Experimental Brown Trout Stocking Program: Brown Trout Strain Hatchery Comparisons

By: Jamie J. Bray
Palermo State Fish Hatchery

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Maine Department of
Inland Fisheries & Wildlife
Fisheries and Hatcheries Division

ABSTRACT

Over a five-year period, the Maine Department of Inland Fisheries and Wildlife (MDIFW) Hatcheries Section evaluated the growth, mortality and feed conversion rates, fish fin quality, fish behavior, and disease resistance of the New Gloucester, Sandwich River, and Seeforellen strain Brown Trout (*Salmo trutta)*. At the conclusion of the hatchery study, monthly production and fish quality reports were gathered and compared for each Brown Trout strain from May 2009 to November 2014. Prior to stocking, there were no significant differences among Brown Trout strains with respect to mean length, mean weight, mean conversion factor, or cultured density environments. Significant differences in mean monthly mortality rates were detected among Brown Trout strains (F (2,295), p = 0.016). A Tukey post hoc test indicated that the mean monthly mortality rate of the New Gloucester strain was significantly greater than the Seeforellen strain (p =0.016); however, there were no differences in mean mortality between the New Gloucester and Sandwich River strains (p = 0.099) or the Sandwich River and Seeforellen strains (p = 0.741). The Kruskal-Wallis test indicated marginal differences in non-caudal fin quality among strains (H = 5.99, df = 2, p = 0.0498), while more significant differences in caudal fin quality among strains were observed (H = 19.54, df = 2, p < 0.0001). The Wilcoxon post-hoc test indicated non-caudal fin erosion percentage was marginally significantly greater in the Sandwich River strain than in both the New Gloucester (p = 0.045) and Seeforellen strains (p = 0.034). The Wilcoxon post-hoc test also indicated that caudal fin erosion was highly significantly greater in the New Gloucester strain than in both the Sandwich River (p = 0.0005) and Seeforellen strains (p = 0.0001). Diagnostic tests for pathogens throughout the study were negative for all three strains. Genetic testing identified the Seeforellen strain had the highest estimates of genetic diversity, followed by the Sandwich River and then New Gloucester strains.

KEY WORDS: BROWN TROUT, NG, SA, SE, LIFE STAGE, AGE & GROWTH, HATCHERY, MORTALITY, SIZE AT AGE, STOCKING

INTRODUCTION

The Maine Department of Inland Fisheries and Wildlife (MDIFW) statewide Brown Trout (*Salmo trutta)* management plan has identified multiple items that may limit successful Brown Trout angling in Maine waters[1]. Genetic variability of Maine's Brown Trout brood stock and the negative impact it may be having on the performance of hatchery produced progeny in the wild was identified as the highest priority for investigation and resolution in the management plan (Brautigam 2007). The Department's current strain of Brown Trout, the New Gloucester strain, has unusually low levels of genetic variation (Leary 1999) and low angler catch rates and returns (Pellerin 2007). As Brown Trout represents the second greatest investment of production resources of the Department on a biomass basis, any improvements to Brown Trout catch rates will significantly improve the overall cost per stocked fish registered in the fishery by the public. In 2007, a Brown Trout strain committee comprised of MDIFW fishery managers, research biologists, hatchery managers, and a fish pathologist met to develop a plan to locate a better performing and healthier genetic strain of Brown Trout. The Brown Trout committee researched available strains of Brown Trout in North America with desired characteristics for stocking in Maine waters. Strains were evaluated against a matrix of characteristics including angling performance, post release survival and catch rates, egg availability, genetic heterogeneity, and disease resistance.

After two Brown Trout strains were selected, the committee determined that an experimental stocking program was warranted to evaluate each Brown Trout strain performance relative to the current strain. Simultaneously the experimental stocking program could evaluate all three Brown Trout strains within the state hatcheries. To be stocked at a size sufficient to create an equivalent fishery; the two new Brown Trout strains would need to perform in the hatchery system at least as well as our current strain. Additionally, the hatcheries were instructed to compare growth rates, mortality rates, feed conversion rates, and fish behavior. During the experimental stocking program, hatcheries reared, stocked, and evaluated three-year classes of three Brown Trout strains – New Gloucester, Sandwich River, and Seeforellen.

This report provides a four-and-a-half-year summary of the program's results as viewed from the MDIFW hatchery system's perspective. It discusses Brown Trout growth, disease resistance, feed conversions, genetic analysis, and other fish husbandry characteristics while cultured within department hatcheries. It concludes with specific recommendations to MDIFW's future Brown Trout hatchery program. Field performance

[1] Statewide performance objectives identified in the Department's 15-year Brown Trout work plans considered a catch rate of 1.0 Brown Trout per day or higher averaging 15 inches and 1.5 pounds each.

comparisons are currently under investigation and will part of a larger study; the results will be reported separately (Ashe, est. 2020).

METHODS

The objective of the multiple observational cohort study was to compare hatchery performance of the three Brown Trout strains to determine the strain most suitable for MDIFW's general Brown Trout program.

Experimental Design

This investigation was set up as an observational cohort study (Ott 1993; Thursfield 1995). Observational studies are used to identify risk factors and to estimate the quantitative effects of the various component causes that contribute to the occurrence of an effect. This experimental design is particularly useful in this situation where fish are being raised as part of normal hatchery operations and it is not possible to control for all undesirable variables. It is also particularly useful in studying groups of individuals through time where exposure to the risk factors and onset of dependent variables does not immediately follow. Observational studies differ from experimental studies because investigators are not free to randomly allocate risk factors to individuals. A cohort study selects groups according to presence or absence of exposure to hypothesized causal factors, and then looks prospectively to the development of the dependent variables (Thursfield 1995).

Hatchery personnel measured the length, weight, and Fulton's condition factor (K) of each Brown Trout strain at least monthly. All groups of fish were reared to a goal size and not fed *ad-lib*. Annual health and fish size quality production reports were also produced by MDIFW's fish pathologist.

Subjects

The three Brown Trout strains evaluated during this project were the New Gloucester Hatchery strain[2] (NG) from MDIFW New Gloucester State Fish Hatchery, the Seeforellen strain[3] (SE) from Connecticut Department of Environmental Protection Kensington State Fish Hatchery, and the Sandwich River strain[4] (SA) maintained by the

[2] Records indicate New Gloucester Brown Trout were established in 1968 from an unknown number of wild parents.
[3] Connecticut first spawned their own Seeforellen brood in 1999 from Seeforellen eggs received from Michigan and one of their own hatcheries starting in 1996. The number of brood pairs used since 1999 has varied between 185 and 426.
[4] In the 1950's a single introduction of Sunderland State Fish Hatchery domestic Brown Trout was introduced to Sandwich State Fish Hatchery to create a brood. During the 1980's and up until 1991, the Sandwich strain was infused with unknown sea-run Brown Trout strains from other states, wild returning sea-run fish from stocking programs and Sandwich Hatchery brood line.

Massachusetts Department of Fish and Game Sandwich State Hatchery. This was the first time that both Seeforellen and Sandwich strains were cultured in the MDIFW hatchery system.

Husbandry

All three strains were spawned *in vitro* at their respective hatcheries and eggs were incubated from green to eyed egg stage before being transferred. Several hatcheries were involved in the husbandry of these three Brown Trout strains during the study. Geographical differences in stocked field performance study waters and hatchery space prevented a single hatchery from rearing all three strains throughout the study. NG strain Brown Trout were reared from green egg to fry stage (80 mm total length (TL); 3.75 grams) at the New Gloucester State Fish Hatchery, New Gloucester, ME. Eyed SA strain Brown Trout eggs were sent to the New Gloucester Fish Hatchery in December 2008, 2009, 2010, 2011 and 2012 from the Sandwich State Hatchery, Sandwich, MA. Eyed SE strain Brown Trout eggs were sent to the New Gloucester State Fish Hatchery in December 2008 from Kensington State Fish Hatchery, Kensington, CT. Green SE Brown Trout eggs were sent to New Gloucester State Fish Hatchery in December 2011 and 2012 from Palermo State Fish Hatchery, Palermo, ME. In the fall of 2009, Connecticut's SE brood source tested positive for furunculosis and MDIFW decided not to import eggs until the health problem was corrected. MDIFW retained 750 of the 2008 brood year SE from Connecticut to use as future brood source. Therefore, SE brood held at the Palermo State Fish Hatchery provided the needed production to support and continue the hatchery Brown Trout strain investigation. The New Gloucester State Fish hatchery provided early rearing from eyed egg to fry stage for both SE (65mm TL; 2.3 grams) and SA (80mm TL; 3.75 grams). The New Gloucester Fish Hatchery was equipped with isolation capabilities and could rear the fishes on well water. Once fish tested negative for pathogens of regulatory concern (NEFHC 2008, USFWS and AFS-FHS 2007-2014) and receiving hatchery waters began to surpass well water temperatures, they were transported to the Casco and Palermo State Fish Hatcheries for grow-out. Fish culturists at both Casco and Palermo kept husbandry records on all three strains and stocked them as directed by the Brown Trout committee and regional fisheries biologists.

Life Stages

In this report, salmonid growth will be broken into three life stages: stage 1, fry to fall fingerling (FRY-FF); stage 2, fall fingerling to spring yearling (FF-SY); and stage 3, spring yearling to fall yearling (SY-FY). Fish reared to approximately 16 months after hatch are spring yearlings (SY) and fish reared for approximately 21 months are fall yearlings (FY). Life stage 1 represents fry transfer to a production facility throughout the month of October, after fall fingerling stocking. Life stage 2 represents all fall fingerlings held from November and cultured throughout the end of May, after being released as spring yearlings. Life stage 3 represents all spring yearlings cultured throughout their second summer and released as fall yearlings by the end of October.

Rearing Environments and Operation

The New Gloucester State Fish Hatchery is supplied with water from Eddy Brook and well water. The hatchery building houses 25, five-foot diameter fiberglass combi-tanks for egg incubation and early fry rearing. Within the two-level combi-tank system, eggs incubate at the top-level operating at an average depth of 0.58 feet with an approximate flow of 3 GPM. Small fry are then transferred to the bottom tank after swim-up in an average operating depth of 2.5 feet and 4-7 GPM flow. The New Gloucester hatchery incubates all MDIFW Brown Trout on well water averaging 7.9°C. New Gloucester densities rarely exceed 1 lb./ft^3 and usually were maintained at 0.75 lb./ft^3. A more complete technical summary of the facility can be found in Fish Pro (2002). All Brown Trout strains were transferred to both Casco and Palermo hatcheries and cultured throughout life stages 1-3.

Palermo State Fish Hatchery is supplied with water from Sheepscot Pond, a 1,193-acre-pond with a maximum depth of 132 ft. Water temperatures ranging from 2°-19°C are best suited for Brook Trout (*Salvelinus fontinalis)* and Brown Trout production. The facility is supplied with water from two separate supply pipelines with two separate intakes. A 24-inch diameter intake pipeline obtains colder water from a depth of 50 feet. A 16-inch diameter shallow intake pipeline obtains warmer water at a depth of 20 feet during summer months. The 3,500 GPM is divided between two separate exterior raceway series. Between the two-raceway series there are 31 concrete raceways that are completely covered with a wooden frame structure for fish protection. Dissolved oxygen is provided to raceways via low head oxygen (LHO) contact chambers combined with bulk liquid oxygen to maintain desired levels of dissolved oxygen after serial reuse. A more complete technical summary of the facility can be found in Fish Pro (2002).

Casco State Fish Hatchery is supplied with 2,100 GPM of ultraviolet (UV) treated water from Pleasant Lake, a 1, 077-acre lake with a maximum depth of 62 ft. Warm summer water temperatures at this hatchery are best suited for Landlocked Atlantic Salmon (*Salmo salar)*, Rainbow Trout (*Oncorhynchus mykiss)* and Brown Trout production. The 2,100 GPM is divided between two separate exterior raceway series. Between the two-raceway series there are 32 concrete raceways that are completely covered with a wooden frame structure for fish protection. Dissolved oxygen is provided to raceways via low head oxygen (LHO) contact chambers combined with bulk liquid oxygen to maintain desired levels of dissolved oxygen after serial reuse. A more complete technical summary of the facility can be found in Fish Pro (2002).

Feeding and Feed Conversion Efficiency

Feeding practices were adjusted monthly throughout the study. Size goals were used as a guide throughout the study while hatchery personnel were instructed to alter feeding regimes to maintain similar mean size to help reduce size dependent differences for field performance comparisons. Feeding methods varied among hatcheries and were dependent on the fishes' age and each strain's feeding behavior. Feed delivery ranged from hand feeding to belt and on-demand feeders. All three strains were fed a Bio-Oregon diet that ranged from #0 mash to a grower/finisher feed pellet of up to 4mm. Cost analyses between strains were calculated using monthly growth rate and feed cost data (cost/kilogram gain). Feed cost was calculated by adding the cost and delivery fee for each bag. For example, if a 20-kg bag of 2mm Bio-Trout cost USD $29.40/bag including delivery fees, the cost of one kilogram of 2mm is $1.47. Monthly kilograms gained data was calculated by sampling the weight of the population at the beginning of each month and subtracting that value from end of the month sample weights. Mean monthly grams/fish data was converted to kilograms/fish and multiplied by the mean feed cost/kilogram gained per age class to compare cost/fish (Table 10). Feed conversions were reported and calculated by figuring the monthly weight of food fed divided by the population's gross monthly weight gain. A parametric one-way analysis of variance (ANOVA) was used to test for differences in mean conversion factors. A Tukey's post-hoc comparison test was then used to detect for significant differences in specific strain groupings (Table 2).

Fish Health Inspections

Every lot of fish held at MDIFW hatcheries are inspected annually for all applicable pathogens of regulatory concern listed in the salmonid fish health inspection section of MDFIW's Chapter 2 Rules. The MDIFW Fish Health Laboratory samples fish from each hatchery multiple times per year, with 60 fish sampled annually for diagnostic screening from each lot present at the facility. In addition to lethal sampling of all fish lots at each hatchery, 100% of all spawned females have their reproductive fluids screened for viruses of regulatory concern and *Renibacterium salmoninarum*. Viral screening utilizes cell culture isolation techniques to screen for infectious hematopoetic necrosis virus, infectious pancreatic necrosis virus, viral hemorrhagic septicemia virus, Oncorhynchus masu virus, infectious salmon anemia virus, and any other viral agent capable of producing a cytopathic effect on CHSE, EPC, or ASK cell lines. Bacteriology was for *Aeromonas salmonicida*, *Yersinia ruckerii*, and *Reinbacterium salmoninarum*. Parasitology was only conducted on the most susceptible lot for *Myxobolus cerebralis*. All diagnostic tests were conducted per standardized procedures as outlined in the American Fisheries Society-Fish Health Section "Blue Book" Suggested Procedures for the Detection and Identification of Certain Finfish and Shellfish Pathogens.

Fish Quality Inspections

Each spring and fall 30 fish from every lot at each hatchery were inspected for size and fin quality. Fish quality inspections included length, weight, body condition factor, an external inspection for body defects and injuries, as well as a fin inspection index (Frantsi et al. 1972). Fin inspection indexes were monitored and reported throughout the hatchery study for internal departmental quality assessment. The author assumes one strain's fin quality may differ from other strains due to the presence or absence of different variable exposures (i.e. dissimilar densities, cannibalism, nutrition, fright response), but feels quality is important to compare.

Semi-annual MDIFW fish quality report data (years 2010-2014) were used to compare all Brown Trout strains at both SY and FY age classes. Mean length, weight, and condition factor data were collected and used to compare specific age size goal attainment throughout the study. All fish quality inspections were performed by the MDIFW fish pathologist and accompanying fish culturists.

Stocking Procedure

Hatcheries involved with culturing all three Brown Trout strains separated predetermined numbers of fish into raceways for comparative stocking. Fish culture supervisors notified the Brown Trout committee chair regarding appropriate stock identifying fin clips[5] prior to stocking. Hatcheries coordinated stocking efforts to ensure equal paired stockings of each strain, same stocking location, and release dates.

Fish Culturists Impression of Brown Trout Strains

Fish culturists involved with raising and/or stocking all three Brown Trout strains were asked to complete a questionnaire. The questionnaire asked culturists to reflect on their own experience raising each study strain to determine which strain they deem most cultivable. All responses were used to best rank Brown Trout strain by overall hatchery performance.

Genetic Testing

Estimates of genetic diversity were compared among all three Brown Trout strain populations. Fin tissue samples were provided by Al Sonski (CDEP), Ken Simmons (MDFG) and Tim Knedler (MDIFW) and microsatellite

[5] Regional fisheries biologist Francis Brautigan developed fin clip marking schedule throughout the hatchery and field performance studies.

analysis was performed (Barton, Julian and Kalie, 2016), (Barton and Julian, 2009). Three NG brood year populations, one SA brood year population, and two SE brood year populations were analyzed during this study.

Data Analyses

Between 2009-2014, a large quantity of hatchery production reports[6], health inspections, fish quality reports, and questionnaire data were collected. The most complete and useful data available throughout the study period was compiled and summarized in this report. Data were managed and analyzed with computer software programs including Microsoft® Excel (Microsoft Corporation, Inc. Redman, WA) and R version 3.1.2 (The R Foundation for Statistical Computing, Vienna, Austria). The original data are available at the respective hatchery.

RESULTS

Egg Survival Rates

Hatchery supervisors provided mean survival rates of their respective Brown Trout strain from fertilization to swim up (first day of feeding). Mean annual survival averages were gathered and three-year mean averages are reported below. The Massachusetts Department of Fish and Game Sandwich State Hatchery reported a 35% survival on SA (A. Davies, Massachusetts Sandwich State Hatchery, personal communication); Connecticut Department of Environmental Protection Kensington State Fish Hatchery reported 40% survival for SE (A. Sonski, Kensington State Fish Hatchery, personal communication) and MDIFW New Gloucester State Hatchery reported 75% survival for NG and 78% mean survival rate on SE (T. Knedler, MDIFW, personal communication).

Mortality Rates

Significant differences in mean monthly mortality rates were detected among the Brown Trout strains ($F_{(2,295)}$, $p = 0.016$) (Table 1, Table 2). There were no significant differences in mortality rates between the NG and SA ($p = 0.099$) or between the SA and SE strains ($p = 0.741$); however, the mean mortality rate of the NG strain was significantly greater than that of the SE strain ($p = 0.016$). Figure 1 illustrates the change in mean monthly mortality for each life stage throughout the study.

[6] A total of 312 monthly production reports were used for this hatchery comparison.

Growth Rates

Growth rate data below reflects all combined monthly fish hatchery production reports from the Palermo and Casco hatcheries. Mean data reported below is combined hatchery information that represents a State product. Throughout the study, NG and SA strains had a one-month feeding and size advantage over SE in the hatchery environment before shipment to Casco and Palermo due to late season spawning attributes of the SE strain and the later date of first feeding as a consequence.

Sandwich Brown Trout were longer than NG and SE at SY and FY age classes (Figures 2 and 3). Spring-yearling SA (251 mm) were 3 mm longer than NG and 14 mm longer than SE. The mean length of a FY SA was 325 mm, and marginally longer than both FY NG (314 mm) and FY SE (314 mm) (Table 3).

Mean weight of SY SA was 218 g. Spring yearling SA were 28 g heavier than SY NG (190 g) and 49 g heavier than SY SE (169 g). Mean weight of FY SA was 431 g, considerably heavier than FY NG and FY SE weighing 369 and 388 g, respectively. While all Brown Trout grew well within the MDIFW hatchery system, a one-way ANOVA indicated there were no significant differences among strains with respect to mean length ($F(2,296) = 1.138$, $p = 0.322$) or mean weight ($F(2,296) = 1.911$, $p = 0.15$)(Table 2). Figure 4 shows a scatter plot comparing mean weight for each Brown Trout strain throughout the study. Regression lines appear similar in slope and this may reflect comparable growth rates among strains.

Size Production Goals

Semi-annual MDIFW fish quality report data (years 2010-2014) were used to compare all Brown Trout strains at both SY and FY age classes. Mean length, weight, and condition factor data were collected and used to compare specific age size goal attainment throughout the study. Seeforellen Brown Trout fell short of SY length and weight goals compared to both SY SA and NG however; both FY NG and FY SE exceeded all size quality goal requirements throughout the study (Table 4). In 2014, FY SA missed mean length requirements by seven millimeters.

All three strains did not attain the SY condition factor goal. Each strain showed no signs of malnourishment and were uniquely patterned. The mean condition factor for each strain was 1.26, 1.24, and 1.23 for SA, NG and SE, respectively.

Fin Quality Goal Requirements

The results from the Kruskal-Wallis test indicated that there were no significant differences in the densities of each hatchery reared Brown Trout strain ($H = 0.658$, $df = 2$, $p = 0.720$) (Table 6).

Fin quality results from the Kruskal-Wallis test indicated that there were marginal differences in non-caudal fin quality by Brown Trout strain ($H = 5.99$, $df = 2$, $p = 0.0498$), while significant differences in caudal fin quality among strains were detected ($H = 19.54$, $df = 2$, $p < 0.0001$) (Table 7). The Wilcoxon post-hoc test indicated that the non-caudal fin erosion was marginally significantly greater in the SA than in both the NG ($p = 0.045$) and SE strains ($p = 0.034$) (Table 8). The Wilcoxon post-hoc test also indicated that the caudal fin erosion was highly significantly greater in the NG strain than in both the SA ($p = 0.0005$) and SE strains ($p = 0.0001$) (Table 8).

Disease Resistance

All fish were inspected annually and tested negative for all pathogens of regulatory concern. Hatcheries participating in the study received fish health inspection reports confirming Class "A" status, per Northeast Fish Health Committee Guidelines.

Feed Conversion Factors

End of the month feed conversion factors were recorded and gathered for each strain over the study period. The four-year mean conversion factor between all three was 0.86. Individual four-year median feed conversions were 0.84, 0.86 and 0.89 for the SA, SE and NG, respectively. Cumulative mean of the mean feed conversion factors is reported in Table 9. At the conclusion of this study, data showed no significant difference in feed conversions between the three Brown Trout strains (NG-SA ($p=0.393$), NG-SE ($p=0.548$) and SA-SE ($p=0.966$)).

Cost Comparison

At $0.69, FY SA were cheaper to produce than both FY SE ($0.72) and FY NG ($0.81) (Table 10).

Fall yearling SA are slightly larger than FY NG and FY SE, however, they are not significantly larger (Table 2). Fall yearling SA were 16.8% greater in weight and $0.12/fish less expensive than FY NG. Data also show that FY SA were 11.0% greater in weight and $0.03/fish less expensive than FY SE. Interestingly, FY SA were both less expensive and greater in weight than FY NG and SE. Table 11 shows the adjusted feed cost to raise both FY SE (increase $0.11/fish) and FY NG (increase of $0.26/fish) to the heavier FY SA. Overall, FY SA were the least expensive to culture ($0.69). Adjusted feed costs were developed to more accurately compare expenses associated with producing similar size FY BNT.

Fish Culturist Questionnaire

Nine of the eleven questionnaires distributed were properly answered and returned; therefore, each Brown Trout strain had the potential to accrue a "BEST AT" total of 90 points. MDIFW fish culturists rated NG (40 points) strain Brown Trout most cultivable. Seeforellen (28 points) Brown Trout were rated second and SA (22 points) Brown Trout were least desired within the MDIFW hatchery system (Table 12).

Genetic Testing

Despite different sample collection dates, genotypes were standardized and consistent in allele size between all three Brown Trout strains and all data were analyzed together for comparison. The NG strain had lower number of alleles (N_a=4-4.5) than the SA (N_a=5.8) and SE strains (N_a=7.2 and 8.6). Estimates of observed and expected heterozygosity were lower in the NG strain compared to the other strains as well. Effective population size estimates ranged from a high of N_e=267.7 for one of the SE strain samples and a low of N_e=51.3 in one of the NG strain samples. All pairwise estimates (relatedness) of differences in allele frequencies were statistically significant from one another. Pairwise relationship comparisons within each brood year sample indicated that NG had the highest proportion of related individuals. Half-sibling and full-sibling or parent-offspring relationships were used for comparison. Two NG brood year groups had the highest percentage of comparisons related at greater than the half-sibling level (6.9% and 6.4%), followed by the SA (5.5%) and the lowest levels of relatedness were SE (1.7% and 4.0%) brood year groups (Barton and Julian, 2009; Barton, Julian and Kalie, 2016).

DISCUSSION

Mortality Rates

Mean egg survival rate data showed NG (75%) produced superior egg survivability compared to both SE (40%) and SA (35%) strains. Contrastingly, when MDIFW hatchery staff cultured and spawned SE brood stock, mean egg survival rates were 78%. The MDIFW hatchery staff almost doubled the Connecticut Kensington State Fish Hatchery survival rates. Although it was not the intent of MDIFW to culture and manage SE brood stock in house (this was deemed necessary due to Connecticut's SE brood source testing positive for furunculosis), it is interesting to compare egg survival rates between MDIFW and Connecticut SE. Sandwich strain brood stock were never cultured by MDIFW throughout the study. There are various factors to consider (husbandry practices, age of brood stock, diet, spawning protocol, water quality, etc.) when comparatively evaluating egg survival success. More importantly, greater SE egg survival rates produced at MDIFW showed exceptional abilities to culture a quality resource through sound biosecurity management and strict spawning protocol. Egg survival rates are not being used for comparison and were only gathered to help aid future Brown Trout brood stock consideration.

Overall, mean monthly mortality rates for each strain were less than 1.0%. The NG mean mortality rate was significantly greater than that of the SE strain. NG had higher mortality rates than SE during both first and second cultured summers. All three Brown Trout strains were raised at the same hatcheries and experienced similar water temperature and stress fluctuations. Although mortality rates were significantly different, taking a few more eggs of a particular strain will help buffer future production needs. Population dynamics are easy to manage and plan for in a hatchery environment. It will be interesting to see how hatchery mortality rates equate to field performance returns.

Growth Rates

Throughout the study, data show that both SY SA (251mm; 218g) and FY SA (325mm; 431g) were a little heavier and longer than SY SE, SY NG and FY SE, FY NG. All strains at Casco and Palermo were fed with belt feeders and by hand. Both Casco and Palermo reported that they could have increased both SY and FY SA sizes throughout the study (S. Tremblay, MDIFW, personal communication). Casco altered SA feeding regimes to maintain similar Brown Trout sizes, while Palermo also adjusted feeding regimes and cultured SA Brown Trout in raceway water 2°C cooler than NG and SE during peak summer growth. Figures 2 and 3 illustrate mean length growth rate similarities between the two hatcheries, while Figure 4 show a scatter plot of mean weights throughout the study period.

Size and Fin Quality Goals

Size and fin quality goals are pre-determined by a committee of field biologists, fish culturists, and a fish pathologist. Goals are developed for each age class and based on the biologists' management needs and the fish culturists' ability to obtain such goals. Table 2 summarizes each strain's ability to achieve certain age class size goals. Spring yearling NG and SA did well obtaining most goals while SY SE fell short a few times throughout the study. All three Brown Trout strains met FY size goals besides the FY SA length in 2014 that fell short by seven millimeters. Condition factors were recorded and listed for reference but will not be used to compare differences between strains. Condition factors represent a length-weight relationship and determine a strain's unique appearance. One strain may surpass another in both length and weight only to be less in comparison to another fish's condition factor (Short 2001).

Each Brown Trout strain will react differently to rearing densities, thus affecting fin quality to varying degrees. Table 5 summarizes each strain's fin quality throughout the study while also comparing cultured rearing densities. Both SY and FY SE fin quality were impressive compared to SA and NG. Data show that there was no significant difference in rearing densities.

Cost Comparison

Precise and consistent weight sampling is crucial to adequately compare cost to weight gain. Less range within the monthly weight sampling will lead to more accurate and concise cost to weight gained ratios per fish population. Data gathered throughout the study reveal very similar standard deviation in individual weights among FY Brown Trout. Total standard deviation of FY weights was 92, 100 and 106 grams, for NG, SE and SA, respectively. Unlike the results of an earlier Rainbow Trout hatchery comparison, standard deviations of weights among three different fish strains were so dissimilar that cost comparisons were difficult to compare (Bray, 2007). Contrastingly, these data show less weight variation among strain populations, therefore providing a more accurate cost comparison.

Feed Conversions

Monthly feed conversion factors varied throughout the study. Lake water source hatcheries feeding fish populations a maintenance diet throughout winter months typically struggle to convert fish feed to flesh. Sixty-five percent of the mean feed conversions ranged from 0.5 to 1.5, 19% were less than 0.49 and 16% were more than 1.51. Mean feed conversions can be greatly influenced by high and low values (outliers). Mean feed conversions reported in Table 9 had the highest and lowest feed conversion outliers removed from each Brown Trout strain population. Median feed conversion factors were 0.89, 0.85 and 0.81, for NG, SE and SA, respectively. Feed efficiencies were similar between all strains when comparing both mean and median values.

Anecdotal Summary of Strain Behavior

Various behaviors anecdotally attributed to each Brown Trout strain were observed during the study. The SE strain exhibited greater scatter reflexes when released into the wild compared to that of NG and SA. Many culturists reported the peculiar post-stock schooling behavior of NG. The NG and SA strains fed well in the presence of fish culturists however, the NG strain often fed more aggressively than SA. The SE strain was more reluctant to feed in the presence of culturists but did actively surface feed.

One year during the cold winter months of the study, both the Casco and Palermo Hatcheries observed a small percentage of the SE strain swimming vertically. The odd swimming behavior was named, "star gazing". The vertical swimming stopped after ice out as temperatures started to increase.

Throughout the study, the Casco and Palermo Hatcheries found the SA strain to have the best growth potential of all three study strains. Although there were no significant size differences to report, both hatchery managers manipulated growth rates to help reduce significant size differences at time of stocking to better balance field performance evaluations. At the Palermo Hatchery, SA strain was cultured in water temperatures 2.0 to 2.5°C cooler than NG and SE. Most fish culturists found the NG and SA strains easier to culture the first year. Many found the SE strain to perform better during the second cultured summer, rather than the first.

The three Brown Trout strains were quite different in appearance and are easy to differentiate phenotypically in our hatchery system at FY age (21-23 months). Sandwich strain are more laterally compressed, lacking in overall color and spotting. Seeforellen's are typically darker in appearance than both NG and SA strains. Their black spotting pattern is heavily distributed both dorsally and laterally against a subtle hue of brown to yellow coloration; more "brassy" in appearance. New Gloucester's appear to have a brighter bronze to yellow coloration while supporting a more evenly distributed black spotting pattern. All three strains possess red spotting; however, NG appear to be brighter and more numerous.

Both hatcheries observed numerous deformities[7] in the SA strain. Numerating deformed fish was not part of the original hatchery study plan. Fish culturists noticed the deformities during the annual spring marking season (predetermined fin removal for field performance identification). Fish quality reports between years 2010-2014 show SA strain deformities that were four times greater than that of NG and SE. Additionally, in 2014, the Palermo Hatchery sampled one percent of each Brown Trout strain population[8] and found SA strain had the highest deformity rate (11%). The NG strain had the second highest (10%) and SE (1%) had the lowest deformity rate.

Regulating water temperatures during warm summer months can increase fish survival and reduce several stress related incidences. Annually, the Casco Hatchery experiences volatile water temperatures in late August and September. Casco Hatchery reported as many as 336 NG strain mortalities daily[9] (Tremblay, personal communication). The SA and SE strains cultured in the same conditions exhibited little to no mortality during

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[7] Fish culturists reported deformities such as humpbacks, scoliosis and deformed caudal peduncles.
[8] Personnel screen entire pool, netted through center of population lot and counted sample (numbers: 115 NG, 110, SA and 60 SE) into buckets where they were anesthetized and thoroughly examined.
[9] Since the study, Casco has added blocks of sodium chloride to help reduce mortalities in NG strain raceways.

the same time frame. It will be interesting if field investigations mimic NG strain hatchery mortality rates (like Casco's summer high water temperature fluctuations) considering many of the state's Brown Trout are typically stocked in marginal waters[10].

Palermo noticed that the SE were more sensitive to formalin treatments (1 hour - 200 ppm) than both the SA and NG and observed roughly a half dozen SE mortalities post treatment. Seeforellen showed improved survival with a 1 hour-170 ppm formalin treatment compared to a 1 hour-200 ppm treatment.

Both hatcheries indicated that SE strain Brown Trout performed better at higher densities than both NG and SA. New Gloucester and SA strains produced better quality fins and aggressive feeding behavior if cultured in densities less than 1.5lb/ft³. Fin quality of SE remained superior until densities exceeded 2.0lb/ft³. Seeforellen exhibited increased feeding behavior if cultured in more dense conditions (1.25lb/ft³ - 2.0lb/ft³) than did NG and SA strains.

Genetic Testing

. Among the three Brown Trout strains, the SE strain had the highest estimates of genetic diversity (Barton et al. 2016). Genetic diversity between these Brown Trout strains will be used to evaluate the hatchery comparison along with survival and growth rates, conversion factors, and ease of culture to name a few. However, it is important to note that the genetic analysis results are not influenced by various environmental factors (i.e. water supplies, densities, flow rates, managerial styles, and feed), but instead due to mechanisms such as mutation, genetic drift, and historical gene flow.

CONCLUSIONS AND RECOMMENDATIONS

Generally, there was no Brown Trout strain that out-performed the others within the MDIFW Hatchery evaluation at all levels. However, The SA and SE did perform as well if not slightly better than the NG strain. The Casco and Palermo Hatcheries cultured all three strains as equitably as possible during the study period. Similar feed conversion rates and disease resistance indicated how well our hatchery system managed feeding rates and minimized various degrees of stress.

Fish culturists evaluated all Brown Trout strains against a matrix of hatchery-friendly characteristics and deemed NG to be favorable. Many fish culturists mentioned the ease of culturing the NG strain annually (regarded as "*The same as always cookie cutter sized fish with nice coloration and very few issues")*. Fish culturists felt the

[10] Factors limiting Brown Trout performance including summer water quality, interspecific competition, forage, etc.

same way about the ease of culturing SA strain; however, their population exhibited numerous body abnormalities and lacked vibrant coloration. Introducing a wilder behaving and more challenging SE strain to culture, put them at a disadvantage from the start.

All three strains performed well, achieving most pre-determined size goal requirements, however; fin quality was an exception. Data showed that SE had exceptional non-caudal and caudal fin quality throughout the study even though statistical analysis showed rearing densities were comparable. The author believes that both fin and size quality regardless of strain, will be further enhanced when MDIFW selects a single Brown Trout strain.

Growth rates and cost favor the SA. Both SY and FY SA were longer and heavier than SE and NG. Although growth rate comparisons were not significant, the fact that SA were also slightly cheaper to culture is noteworthy. Data showed that all three strains yielded mortality rates of less than one percent. However, SE mortality rates were less than half that of NG. Seeforellen exhibited significantly greater survivability than NG within the MDIFW hatchery environment. Both SE and SA at Casco were stress tolerant enough to better handle warm fluctuating water temperatures than NG under very similar conditions. Maine waters receiving Brown Trout tend to be warmer and of marginal salmonid habitat. Such suggests that both SE and SA strains may be better suited for Maine waters typically being stocked with Brown Trout.

Electrophoretic analysis performed in 1999 show Maine's NG strain have a high degree of homogeneity (Leary 1999). More recent microsatellite analysis of all three study strains show SE had the highest estimates of genetic diversity, followed by the SA and then NG. The NG strain also had the highest proportion of related individuals (half-sibling level) within each brood year population (Barton et al. 2016).

While the SA efficiently converted feed and grew well, their fin quality and general appearance were of concern. The SA strain may have been at a disadvantage prior to stocking because their fin erosion percentages where consistently worse throughout the study. The number of physical abnormalities witnessed while performing daily tasks at both participating hatcheries were alarming (Bray and Tremblay, personal communication). Quality reports show SA strain had three times more deformities than both the SE and NG. The Palermo hatchery for two years of the study, sampled and found that 11% of the SA production fish were deformed (deformed caudal peduncle, scoliosis, tumors, abridged operculum, missing fins, etc.) Although genetic testing found SA with the second highest estimates of genetic diversity, the author believes the strain exhibited other potentially negative qualities that should be considered.

If the NG strain outperforms or offers improved field performance characteristics than the SE and SA strains, then it may benefit from a genetically enhanced SE infusion. Continued reduction in levels of genetic variation in NG Brown Trout, are expected to result in a reduction of several performance attributes such as hatching success, growth, survival, and an increased proportion of deformed fish (Mitton and Grant 1984; Allendorf and Leary 1986; Palmer and Strobeck 1986; Zouros and Foltz 1987; Leary and Allendorf 1989). Thus, at a minimum, it would be wise to infuse new SE genetic information with NG to help reduce the likelihood they experience adverse effects of low levels of genetic variation. If NG strain remain in MDIFW's management program, the author believes a NG female and SE male infusion would best suite resource needs. This genetic infusion would take advantage of NG strain's high levels of fecundity and eye-up rates along with early spawning dates. Early spawning would also help aid in increased first year growth rates (SY) and help hatcheries with the ever-increasing demand for larger second year (FY) Brown Trout.

Unfortunately, the MDIFW Hatchery program would need to manage brood lines of both the NG and SE strains to regularly infuse genetic material. Culturing two different strains with dissimilar spawning windows while managing multiple age classes, would reduce overall pool space needed for other production and management goals. Interestingly, the NG strain is a synchronous spawner whereas SE have a larger spawning window. Early or late spawning impacts the size of SY, and lack of synchronicity certainly impacts hatchery labor with the need for multiple spawning events over a one-month period. However, in waterbodies stocked with SE Brown Trout, delayed spawning behavior and delayed migration into fluvial zones could result in decreased predation and improve overall survival due to seasonal differences in the presence of predators. Although later spawning may not be ideal for hatchery operations, it may have benefits for survival of stocked fish.

If the SE strain performs as well or significantly better than the SA and NG strains regarding field performance, then replacing our current NG strain with SE may be the favored recommendation. The author believes the SE strain would not benefit from a NG genetic infusion. Considering the significant genetic differences between the NG and SE strain (Barton et al. 2016), infusing the NG strain would not likely increase the genetic diversity of the SE strain. MDIFW will benefit from managing one strain and maintaining genetic variation through multiple age class paired matings. Reports from the Great Lakes indicate that the SE strain is more pelagic, roaming after baitfish like salmon would; therefore, being caught more often by summertime anglers. As summertime angling opportunity is one of the Brown Trout's attributes, such is a positive aspect of the strain. In waters with Bass and Pike, such pelagic behavior may also enhance survival. The Seeforellen's superior survival rates, comparable growth rates, exceptional fin quality, and increased estimates of genetic diversity make this strain a more suitable replacement. Lastly, the later spawning of SE is also a better match for Brook trout spawning, increasing efficiency at facility. Based solely upon the hatchery component of this study, the author believes the MDIFW Hatchery program would benefit most from culturing and managing the Seeforellen strain in the future.

The MDIFW Hatchery Section has the ability to raise all three strains well, and when a single strain is chosen will continue to strive for enhanced performance. The next question is which strain will perform best in the field to provide increased post stocking survival and grow to create multi-age fishing opportunities? MDIFW could choose the fastest growing and least expensive fish to culture, but if you cannot catch one, how would anglers benefit? If field study returns are unsatisfactory and data is unconvincing, hatchery performance may be key to the strain evaluation and deserving of additional discussion.

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FIGURES

Mortality Comparison

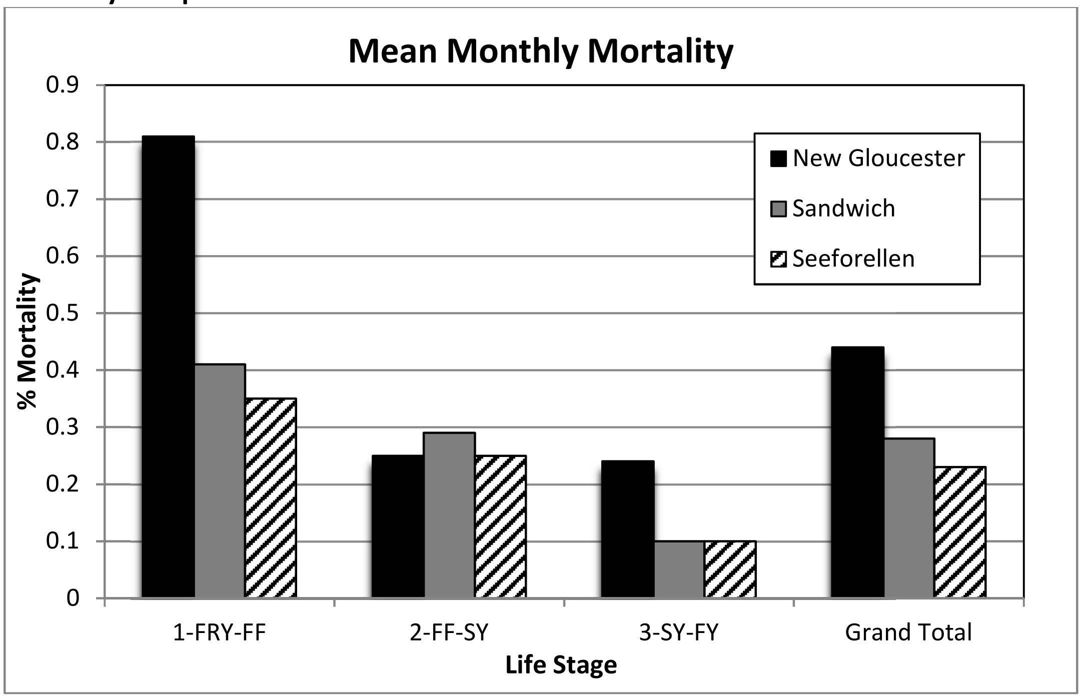

Figure 1. Trends in mean monthly mortality, years 2009-2014.

Length Comparison

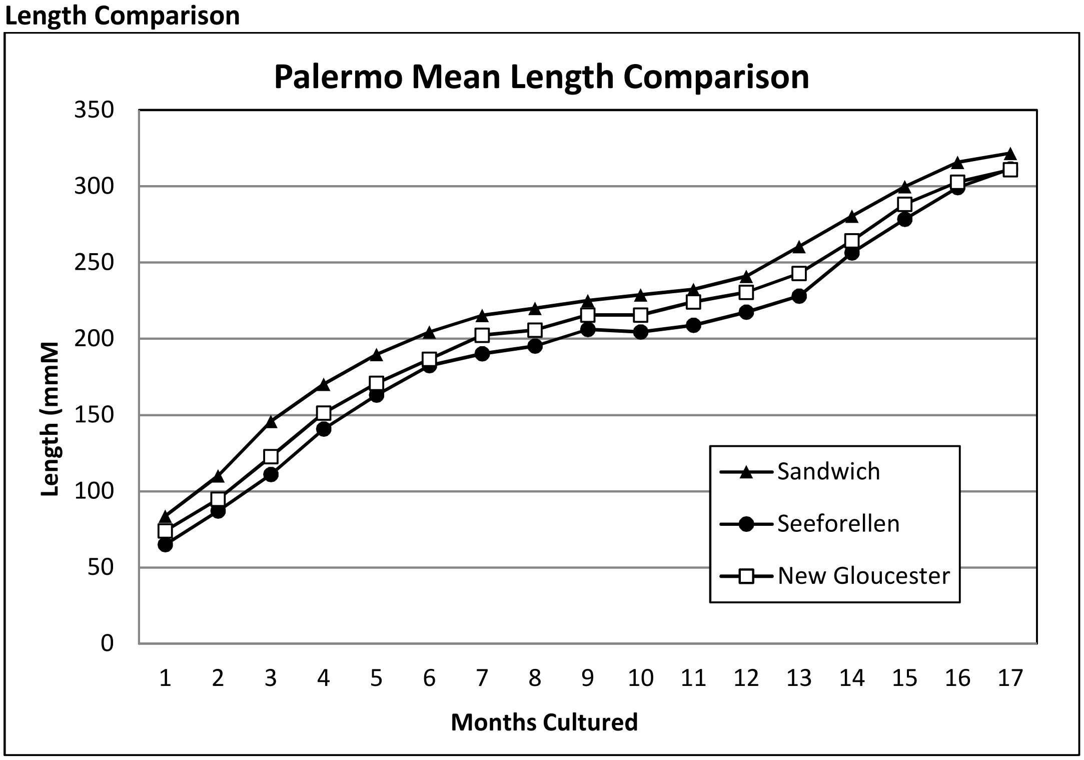

Figure 2. Mean Length at Palermo, years 2009-2014.

Length Comparison

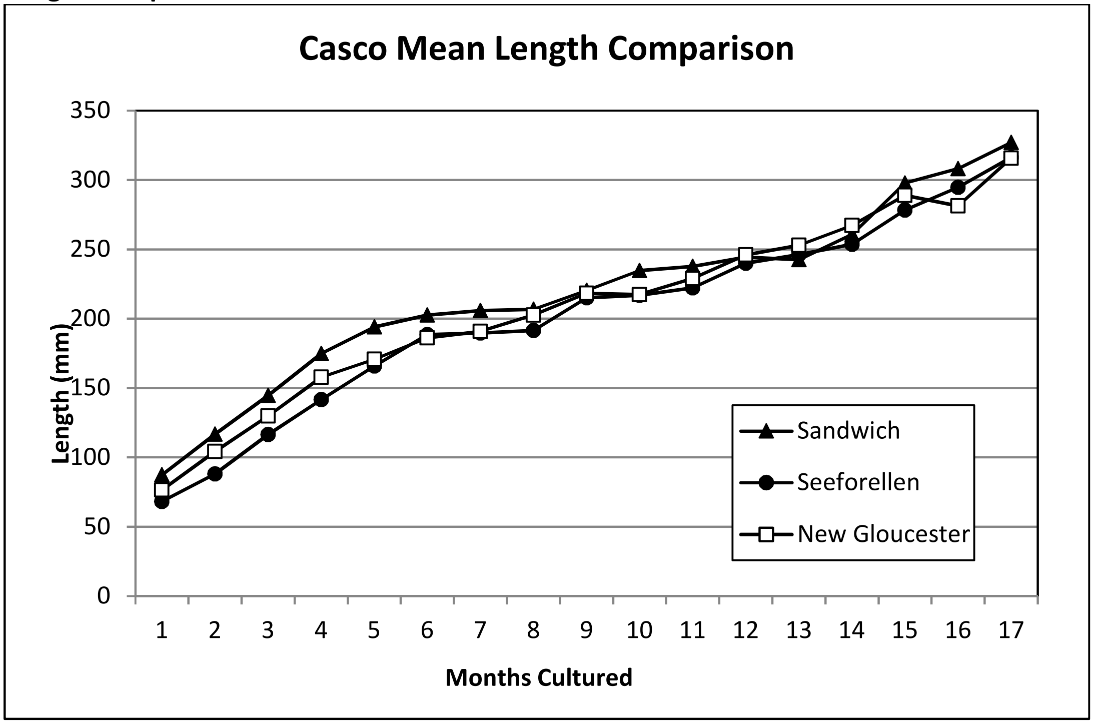

Figure 3. Mean Length at Casco, years 2009-2014

Mean Weight Scatter Plot and Regression

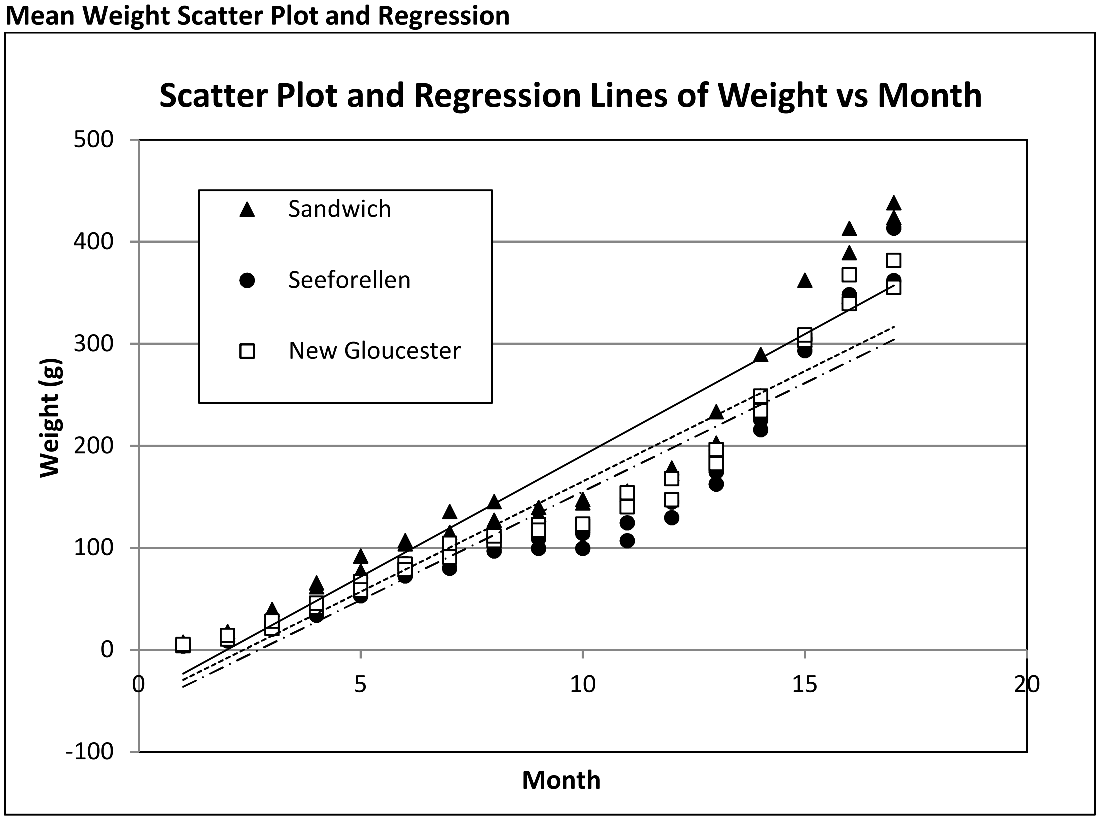

Figure 4. Scatter plot and regression lines of Palermo and Casco weight, years 2009-2014

TABLES

Mean Monthly Mortality Table

Table 1. Mean monthly mortality per life stage, years 2009-2014.

Life stage	NG	SA	SE
1- Fry to fall fingerling	0.81	0.41	0.35
2- Fall fingerling to spring yearling	0.25	0.29	0.25
3- Spring yearling to fall yearling	0.24	0.10	0.10
Average	0.44	0.28	0.23

Statistical Strain Comparison Table

Table 2. Mean length, mass, conversion factor and mortality rate of post-hoc statistical strain comparison (ANOVA, Tukey post-hoc test, alpha <0.05). Significant p-values are in bold.

	Tukey Post Hoc Test p-values			
Strain Comparison	Length	Weight	Conversion Factor	Mortality Rate
NG - SA	0.691	0.432	0.393	0.0992
NG - SE	0.77	0.767	0.548	**0.0155**
SA - SE	0.289	0.132	0.966	0.7411

Mean Length and Weight Table by Hatchery

Table 3. Mean length and weight comparison by strain by age class, 2010-2014.

Age Class	Strain	Length (mm)	Difference (mm)	Weight (g)	Difference (g)
Palermo Mean Length and Weight Data Prior to Comparative Stocking					
	NG	244	-27	167	-41
SY	SA	271	0	208	0
	SE	223	-48	125	-83
	NG	316	-34	365	-183
FY	SA	350	0	548	0
	SE	320	-30	400	-148
	NG	249	-5	189	-17
SY	SA	254	0	206	0
	SE	240	-14	162	-44
	NG	309	-4	382	-31
FY	SA	313	0	413	0
	SE	311	-2	372	-41
	NG	236	-3	166	0
SY	SA	239	0	162	-4
	SE	220	-19	126	-40
	NG	310	0	320	0
FY	SA	308	-2	310	-10
	SE	310	0	320	0
Casco Mean Length and Weight Data Prior to Comparative Stocking					
Age Class	Strain	Length (mm)	Difference (mm)	Weight (g)	Difference (g)
	NG	234	-8	156	-33
SY	SA	242	0	189	0
	SE	238	-4	151	-38
	NG	309	-31	367	-119
FY	SA	340	0	486	0
	SE	320	-20	408	-78
	NG	252	0	197	0
SY	SA	226	-26	160	-37
	SE	238	-14	181	-16
	NG	315	0	453	-1
FY	SA	314	-1	453	-1
	SE	315	0	454	0
	NG	255	-10	195	-15
SY	SA	265	0	210	0
	SE	250	-15	145	-55
	NG	330	-2	454	0
FY	SA	313	-19	453	-1
	SE	332	0	454	0

Fish Size Goal Inspections

Table 4. Summary of fish size quality goals, years 2010-2014.
Bold print indicates unfulfilled goals.

Strain	Age	Length (mm)		Weight (gr)		Condition Factor	
		measured	goal	measured	goal	measured	goal
2010 Palermo Fish Quality Goal Inspections							
NG	SY	232	230	167	150	1.31	1.23
SA	SY	247	230	209	150	1.38	1.23
SE	SY	**214**	230	**123**	150	1.22	1.23
NG	FY	311	305	376	301	1.29	1.06
SA	FY	344	305	548	301	1.32	1.06
SE	FY	314	305	399	301	1.28	1.06
2013 Palermo Fish Quality Goal Inspections							
NG	SY	237	230	164	150	1.23	1.23
SA	SY	241	230	178	150	1.24	1.23
SE	SY	237	230	176	150	1.31	1.23
NG	FY	317	305	387	301	1.18	1.06
SA	FY	313	305	381	301	1.23	1.06
SE	FY	308	305	373	301	1.36	1.06
2014 Palermo Fish Quality Goal Inspections							
NG	SY	231	230	**147**	150	**1.19**	1.23
SA	SY	234	230	154	150	**1.19**	1.23
SE	SY	**221**	230	**121**	150	**1.14**	1.23
NG	FY	311	305	351	301	1.15	1.06
SA	FY	**298**	305	307	301	1.15	1.06
SE	FY	302	305	308	301	1.11	1.06
2010 Casco Fish Quality Goal Inspections							
NG	SY	241	230	179	150	1.23	1.23
SA	SY	251	230	212	150	1.32	1.23
SE	SY	250	230	195	150	**1.21**	1.23
NG	FY	309	305	367	301	1.25	1.06
SA	FY	340	305	489	301	1.23	1.06
SE	FY	321	305	409	301	1.24	1.06
2013 Casco Fish Quality Goal Inspections							
NG	SY	248	230	193	150	1.23	1.23
SA	SY	**229**	230	157	150	1.28	1.23
SE	SY	236	230	176	150	1.28	1.23
NG	FY	309	305	367	301	1.21	1.06
SA	FY	309	305	384	301	1.28	1.06
SE	FY	316	305	401	301	1.23	1.06
2014 Casco Fish Quality Goal Inspections							
NG	SY	235	230	184	150	1.37	1.23
SA	SY	232	230	150	150	**1.19**	1.23
SE	SY	**225**	230	**137**	150	**1.19**	1.23
NG	FY	321	305	435	301	1.28	1.06
SA	FY	317	305	435	301	1.35	1.06
SE	FY	311	305	371	301	1.22	1.06

Fish Fin Quality Inspections

Table 5. Summary of fish fin quality goals, years 2010-2014.
Bold print indicates unfulfilled goals.

Strain	Age	Non-Caudal Fin Index measured	Non-Caudal Fin Index goal	Caudal Fin Index measured	Caudal Fin Index goal	Densities lb/cu.ft
2010 Palermo Fin Quality Goal Inspections						
NG	SY	**8.4%**	<5%	**18.3%**	<5%	1.1
SA	SY	**6.0%**	<5%	2.2%	<5%	1.0
SE	SY	**7.8%**	<5%	**6.1%**	<5%	1.1
NG	FY	**5.2%**	<5%	**11.1%**	<5%	1.7
SA	FY	**5.7%**	<5%	0.0%	<5%	1.4
SE	FY	**5.1%**	<5%	0.6%	<5%	1.4
2013 Palermo Fin Quality Goal Inspections						
NG	SY	**8.6%**	<5%	**5.6%**	<5%	1.3
SA	SY	**13.0%**	<5%	1.1%	<5%	1.4
SE	SY	3.2%	<5%	0.6%	<5%	1.9
NG	FY	**8.7%**	<5%	**12.8%**	<5%	1.3
SA	FY	**12.4%**	<5%	0.6%	<5%	2.3
SE	FY	4.0%	<5%	0.6%	<5%	1.8
2014 Palermo Fin Quality Goal Inspections						
NG	SY	**6.5%**	<5%	**8.3%**	<5%	1.3
SA	SY	**11.9%**	<5%	1.7%	<5%	1.2
SE	SY	**10.5%**	<5%	0.0%	<5%	1.1
NG	FY	1.4%	<5%	2.8%	<5%	1.8
SA	FY	4.3%	<5%	0.0%	<5%	1.8
SE	FY	3.2%	<5%	0.0%	<5%	1.1
2010 Casco Fin Quality Goal Inspections						
NG	SY	**5.7%**	<5%	**11.7%**	<5%	1.0
SA	SY	**18.1%**	<5%	4.4%	<5%	1.9
SE	SY	**7.0%**	<5%	1.7%	<5%	0.9
NG	FY	**5.4%**	<5%	**15.0%**	<5%	2.2
SA	FY	**6.8%**	<5%	0.6%	<5%	1.3
SE	FY	4.1%	<5%	0.0%	<5%	2.2
2013 Casco Fin Quality Goal Inspections						
NG	SY	3.0%	<5%	0.6%	<5%	1.5
SA	SY	**10.2%**	<5%	1.1%	<5%	1.7
SE	SY	0.2%	<5%	0.0%	<5%	1.3
NG	FY	1.9%	<5%	**16.1%**	<5%	2.1
SA	FY	**5.9%**	<5%	1.7%	<5%	1.5
SE	FY	2.1%	<5%	1.7%	<5%	1.7
2014 Casco Fin Quality Goal Inspections						
NG	SY	4.8%	<5%	**42.2%**	<5%	1.3
SA	SY	**20.0%**	<5%	3.3%	<5%	1.3
SE	SY	**6.3%**	<5%	0.0%	<5%	1.2
NG	FY	1.0%	<5%	**33.3%**	<5%	2.7
SA	FY	1.9%	<5%	0.6%	<5%	1.3
SE	FY	1.3%	<5%	0.0%	<5%	1.6

Fish Rearing Densities

Table 6. The density (lb/ft³) of Brown Trout by strain reared in the Casco and Palermo Hatcheries - MDIFW (2010-2014).

Strain	n	Density in Hatchery (lb/ft³)
New Gloucester	12	1.61
Sandwich	12	1.51
Seeforellen	12	1.44

Fin Erosion Percentages

Table 7. Brown Trout non-caudal and caudal erosion percentages by strain for spring and fall yearlings 2010-14.

Strain	n	Non-Caudal Erosion (%)	Caudal Erosion (%)
New Gloucester	12	5.05	14.81
Sandwich	12	9.38	1.47
Seeforellen	12	4.57	0.94

Fin Erosion Statistics

Table 8. Non-caudal and caudal fin erosion percentage post-hoc statistical comparisons by brown trout strain (Kruskal-Wallis, Wilcoxon post-hoc test, alpha <0.05). Significant p-values are in bold print.

	Wilcoxon Test - p-values	
Strain Comparison	Non-Caudal Fin Erosion	Caudal Fin Erosion
NG-SA	**0.045**	**0.0005**
NG-SE	0.624	**0.0001**
SA-SE	**0.034**	0.127

Feed Conversion Factors

Table 9. Mean of the mean feed conversion factors, years 2009-2014.

Cumulative Mean of the Mean Feed Conversion Factors			
	NG	SA	SE
Palermo	1.08	0.85	1.11
Casco	1.29	0.93	0.77
Average	1.19	0.89	0.94

Mean Feed Cost

Table 10. Mean Monthly Feed Cost/Fish, years 2009-2014.

Feed Cost/Fish vs. Fall Yearling Size			
	NG	SA	SE
Length/fish at FY size (mm)	314	325	314
Weight/fish at FY size (g)	369	431	388
Cost to raise up to FY size	$0.81	$0.69	$0.72

Mean Adjusted Feed Cost

Table11. Mean and Adjusted Mean Feed Cost/Fish, years 2009-2014.

Mean Feed Cost/Fish, years 2009-2014				
Age Class	NG	SA	SE	Feed Cost/Fish
Mean Feed Cost/Kilogram Gain (FY)	$2.20	$1.59	$1.85	
Actual Mean FY sizes		Calculations		
FY NG weighing 369 grams/fish		.369 Kg/fish x $2.20 cost/Kg		$0.81/fish
FY SA weighing 431 grams/fish		.431 Kg/fish x $1.59 cost/Kg		$0.69/fish
FY SE weighing 388 grams/fish		.388 Kg/fish x $1.85 cost/Kg		$0.72/fish
Adjusted FY sizes				
FY NG weighing 431 grams/fish		.431 Kg/fish x $2.20 cost/Kg		$0.95/fish
FY SA weighing 431 grams/fish		.431 Kg/fish x $1.59 cost/Kg		$0.69/fish
FY SE weighing 431 grams/fish		.431 Kg/fish x $1.85 cost/Kg		$0.80/fish

Questionnaire

Brown Trout Strain Hatchery Questionnaire

As part of the State of Maine Fisheries and Hatchery Division brow n trout study, strain comparisons need to be evaluated w ithin the hatchery system. Please answ er the follow ing questions based on your ow n fish culture experience w ith each strain. Answ er the questions to the best of your ability know ing that your professional opinion w ill be part of the decision making process. The strains being evaluated are: New Gloucester (**NG**), Sandw ich (**SA**) and Seeforellen **(SE)** strain brow n trout.

Please answ er and mark one box w ith an **X**.

	STRAINS		
Which strain has the best:	NG	SA	SE
1. Appearance (symmetry, coloration, spots, etc.)?			
2. Fin Quality (normal fin, injured and eroded fin w ear, etc.)?			
3. Body condition (normal vs. humpback/pumpkinseed shape, deformed caudal peduncle, tumors, etc)?			
4. Feeding behavior characteristics (hand vs belt feeder, daily feeding response, etc)?			
5. Genetics?			
6. Parasite and fungal infection resistance (requires less formalin or salt treatments)?			
7. Performance cultured in high density situations (> 1.5 lb/ft^3)?			
8. Stress tolerance level w hile traveling to stocking destinations?			
9. Dispersal ability after being stocked (no schooling or rock hiding, disperse w ell)?			
10. Grow th Potential?			

Please w rite additional comments below :