

**POPULATION STATUS AND ECOLOGY OF BROWN TROUT:
RIO GRANDE, TIERRA DEL FUEGO, ARGENTINA,
2008 SEASON**

Submitted to:

Nervous Waters of Argentina
and
Estancia María Behety

Rachel L. Malison, Jack A. Stanford and Sarah L. O'Neal

Flathead Lake Biological Station
The University of Montana
32125 Bio Station Lane
Polson, MT 59860-6815 USA
Phone: (406) 982-3301
Fax: (406) 982-3201
www.umt.edu/flbs

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INTRODUCTION

During the 2008 angling season, Nervous Waters of Argentina (NWA), Estancia María Behety (EMB), The Fly Shop, and Frontiers International Travel contracted the Flathead Lake Biological Station (FLBS) for the third year of a scientific assessment of the economically important sea trout population of the Rio Grande in Tierra del Fuego. The goals of the project are to understand:

- 1) The status of the brown trout population,
- 2) The effect of sport fishing on population structure and productivity, and
- 3) What factors, other than angling, may limit trout productivity in different reaches of the river system.

Field work in 2008 was done by John Merritt and Tom Chandler of the Flathead Lake Biological Station in cooperation with the lodges as in the past. They conducted the work in two major parts. The first part concerned continued data collection of the basic ecology of the river. In 2008, this involved collection of temperature data and electrofishing to determine the spatial distribution of juvenile and resident brown trout in light of data previously collected in 2006 and 2007. The second part of the study involved continued work with NWA and EMB fishing guides and clients to collect mark-recapture data as well as size data and scale samples from the adult sea run brown trout population. These data taken now over three years allow us to estimate the size and age structure of the population as well as mortality rates. We present herein results from the third year of study. A final objective of this year's work was to complete Sarah O'Neal's Master of Science thesis. She successfully defended the thesis in spring, 2008. The thesis represents a complete synthesis of work done through 2007.

METHODS

River Ecology

For the 2008 season, we continued to evaluate river ecology and juvenile trout populations in all accessible major tributaries (Herminita, Menéndez, MacLennan, Moneta, and Candelaria) and in seven mainstem sites with varying habitat types throughout the lateral extent of the flood plain. All of these sites were studied in both 2008 and 2007; five of the seven mainstem sites were evaluated rigorously during the 2006 season. The mainstem sites were located in upper, middle, and lower reaches of the main channel; in secondary channels within

the regularly flooded (parafluvial) zone of the river and in orthofluvial channels that are rarely flooded but are fed by upwelling ground water from the floodplain aquifer (Stanford et al. 2005). At each of the sites, temperature data were collected every ninety minutes using iButton temperature data loggers. Loggers were pre- and post-calibrated at FLBS using controlled temperature baths to correct for any systematic bias or error. Temperatures were averaged on a daily basis for the purposes of this report.

Juvenile Trout

Three-pass electrofishing, using a Smith Root LR-24 backpack unit, was conducted once during the season to determine juvenile densities and growth rates at the seventeen sites (described in 2007 report) for river ecology sampling. All fish were weighed to the nearest 0.1 gram (g) and measured to the nearest millimeter (mm). Fish over 90 mm were sampled for stomach contents, scales, tissue (fin clips), muscle, and otoliths (ear stones). Stomach contents were sampled using a syringe and narrow diameter plastic tubing with sufficient length to reach the stomach. Water was flushed into the stomach cavity to force evacuation of its contents. In addition, larger fish were individually marked with passive integrated transponder (PIT) tags. Fin samples were stored in 95 % ethanol in labeled cryovials and later dried for airline transport. Otolith samples were dried and placed in labeled cryovials for transport. Muscle samples were stored on ice throughout the season, as well as during their transport to FLBS. All scale samples were dried and preserved on cards for transport to FLBS. Electrofishing data were entered into Microsoft Excel and densities were calculated using depletion estimates generated by MicroFish software (Van Deventer and Platts 1989). Due to logistical complications only one-pass electrofishing was completed for 5 of the sites in 2008 (including Upper Rio Grande, Lower Candelaria, Upper Moneta, Lila's spring brook, and Maldito Canal) and densities could not be estimated. Therefore densities based on one-pass were reported for these sites, an underestimate of actual fish density.

Adult Sea Trout

Sea run fish were caught and tagged in cooperation with NWA and EMB guides. Guides were provided with sampling equipment from FLBS, which included: a notebook for recording information about tagged fish, a quick-reference guide to the tagging and sample collection procedure, a soft tape measure, envelopes including a scale card for storing samples as well as recording fish-specific data, Floy tags, extra tagging needles, and tagging guns. Guides were

provided with a brief training discussion at the beginning of the season; those who were new to the project this year were accompanied in the field by the on-site biologists for further training. The tagging procedure generally lasted less than five minutes and included: measuring length and girth; inserting a Floy tag for individual identification; and collecting 10–20 scales from above the lateral line, between the dorsal and adipose fins, using a knife. Scale samples were placed on a scale card, which was stored in an envelope labeled with the date, time, and location of capture, and Floy tag number, length, girth, weight, gender, life stage, and migratory status.

Additional sampling was conducted on those fish that were accidentally killed during the capture, landing, and/or sampling procedure (less than one percent of all samples). Otoliths (ear stones) were collected from the heads as well as muscle samples for stable isotope analysis, fins for genetic analysis, and scales for life history analysis. Samples were preserved as described above for juvenile fish.

Mark-recapture data was analyzed using a Schnabel (1938) estimate that requires the following assumptions are met: 1) marked fish do not lose their marks; 2) marked fish are not overlooked when recaptured; 3) marked and unmarked fish are equally vulnerable to capture; 4) marked and unmarked fish experience low to no mortality during the course of the study; 5) following release, marked fish become randomly mixed with unmarked fish; and 6) there are no additions to the population during the study interval. All assumptions were closely met with the exception of the last assumption regarding a closed population. A combined open and closed population Robust Design model is likely to be more applicable to the Rio Grande population, because the fish are frequently immigrating and emigrating. Following further analysis, this third year of mark-recapture data should allow the use of such a model. All data were entered into Microsoft Access and/or Excel spreadsheets, from which the bulk of analyses were performed.

RESULTS AND DISCUSSION

Temperature is often considered the most important factor influencing trout growth and activity (Raleigh et al. 1986). Temperature was recorded every ninety minutes at each of our seventeen sampling sites throughout the fishing season. Resulting thermographs are presented in Figs. 1A and 1B. Similarly to 2007, several sites fell just below the optimal minimum threshold (7°C) for juvenile trout growth near the end of the season. However, temperatures in mid March were about a degree colder in 2008 than 2007. Cooler temperatures are expected during fall and

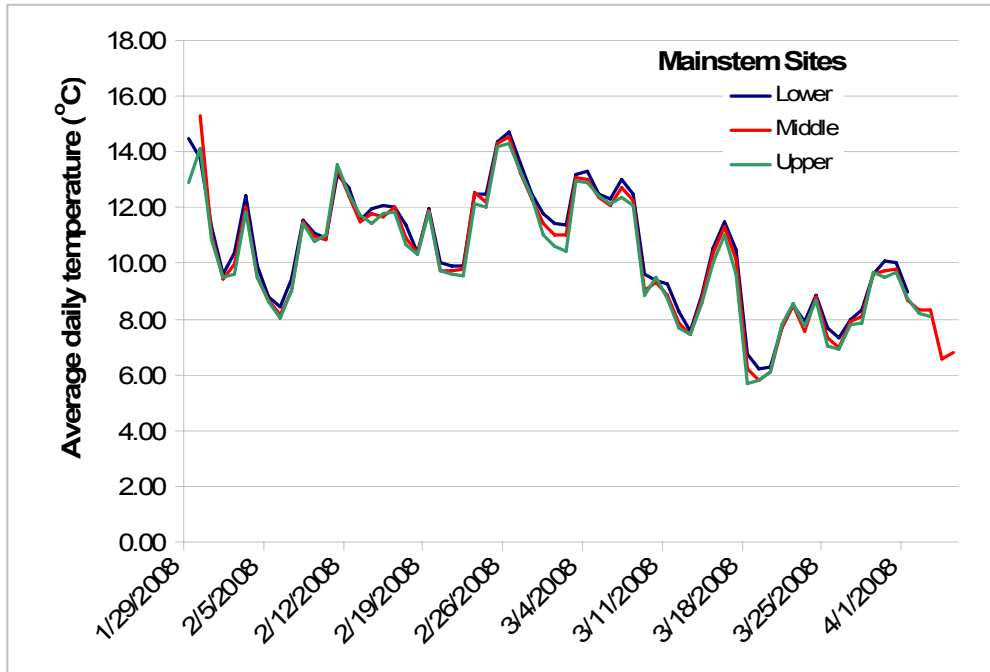


Figure 1A. Average daily temperature profiles for mainstem.

winter seasons, when growth slows significantly. Temperatures at all sites remained within the tolerated range for all trout life stages. Interestingly, the parafluvial springbrook habitats did not exhibit the typical dampened (cooler in summer and warmer in winter) thermal regime caused by the influx of groundwater (Stanford et al. 2005). The orthofluvial springbrook habitats (Lila’s spring brook and Maldito Canal) exhibited more dampened conditions than those of the parafluvial habitats, with generally cooler temperatures in the summer, but no warmer temperatures in the winter. Such “dampened” conditions are considered conducive to juvenile rearing; however, both orthofluvial springbrook habitats had very few juvenile fish. Future investigations should evaluate groundwater dynamics throughout the mainstem Rio Grande and its tributaries.

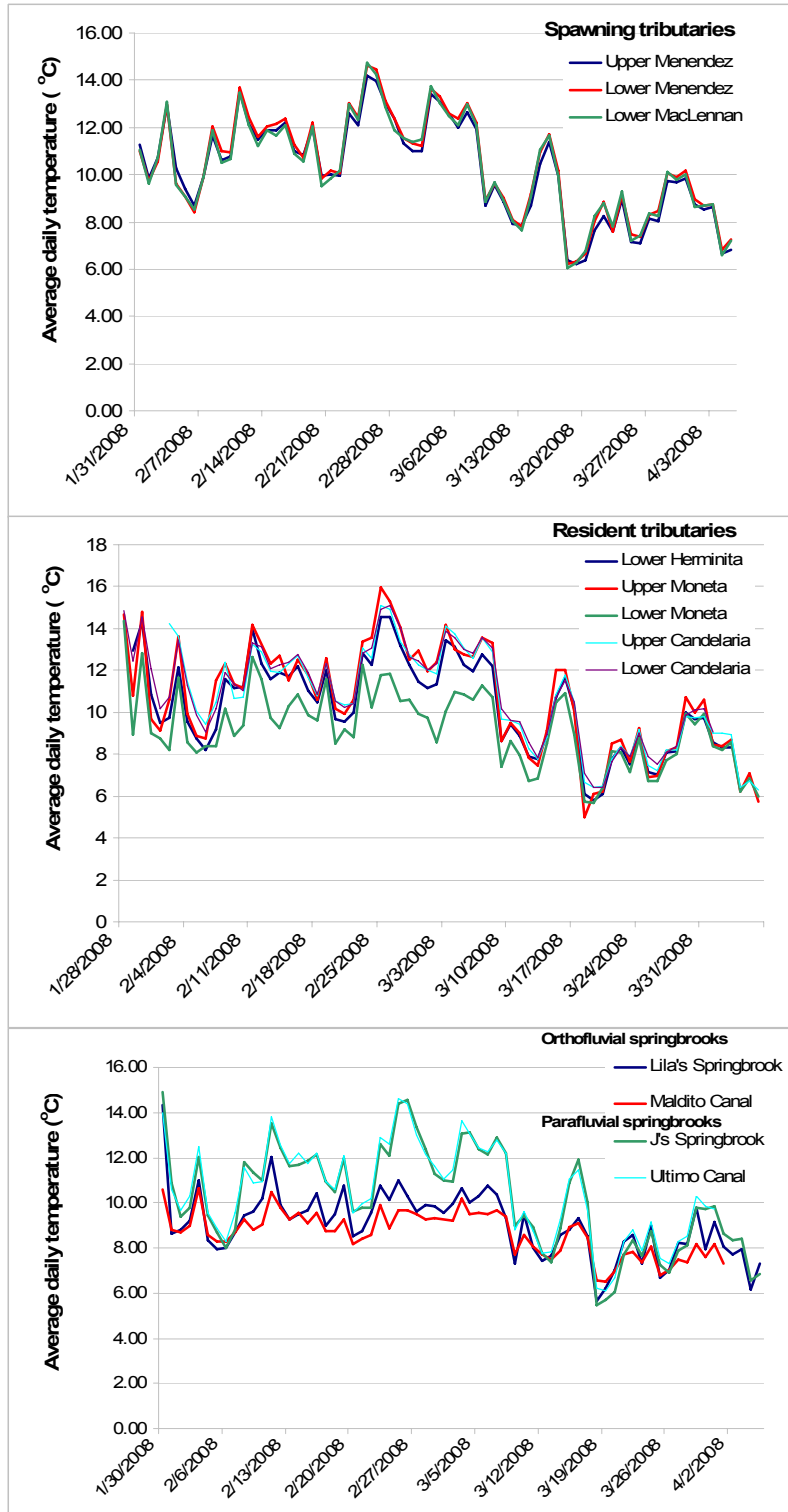


Figure 1B. Average daily temperature profiles for tributaries and spring brooks.

The number of accumulated degree days, a metric used to quantify growth opportunities for biological organisms, is a function of the average daily temperatures over such a period. Metabolism, and thus growth, generally increase with increasing degree days. Degree days from the temperature profiles for each site were calculated using the following equation (Elliott 1994) and results are presented below (Fig. 2).

$$\text{Cumulative degree days} = \sum [(\text{maximum daily temperature}(\text{°C}) + \text{minimum daily temperature}(\text{°C}))/2] - 4 \text{ for the period during which temperatures exceed the minimum for growth (4°\text{C})}$$

This calculation allows for the evaluation of an important aspect of habitat suitability, particularly for juvenile and resident fish. Results are presented for both 2008 and 2007 in Figure 2. Growth opportunities were highest in the Candelaria in both 2007 and 2008, but also very high in Upper Moneta in 2008. Growth opportunities were lowest for orthofluvial spring brooks in both years, and were intermediate for all other sites both years.

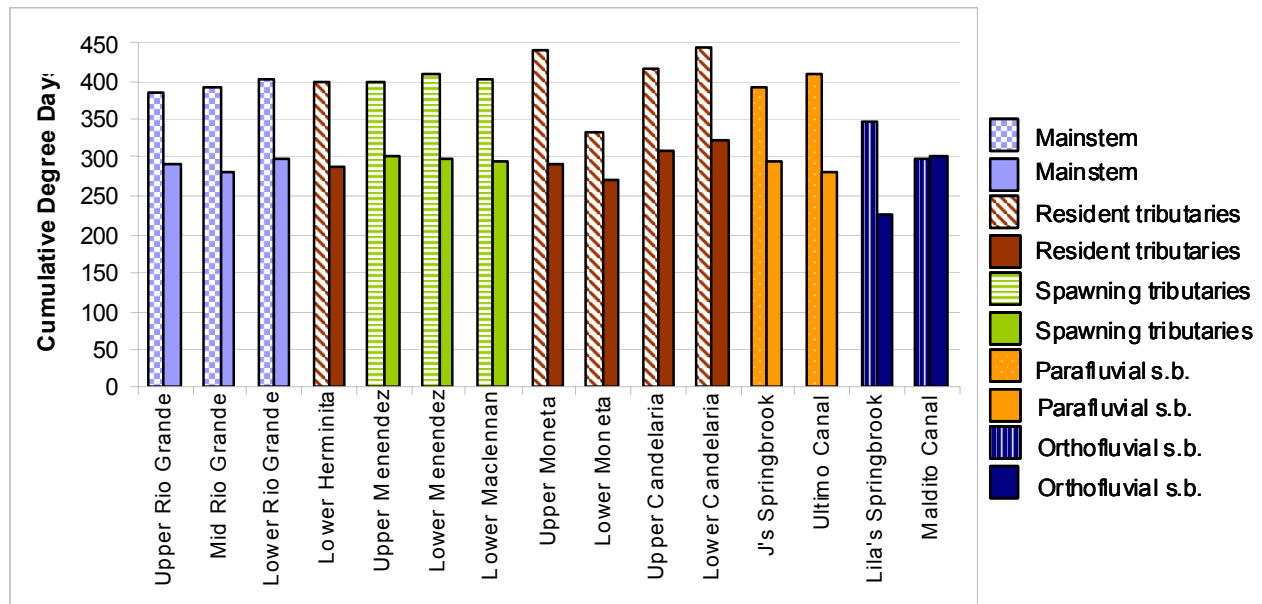


Figure 2. Comparison of cumulative degree days by habitat type (Mainstem, light blue; resident tributaries, brown; spawning tributaries, green; parafluvial spring brooks, orange; orthofluvial spring brooks, dark blue) and by year (2008 patterned bars, 2007 solid bars).

In addition to seasonal temperature profiles, reliable annual temperature profiles were acquired for the lower mainstem Rio Grande, upper and lower MacLenna, lower Herminita, Maldito Canal, and Lila's spring brook. Temperatures peaked in late January and early February

(data was not collected between mid December and most of January), and reached their minimum during late June, July, and early August. The minimum temperature for trout growth was consistently exceeded starting in early October, a slightly later start than in 2007. Temperature is one of the most critical parameters affecting spawning behavior (Byrne et al. 2004). Annual temperature data suggest the entire 2007 spawning period may have taken place from early March to early April and 2008 temperature data show a similar pattern (Fig. 3).

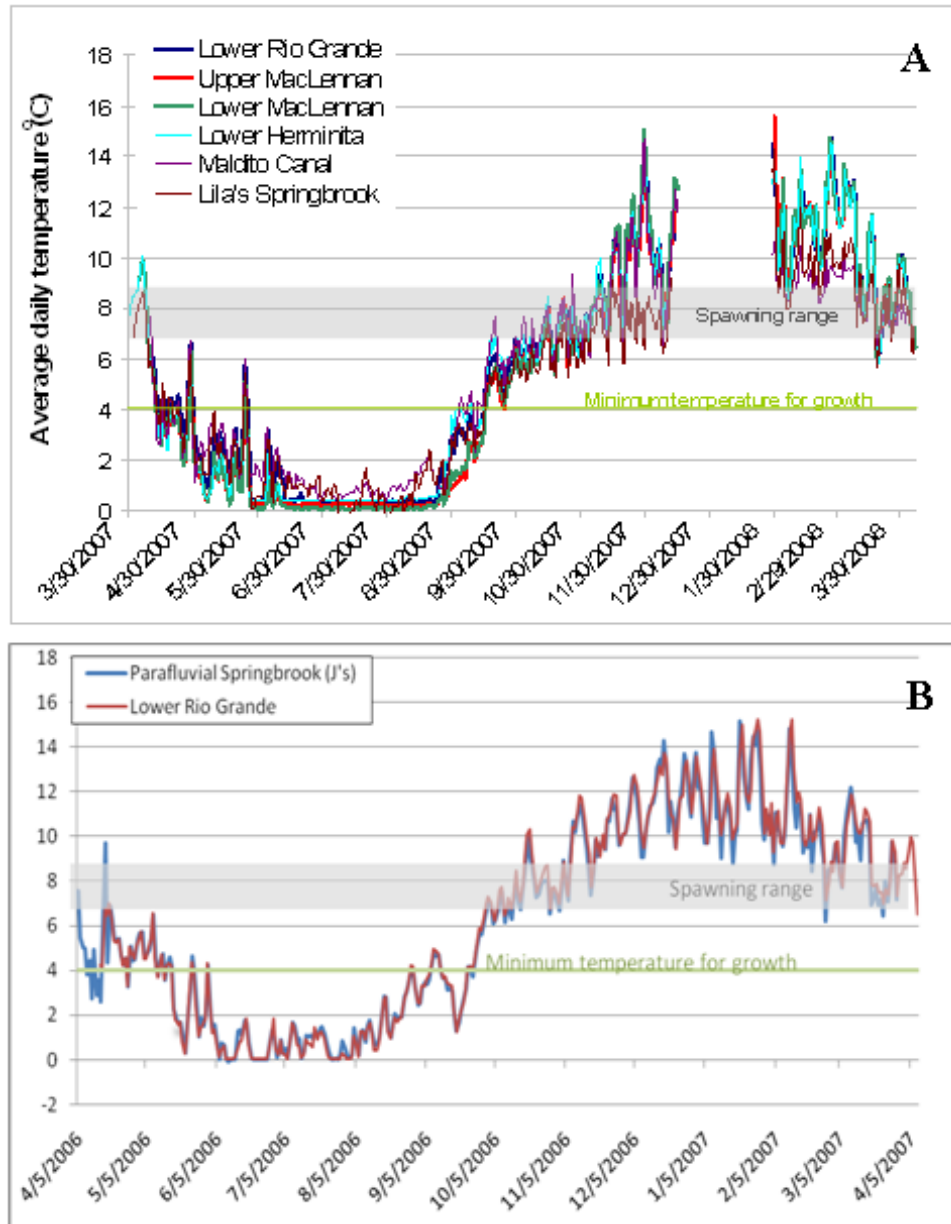


Figure 3. Average daily temperature profiles for 2008 (A) and 2007 (B).

This information is partially confirmed by spawning observations made in the mainstem Rio Grande, the MacLennan, and the Menéndez Rivers in February, March, and early April, 2007. It is still of concern, however, that dense spawning may be confined to March and April, when fishing and thus regular wading throughout the river are simultaneously occurring. Wading may interfere with spawning behavior, as well as disturb redds (trout nests) once they are formed.

Juvenile Trout

Repeated study of the sites sampled for the 2007 season allowed us to evaluate the relative importance of each tributary as juvenile rearing habitat (Fig. 4). In 2008, lower MacLennan clearly supported the highest density of juvenile trout, followed by the Herminita as well as the parafluvial channels (J's spring brook and Ultimo Canal). In 2007, the highest density was in the Candelaria (Fig. 5) but in 2008, the density estimate for Candelaria ranked 5th highest. However, it is distinctly possible the Candelaria still has higher fish densities, as the reported estimate is an underestimate of the actual density due to logistical complications while electrofishing. Electrofishing data suggest that juveniles are selecting these habitats, possibly due to the availability of food resources driven by their higher nutrient levels (data collected in 2007).

In contrast to 2007, the mainstem Rio Grande juvenile densities did not decrease with proximity to the mouth of the river, but were greatest at the mid Rio Grande site (Fig. 5). Additionally, the Menéndez and MacLennan Rivers both exhibited higher densities of juvenile trout in 2008 vs. 2007, with a 9-fold increase in trout density from 2007 to 2008 in lower MacLennan. Both orthofluvial spring brooks exhibited very low juvenile trout densities in both 2007 and 2008. In 2007 the majority of the juvenile abundance (67 %) in the MacLennan River was composed of rainbow trout (*Onchorynchus mykiss*), but in 2008 only 11 % of the MacLennan River was composed of rainbow trout. This was the only site in which we encountered rainbows in 2008. Brown and rainbow trout tend to coexist only in large, complex rivers. Generally, brown trout prefer areas closer to banks with dense cover, while rainbow trout tend to inhabit higher velocity areas of the main stream channels. Additionally, brown trout are better adapted for vision in dim light (Behnke 2002). While our data do not reflect significant structural habitat differences between the MacLennan and other rivers, we did note a slightly elevated (less acidic) pH level (average 8.14 at the lower river site). As discussed in 2007,

rainbows may be able to persist in the MacLennan partially due to a lighter (less tannin-stained) water color, in which they are better able to see both food items as well as potential predators. However, their numbers do seem to be decreasing as of 2008 surveys, but further data are required to corroborate this observation.

Another difference between years is in the galaxiids. In 2007, the majority of fish density (60 %) in Maldito Canal was composed of two species of native galaxiids: *Galaxias maculatus* and *Galaxias platei*. These fish are extremely rare throughout the watershed despite their presumably widespread historical distribution. However, no galaxiids were found in Maldito Canal or any other sites in 2008.

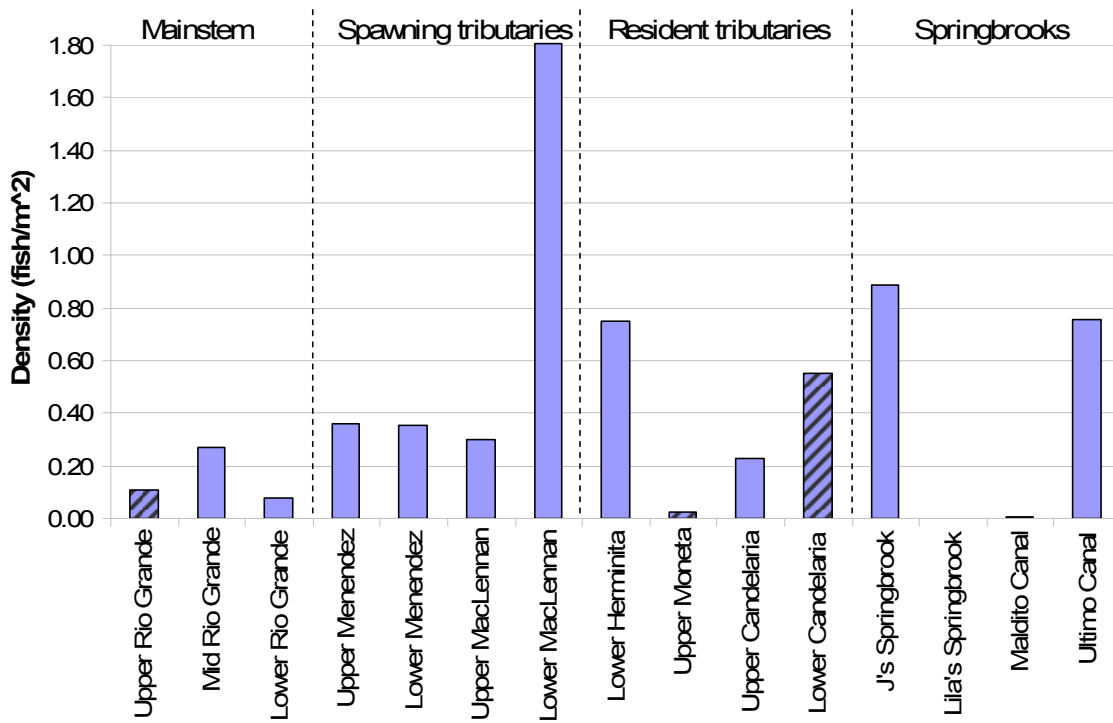


Figure 4. Juvenile fish density from 2008 electrofishing surveys. Hatched bars (Upper Rio Grande, Upper Moneta, Lower Candelaria) are density estimates based on only one-pass electrofishing, and likely underestimate actual fish densities.

All told, the electrofishing data highlight the importance to juvenile rearing of 1) tributary habitat, namely in the MacLennan, Herminita, Candelaria Rivers; and 2) off-channel habitat, particularly parafluvial spring brooks. What remains to be seen is the contribution of these habitats to the anadromous (as opposed to the resident) adult population. Analysis of otolith samples collected from adult mortalities may be able to illuminate this issue by chemically

identifying natal and juvenile rearing sites of both resident and anadromous trout. However, otolith analysis is a complex process and requires additional funding.

During the 2008 season, we electrofished in seventeen of the same sites electrofished during the 2007 season, 5 of which were electrofished in 2006. The results are presented in Fig. 5 and indicate a shift in habitat preferences by juvenile trout during the course of the 3-year study. Orthofluvial habitat (Lila's spring brook) and parafluvial habitat (J's spring brook) supported the vast majority of juvenile density during the 2006 season when compared to the mainstem sites. In both 2007 and 2008, however, densities were negligible in orthofluvial spring brooks (Lila's spring brook and Maldito Canal), but significantly higher in parafluvial spring brooks (J's spring brook and Último Canal). Densities were not significantly different in the mainstem Rio Grande between years.

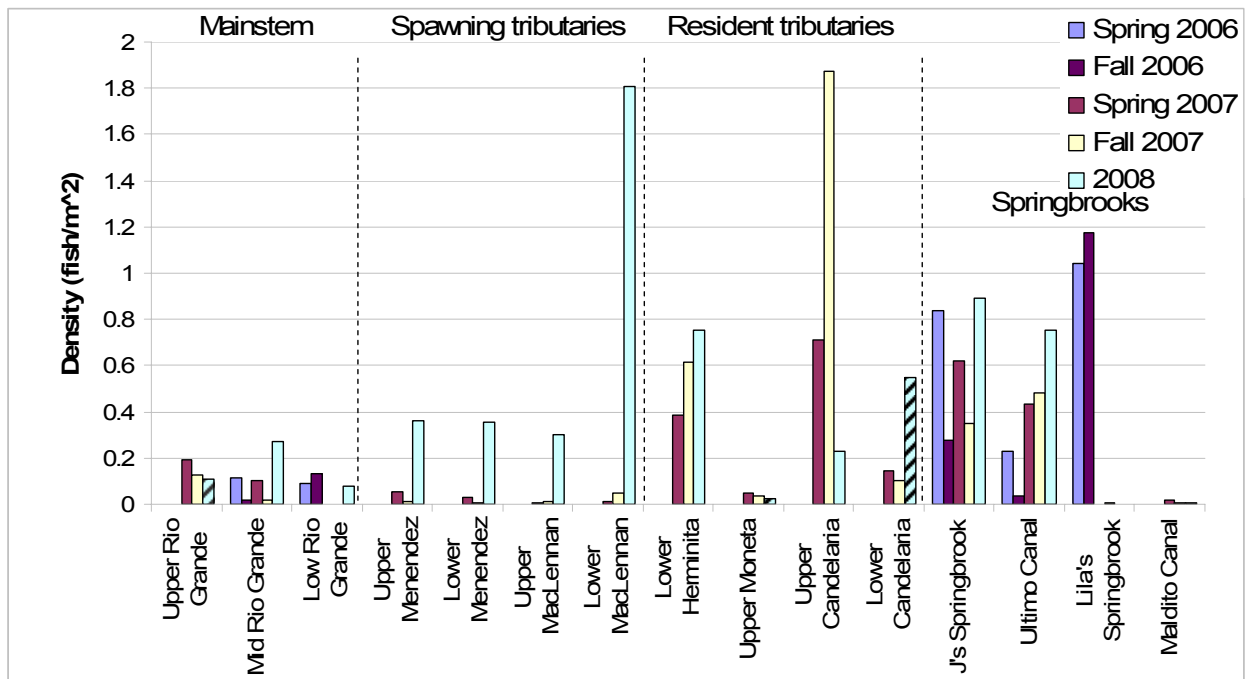


Figure 5. Comparison of juvenile densities between 2006, 2007, and 2008.

These data suggest major changes in springbrook habitat occurred between 2006 and 2007. It is likely this results from a combination of the major flood, which took place during the winter season of 2006, as well as the comparatively low flow rates during the 2007 summer season. Additionally, increased densities of juveniles were recorded in the resident tributaries lower Herminita and upper Candelaria, densities in lower Herminita being comparable with

those of parafluvial spring brooks and densities in upper Candelaria almost double those found in parafluvial spring brooks. The increase in fish densities seems to have continued into 2008 when we see a marked increase in densities of all spawning tributaries, and especially in lower MacLennan, which holds the greatest densities for 2008. However, it is possible that lower Candelaria has comparable or even higher densities of juveniles than lower MacLennan in 2008, but unfortunately we were not able to make an accurate density estimate because only one pass of electrofishing was completed for this site.

Overall it appeared that there were lower juvenile densities in 2007 than 2006, which could have been a concern for the future adult sea trout population. Fewer juveniles may produce fewer adults during the years in which these fish return from marine feeding, but it is also possible that resulting decreased competition amongst juveniles would give year classes with fewer individuals a competitive advantage. However, with the addition of 2008 data it actually appears that densities of juvenile fishes are increasing, especially in spawning tributaries, and quite likely in resident tributaries as well.

Adult Sea Trout Population

During the course of the 2008 season, guides and others tagged a total of 5039 fish from the five participating lodges. Of the 5039 fish tagged, 290 (5.8 %) were recaptured during the season. Of those 290 recaptured fish, 143 were originally tagged in 2008, 116 in 2007, and 24 in 2006. The recapture rate (5.8 %) was higher than that of both the 2007 (2.3 %) and 2006 seasons (1.9 %), and does include fish tagged over a 3-year period.

The 2008 data produced an instream population estimate of 75,576 adult sea trout (Fig. 6), with a 95 % confidence interval of 64,933 to 90,391, indicating a 95 % chance that the population size lies within that interval. The smaller population estimate for 2006 (37,803) might have been due to interannual variability (i.e., natural population fluctuations), but was likely due to underestimation as indicated by the wide confidence interval associated with the 2006 data. The narrow confidence intervals for 2007 and 2008 relative to the first year of the investigation underscores the value of an increased sample size, and suggests the importance of continuing the tagging program, as well as increasing tagging rates further yet if possible. The 2008 estimate, though subject to the same assumptions outlined in the 2006 report, confirms the extremely productive nature of the Rio Grande and its adjacent estuary. Regardless of its

precision, this year's estimate reaffirms that the Rio Grande supports tens of thousands of adult sea trout.

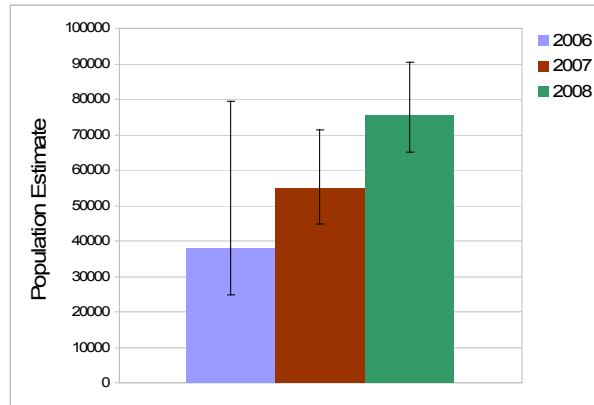


Figure 6. Adult sea trout population estimates for 2006, 2007, and 2008.

The size distribution of tagged fish is provided in the histogram below (Fig. 7), in addition to a comparison of size classes between the three years of investigation. As for the 2006 and 2007 seasons, the samples appear to be biased toward larger fish. This is likely due to biases inherent to the methods of capture, which target larger fish, as well as a possible bias in guide sampling. The lack of a smaller size class during the 2007 season was of some concern, because it suggested a declining population. However, the 2008 data show a reappearance of the smaller size class that was missing in previous years, likely due to unfavorable rearing conditions during a year in the past. It seems unlikely that the missing size classes in 2006 and 2007 were due to a declining population trend.

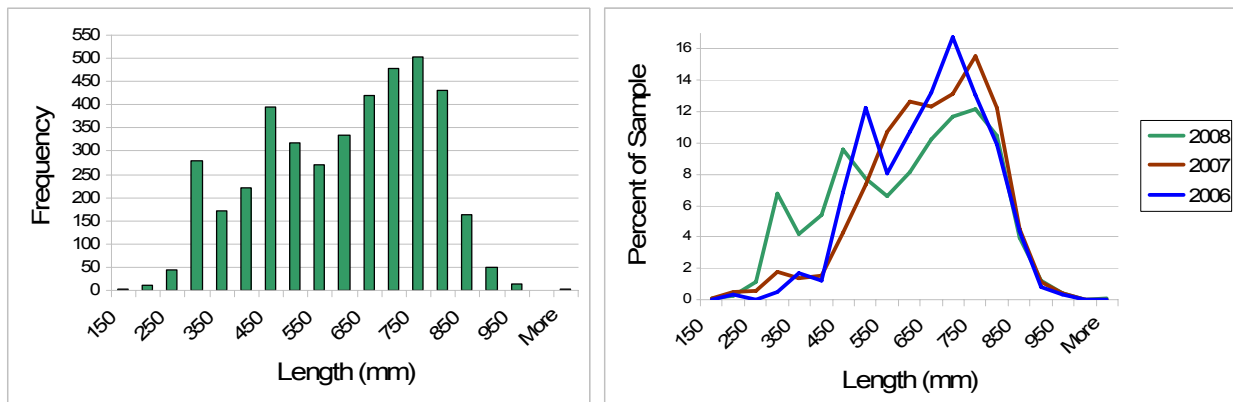


Figure 7. Length frequency distribution of 2008 catch, and comparison between 2006, 2007, and 2008.

Comparison of the datasets from all three years clearly illustrates the growth of fish (Fig. 7). Peaks during the 2006 season occurred at 550 mm and 700 mm while peaks in the 2007 season occurred at 650 mm and 800 mm, suggesting an average of 100 mm of growth of adult fish during that year. Peaks during the 2008 season occurred at 300 mm, 450 mm, and 750 mm, again suggesting an average of 100 mm of growth for adult fish between 2007 and 2008. Future scale analyses should corroborate these data.

The ratio of female to male sea trout captured during the past season was 3.01:1, such that 75 % of fish for which gender was recorded were female. This is slightly higher than the proportion of females documented during 2006 (72 %) and 2007 (71 %). Male sea trout exhibited a significantly larger average length (656 mm) than females (615 mm). This is an unusual pattern relative to European sea trout populations (Harris and Milner 2006) as larger size tends to reap greater fitness advantages for females than for males due to the strong positive correlation between body size and female fecundity.

SUMMARY AND RECOMMENDATIONS

Sampling during the 2008 fishing season included same sites studied in 2007 with the intention of continuing to expand our understanding of juvenile rearing and adult spawning habitat. The 2008 data indicate water temperature does not appear to be limiting to any life stage of brown trout in the Rio Grande. Temperature data from both 2007 and 2008 did however suggest that the primary spawning period may overlap entirely with the current fishing season. Wading may impact spawning behavior and subsequent success of redds, though given the robust population size, we do not presently deem it critical to further shorten the fishing season. It may behoove long-term success of the fishery, however, to limit fishing activity in areas when and where dense spawning is occurring. Currently it seems juvenile densities are generally increasing, however changes in juvenile densities in future years should be carefully monitored in order to assess the success of spawning and subsequent juvenile emergence.

Electrofishing data indicated a marked increase in juvenile densities, in the spawning tributaries (Menendez and MacLennan), with the great density recorded in MacLennan. The resident tributary Herminita and the parafluvial springbrook sites (J's spring brook and Ultimo Canal) also exhibited higher densities. It is likely the other resident tributary Candelaria also continues to have high juvenile densities however were not able to collect enough data at this site for proper density estimation. Data collected during the 2006 season were contrary, when

densities were highest in orthofluvial spring brooks. However, no data were available in 2006 for either resident or spawning tributaries. The difference in orthofluvial springbrook juvenile densities may be due to major habitat alteration as a result of the massive 2006 winter flood and/or to generally lower water levels during the 2007 season. Overall, we noted higher juvenile densities in 2008. It is suggested that success of redds may indeed have been impacted by the aforementioned flood in 2007, however juvenile densities seem to be recovering in 2008.

Mark-recapture data collected during the 2008 season allowed for a population estimate with even higher confidence, due to a larger sample size. The 2008 data generated a population estimate of 75,576 catchable fish. Taking some level of imprecision into account, we believe the catch rate amongst the fly fishing lodges operating in Rio Grande is unlikely to exceed 15 % of all fish in the river. We further calculated an overall mortality rate of 22 % for the population, which is exceptionally low relative to native European populations. Both of these factors undoubtedly contribute to the great success of Rio Grande sea trout. We once more remark on the apparent extraordinary returns of adult sea trout to this river. Whether or not the river is very productive remains unclear because O'Neal (2008) did not find the food web to be particularly robust; the high numbers of fish may be simply the result of enforced catch and release fishing. Sea trout are multiyear spawners and since the mortality is low and ocean conditions apparently are very good, extraordinary numbers of fish return for spawning even though smolt production from the may be quite low in relation to spawner numbers. O'Neal tried to capture smolts by deploying a fyke net for extended periods during the time of supposed out-migration, but failed to obtain even one smolt. If overall productivity of the river is low (this needs further investigation), the current great fishing in the Rio Grande would decline rapidly should substantial harvest be allowed.

Length-frequency data again indicated a distribution skewed toward larger fish, however two smaller size classes appeared in 2008 (300 mm and 450 mm) suggesting the population is not declining, but that perhaps these age classes were just missing in previous years due to biased capture of larger fish in the first two years of the study. It is critical to continue to monitor length-frequency distributions in order to predict population stability and future trends.

We have considerably expanded our understanding of the Rio Grande trout fishery over the course of the 3-year study by shedding light on important juvenile rearing habitat, bolstering population estimates, and gaining historical perspective on population dynamics. We

recommend continuation of the tagging program, corroboration of the tag estimated run sizes by sonar counts, and better definition of habitat quality for juveniles and spawning adults. The Rio Grande River certainly is one of the best, if not the very best, sea trout producers in the world. Thorough understanding of the ecology of the population will underpin conservation of this world class resource.

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LITERATURE CITED

- Behnke, R. J. 2002. Trout and Salmon of North America. Free Press, New York.
- Byrne, C. J., R. Poole, M. Dillane, G. Rogan, and K. F. Whelan. 2004. Temporal and environmental influences on the variation in sea trout (*Salmo trutta* L.) smolt migrations in the Burrishoole system in the west of Ireland from 1971 to 2000. Fisheries Research 66: 85–94.
- Elliott, J. M. 1994. Quantitative Ecology and the Brown Trout. Oxford University Press. Oxford.
- Harris, G., and N. Milner (Eds.). Sea Trout Biology, Conservation and Management. Blackwell Publishing. Oxford, UK.
- O’Neal, S. L. 2008. Lessons to learn from all out invasion: life history of brown trout (*Salmo trutta*) in a Patagonian River. M.S. Thesis. The University of Montana, Missoula, Montana, USA.
- O’Neal, S. L., J. A. Stanford, and A. L. Liberoff. 2007. Population status and ecology of brown trout: Rio Grande, Tierra del Fuego, Argentina, 2007 Season. FLBS Report 198-07. Prepared for Nervous Waters of Argentina and Estancia María Behety by Flathead Lake Biological Station, The University of Montana, Polson, Montana. 30 pp.
- O’Neal, S., and J. A. Stanford. 2006. Population status and ecology of brown trout Rio Grande, Tierra del Fuego, Argentina. FLBS Report 193-06. Prepared for Nervous Waters of Argentina and Estancia María Behety, by Flathead Lake Biological Station, The University of Montana, Polson, Montana. 18 pp.
- Raleigh, R. F., L. D. Zuckerman, and P. C. Nelson. 1986. Habitat suitability index models and instream flow suitability curves: Brown trout, revised. U.S. Fish Wildlife Service Biological Report 82(10.124). 65 pp. [First printed as: FWS/OBS-82/10.71, September 1984].
- Schnabel, Z. E. 1938. The estimation of the total fish population of a lake. American Mathematical Monographs 45: 348–368.
- Stanford, J. A. M. S. Lorang, and F. R. Hauer. 2005. The shifting habitat mosaic of river ecosystems. Verh. Internat. Verein. Limnol. 29: 123–136.

Van Deventer, J.S., and W.S. Platts. 1989. Microcomputer software system for generating population statistics from electrofishing data: User's guide for Microfish 3.0. General Technical Report INT-254. Intermountain Research Station. Forest Service. United States Department of Agriculture.