Experimental Brown Trout Stocking Program: Brown Trout Strain Field Comparisons

By: Wes Ashe, Belgrade Lakes Region
Jim Pellerin, Sebago Lake Region

November 2020

Maine Department of
Inland Fisheries & Wildlife
Fisheries and Hatcheries Division

ABSTRACT

Brown Trout (BNT) (*Salmo trutta*) were first introduced to Maine waters in 1885 for recreational angling, but the stockings were largely unsuccessful and were suspended in 1932. When the program was restarted, fisheries managers were more knowledgeable of BNT habitat requirements and the overlap with Maine's native salmonids. Various BNT strains were stocked over the next several decades, but in 1968 the New Gloucester (NG) strain was developed and used almost exclusively until 2018. In the late 1990's and early 2000's, fisheries managers and anglers recognized a statewide decline in BNT performance, and electrophoretic analysis confirmed very poor genetic integrity in the NG strain. As a result, a comprehensive BNT strain evaluation was initiated in 2003. Three strains including the NG, Sandwich River (SA), and Seeforellen (SE) BNT were selected for the study, and both a field and hatchery component were incorporated into the study design. The field performance evaluation began in 2010 and a representative sample of waters from Region A (n = 13), B (1), and C (4) were stocked with paired strains. The four selection criteria (i.e. genetic integrity, growth, survival, and catchability) were evaluated with a lab analysis, along with various gill-nettings, trap-nettings, and winter creel surveys. The SE strain had significantly more genetic integrity than the SA and NG BNT, respectively. A Kruskal - Wallis (K-W) test concluded that the SE strain was significantly shorter and lighter than the NG (α = 0.05; $P < 0.001$) and SA ($P < 0.001$) strains prior to stocking. However, the K-W test determined that SE's from netted post-stocking were significantly longer and heavier than the NG BNT at all ages (II+, III+, & IV+ - VII+) and SA's at age-II+; and SE's measured on creel surveys were significantly longer and heavier than both NG and SA BNT at older ages (≥ III+). Survival estimates indicated that the SE strain had the lowest annual mortality and highest theoretical maximum age followed by the SA and NG strains. A Wilcoxon signed rank test compared strain-specific BNT harvest rates (# of BNT/angler) based on pooled winter creel survey data and suggested that SE's were most catchable followed by SA and NG BNT. A rudimentary scoring system unanimously ranked the SE strain above the NG and SA strains based on the four selection criteria.

KEY WORDS: BROWN TROUT, NEW GLOUCESTER, SEEFORELLEN, SANDWICH RIVER, FIELD PERFORMANCE

INTRODUCTION

Brown Trout (*Salmo trutta*) (BNT) are indigenous to Europe, North Africa, and western Asia, but they are now present on every continent (except Antarctica) due to their recreational angling popularity (Klemetson et al. 2003, MacCrimmon & Marshall 1968). BNT eggs were first shipped to the United States in 1883 and established in Maine fish hatcheries in 1885 (MacCrimmon & Marshall 1968). Initial BNT introductions into Maine waters were largely unsuccessful, and by 1932 the state suspended the stocking program (Boland 2001). When the program was reinstituted later that same decade, fisheries managers had a better understanding of the habitat and forage similarities with BNT and Maine's native salmonids (i.e. Brook Trout (BKT) (*Salvelinus fontinalis*) and Landlocked Atlantic Salmon (LLS) (*Salmo salar*)). There were also data suggesting BNT were more tolerant of harsher environmental conditions (i.e. warmer water, more competitor fishes, more opportunistic feeders) deemed unsuitable for native salmonids. This realization prompted a renewed interest in the stocking program, and the development of empirically-researched guidelines for Maine waters best suited for nonnative BNT introductions.

Prior to 1970, numerous BNT strains including Cortland, Plymouth, and Lock Leven were stocked in Maine from a brood source maintained at a federal hatchery (MacCrimmon & Marshall 1968). In 1968, Maine fish culturists developed a BNT brood from a feral population (unspecified source) at the New Gloucester State Fish Hatchery (Leary 1999). It is this same BNT, appropriately termed the New Gloucester (NG) strain, that was still the primary one used in the Maine Department of Inland Fisheries & Wildlife (MDIFW) stocking program as of 2018.

MDIFW's stocking guidelines endorse BNT stocking in lacustrine waters that are unable to support high-quality fisheries for Maine's indigenous salmonids, namely BKT and LLS. Typically, these are mesotrophic waters characterized by marginal summer water quality (i.e. limited volume of cool, oxygenated water), high levels of competition and predation, reduced forage availability, and inadequate spawning and nursery habitat. While these guidelines ensure protection to our native trout and salmon, they limit the number of quality waters where BNT are stocked. Over the past several decades, agricultural inputs, erosion and sedimentation, climate change, antiquated septic systems, and atmospheric nutrients have downgraded the trophic status of some Maine lakes (Trolle et al. 2011, Bertahas et al. 2006, Pensa and Chambers 2004, Hamilton et al. 2001). As a result, many BNT waters across the state have experienced degraded water quality and what was once marginal BNT habitat decades ago, has become unsuitable. This trophic change has negatively impacted historical BNT fisheries across the state.

State fisheries biologists acknowledged a statewide decline in BNT field performance, particularly in lacustrine systems, around 2000. While some of this decline was based on qualitative and anecdotal evidence, quantitative data, including the documented collapse of the nationally-renowned Shawmut BNT fishery on the Kennebec River incited further investigation (Ashe et al. 2019). Electrophoretic analysis was performed on NG BNT in 1997, and the results showed unusually low levels of genetic variation (Leary 1999). Since this level of homogeneity has the potential to negatively influence hatching success, fish growth and survival, overall performance, and susceptibility to disease and pathogens, a comprehensive BNT strain evaluation project was initiated in 2003 to assess strain performance in both the hatchery and field settings. The field performance component did not begin until 2010. Ultimately, due to hatchery space limitations, it was hoped that this evaluation would aid in the selection of a single BNT strain to be used exclusively in MDIFW's hatchery system.

There were three primary objectives specific to the field performance evaluation. They were as follows:

1. Select a BNT brood strain with robust genetic heterozygosity and vigor.
2. Select a BNT brood strain with improved field performance, with a focus on angler catch rates and post-stocking survival.
3. Determine whether the declining field performance of the NG BNT is predominantly a result of genetics and/or other biotic or physical factors.

**Note: This report is a companion document to the 2018 report "Experimental Brown Trout Stocking Program: Brown Trout Strain Hatchery Comparisons" which summarizes an evaluation of hatchery performance of the same BNT strains included herein.*

METHODS

BNT Strain Selection

After a thorough, nationwide selection process supported by an intra-agency search committee, a review of the national brood register, state survey questionnaires, a review of literature on BNT strain performance, communication with other states managing BNT, and an emphasis on the that importance of genetic integrity and pathogen absence, three strains of BNT were chosen for the BNT strain evaluation project. They were as follows:

1. **New Gloucester (NG)**: the NG BNT is the current strain used in the Maine hatchery system and likely originated from a feral population that was developed at the New Gloucester State Fish Hatchery in ~1968.
2. **Sandwich River (SA)**: originated in Massachusetts and maintained with a captive brood program that was genetically enhanced in the 1980's and 1990's with various sea-run strains from other states, wild returning sea-run BNT, and a broodline kept at the East Sandwich Hatchery. Anecdotal evidence suggested good performance in riverine environments.
3. **Seeforellen (SE)**: originated from SE eggs shipped from Michigan and one Connecticut hatchery in 1996. This strain used most by other state hatchery systems and is the last known strain

imported into the United States. Anecdotal evidence indicated good performance in lacustrine environments along with high angler returns.

Study Waters

Nearly 90% of the lake and ponds managed for BNT by MDIFW are in the southern, south-central, and coastal parts of Maine – in Management Regions A, B, & C (Figure 1, Table 1). Only waters located in these three regions were included in the BNT field performance component of the study with most of the fieldwork (i.e. winter creel survey, gillnetting, and/or trapnetting) completed in Region A (n = 13 waters) and less in Region C (4) and Region B (1) (Table 2). Starting in 2010, study waters were stocked with paired allocations of BNT strains and included the following combinations – NG-SA (n = 7), NG-SE (8), and SA-SE (3). All BNT were given a strain-specific fin clip by year stocked (Table 3).

Genetic Analysis

Genetic assessment of all three BNT study strains was outsourced and conducted by U.S. Fish & Wildlife Service's Northeast Fishery Center Conservation Genetics Lab (NEFC) in 2009 and 2016. The assessment measured the genetic diversity of each strain by providing values for the # of alleles/locus, along with their expected and observed heterozygosity.

Strain Size at Stocking

Mean length, mass, and Fulton's condition factor (K) were calculated for each annual allocation by strain stocking size (age I+) for each study water for the entirety of the project (Table 4). A Shapiro-Wilk (S-W) test was conducted for each strain-specific dataset to test for normality. A Kruskal-Wallis (K-W) test compared whether significant differences in mean strain size at stocking were present.

BNT Post-Stocking Growth & Survival

All BNT collected in gillnets/trapnets or creel surveys (two separate groupings) were measured and aged (Table 5, Table 6). These two datasets were then grouped by strain at ages II+, III+, and IV+ to VII+ and compared. All BNT data grouped by growth (i.e. mean length, mass, and condition factor) at age were analyzed for normality using a S-W test. A K-W test then compared whether significant differences in growth values by strain were present.

Total annualized mortality estimates (% of strain-specific BNT that die each year) were generated using pooled BNT length, mass, and age measurements taken from gillnet/trapnet data for all regions across all years (Shoup 2011). Along with mortality calculations, theoretical maximum ages (the maximum amount of years each BNT strain could survive between birth and death) were also estimated for each strain. These estimates were compared to determine strain-specific differences in survival and longevity.

Strain-Specific BNT Harvest Rates

Comprehensive winter creel survey data over three consecutive years taken from select Region A waters (n = 7) (Table 2) were each pooled and used to estimate strain-specific BNT angler harvest rates. Data normality was tested using a S-W test, while a non-parametric Wilcoxon signed rank test was then used to test whether differences in median harvest rates (# of BNT/angler) for each paired strain study water were present (Table 7).

RESULTS

Genetic Analysis

The SE strain had the highest number of alleles/locus (7.8), followed by the SA strain (5.8) and the NG stain (4.3) (Table 8). Both expected and observed heterozygosity were highest in the SE strain (0.708 & 0.701, respectively) followed by the SA (0.628 & 0.612) and NG (0.548 & 0.553) strains.

Strain Size at Stocking

The S-W test indicated a significantly non-normal distribution of the strain-specific stocking size data. Subsequently, a K-W test indicated that at the time of stocking SE BNT were significantly shorter and lighter than both the NG and SA strains (Table 9). Additionally, the SA strain was significantly longer and heavier than the NG strain.

BNT Post-Stocking Growth & Survival

Gillnet/Trapnet Collections – A S-W test indicated a significantly non-normal distribution of the age by strain growth data. A K-W test specified that at all ages SE BNT were significantly longer and heavier than the NG strain (Table 10). The test also showed that SE BNT were significantly longer at age II+ and marginally significantly longer at ages IV+ to VII+ than SA BNT. And, SE BNT were heavier at age II+ than SA BNT. Survival estimates (i.e. # of BNT/netting) showed that NG BNT were most abundant at age II+, NG and SE BNT were comparably most abundant at age III+, and SE BNT were most abundant at the oldest ages.

Survival estimates indicated that SE BNT experienced the lowest total annualized mortality (47.7%), followed by SA's (56.8%) and the NG strain (58.4%). Additionally, the theoretical maximum age for SE's (8.1 years-old) was also considerably longer than SA (6.4) and NG (7.0) BNT.

Creel Survey Collections – A S-W test indicated a significantly non-normal distribution of the age by strain growth data. A K-W test specified that at ages III+ and at IV+ to VII+ SE BNT were significantly longer and heavier than both the NG and SA strains (Table 11).

Strain-Specific BNT Harvest Rates

Due to many zero values in pooled creel survey data, BNT harvest rates were skewed heavily to the right, and the S-W test indicated data non-normality. The Wilcoxon signed rank test showed no significant differences in median winter strain-specific BNT harvest rates (# of BNT/angler) for 5 of 7 paired strain study waters (Table 7). But, in Upper Range Pond (3688) SA BNT were harvested significantly more than NG BNT (p-value = 0.057 – marginal significance). In Little Sebago Lake (3714), anglers harvested significantly more SE's than NG BNT (p = 0.021).

DISCUSSION

Genetic Analysis

The results from the 2009 and 2016 genetic assessments clearly separated the three BNT study strains in terms of genetic integrity. The SE strain was the significant, clear-cut winner in all categories (greater # of alleles/locus, expected heterozygosity, and observed heterozygosity), while the NG strain, as anticipated, was the worst (Table 7).

Genetic integrity, in the field and the hatchery environments, cannot be undervalued. Fishes with low levels of genetic integrity experience loss of adaptation to wild environments, lessened competition in the natural habitat, decreased survival, and reduced overall performance (Bourret et al. 2011, Cooke et al. 2005, Stickney 1994, Meffe 1986, Brauhn and Kincaid 1982). Findings from a second BNT strain evaluation focused on hatchery performance confirmed significantly higher mortality levels in the NG strain than in both the SA and SE BNT (Bray 2018). Lower genetic integrity has been directly correlated with greater environmental susceptibility; hence lower survival in both the hatchery and natural habitat (Allendorf et al. 1987).

Strain Size at Stocking

BNT are primarily stocked into lakes and ponds that have marginal water quality, greater species richness, more competition, forage limitations, and/or larger fish predators (i.e. Largemouth Bass (*Micropterus salmoides*), Chain Pickerel (*Esox niger*), Northern Pike (*Esox Lucius*)). Unlike BKT (& less so with LLS), BNT can withstand higher mid-summer water temperatures, lower dissolved oxygen, and lower abundance or absence of Rainbow Smelt (*Osmerus mordax*). Stocked in these marginal waters, larger BNT are better competitors and more efficient at foraging (Garman and Nielsen 1982).

Although Bray (2018) indicated that the NG and SA strains hatched one month prior than the SE's and thus had a head start on feeding and growth in a lake-fed hatchery, the study didn't uncover any statistically significant size differences among the three BNT strains reared in the Palermo Fish Rearing Hatchery. However, because many of the study BNT were reared in the New Gloucester Hatchery (a state hatchery that sources its water from a spring-fed impoundment stream that produces smaller SE

BNT than other hatcheries due to late egg hatch, high summer water temperatures, low dissolved oxygen, and more drastic daily temperature swings), just the opposite resulted in the field component portion of the study, as there were significant differences in length and mass between all strains. SE BNT were highly significantly shorter and lighter than both SA & NG, and NG BNT were significantly shorter and lighter than SA BNT (Table 4, Table 11). Larger BNT are better at competing and evading predation, so fisheries managers prefer larger BNT - particularly in the highly competitive and predator rich environments that most are allocated.

BNT Post-Stocking Growth & Survival

Gillnet/Trapnet Collections – Despite its smaller size at stocking, the SE strain, outpaced both the SA and NG strains based on gill-/trapnetting results (Table 12). After less than a year post-stocking, SE's surpassed both other strains in length and mass. Thru age VII+, SE BNT continued its dominance, and thru the oldest grouping (age IV+ - VII+) SE's were nearly 3-in and 1.3-lb larger than NG BNT. SE were also larger and heavier than SA BNT thru the older age classes, but the results were not statistically significant.

SE's experienced considerably lower total annual mortality than both the SA and NG strains. These results were a bit surprising considering their smaller stocking size (Table 4) and increased vulnerability to predation, but their performance post-stocking was excellent and likely contributed to greater survival of annually stocked cohorts. Since BNT are notoriously difficult to catch, those that survive longer (and grow larger) create more desirable recreational fisheries.

Creel Survey Collections – The SE strain was the clear-cut winner in terms of growth for BNT measured on creel surveys. Since surveys are conducted just a few weeks post-fall stocking, there were no significant growth differences in age II+ BNT. But, from age III+ on, SE BNT dominated in length and mass. By the oldest ages (IV+ - VII+), SE's were 2.5-in and 1.3-lbs larger than their next strain challenger.

Strain-Specific BNT Harvest Rates

Since NG's were paired with either SA (n = 4) or SE (n = 3) BNT for all winter creel survey study waters used in analyzing strain-specific harvest rates, equitable comparisons across all three strains were not possible. But the results indicated that the SE and SA strains were slightly more (5 of 7 waters) harvested than NG's. These findings corroborate the survival results. Both SE and SA strain BNT had lower total annual mortality rates, and therefore had more individual fish at large than NG's at any given time. With more SA or SE at large in paired NG fisheries, harvest rates were justifiably higher for the more abundant strains.

CONCLUSIONS

Brown Trout, unlike all other stocked trout and salmon, are notoriously difficult to catch with rod and reel – particularly as they grow to older ages. Despite their low catchability, anglers find BNT especially rewarding as they more regularly attain larger sizes compared to BKT, LLS, and RBT. This field performance evaluation (along with the hatchery component of the study) was a selection process to identify a single BNT strain by comparing genetic integrity, growth, survival, and catchability in select Maine waters. The chosen BNT will serve as the lone strain to be stocked in all BNT fisheries for the foreseeable future.

In reviewing the study results, we ranked each strain from the four selection criteria (genetics, growth, survival, & catchability) using a rudimentary scoring system by assigning a 1 to the lowest rank, a 2 to the moderate rank, and a 3 to the highest ranking. This scoring provided a numeric summary of the field performance results.

The **Genetic Integrity** assessment scored the SE's as the most genetically fit (3), the SA's as moderate (2), and the NG's with the least genetic integrity (1) (Table 12). Despite being the smallest BNT at the time of stocking, the SE strain (3) outperformed both the NG (1) and SA (2) strains in terms of **Growth** in both the netting and creel survey collections. **Survival** estimates (i.e. Total Annualized Mortality & Theoretical Maximum Age) scored the SE strain (3) with the top score, the NG strain secondary (2), and the SA strain with the highest mortality (1). Lastly, based on winter creel survey data, **Angler Harvest Rates** (# of BNT/angler) were lowest for the NG strain (1), but since direct comparisons were not made between the SE and SA BNT, both strains were given the same score (2.5).

The results unanimously favored the SE strain as the top performer in the field evaluation comparison. SE's were the dominant strain in all four selection criteria. The hatchery component of this evaluation also favored the SE strain, stating that the strain's "superior survival rates, comparable growth rates, exceptional fin quality and increased estimates of genetic diversity make this strain a more suitable replacement" for the NG strain (Bray 2018). Ultimately, Maine fisheries managers want to provide a BNT strain that grows quickly, survives multiple years in adverse environments, is genetically fit, and is as catchable to anglers as possible. The SE strain fits these criteria the best of the three strains.

RECOMMENDATIONS / OTHER INFO

1. BNT strain evaluations in riverine environments would also prove beneficial. Although this field performance evaluation did incorporate streams and rivers in its initial design and implementation, the resulting data were limited and only included creel survey data on a small number of waters. The data were therefore removed from the analysis and final report. According to a report by Wills (2005), who investigated the performance of three BNT strains in several MI rivers, the SE strain had poor survival and should be used with caution in riverine stocking programs. Wills (2005) observed that SE's rarely lived to age-III+, so waters with higher

length limits may prohibit attainment to the minimum legal size. Assessment of overwinter survival for fall-yearling (FY) stocked SE's in Maine rivers would offer insight regarding performance expectations and attainment of realistic management objectives.

2. Recently, small size at stocking for spring-yearling (SY) SE's (6-8") essentially precludes their use to provide extended season, put-and-take fishing opportunities in small/medium sized rivers with marginal summer water temperatures. Fisheries managers and anglers find the smaller size of the SY SE's to be undesirable. Although the hatchery system is encouraged by an earlier SE egg take in October 2019 (several weeks earlier than historic takes)(Todd Langevin, personal communication, 8/6/2020), if hatchery growth cannot be consistently improved for SY's, fisheries managers may consider replacing some BNT stream stocking programs and replacing them with larger SY Rainbow Trout (RBT) (*Oncorhynchus mykiss*) where feasible and appropriate.
3. Despite its inferior genetics and relatively poor field performance, with its golden coloration and red, brown, and black spotting, the NG strain is considered by many to be a beautiful Brown Trout. The SE's coloration isn't quite as attractive; with its silver body color and black spots, they are commonly mistaken for LLS by anglers. BNT coloration was not included in the strain selection criteria. Maine anglers have grown accustomed to the NG's bright coloration, and its loss may reduce satisfaction of some successful diehard BNT enthusiasts (and other casual anglers).
4. MDIFW's BNT stocking program is already a small, niche fishery that attracts a specific group of hardcore anglers. Fisheries biologists recognize that some BNT stocking programs, especially those stocked in the more marginal of waters, have lower year-to-year survival where fewer fish grow to larger sizes. While there is optimism that the SE strain will offer improved fishing and increased angler use, stocking locations where that outcome is not achieved may eventually be phased out and replaced with RBT (where feasible and appropriate). As MDIFW's Fisheries and Hatcheries Division more closely examines the role and future of RBT production and stocking, some BNT fisheries may be terminated, and those that remain will be mainly in less marginal waters where BNT typically exhibit their best performance and offer a better chance of being caught.
5. It would be beneficial to develop guidelines regarding the types of waters where BNT are best utilized to create quality fishing opportunities, considerate of preferred opportunities to manage for native coldwater fishes. This recommendation would also create more statewide consistency in the development of BNT fishing opportunities. Consideration should be given to using BNT in "better than marginal" waters, where limited opportunity exists to create cost effective fisheries for native trout and salmon.

ACKNOWLEDGEMENTS

Thanks to the many MDIFW hatchery and fisheries folks including Tom Barrows, Jamie Bray, Greg Burr, Mike Coulombe, Scott Davis, Nick Kalejs, Dave Lalancette, Todd Langevin, Brian Lewis, Jim Lucas, Jacob Scoville, Jason Seiders, Colin Shankland, Laird Townsend, Bobby Van Riper, Bill Woodward, and many others who worked so diligently on this project. Additionally, thanks to Jamie Bray, Greg Burr, and Joe Overlock who's edits improved the overall quality of this report. Lastly, a special acknowledgement goes out to Francis Brautigam, who designed and helped execute and write this complex, long-term BNT field performance study.

REFERENCES

Allendorf, F., N. Ryman, and F. Utter. 1987. Genetics and fishery management: past, present, and future. Population Genetics and Fishery Management: 1-19.

Ashe, W., J. Seiders, and S. Davis. 2019. The Shawmut Fishery: A comprehensive study of a once renowned brown trout water. Maine Department of Inland Fisheries & Wildlife – Fisheries Division Report Series No. 19-1.

Bertahas, I., E. Dimitriou, I. Karaouzas, S. Laschou, I. Zacharias. 2006. Climate change and agricultural pollution effects on the trophic status of a Mediterranean lake. Acta hydrochimica et hydrobiologica 34.

Boland, J.J. 2001. Brown Trout Management Plan. Maine Department of Inland Fisheries and Wildlife. Augusta, Maine. 39 pp.

Bourret, V., P.T. O'Reilly, J.W. Carr, P.R. Berg, and L. Bernatchez. 2011. Temporal change in genetic integrity suggests loss of local adaptation in a wild Atlantic salmon (Salmo salar) population following introgression by farmed escapees. Heredity 106: 500-510.

Brauhn, J.L. and H. Kincaid. 1982. Survival, growth, and catchability of rainbow trout of four strains. North American Journal of Fisheries Management 2: 1-10.

Bray, J. 2018. Experimental Brown Trout Stocking Program: Brown Trout Strain Hatchery Comparisons. Maine Department of Inland Fisheries and Wildlife – Hatcheries Division Report. Augusta, Maine. 27 pp.

Cooke, S.J., T.W. Kassler, and D.P. Philipp. 2005. Physiological performance of largemouth bass related to local adaptation and interstock hybridization: implications for conservation and management. Journal of Fish Biology 59: 248-268.

Garman, G.C. and L.A. Nielsen. 1982. Piscivority by stocked brown trout (*Salmo trutta*) and its impact on the nongame fish community of Bottom Creek, Virginia. Canadian Journal of Fisheries and Aquatic Sciences 39: 862-869.

Hamilton, D., C. Spillman, K. Prescott, T. Kratz, and J. Magnuson. 2001. Effects of atmospheric nutrient inputs and climate change on the trophic status of Crystal Lake, Wisconsin. SIL Proceedings: 1922-2010. 28. 467-470.

Klemetsen, A., P.-A. Amundsen, J.B. Dempson, B. Jonsson, N. Jonsson, M.F. O'Connell, and E. Mortensen. 2003. Atlantic salmon *Salmo salar* L., brown trout *Salmo trutta* L., and Arctic charr *Salvelinus alpinus* (L.): a review of aspects of their life histories. Ecology of Freshwater Fish 12: 1-59.

Leary, Robb. 1999. Letter to MDIFW Fish Pathologist, Russell Danner, relating the results of electrophoretic analysis of the New Gloucester Fish Hatchery brown trout strain. University of Montana, Missoula. 15 pp.

MacCrimmon, H.R. and T.L. Marshall. 1968. World Distribution of Brown Trout, *Salmo trutta*. Journal of the Fisheries Research Board of Canada 25: 2527-2548.

Pensa, M.A. and R.M. Chambers. 2004. Trophic transition in a lake on the Virginia coastal plain. Journal of Environmental Quality Abstract 33: 576-580.

Shoup, D.E. 2011. Fisheries Survival Excel Spreadsheet. Oklahoma State University.

Stickney, R.R. 1994. Use of Hatchery Fish in Enhancement Programs. Fisheries 19: 6-13.

Trolle, D., D.P. Hamilton, C.A. Pilditch, I.C. Duggan, and E. Jeppesen. 2011. Predicting the effects of climate change on trophic status of three morphologically varying lakes: implications for lake restoration and management. Environmental Modelling & Software 26: 354-370.

Wills, T.C. 2005. The field performance of one wild and two domestic brown trout strains in seven Michigan rivers. State of Michigan Department of Natural Resources: 47 pp.

TABLES AND FIGURES

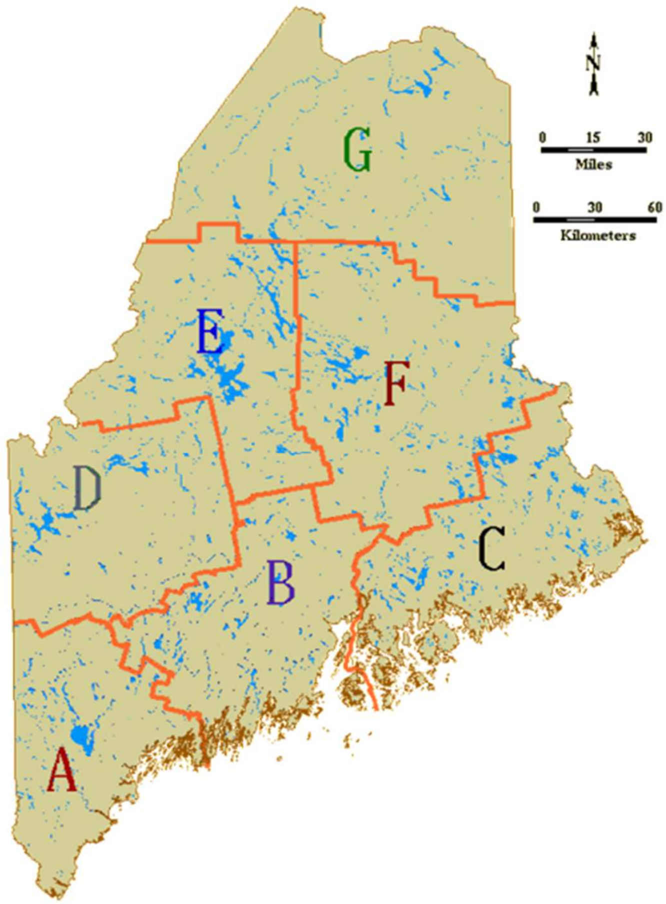

Figure 1. Fisheries Management Regions – MDIFW.

Table 1. Statewide total of stocked BNT lakes/ponds along with the number and percentage of BNT allocated across Fisheries Management Regions – 2019 (excludes FRY allocations).

REGION	BNT WATERS	# OF BNT	% OF BNT
A	35	12884	29.5
B	38	17980	41.2
C	19	6805	15.6
D	8	3993	9.1
E	1	1300	3.0
G	2	700	1.6
TOTAL	**103**	**43662**	**100**

Table 2. Study waters by watcode, Fisheries Management Region, and paired BNT strain stockings (NG - New Gloucester, SA - Sandwich River, SE - Seeforellen) along with the respective year(s) that creel survey(s), gillnetting(s), and/or trapnetting were completed for the BNT field performance evaluation.

STUDY WATER	WAT	REG	STRAINS	CREEL SURVEY	YEAR	GILLNET	YEAR	TRAP NET	YEAR
Crystal Lake	3708	A	NG-SA	X	2014-16	X	2016	X	2015
Middle Range Pond	3762	A	NG-SA	X	2014-16	X	2016	X	2015
Mousam Lake	3838	A	NG-SA	X	2014-16	X	2016	X	2015
Upper Range Pond	3688	A	NG-SA	X	2014-16	X	2016	X	2015
Little Sebago Lake	3714	A	NG-SE	X	2017-19	X	2019		
Long Pond	9701	A	NG-SE	X	2017-19	X	2019		
Sabbathday Lake	3700	A	NG-SE	X	2017-19	X	2019		
Bickford Pond	3158	A	NG-SA			X	2015		
Hancock Pond	3132	A	NG-SE			X	2019		
Highland Lake	3454	A	NG-SE			X	2019		
Sand Pond	3130	A	NG-SE			X	2019		
Stearns Pond	3234	A	SA-SE			X	2018		
Wood Pond	3456	A	NG-SA			X	2015		
Alford Lake	4798	B	SA-SE	X	2017	X	2014	X	2016
King Pond	4600	C	SA-SE			X	2016		
Long Pond	4430	C	SA-SE			X	2013, 2016-18		
Pennamaquan Lake	1402	C	NG-SE			X	2012		
Round Lake	0171	C	NG-SE			X	2013		

Table 3. BNT strain-specific fin marking scheme for the BNT strain evaluation - 2010-18. Study waters with paired SA-SE stockings applied a left maxillary clip (LM) to all SA BNT.

	BNT STRAIN	
YEAR	**NG**	**SE & SA**
2010	LV	LV-AD
2011	BV	BV-AD
2012	RV	RV-AD
2013	AD	UM
2014	LV	LV-AD
2015	BV	BV-AD
2016	RV	RV-AD
2017	AD	UM
2018	LV	LV-AD

*LV = left ventral fin, RV = right ventral fin, BV = both ventral fins, AD = adipose fin, UM = unmarked

Table 4. Sample size (n), length (in), mass (lb), and Fulton's condition factor (K) for BNT strains at the time of stocking for all study waters across all respective study years.

	SIZE AT STOCKING		
	NG	**SA**	**SE**
SAMPLE (n)	91	65	66
LENGTH (in)	12.40	12.52	12.09
MASS (lb)	0.84	0.88	0.76
CONDITION (K)	1.22	1.24	1.20

Table 5. No. of nettings, sample size (n), mean length (in), mean mass (lb), mean Fulton's condition factor (K), and mean # of BNT/netting by strain for specific age classes (II+, III+, & IV+ - VII+) - for all BNT collected in gillnets and trapnets.

	AGE II+			AGE III+			AGE IV+ to VII+		
	NG	SE	SA	NG	SE	SA	NG	SE	SA
# OF NETTINGS	18	16	18	18	16	18	18	16	18
BNT SAMPLE (n)	74	52	51	33	27	12	26	29	13
LENGTH (in)	14.7	15.5	14.6	16.5	17.9	17.3	18.6	21.3	19.6
MASS (lb)	1.24	1.48	1.23	1.90	2.47	2.35	2.72	4.04	3.46
CONDITION (K)	1.06	1.07	1.07	1.12	1.15	1.21	1.06	1.13	1.15
# BNT / NETTING	4.1	3.3	2.8	1.8	1.7	0.7	1.4	1.8	0.7

Table 6. No. of surveys, sample size (n), mean length (in), mean mass (lb), mean Fulton's condition factor (K), and mean # of BNT/survey by strain for specific age classes (II+, III+, & IV+ - VII+) - for all BNT measured on creel surveys.

	AGE II+			AGE III+			AGE IV+ to VII+		
	NG	SE	SA	NG	SE	SA	NG	SE	SA
# OF SURVEYS	7	4	5	7	4	5	7	4	5
SAMPLE (n)	11	19	21	41	32	11	21	18	5
LENGTH (mm)	14.1	14.2	14.3	16.5	18.0	16.2	19.4	21.9	18.5
MASS (g)	1.06	1.04	1.07	1.82	2.37	1.74	2.75	4.06	2.79
CONDITION (K)	1.03	0.99	1.03	1.09	1.09	1.13	1.02	1.05	1.20
# BNT / SURVEY	1.6	4.8	4.2	5.9	8.0	2.2	3.0	4.5	1.0

Table 7. Watcodes, stocked BNT strains (NG = New Gloucester, SA = Sandwich River, SE = Seeforellen), N (# of ice angler parties interviewed), median harvest rates (# of BNT/ice angler) (w/ 2 SE), and Wilcoxon Signed Rank Test results (W-Stat, P-Value - α = 0.05) based on pooled winter creel survey data (3-yrs/water) by study water.

					WILCOXON SIGNED RANK TEST	
WATCODE	STRAIN	N	HARVEST RATE	2 SE	W-STAT	*P*
3708	NG	305	0.003	0.006	93177	1.00
	SA		0.003	0.006		
3838	NG	1049	0.006	0.004	1100946	0.99
	SA		0.005	0.004		
3762	NG	509	0.001	0.002	258572	0.26
	SA		0.004	0.004		
3688	NG	464	0.003	0.004	214140	***0.06***
	SA		0.008	0.006		
3714	NG	489	0.003	0.004	237416	***0.02***
	SE		0.008	0.006		
9701	NG	409	0.009	0.003	167478	0.99
	SE		0.009	0.003		
3700	NG	517	0.022	0.005	264856	0.19
	SE		0.035	0.014		

Table 8. The # of alleles/locus, and expected and observed heterozygosity for NG, SE, and SA BNT study strains. Genetic assessment conducted by USFW's Northeast Fishery Center Conservation Genetics Lab (NEFC) - 2009 & 2016.

		Heterozygosity	
BNT Strain	# of Alleles/Locus	Expected	Observed
NG	4.3	0.548	0.553
SE	7.8	0.708	0.701
SA	5.8	0.628	0.612

Table 9. Length, mass, and Fulton's condition factor comparisons by BNT strain pairings at the time of stocking using p-values derived from a Kruskal-Wallis test (α = 0.05).

STRAIN COMPARISON	SIZE AT STOCKING (I+)
LENGTH	***P-VALUE***
NG - SE	***< 0.001***
NG - SA	***0.015***
SE - SA	***< 0.001***
MASS	
NG - SE	***< 0.001***
NG - SA	***0.008***
SE - SA	***< 0.001***
CONDITION	
NG - SE	0.144
NG - SA	0.452
SE - SA	0.072

Table 10. Length, mass, and Fulton's condition factor comparisons by BNT strain pairings for specific age classes (II+, III+, and IV+ - VII+) using p-values derived from a Kruskal-Wallis test (α = 0.05). All BNT were collected and measured from study gill- & trapnetting.

	KRUSKAL-WALLIS (*P*)		
STRAIN COMPARISON	AGE II+	AGE III+	AGE IV+ - VII+
LENGTH			
NG - SE	***0.001***	***0.007***	***< 0.001***
NG - SA	0.490	0.248	0.493
SE - SA	***< 0.001***	0.420	0.064
MASS			
NG - SE	***0.005***	***0.013***	***< 0.001***
NG - SA	0.401	0.143	0.251
SE - SA	***0.002***	0.681	0.104
CONDITION			
NG - SE	0.429	0.705	0.137
NG - SA	0.484	0.259	***0.049***
SE - SA	0.934	0.484	0.501

Table 11. Length, mass, and Fulton's condition factor comparisons by BNT strain pairings for specific age classes (II+, III+, and IV+ - VII+) using p-values derived from a Kruskal-Wallis test (α = 0.05). All BNT collected and measured from creel surveys.

	KRUSKAL-WALLIS (*P*)		
STRAIN COMPARISON	**AGE II+**	**AGE III+**	**AGE IV+ - VII+**
LENGTH			
NG - SE	0.714	***0.002***	***0.001***
NG - SA	0.592	0.737	0.580
SE - SA	0.724	***0.013***	***0.017***
MASS			
NG - SE	0.910	***0.006***	***< 0.001***
NG - SA	0.863	0.708	0.896
SE - SA	0.988	***0.035***	***0.052***
CONDITION			
NG - SE	0.928	0.520	0.573
NG - SA	0.949	0.148	0.126
SE - SA	0.671	0.323	0.263

Table 12. Strain scoring system for BNT selection based on 4 criteria - genetic integrity, post-stocking growth, survival, and harvest rate. Top score = 3, moderate score = 2, and low score = 1.

	Scoring by Strain		
	NG	**SA**	**SE**
Genetic Integrity	1	2	3
Post-Stocking Growth	1	2	3
Survival	2	1	3
Harvest Rate	1	2.5	2.5
TOTAL	**5**	**7.5**	**11.5**

COOPERATIVE

STATE FEDERAL

PROJECT

This report has been funded in part by the Federal Aid in Sport Fish Restoration Program. This is a cooperative effort involving federal and state government agencies. The program is designed to increase sport fishing and boating opportunities through the wise investment of angler's and boater's tax dollars in state sport fishery projects. This program which was founded in 1950 was named the Dingell-Johnson Act in recognition of the congressmen who spearheaded this effort. In 1984 this act was amended through the Wallop Breaux Amendment (also named for the congressional sponsors) and provided a threefold increase in Federal monies for sportfish restoration, aquatic education and motorboat access.

The program is an outstanding example of a "user pays-user benefits" or "user fee" program. In this case, anglers and boaters are the users. Briefly, anglers and boaters are responsible for payment of fishing tackle, excise taxes, motorboat fuel taxes, and import duties on tackle and boats. These monies are collected by the sport fishing industry, deposited in the Department of Treasury, and are allocated the year following collection to state fishery agencies for sport fisheries and boating access projects. Generally, each project must be evaluated and approved by the U.S. Fish and Wildlife Service (USFWS). The benefits provided by these projects to users complete the cycle between "user pays – user benefits."

Maine Department of Inland Fisheries and Wildlife
284 State Street, 41 SHS, Augusta, ME 04333-0041