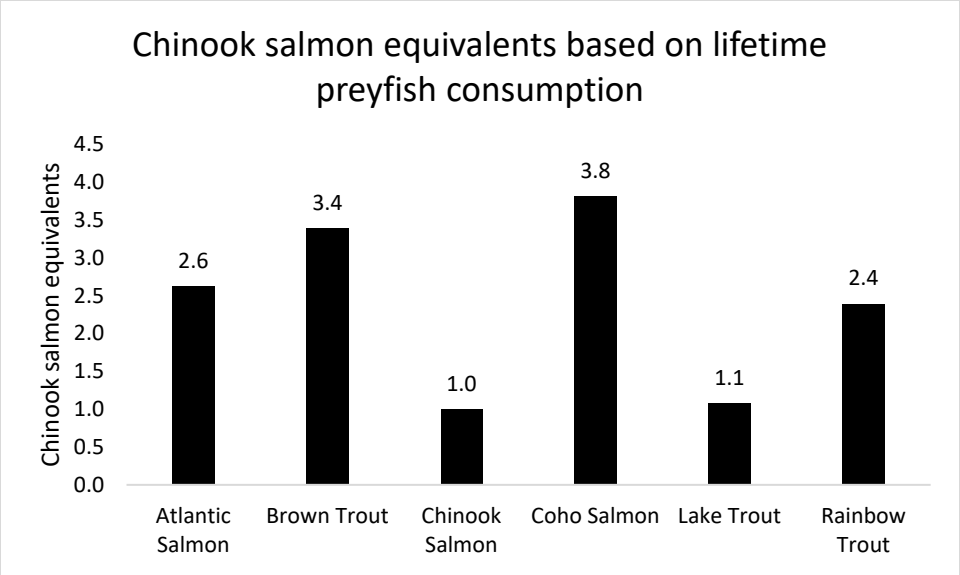

Figure 1. Chinook Salmon equivalents based on estimated lifetime preyfish consumption of Chinook salmon compared to Atlantic salmon, brown trout, coho salmon, lake trout, and rainbow trout.

References

Connerton, M.J., S.E. Prindle, R.J. Moore, C. Lake and M.J. Yuille. 2023. The Relative Survival of Stocked Fall Fingerling vs Spring Yearling Coho Salmon and the Proportions of Wild and Hatchery Coho Salmon in Lake Ontario. Section 3 *in* NYSDEC 2021 Annual Report, Bureau of Fisheries, Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee.

Elrod, J. H., Schneider, C. P., and Ostergaard, D. A. 1988. Comparison of hatchery-reared lake trout stocked as fall fingerlings and as spring yearlings in Lake Ontario. N. Amer. J. Fish. Manage. 8:455-462.

Murry, B. A., M. J. Connerton, R. O'Gorman, D. J. Stewart, and N. H. Ringler. 2010. Lakewide estimates of alewife biomass and Chinook salmon abundance and consumption in Lake Ontario, 1989-2005: Implications for prey fish sustainability. Transactions of the American Fisheries Society. 139:223-240.

Tsehaye, I., M. L. Jones, J.R. Bence, T.O. Brenden, C.P. Madenjian, and D.M. Warner. 2014 A multispecies statistical age-structured model to assess predator–prey balance: application to an intensively managed Lake Michigan pelagic fish community. Canadian Journal of Fisheries and Aquatic Science. Vol. 71.
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https://doi.org/10.1139/cjfas-2013-0313