APPENDIX A-7

SALUDA HYDROELECTRIC PROJECT TROUT EVALUATION AND MONITORING PROGRAM

SOUTH CAROLINA ELECTRIC & GAS COMPANY

COLUMBIA, SOUTH CAROLINA

SALUDA HYDROELECTRIC PROJECT

(FERC NO. 516)

TROUT EVALUATION AND MONITORING PROGRAM FOR THE LOWER SALUDA RIVER

FINAL

JULY 2009

Prepared by:

Kleinschmidt

Energy & Water Resource Consultants

SOUTH CAROLINA ELECTRIC & GAS COMPANY
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

SOUTH CAROLINA ELECTRIC & GAS COMPANY
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FINAL

1.0 INTRODUCTION

The South Carolina Electric & Gas Company (SCE&G) filed an Application for New License on August 27, 2008, and as part, has developed a Comprehensive Relicensing Settlement Agreement for Protection, Mitigation and Enhancement of environmental resources at the Saluda Hydroelectric Project (FERC No. 516) (Saluda Hydro or Project). The enhanced relicensing process implemented was a multi-year cooperative effort between SCE&G and interested stakeholders to address operational, recreational and ecological concerns associated with hydroelectric project operations.

As part of that relicensing process, SCE&G consulted with a wide variety of stakeholders including, state and federal resource agencies, non-governmental organizations and concerned citizens seeking their input on important relicensing issues. As a result of that consultation and subsequent stakeholder meetings, relicensing participants identified several issues that they believed needed to be addressed during the relicensing process. One of the identified issues included monitoring and potential enhancement of the Put, Grow and Take trout fishery located in the Saluda Hydro Tailrace.

The current Put-Grow and Take program supports a cold water fishery via annual stockings of brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*). The trout are stocked and managed by the South Carolina Department of Natural Resources Freshwater Fisheries Section. Several efforts are currently underway by SCE&G to improve DO conditions in the lower Saluda River (LSR) that are likely to further improve habitat for trout. Enhancement measures consist of turbine venting, alternate operating scenarios, and implementation of instream flow recommendations.

The *Trout Evaluation And Monitoring Program for the Lower Saluda River* (Program) described herein was developed by the Instream Flow and Aquatic Habitat Technical Working

Committee (TWC) and initiated by SCE&G to monitor and assess the success of water quality and flow enhancement measures on the trout fishery. It is a culmination of SCE&G's work with stakeholders to define resource goals and objectives for the lower Saluda trout fishery. Furthermore, the Program will determine a process for evaluating changes and making decisions that contribute to the South Carolina Department of Natural Resources' (SCDNR) management of the fishery based on the best available information. This document explains the goals, objectives, management, and methods of the Program, and was developed to serve as a guidance document for future monitoring and evaluation of the tailrace trout fishery during the new license term of the Saluda Project.

This document is organized to describe the Program in the following manner:

- Section 2 Background of Saluda Project and LSR Fishery
- Section 3 Program Goals and Objectives
- Section 4 Management of the Program
- Section 5 Program Monitoring Methods
- Section 6 Implementation Schedule
- Section 7 Decision Process for Program Modifications

2.0 BACKGROUND OF SALUDA PROJECT AND LSR FISHERY

2.1 Saluda Project

The Saluda Hydro Project is an existing licensed hydroelectric project, owned and operated by SCE&G. The Project is located on the Saluda River, in the counties of Lexington, Richland, Newberry and Saluda, South Carolina. The Project consists of an earth fill embankment Dam (Saluda Dam) impounding a 48,000-acre reservoir (at elevation 356.5' NAVD88[1]), a gated emergency spillway, a back-up Dam, a powerhouse, five concrete intake towers and associated penstocks. Construction of the Project was completed in 1930, and construction of the back-up dam was completed in 2005.

The lower Saluda River (LSR) is approximately 10 miles in length and is characterized by bedrock-dominated riffles, with limited gravel and cobble substrates, and a high percentage of pool habitats. The river receives hypolimnetic (i.e., coldwater) flows from Lake Murray via the Saluda Hydro Project. This cold water has created the opportunity for the SCDNR to establish a successful Put, Grow and Take trout fishery for brown trout and rainbow trout. The following sections summarize features of the fishery and water quality resources of the LSR, including results of applicable studies.

2.2 Fishery Resources

The LSR fishery is unique in that it provides fishing opportunities for both resident warmwater species, as well as stocked coldwater species (trout). As mentioned previously, the LSR currently supports a tailrace trout fishery for rainbow and brown trout that is managed by the SCDNR as a Put, Grow and Take fishery. Trout are not native to the LSR, and the fishery is maintained through stocking of sub-adult rainbow and brown trout. Typically, the SCDNR stocking program runs from early December until mid-April. The total number of trout stocked annually typically averages around 30,000 and are produced at the Walhalla State Fish Hatchery. This management approach, which has

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[1] Unless otherwise noted, all elevation references in this document are given in North American Vertical Datum 1988 (NAVD 88); conversion to traditional plant datum (PD) requires the addition of 1.50 feet.

been employed since the 1960's, is appropriate where trout habitat can provide the acceptable growth and survival of enough sub-adult trout to support a fishery (D. Christie, SCDNR, Pers. Comm.). Similarly, the LSR is classified by the South Carolina Department of Health and Environmental Control (SCDHEC) for regulatory purposes as Put, Grow, and Take Trout Waters, which are defined as freshwaters suitable for supporting the growth of stocked trout populations and a balanced, indigenous aquatic community of fauna and flora (SCDHEC, 2004).

A trout growth study conducted in 2003 in support of establishment of a site-specific DO standard for the LSR found that growth of trout in the LSR exceeds many other southeastern tailwaters (0.7 percent weight gain per day, 0.67 inches per month) (Kleinschmidt et al., 2003). Further, the study found that 74 of 441 brown and rainbow trout collected during 2003 were greater than 16 inches in length, suggesting a significant number of carryovers from previous stocking years. The study was conducted during a time period when near run of river flow release were being maintained to hold the lake pool elevations constant during dam remediation. The study concluded that the high growth rates and large number of carryovers observed in 2003 could potentially be attributed to higher DO levels since the inception of SCE&G's turbine venting program (Kleinschmidt et al. 2003). Conversely, a recent study begun by SCDNR to evaluate the annual mortality of the stocked trout in the LSR documented significantly less carryover of trout during the spring and summer of 2007 (H. Beard, SCDNR, Pers. Comm.). Disparity between study results suggests significant annual variability in carryover.

2.3 Water Resources

SCE&G began monitoring DO and temperature in the Saluda Project turbine releases in 1989 and continues the effort to the present day. Most recently, SCE&G conducted a study from 2000 to 2006 to characterize water resources by collecting baseline water quality data in the Saluda Tailrace extending downstream to the confluence with the Broad River. Results of this study and other water quality data are summarized below.

2.3.1 Dissolved Oxygen

The LSR occasionally suffers from short periods of low DO during high flow or when the pool level of Lake Murray is drawn down for special purposes. Characteristics of the project reservoir, namely the relatively high water retention time and considerable depth of Lake Murray, coupled with regional climate conditions, results in seasonal thermal stratification of the lake and an associated decrease in DO in the lower water column. The problem is further exacerbated by watershed factors such as high nutrient loading, particularly from point discharges of phosphorus. High nutrient inputs to Lake Murray leads to an increase in the biological oxygen demand, especially during periods of high runoff (high flow), and consequent depletion of DO from the water column.

In 1999, to address issues associated with low DO of Project discharges, SCE&G installed an aeration system. This aeration system, which along with modified operational patterns, has since improved water quality of releases from Saluda Hydro. Currently, Project discharges of low DO waters to the LSR are infrequent. For example, during the period from 1989-1998 (prior to aeration), the median DO concentration in Project release during the late summer and early fall months was only 2.7 mg/L and exceeded the daily DO standard of 5.0 mg/L only approximately 19% of the time based on USGS water quality monitoring data. By contrast, USGS water quality monitoring data from 2000 to 2008 (since aeration) indicate that DO levels have been above the daily DO standard of 5.0 mg/L 96 percent of the time, with a daily median of 7.2 mg/L. It should be noted that no daily averages of less than 5.0 mg/L have occurred since 2007.

2.3.2 Temperature

According to the 2000-2008 USGS water quality monitoring data, average daily water temperature throughout the late winter, spring, and early summer months (February – July) in the LSR downstream of the dam ranges from 7.5 to 18.5º C. Specifically, during the spring and early summer months (March – June) average water temperature typically remains between 8.3º C and 17º C. As the summer progresses, water temperatures rise and are at their highest, generally around 18º C, between mid-September and early November. During the 2000-

2008 USGS water quality monitoring data, water temperatures never exceeded the lethal limit for trout of 25°C at any of the monitored trout habitat sites.

2.4 Technical Work Committee Consultation History

In comments to the Initial Consultation Document, the Saluda River Chapter of Trout Unlimited (TU) requested that SCE&G evaluate the potential for establishment of a self-sustaining trout fishery on the LSR downstream of the Project. TU later clarified their request, stating they were interested in evaluating any potential for natural trout reproduction (not just a level sufficient for a self-sustaining population). Under direction of the Instream Flow/Aquatic Habitat Technical Working Committee (TWC), SCE&G subsequently drafted a technical white paper summarizing the spawning requirements of the two trout species currently stocked in the lower Saluda (rainbow and brown trout) and comparing those spawning preferences to habitat conditions in the lower Saluda River (Kleinschmidt, 2007). Adult, juvenile and spawning rainbow trout and adult and juvenile brown trout were also included as target species in the Lower Saluda River Instream Flow Study (Kleinschmidt, 2008), which evaluated the influence of variance flow releases on these species and lifestages.

Later consultation within the TWC identified the need for a trout monitoring program to evaluate the improvements provided by the proposed instream flow regime and improved water quality on the LSR trout fishery during a the term of a new FERC license. The Trout Evaluation and Monitoring Program (Program) contained herein was subsequently developed under direction of the TWC, which included representatives from TU, SCDNR, USFWS and other interested stakeholders. The Program was developed cooperatively with resource agencies, TU and other interested stakeholders through review at numerous meetings of the TWC and Fish and Wildlife RCG, correspondence of which was filed with the Saluda Final License Application and corresponding additional information filed with the FERC.

3.0 PROGRAM GOALS AND OBJECTIVES

The goals and objectives of the Trout Evaluation And Monitoring Program for the LSR were developed using a consensus-based approach during stakeholder discussions by the Instream Flow and Aquatic Habitat TWC. Specifically, the goals and objectives are focused in two areas the understanding of which are fundamental to effective management of the LSR trout fishery, namely water quality and fishery resources. For each goal identified in these two areas, there are several qualitative and quantitative objectives for measuring the progress made towards meeting the goals. The Program goals for fishery resources and water quality, and their associated objectives, are described below.

3.1 Fishery Resources

Goal #1 To provide data to SCDNR beneficial to their efforts to enhance the Put, Grow, and Take trout fishery to maximize fishing opportunities for the public.

Objectives

- Assess relative contribution of brown and rainbow trout, as well as native warmwater species, to the LSR fishery community by summarizing data in standard community-level metrics, such as species diversity, richness, relative abundance, trophic levels, presence and distribution of key species, etc.
- Document and assess qualitative changes in trout habitat, including food resources (benthic macroinvertebrates) and water quality factors, resulting from flow modifications and DO enhancements.

Success Criteria

Note to readers : to be developed within the Advisory Committee (Committee or AC)

Goal #2 To investigate reproductive successes of trout to augment stocked fishery.

Objectives

- Document recruitment of young-of-year trout within the LSR
- Document trout eggs or larval life-stages in the LSR

Success Criteria

- **Note to readers: to be developed within the AC**

Goal #3 Evaluate the potential for a naturally reproducing trout population as a SCDNR management goal.

Objectives

- Advisory Committee to conduct annual review and assessment of water quality, IFIM, and biological data. Committee to issue a report of findings and assessment of progress towards goals.

Success Criteria

- **Note to readers: to be developed within the AC**

Goal #4 Determine growth rates of adult trout after implementing new instream flow regimes.

Objectives

- Conduct a trout growth study following completion of sampling as outlined in the Lower Saluda River Benthic Macroinvertebrate Monitoring and Enhancement Program. This will occur no sooner than year 7 after issuance of the new license. The study will document trout growth and be consistent with the study conducted in 2003 during the development of the LSR site specific DO standard. SCE&G will coordinate the study with the SCDNR and their trout production facilities. Should extended adverse meteorlogical or hydrologic conditions (i.e. persistent drought, low flows, etc.) or other extenuating circumstances occur during the years prior to implementation of the growth study, the study may be delayed after consultation with the AC.

Success Criteria

- **Note to readers: to be developed within the AC**

3.2 Water Quality

Goal #5 To release water from the Saluda Project that meets, to the extent possible, applicable State Water Quality Standards.

Objective

- Collect water quality data in the LSR year-round throughout completion of Benthic Macroinvertebrate Monitoring and Enhancement Program to capture conditions during all seasons and for wet and dry years.

Success Criteria

- **Note to readers: to be developed within the AC**

4.0 MANAGEMENT OF THE PROGRAM

The Instream Flow and Aquatic Habitat TWC has developed this Trout Evaluation and Monitoring Program for the LSR during the relicensing process for inclusion in the FERC license application and eventual incorporation into the new Saluda Project License. SCE&G is ultimately responsible for collection and analysis of Program data; however, an Advisory Committee (Committee or AC) will be convened, as described below, and it is anticipated and desired that Committee members will actively participate in all facets of the Program.

4.1 Formation of Advisory Committee

To help develop and oversee implementation of the Program, a Committee will be created. Member organizations and their responsibilities, as well as the approved dispute resolution procedures, are described below.

4.1.1 Committee Members and Responsibilities

The Committee will be comprised of representatives from SCE&G, SCDHEC, SCDNR, the United States Fish and Wildlife Service (USFWS), Trout Unlimited (TU), and other interested Stakeholders. With the exception of DHEC, members of the Advisory Committee must be signatories to the CRSA. Each entity will have the opportunity to select its own representation to the Committee. SCE&G (or their designee) will serve as chairperson of the Committee and be responsible for organizing meetings and distributing documents to committee members.

The Committee will ultimately be responsible for guiding the decision making processes specified in the Program. It is anticipated that the Committee will be comprised of many members of the TWC responsible for development of this Program. The Committee's responsibilities may include, but are not limited to the following:

- Collection and evaluation of baseline information and evaluation of study plans;

- Providing overall guidance and decision making for the Program process;
- Evaluating other study (*i.e.,* existing) information or information which becomes available during the time period of evaluations;
- Establishing and documenting the goals and objectives of each modification and determine the appropriate metrics for evaluative purposes;
- Keeping other stakeholders aware of information relative to potential decisions and providing opportunities to comment prior to decisions on modifications and provide a notification system of Advisory Committee meetings;
- Determining and considering long term impacts of operational modifications on downstream projects and project economics when evaluating the feasibility of implementing instream flow modifications; and
- Reviewing the annual report that provides information on the prior year's activities which SCE&G will file with FERC.

The Committee acknowledges the importance of allowing interested stakeholders to review and comment on major documents, such as study results, that may impact the evaluation and potential modification to the Project. The Committee chairman (an SCE&G representative or designee) will distribute these study results and make annual reports available to interested stakeholders. Interested stakeholders can request documents in writing to the Committee chairman. The Committee chairman will ensure that interested stakeholders have adequate notice and review time prior to final decisions of the Committee relative to modifications to test flows, etc. For all other documents on which stakeholders wish to comment, the Committee will review all timely comments and include these comments in the official record.

All information from the Committee relative to this Program, including notification of meetings, meeting summaries, study results and final study plans will be coordinated by SCE&G and shared with each committee member.

4.1.2 Advisory Committee Meetings

The Advisory Committee will establish a meeting schedule based on the activities and deliverables in any given year. To keep all committee members abreast of the schedule, the Advisory Committee will establish an annual calendar that will be distributed to members, along with any notes from previous meetings. The tentative Program schedule is provided in Section 5.2 of this plan.

4.2 Budget and Program Resources

Responsibility for implementing this Program will rest primarily with SCE&G, as licensee for the Saluda Project. Annual budgets will be developed by SCE&G relative to the monitoring and study costs as well as administrative costs and expenses. SCE&G will also rely on other resources outside of its establishment including, but not limited to, the following:

- federal, state and local grants
- donated services (federal and state agency involvement)
- equipment (purchases and loaners)
- expertise (governmental, non-governmental, private)

5.0 PROGRAM MONITORING METHODS

(Note to readers: Further refinement of Sampling Methodologies will be conducted within the AC)

5.1 Sampling Techniques

5.1.1 Water Quality Monitoring

Water Quality monitoring in the Saluda Tailrace is necessary to establish an accurate baseline and to evaluate changes in water quality resulting from DO enhancements and changes to project operations. Further, it will be the basis from which to determine whether the Project is in compliance with the LSR site-specific water quality standard (Goal #4).

Continuous water temperature and DO data will be sampled annually using installed USGS gages located below the Project dam and near Riverbanks Zoo (#02168504 - Saluda River Below Lake Murray Dam and #02169000 - Saluda River Near Columbia, respectively). Data will be collected at 15 minute intervals or as determined by the USGS equipment capabilities.

5.1.2 Flow Monitoring

Flow monitoring in the LSR is necessary to establish an accurate baseline and to evaluate changes in instream flows as they relate to TWC recommended flows, recreational flow releases and changes in project operations.

Continuous flow data will be collected annually using installed USGS gages located below Saluda Hydro dam and near Riverbanks Zoo (#02168504 - Saluda River Below Lake Murray Dam and #02169000 - Saluda River Near Columbia, respectively). Data will be collected at 15 minute intervals or as determined by the USGS equipment capabilities.

5.1.3 Trout Sampling

In addition to the two fish community surveys per year outlined in the Saluda Hydro Comprehensive Relicensing Settlement Agreement (CRSA), SCE&G will conduct additional targeted electrofishing for adult and sub-adult trout. The purpose of this sampling will be to document carryover of trout stocked during previous years and to evaluate other changes in the trout fishery resulting from DO enhancements and changes to project operations. Trout collections may also assist in documenting whether spawning in occurring in the LSR.

Trout will be sampled in the LSR on two days during the spring months (April/May) and two days during the fall (September-October). Exact locations to be sampled will be determined in consultation with the Advisory Committee (See Section 4.1 above), although the Oh Brother/Ocean Boulevard island complex downstream of Interstate 26 has been identified as a likely location due to the abundance and quality of habitat compared with other reaches of the LSR.

To the extent possible, sampling will be by daytime boat electrofishing, supplemented by backpack electrofishing in habitats not accessible by boat. Effort will be placed on adequate sampling of habitats typically utilized by adult and sub-adult trout, such as mid-channel velocity refuges at the base of shoals and undercut vegetated banks. Additional methodology will be developed in consultation with the Advisory Committee.

All stunned trout will be identified to species, weighed (to nearest gram), measured for total length, marked with a unique alphanumeric Floy-type tag and returned to the LSR. Other pertinent information that will be collected during electrofishing efforts will include date, time, weather conditions, sample location, collection technique, sampling effort, water temperature, DO, and secchi disc, etc.

5.1.4 Benthic Macroinvertebrate Sampling

Benthic Macroinvertebrate sampling will be conducted in accordance with the LSR Benthic Macroinvertebrate Monitoring and Enhancement Program approved by the Freshwater Mussel/Benthic macroinvertebrate TWC.

5.1.5 Ichthyoplankton Sampling

Sampling for trout at the egg and larval stages, or ichthyoplankton sampling, will be performed annually at two locations in the LSR: (1) Corley Island and (2) the Ocean Boulevard/Oh Brother rapids area. Sampling will be performed 1 time per week for a two-month period, likely March and April. Specific sampling periods may be adjusted based on consultation with the Advisory Committee and/or regional trout experts in an effort to ensure that sampling occurs when water temperatures most closely match trout spawning criteria.

Duplicate samples will be collected at each location using D-shaped or rectangular drift net (maximum mesh size 2mm), equipped with a flowmeter. Nets will be anchored facing upstream in sufficient flow to sample effectively and will be deployed for a maximum of 8 hours. Samples from egg nets will be preserved in ethyl alcohol and returned to the laboratory for identification. All eggs collected will be examined to determine stage and all larval specimens will be measured for standard length (0.1 mm). Larval densities (number / cm^3) will be calculated, compared by date and location, and presented in the final report.

5.1.6 Trout Growth Study

SCE&G proposes to conduct an in-situ growth study in the LSR to determine growth rates as inputs to bioenergetics modeling of rainbow trout consistent with studies in the LSR done in 2003. The trout growth study will be conducted during December – May and employ tag and recapture techniques utilized in the 2003 growth study conducted in LSR (Appendix A).

Annual Report Format and Summary Data Package

At the conclusion of the sampling season for each year of the Program, SCE&G will prepare reports for the various data collection components of the Program and consolidate them into a summary report that will be used by the Committee to track trends in the LSR.

The annual summary report package will include summaries of the following information:

- Water quality sampling data
- LSR flow data for the year
- Trout carryover sampling data
- Benthic macroinvertebrate sampling data
- Ichthyoplankton sampling data
- Trout stocking data
- Trout growth study results (earliest will be 7 years after issuance of new license)

Water quality data will be summarized and displayed graphically by daily average and instantaneous temperature and DO value. Each annual report will include a discussion of any occurrences when water quality did not meet State standards as well as an analysis of the influence of generation on water quality in the Tailrace. Also, as the Program progresses, each report should include a discussion comparing the current years data to previous years data to identify any trends or anomalies.

Electrofishing data will be compared to the Program goals to determine the potential and observed changes (positive or detrimental) to the trout fishery associated with changes in project operations. Analysis of data may include, but not be limited to, a comparison of the following metrics:

- species richness/diversity
- species distribution
- species density

- trophic shifts
- young-of-year recruitment
- distribution of migratory species
- catch rate (average number / 300 FT^2 or 10 minutes of boat shocking)
- percentage of individuals with disease, tumors, fin damage or other anomalies
- Other sources of available fishery data may also be incorporated into this analysis
- Occurrence of carryover adult trout

Benthic macroinvertebrate sampling data will be summarized to determine the potential and observed changes (positive or detrimental) to trout food sources with changes in project operations. Analysis of data may include, but not be limited to, a comparison of the following metrics:

- species richness/diversity
- species distribution
- species density

Ichthyoplankton sampling data will be summarized to reflect whether reproduction of trout was documented. This data will be used to determine the reproductive potential and success within the LSR.

6.0 FUNDING FOR SCDNR TROUT MORTALITY STUDY

SCE&G will contribute $ 30,000.00 to the SCDNR to assist in funding a trout mortality study conducted by their agency. SCDNR will perform all aspects of the mortality study and will provide a copy of the study plan or scope of work to SCE&G prior to implementing the study. SCE&G will make the funds available to SCDNR in the year the study is to be performed.

7.0 IMPLEMENTATION SCHEDULE

The water quality monitoring, flow monitoring and trout sampling aspects of the Program will be implemented concurrently with and according to the schedule outlined in the LSR Benthic Macroinvertebrate Monitoring and Enhancement Program. The Trout Growth Study will be implemented in the year following completion of the benthic macroinvertebrate, water quality, and flow monitoring and the trout carryover sampling.

Table 7-1: Example Macroinvertebrate, Trout, and Water Quality Sampling Timeline—Assumes Four Turbine Upgrades are Needed to Meet the Lower Saluda River Site-Specific Dissolved Oxygen Standard*

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Unit	New License													
Unit 5				Upgrade	Wait	Sample**								
Unit 3						Upgrade	Wait	Sample						
Unit 4								Upgrade	Wait	Sample				
Unit 1										Upgrade	Wait	Sample		Trout Study

*This schedule assumes that only 4 units would need upgrades (Units 1, 3, 4, 5)

** Sampling would include water quality, trout (adult and ichthyoplankton) and macroinvertebrates

8.0 DECISION PROCESS FOR PROGRAM MODIFICATIONS

The Advisory Committee will evaluate the annual data and make recommendations to SCE&G for any changes in the Program.

9.0 LITERATURE CITED

Kleinschmidt Associates. 2008. Final Data Report: Instream Flow Final Report for Lower Saluda River – March 2008. Prepared for South Carolina Electric & Gas. Columbia, SC.

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APPENDIX A

LOWER SALUDA RIVER TROUT GROWTH STUDY

SOUTH CAROLINA ELECTRIC & GAS CO.
COLUMBIA, SOUTH CAROLINA

SALUDA DO STANDARD PROJECT
LOWER SALUDA RIVER TROUT GROWTH STUDY

1.0 DISSOLVED OXYGEN CRITERIA

In 1986 the U.S. Environmental Protection Agency (EPA) produced the Ambient Water Quality Criteria for Dissolved Oxygen (freshwater). This document replaced all previously published EPA aquatic life criteria for dissolved oxygen (DO). State water quality criteria may have the same numerical values as those in the EPA document or States may want to adjust their criteria to reflect local environmental conditions.

Site-specific criteria are allowed by regulation and are subject to EPA review and approval. Although no specific procedures are in place for establishing site-specific criteria for DO in freshwater, existing guidance and practice are that EPA will approve site-specific criteria developed using appropriate procedures. Site-specific criteria must be based upon a sound scientific rationale in order to protect the designated use. A site-specific criterion is intended to come closer than the national criterion to providing the intended level of protection to the aquatic life at the site, usually by taking into account the biological and/or chemical conditions at the site. The LSR trout growth study was the initial step in the use of the bioenergetic model to predict a DO standard that provides a level of protection of trout growth consistent with the EPA DO criteria.

The LSR growth study and the resultant growth model predictions are used to establish a long-term average concentration that will adequately protect trout growth in the LSR. In addition to the long-term average, the DO criteria also contain a short-term DO concentration that will prevent mortality as a result of acute hypoxia. Even short-term exposure to DO levels in the range of 1 to 2 mg/L can kill trout in a short period of time if they are not able to find local refugia where DOs are higher. In one case, mortality of trout has been reported after 3-4 day exposure to 2.4 mg/L at 20 C. In general, low DO is better tolerated at cooler temperatures than at warmer temperatures. In order to avoid direct mortality due to low DO, the EPA criteria document recommends a minimum DO of 3 mg/L, a DO concentration that is survived by salmonids, including trout, in long-term growth studies.

Although EPA cited, and agreed with, reviews that concluded that invertebrates are generally protected by DO levels that protect fish, there were potential exceptions that induced EPA to recommend a minimum DO of 4 mg/L to protect sensitive species of mayflies, caddisflies, and stoneflies that are present in some areas of the western U.S. There are no data available on the many insect species that inhabit other habitats and regions.

In order to protect trout growth, EPA concluded that the growth attained at a constant, or 30-day running mean, DO concentration of 6.5 mg/L was adequate. The assumed level of protection was estimated to be the threshold of effect of DO on growth. Lower mean concentrations are adequate to protect important fishery resources, but risk slight growth impairment (6 mg/L) or moderate growth impairment (5 mg/L). EPA concluded that reductions in growth rate sometimes seen above 6 mg/L are usually not significant and that DO concentrations below 4 mg/L can have severe effects on growth. Between 4 and 6 mg/L the effect on growth is moderate to slight if the exposure is sufficiently long. It must be noted that these findings are derived from laboratory studies in which food was surplus.

Because DO affects fish growth primarily by reducing appetite and food consumption, growth effects are greatest when food is not limited according to the EPA criteria document. For example, in tests with coho salmon and DOs of 3, 5 and 8 mg/L, growth effects were seen only at food availability greater than 70% of maximum consumption and a DO of 3 mg/L. No effects were seen at 5 mg/L. This 70% food availability is similar to that estimated from the LSR growth study.

The most “natural” DO study included in the EPA criteria document was a test conducted in laboratory streams in which coho salmon fed on insects produced in the streams (9.5-15.5 C). At high growth rates (0.04 to 0.05 g/g/d) dissolved oxygen levels below 5 mg/L reduced growth, but at lower growth rates (0 to 0.02 g/g/d) no effects were seen at concentrations down to 3 mg/L. These lower growth rates are similar to those observed in the LSR. Although these studies were not conducted with rainbow trout, there is a general similarity in growth response to DO in all tested salmonid species and these results are probably representative of rainbow trout as well.

Perhaps the most critical issue identified in the EPA criteria document was the application of data from tests with constant DO exposure levels to natural situations in which DO may fluctuate significantly. They concluded that existing data allowed for a tentative theoretical dosing model for fluctuating DO as applied to fish growth if daily average DO was calculated using as a maximum value the threshold concentration below which growth effects are observed under constant exposure conditions.

The publication of several fish bioenergetic model papers occurred almost simultaneously with the publication of the EPA criteria document for DO (Cuenco et al., 1985 a, b, c). It was immediately evident that the fish growth analysis performed for the EPA DO criteria document (JRB Associates, 1984) provided the DO-food consumption link that would enable a similar modeling approach to be used for generating growth-effect predictions for natural conditions with cycling DO. Consequently, EPA and TVA entered into a cooperative agreement to develop and test a fish growth model using DO-growth effect data and the other bioenergetic parameters common to established fish growth models. The EPA-TVA model also utilized many physiological parameters from another bioenergetics model developed by the University of Wisconsin Sea Grant Program (Hewett and Johnson, 1991). The resultant model (Shiao et al., 1993) forms the basis for the LSR growth study and the LSR site-specific DO criteria proposal. The 1993 model has been updated with data of better precision for rainbow trout respiration and food consumption relationships with temperature (From and Rasmussen, 1984) and with additional analysis of the rainbow trout growth studies from the EPA criteria document (Spoor, 1981).

This modeling approach provides a tool to address what EPA termed a most critical and poorly documented aspect of the dissolved oxygen criterion which is the acceptable minimum DO under cycles of varying periodicity.

2.0 LOWER SALUDA RIVER TROUT GROWTH STUDY

Prediction of trout growth in the LSR requires adequate knowledge of three key parameters: temperature, DO concentration, and food availability to trout. In-stream monitoring of temperature and DO, coupled with turbine intake DO, a turbine aeration model, and a tailwater water quality model, provided very good data and estimates of the actual temperature and DO to which trout are exposed. Food availability can be estimated by measuring fish growth, determining the temperature and DO during the period that growth was measured, and using the FISH bioenergetics model to estimate food consumption (availability). During the period of this growth study DO was sufficiently high that there was no significant effect of DO. Therefore, food consumption and growth were determined almost exclusively by temperature and food availability.

The growth study was conducted to closely simulate the typical pattern of rainbow trout release into the put, grow, and take trout fishery in the LSR. This pattern is characterized by periodic releases of catchable trout (8-10 inches) at several locations along the LSR.

The growth study began with the tagging of approximately 15,000 rainbow trout obtained from the South Carolina Department of Natural Resources Walhalla Fish Hatchery. The tagging efforts were divided into four nearly equal monthly batches beginning in November and concluding in February. The November batch of rainbow trout contained 3000 individuals while the remaining 3 batches contained approximately 4000 individuals.

Each monthly batch of rainbow trout (201.4 ± 49.7 mm total length, 136 ± 36.7 g; mean ± SD) was tagged with sequentially numbered, large format, soft Alphanumeric Visible Implant Elastomer (VI-alpha) tags produced by Northwest Marine Technology Inc. To conduct the tagging exercise, fish were crowded in a raceway and 10 - 20 individuals were transferred to 50 – L aerated holding containers containing an anesthetic (~ 90 mg/L MS 222). Once fish were anesthetized, each rainbow trout received one visible implant tag, injected using a syringe-like tag applicator designed and supplied by the manufacturer just below the surface of the clear adipose postorbital eye tissue. The fish were then returned to a separate raceway and held for a minimum of 21 days as required by federal regulation for drug clearance as mandated by the Food and Drug Administration. During the holding period, fish were maintained in a flow-through raceway system at 4 – 12 C.

After the 21 day waiting period, all fish tagged for that month were individually weighted and measured {Total length (mm) and wet weight (g)} and the tag code recorded for each fish. All fish were left unfed two days prior to weighing and measuring. Each monthly batch of tagged fish were divided up into 1000 fish sub-units, with each sub-group designated for release at one of the four release locations. The December plantings were divided into 4 lots, one 300 batch (Lake Murray Dam), one 700 fish grouping (Saluda Shoals) and 2 1000 fish batches (Allied Signal and Quail Hollow) All other monthly stockings contained relatively equal stockings of 1000 (less tag loss). Monthly tagging numbers and tag retention rates appear in Table B1.

Trout were planted in four discreet releases, one each in December 2002, and in January, February and March of 2003. Release sites were three that are routinely used for the fishery (Saluda Shoals Park, Allied Signal, and Quail Hollow) plus an additional upstream site just below Lake Murray dam (Figure B-1).

The tagged fish arrived in hatchery trucks each outfitted with multiple cells to keep fish separated. To accomplish this, fish were taken from numbered raceways at the hatchery with each raceway containing known tagged fish. Fish were then placed in each of the designated cells for transport and release to the LSR. For the helicopter stocking, the fish were placed in the helicopter bucket and the pilot was given specific directions where to place the fish in the LSR. The remaining stockings were conducted via truck with each driver having a designated stocking location to release fish based on a pre-arranged raceway numbered matrix. During the January stocking, the lock on the access gate to Quail Hollow had been changed which required the driver to stock the fish at Allied Signal. To compensate and provide an even distribution of fish at all stocking locations, two 1000 batches of fish were released in the Quail Hollow area during February stocking event.

To determine trout growth, recovery of tagged trout was carried out by obtaining trout from the LSR by electrofishing as well as by obtaining weight and length data of freshly caught trout in the LSR sports fishery. Fish were collected from the LSR from April thru June using primarily boat electrofishing means. The sampling area extended from the base of Lake Murray Dam to the I -26 bridge (Figure B-1). While no sampling was conducted below the I-26 Bridge, there were anecdotal reports of tagged fish being caught near Riverbanks Zoo, approximately 1 mile downstream. Boat electrofishing was conducted using a 16 foot aluminum boat outfitted with a generator, Smith-Root model VII-A Electrofisher, and anode and cathode umbrella droppers. Pulsed DC current was placed in the water and output amperage was adjusted to maximize electric current in the water. Voltage was regulated in attempts to maintain approximately 5 amps. During electrofishing sampling, electric current was directed to all microhabitats (shoals, ruffle run complexes and rock outcroppings) throughout the LSR. Electrofishing effort was typically expended over a two and three day period. All trout captured were placed in 100 L aerated containers. Fish were then evaluated to determine if they were tagged. Those fish that were tagged individual length and weight, data was collected, along with the corresponding tag color and number and recorded on field data sheets. Fish were then released back to the LSR in the general location of capture. Additionally untagged trout were collected and those individuals were enumerated and length data obtained.

2.1 Growth Results

A total of 111 tagged trout were collected, weighed and measured during April, May and June. The growth data were analyzed to determine if the data were sufficiently homogeneous to allow use of the entire data set for estimation of food availability in the LSR. There were several factors that might have caused growth (and food availability estimates) to be significantly different for one or more subsets of fish in the growth study. These factors included:

- Release site
- Release date
- Recapture site
- Size at release
- Condition at release
- Condition at recapture
- Direction of movement after release
- Distance of movement after release
- Time between release and recapture

Because growth was primarily influenced by temperature and food availability during the study period (DO was always high), any difference in these factors related to tailwater location or date could have caused differences in growth rate. In addition, size and condition of the fish might be related to fitness to the tailwater environment, including adaptability to feeding, as well as finding and competing for most-suitable habitat. Obviously, any factors that might tend to selectively crop fish through predation, movement out of the study area, or susceptibility to angler harvest could influence the study result. However, as these factors are always present, their exclusion, even if possible, would make the study less representative of the actual conditions for the trout remaining in the system.

2.2 Initial Data Analysis

A summary of the data collected for each recaptured fish from the growth study is provided in Table 2. The weight at release and recapture of the 111 fish used for the growth analysis is shown in Figure B-2. It is immediately evident that there was a large range in fish weight both at release and recapture. The range of trout weight at release is typical, as trout will feed and grow at different rates even in a hatchery environment where feeding is regular. The same phenomenon occurs in nature, as individual fish become more-or-less adapted to the natural habitat and more-or-less dominant in retaining better habitat niches.

2.3 Release Site and Date

The initial analysis of growth rate by release site and release date indicated that differences in median growth raters were relatively small (Table B-3). Because of periodic access problems, only 14 of the 16 potential release combinations (4 sites x 4 dates) were possible. The number of fish recaptures represented in these 14 combinations ranged from 1 to 14, with several releases being represented by less than a half-dozen individuals.

Comparing individual trout growth rates as a function of release site and release date indicated that only two of fourteen release groups had growth rates that appeared to be lower than the norm for the other release groups (Figures B-2a and 2b). The two groups with lower growth rates were the December group released at Quail Hollow and the March group released at Allied Signal. However, these two groups were represented by only four and one fish, respectively. With the large range of growth rates represented within each of the other groups and the fact that most groups in the March release had fish which lost weight following release, there was no reason to remove these two groups (five fish) from the overall data set of 111 trout.

2.4 Recapture Site

It is not possible to determine where an individual fish resided between the time of release and the time of recapture. For those fish that were recaptured near the release site it might be concluded that there was not a significant movement upstream or downstream from the point of release. Other fish that were recaptured farther from the release site may or may not have moved rapidly to the vicinity of the point of recapture. Given the pool-like nature of much of the study area, it is possible that many of the released trout moved freely up and down long stretches of the LSR and established no small-scale area of residency. On the assumption that recapture site might indicate the primary area of residency following release, the growth rate data were analyzed to see if there was a relationship between growth rate and recapture site (Figure B-3).

Growth rates were highly variable regardless of recapture site. Almost twice as many fish were recaptured between Allied Signal and Saluda Shoals than in the upstream or downstream sections. Median growth rates were slightly higher in this intermediate stretch (0.75 percent per day) as compared with upstream (0.68 percent per day) and downstream (0.65 percent per day). Given the highly variable growth rates, these relatively small differences were not seen as significant to the modeling effort. Fish from the Saluda Shoals releases were the most common at all recapture sites below RM 8 (and below the Saluda Shoals release site, ca. RM 8.3), and fish from the release immediately below the dam were most common above RM 8 (Figure B-4). The effect of movement from the site of release was analyzed separately from the site of recapture.

2.5 Growth and Movement

All four release times were characterized by fish moving both up- and down-stream from the release sites. In general, more fish moved downstream than upstream, with median movement ranging from 0.3 to 1.2 miles downstream. Although the pattern of movement differed slightly among the four release dates (Figure B-5) only fish from the January releases appeared to differ in any noticeable way from the overall pattern. This exception is perhaps more noteworthy because no fish were released at Quail Hollow during January, and fish that moved downstream from Quail Hollow were outside of the recapture area. In fact, only trout that were released at the two intermediate sites, Saluda Shoals and Allied Signal, could be sampled both above and below the release site. The Quail Hollow released fish were not sampled below the site of release and the fish released just below the dam were obviously limited to the immediate area of the release or movement downstream.

Analysis of fish movement for the two intermediate release sites indicated that both the Saluda Shoals and Allied Signal fish from the December release tended to move downstream (Figure B-6). [Note that in this and other figures some data points are identical and are superimposed in the figures, thus, the number of points visible may not equal the number of data points represented (n).] Later releases at Saluda Shoals followed this pattern, but the indications are that the Allied Signal fish may have moved upstream more frequently following the January and March releases (there was no February release at that site). The release of fish immediately below the dam may have populated the upstream section to the extent that competitive pressure produced the net downstream movement of Saluda Shoals fish. Of course, this movement pattern may also be a direct response to physical habitat characteristics.

Although the movement of trout released at the dam was limited to essentially staying put or moving downstream, and the Quail Hollow releases were only sampled at and above the release site, the analysis of this data is of interest (Figure B-7). The Lake Murray dam releases routinely had a median movement of 0.8 miles downstream. Perhaps the most interesting aspect of all the movement data was the relatively rapid upstream migration of several fish from the March release at Quail Hollow. Although median movement was still less than one mile upstream, at least four fish moved 3-5 miles upstream in the period between release and sampling.

Given the wide range of dispersal seen among the fish (up to 5 miles up and downstream from the release site) the potential effect of this movement on growth was considered potentially important. As shown in Figure B-8, there was essentially no pattern seen in the growth data when distance and direction of post-release movement was included as a variable. A similar analysis broken down by release site and release date showed no appreciable pattern (Figures B-9-12). Figure B-13 shows the analysis of the relationship between time in the LSR after release and distance traveled between release and recapture. In general, there was no relationship between distance traveled and the time between release and recapture.

2.6 Size at Release and Growth Rate

The maximum growth rate of fish is in part dependent upon fish size, with smaller fish capable of higher food consumption rates and higher growth rates than larger fish. Hatchery feeding practices have routinely used size as a determinant of how much feed to provide trout (e.g., Leitritz, 1972: 2-inch fish 4x and 5-inch fish 2x the food fed 9-inch fish). The growth rate observed for fish in the LSR study indicated a weak relationship to size at release, with most growth rates >1 percent per day occurring in trout that were <150 grams at release (Figure B-14). Given the wide range of growth rates for fish of any particular size and the growth model expression of food availability as a percent of maximum consumption potential rather than absolute amounts of food consumed, there was no compelling need to consider size in determining food availability for the growth model.

2.7 Condition Factor and Growth Rate

Trout of any length may be judged as to their general condition by overall appearance and described as skinny, solid, plump, fat, etc. A quantitative term that describes the length and weight relationship is the "condition factor." The condition factor (c.f.) is expressed as:

$$c.f. = (W \times 100) / (L)^3$$

where: W = weight in grams and L = length in cm.

A condition factor of 1.0 may be used as a general guide with factors <1 representing less than optimal condition in trout and those >1 representing well-fed trout.

Trout with lower initial condition factors tended to grow at a faster rate than those with higher initial condition factors (Figure B-15). This is an expected finding under circumstances where hatchery conditions can cause a wide spread in condition factor and where field conditions allow dispersal of fish into areas of adequate food. The overall range in initial condition factors (ca. 0.8-1.8 in this study) is not unusual in crowded fish culture units without extensive and frequent grading and separation of fish sizes. Once released into the LSR the fish were able to disperse and feed more uniformly. This tends to allow the skinny fish to bulk up and the fatter fish to become more trim, resulting in the growth rate relationship seen in Figure B-15. This phenomenon is probably typical of the LSR put, grow, and take trout fishery and does not complicate the use of this growth study with the bioenergetic growth model.

The change in condition factor is illustrated in Figure B-16. In general, trout with initial condition factors >1.2 became more trim and those with initial condition factors <1.0 became more robust. The central tendency in the population was to develop a condition factor of about 1.1. This same trend was evident for trout recaptured from each of the release periods (Figures B-17a and b). This trend towards uniformity of condition factor is clearly evident in the decreasing variability in the length-weight relationships between release and recapture (Figure B-18) where r^2 values improved from 0.61 to 0.87 during residency in the LSR. The trend to greater uniformity in condition simplifies the application of the bioenergetic growth model.

Because growth was related to condition factor, the data were analyzed to see if there was any relationship between post-release movement in the LSR and the condition factor of the trout at time of release (Figure B-19). There was no effect of condition factor on the movement of trout following release.

A final analysis of the data was to determine if there was any relationship between growth rate and the time between release and recapture. Except for an apparently reduced growth rate for fish captured shortly after the March release, growth was essentially independent of residence time. The slightly reduced growth seen in the early recapture of the March release is probably attributable to a period of recovery from handling procedures inherent in capture, transport and release of fish in the planting process. Some period of time is also probably needed for the fish to adapt to feeding in nature as opposed to feeding under hatchery conditions. It is likely that all four release periods underwent the same handling stress and adaptation process, but the December-February releases experienced that pattern long before the initial recapture effort in April 2003.

2.8 LSR Trout Fishery Information

Additional information collected during the growth study revealed significant numbers of rainbow and brown trout that appear to be carryovers from previous stockings. A total of 441 tagged and untagged trout were collected from the LSR, with 253 rainbow and 188 brown trout comprising the total catch.

Of the 441 rainbow and brown trout collected, 74 exceeded 16 inches in length, or nearly one in every six fish. The largest rainbow and brown trout collected during these surveys were 22 and 24 inches, respectively, with all fish appearing robust and healthy. Further examination of the data indicates that trout do appear to carryover from annual stockings. Figure B-21 illustrates that at a minimum two distinct age classes of fish were collected in the LSR during the study. However, without otolith examination it is not readily possible to determine what year classes these individuals represent. One likely contributor to this observed carryover is likely is the higher DO levels maintained in the LSR since the inception of SCE&G's turbine venting program than those DO levels historically observed.

3.0 SUMMARY

A detailed analysis of growth patterns and relationships with potentially significant variables relating to the LSR sites, release dates, and fish size indicated that there were no factors requiring either data deletion or subdivision prior to the use of observed growth rates for calculating food availability. Consequently growth rate data from all 111 recaptured trout were used to calibrate the bioenergetics model for the LSR.

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COLUMBIA, SOUTH CAROLINA

SALUDA DO STANDARD PROJECT
LOWER SALUDA RIVER TROUT GROWTH STUDY

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SOUTH CAROLINA ELECTRIC & GAS CO.

SALUDA DO STANDARD PROJECT

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AUGUST 2003

Prepared by:

Paladin Water Quality Consulting

Kleinschmidt Associates
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Table B-1: Number tagged, number of survivors, survival (%), number retaining tags, and proportion (%) retaining tags of rainbow trout tagged with large format, soft VI-alpha tags and held for 25 days

TAG DATE	TAGGED (N)	SURVIVORS (N)	SURVIVAL (%)	NUMBER RELEASED (N)	RETENTION (%)
12/8/02	3000	2975	99.2	2405	80.8
1/6/03	4000	3780	94.5	2979	78.8
1/20/03	4400	4281	97.3	3331	77.8
2/13/03	4000	3251	81.3	3089	95.0
Total	15400	14287	92.8	11804	82.6

Table B-2: Data on rainbow trout recaptured and used in the Bioenergetics Model from the Lower Saluda River Growth Study April- June

	Tag Color	Tag Number	Stocked Total Length (mm)	Recaptured Total Length (mm)	Stock Weight (g)	Recaptured Weight (g)	Location Recaptured	Location on Figure B-1 (blue except where noted)	Location Stocked	Location on Figure B-1 (Red unless noted	Stock Date	Recaptured Date
1	yellow	C27	242	307	179	353	Sandy Beach, way point 106	3	Saluda Shoals Park	2	12/17/2002	4/2/2003
2	yellow	D55	217	230	157	171	Sandy Beach, way point 106	3	Saluda Shoals Park	2	12/17/2002	4/2/2003
3	yellow	22D	233	290	164	299	Corley Island shoal	7	Saluda Shoals Park	2	12/17/2002	4/3/2003
4	yellow	X26	253	298	216	302	downstream of I-20 at house	10	Quail Hollow	4	12/17/2002	4/3/2003
5	yellow	R73	261	324	221	438	tailrace, near spillway inflow	1	Lake Murray Dam	1	12/17/2002	4/28/2003
6	yellow	50E	245	315	197	347	above Sandy Beach (near shoal)	2	Saluda Shoals Park	2	12/17/2002	4/28/2003
7	yellow	D42	233	290	156	273	Sandy Beach	3	Saluda Shoals Park	2	12/17/2002	4/28/2003
8	yellow	L97	243	320	165	379	Upstream of Rawls Creek at shoal	5	Saluda Shoals Park	2	12/17/2002	4/28/2003
9	yellow	R72	245	325	156	350	downstream of I-20 bridge	11	Allied Signal	3	12/17/2002	5/1/2003
10	yellow	K20	244	315	143	328	downstream of I-20 bridge	11	unknown	n/a	12/17/2002	5/1/2003
11	yellow	J59	265	348	234	501	downstream of I-20 bridge	11	Allied Signal	3	12/17/2002	5/1/2003
12	yellow	L41	234	278	204	294	downstream of I-20 bridge	11	Saluda Shoals Park	2	12/17/2002	5/1/2003
13	yellow	G73	239	305	210	375	downstream of I-20 bridge	11	Quail Hollow	4	12/17/2002	5/1/2003

	Tag Color	Tag Number	Stocked Total Length (mm)	Recaptured Total Length (mm)	Stock Weight (g)	Recaptured Weight (g)	Location Recaptured	Location on Figure B-1 (blue except where noted)	Location Stocked	Location on Figure B-1 (Red unless noted)	Stock Date	Recaptured Date
14	yellow	I38	208	275	117	211	downstream of I-20 bridge	11	Saluda Shoals Park	2	12/17/2002	5/1/2003
15	yellow	09D	239	302	168	309	downstream of I-20 bridge	11	Allied Signal	3	12/17/2002	5/1/2003
16	yellow	54E	250	335	194	461	Corley Island shoal	7	Allied Signal	3	12/17/2002	5/1/2003
17	yellow	35C	277	345	204	472	Corley Island shoal	7	Saluda Shoals Park	2	12/17/2002	5/1/2003
18	yellow	O7E	239	282	113	255	upstream of Quail Hollow, mile 4+	12	Saluda Shoals	2	12/17/2002	5/20/2003
19	yellow	X04	216	281	197	236.0	upstream of Quail Hollow, mile 4+	12	Quail Hollow	4	12/17/2002	5/20/2003
20	yellow	B97	245	311	209	283	upstream of Quail Hollow, mile 4+	12	Quail Hollow	4	12/17/2002	5/20/2003
21	yellow	56D	254	333	179	377	asphalt plant, mile 4+	11	Allied Signal	3	12/17/2002	5/20/2003
22	yellow	J22	245	336	166	361	tailrace boat ramp & upstream	1 (red)	Lake Murray Dam	1	12/17/2002	6/2/2003
23	yellow	L92	224	334	165	415	Corley Island shoal	7	Saluda Shoals	2	12/17/2002	6/2/2003
24	red	A96	240	295	185	307	Sandy Beach, way point 106	3	Lake Murray Dam	1	1/7/2003	4/2/2003
25	red	S22	220	266	145	222	Sandy Beach, way point 106	3	Lake Murray Dam	1	1/7/2003	4/2/2003
26	red	46B	212	271	102	223	Sandy Beach, way point 106	3	Saluda Shoals Park	2	1/8/2003	4/2/2003
27	red	B84	207	258	133	206	Sandy Beach, way point 106	3	Saluda Shoals Park	2	1/8/2003	4/2/2003
28	red	C59	260	308	238	313	downstream of Hope Ferry Landing	4	Saluda Shoals Park	2	1/8/2003	4/2/2003

	Tag Color	Tag Number	Stocked Total Length (mm)	Recaptured Total Length (mm)	Stock Weight (g)	Recaptured Weight (g)	Location Recaptured	Location on Figure B-1 (blue except where noted)	Location Stocked	Location on Figure B-1 (Red unless noted	Stock Date	Recaptured Date
29	red	64K	231	275	125	228	Corley Island shoal	7	Saluda Shoals Park	2	1/8/2003	4/3/2003
30	red	50G	226	290	162	227	Corley Island shoal	7	Saluda Shoals Park	2	1/8/2003	4/3/2003
31	red	P13	250	285	183	252	Corley Island shoal	7	Allied Signal	3	1/9/2003	4/3/2003
32	red	88L	185	279	70	243	Corley Island shoal	7	Allied Signal	3	1/9/2003	4/3/2003
33	red	77D	236	275	168	227	Corley Island shoal	7	Allied Signal	3	1/9/2003	4/3/2003
34	red	E36	237	280	166	227	above Sandy Beach (near shoal)	2	Allied Signal	3	1/9/2003	4/28/2003
35	red	E17	213	282	130	240	above Sandy Beach (near shoal)	2	Lake Murray Dam	1	1/7/2003	4/28/2003
36	red	85E	220	304	130	319	Upstream of Rawls Creek at shoal	5	Saluda Shoals Park	2	1/8/2003	4/28/2003
37	red	A44	228	305	171	333	Upstream of Rawls Creek at shoal	5	Saluda Shoals Park	2	1/8/2003	4/28/2003
38	red	80M	219	271	124	230	Corley Island shoal	7	Allied Signal	3	1/9/2003	4/28/2003
39	red	92I	264	315	223	339	downstream of I-20 bridge	11	Allied Signal	3	1/9/2003	5/1/2003
40	red	P97	230	283	146	232	downstream of I-20 bridge	11	Allied Signal	3	1/9/2003	5/1/2003
41	red	51D	217	280	125	242	Honeywell Intake	9	Saluda Shoals Park	2	1/8/2003	5/1/2003
42	red	P95	226	298	130	311	Honeywell Intake	9	Allied Signal	3	1/9/2003	5/1/2003

	Tag Color	Tag Number	Stocked Total Length (mm)	Recaptured Total Length (mm)	Stock Weight (g)	Recaptured Weight (g)	Location Recaptured	Location on Figure B-1 (blue except where noted)	Location Stocked	Location on Figure B-1 (Red unless noted	Stock Date	Recaptured Date
43	red	52M	240	296	157	282	Corley Island shoal	7	Allied Signal	3	1/9/2003	5/1/2003
44	red	V97	217	284	150	272	Corley Island shoal	7	Allied Signal	3	1/9/2003	5/1/2003
45	red	63C	228	301	155	282	Honeywell Intake	9	Saluda Shoals Park	2	1/7/2003	5/20/2003
46	red	K51	223	278	112	206	Honeywell Intake	9	Lake Murray Dam	1	1/8/2003	5/20/2003
47	red	P72	228	289	126	222	Honeywell Intake	9	Allied Signal	3	1/9/2003	5/20/2003
48	red	07I	255	317	235	326	Honeywell Intake	9	Allied Signal	3	1/9/2003	5/20/2003
49	red	F67	224	313	168	339	asphalt plant, mile 4+	11	Allied Signal	3	1/9/2003	5/20/2003
50	red	H29	205	280	91	231	Corley Island shoal, mile 7+	7	Allied Signal	3	1/9/2003	5/20/2003
51	red	82H	221	329	141	434	Corley Island shoal, mile 7+	7	Saluda Shoals	3	1/8/2003	5/20/2003
52	red	23K	245	311	180	298	tailrace boat ramp & upstream	1 (red)	Lake Murray Dam	1	1/7/2003	6/2/2003
53	red	19B	232	320	102	343	downstream of Saluda Shoals	4	Lake Murray Dam	1	1/7/2003	6/2/2003
54	red	50N	243	335	179	397	downstream of Saluda Shoals Park	4	Saluda Shoals	2	1/8/2003	6/2/2003
55	red	P41	203	289	149	264	downstream of Saluda Shoals Park, above "Logan's Point"	5	Saluda Shoals	2	1/8/2003	6/2/2003
56	orange	V09	224	258	119	194	Sandy Beach, way point 106	3	Lake Murray Dam	1	2/11/2003	4/2/2003
57	orange	I77	232	277	141	222	Sandy Beach, way point 106	3	Lake Murray Dam	1	2/11/2003	4/2/2003

	Tag Color	Tag Number	Stocked Total Length (mm)	Recaptured Total Length (mm)	Stock Weight (g)	Recaptured Weight (g)	Location Recaptured	Location on Figure B-1 (blue except where noted)	Location Stocked	Location on Figure B-1 (Red unless noted	Stock Date	Recaptured Date
58	orange	D20	247	273	165	244	downstream of Hope Ferry Landing	4	Lake Murray Dam	1	2/11/2003	4/2/2003
59	orange	Y10	233	244	153	161	Corley Island shoal	7	Saluda Shoals Park	2	2/12/2003	4/3/2003
60	orange	88J	217	247	112	168	Corley Island shoal	7	Quail Hollow	4	2/13/2003	4/3/2003
61	orange	N04	235	252	136	166	Corley Island shoal	7	Saluda Shoals Park	2	2/12/2003	4/3/2003
62	orange	47A	247	265	145	210	Corley Island shoal	7	Saluda Shoals Park	2	2/12/2003	4/3/2003
63	orange	46V	222	227	102	147	downstream of I-20 at house	10	Quail Hollow	4	2/13/2003	4/3/2003
64	orange	73V	218	254	113	185	tailrace, near spillway inflow	1	Lake Murray Dam	1	2/11/2003	4/28/2003
65	orange	G07	212	251	107	171	above Sandy Beach ("flat")	2	Lake Murray Dam	1	2/11/2003	4/28/2003
66	orange	U87	219	260	118	215	above Sandy Beach (near shoal)	2	Lake Murray Dam	1	2/11/2003	4/28/2003
67	orange	26V	220	252	154	179	above Sandy Beach (near shoal)	2	Lake Murray Dam	1	2/11/2003	4/28/2003
68	orange	90P	208	260	108	214	Upstream of Rawls Creek at shoal	5	Lake Murray Dam	1	2/11/2003	4/28/2003
69	orange	09Y	186	288	62	246	downstream of I-20 bridge	5	Lake Murray Dam	1	2/11/2003	5/1/2003
70	orange	Y79	249	295	146	266	downstream of I-20 bridge	10	Quail Hollow	4	2/13/2003	5/1/2003

	Tag Color	Tag Number	Stocked Total Length (mm)	Recaptured Total Length (mm)	Stock Weight (g)	Recaptured Weight (g)	Location Recaptured	Location on Figure B-1 (blue except where noted)	Location Stocked	Location on Figure B-1 (Red unless noted	Stock Date	Recaptured Date
71	orange	13B	225	265	126	218	downstream of I-20 bridge	10	Saluda Shoals Park	2	2/12/2003	5/1/2003
72	orange	74A	232	270	124	186	downstream of I-20 bridge	10	Quail Hollow	4	2/13/2003	5/1/2003
73	orange	M37	249	264	131	208	Honeywell intake area	9	Saluda Shoals Park	2	2/12/2003	5/1/2003
74	orange	18A	236	257	143	165	Honeywell intake area	9	Saluda Shoals Park	2	2/12/2003	5/1/2003
75	orange	73B	224	274	131	211	Corley Island shoal	7	Lake Murray Dam	1	2/11/2003	5/1/2003
76	orange	R44	261	306	183	360	asphalt plant, mile 4+	11	Quail Hollow	4	2/13/2003	5/20/2003
77	orange	62P	203	264	112	193	BC Components intake	8	Saluda Shoals	2	2/12/2003	5/20/2003
78	orange	J45	230	273	148	216	BC Components intake	8	Saluda Shoals	2	2/12/2003	5/20/2003
79	orange	D60	203	241	106	130	Corley Island shoal, mile 7+	7	Quail Hollow	4	2/13/2003	5/20/2003
80	orange	R77	216	280	100	250	Corley Island shoal, mile 7+	7	Saluda Shoals	2	2/12/2003	5/20/2003
81	orange	17C	223	282	142	239	downstream of Saluda Shoals Park	4	Lake Murray Dam	1	2/11/2003	6/2/2003
82	green	R76	267	278	234	243	Sandy Beach, way point 106	3	Lake Murray Dam	1	3/11/2003	4/2/2003
83	green	R79	260	258	173	165	SCE&G boat landing - tailrace, way point 108	1 (red)	Lake Murray Dam	1	3/11/2003	4/2/2003
84	green	Z71	237	279	215	243	downstream of Hope Ferry Landing	4	Quail Hollow	4	3/14/2003	4/2/2003

	Tag Color	Tag Number	Stocked Total Length (mm)	Recaptured Total Length (mm)	Stock Weight (g)	Recaptured Weight (g)	Location Recaptured	Location on Figure B-1 (blue except where noted)	Location Stocked	Location on Figure B-1 (Red unless noted)	Stock Date	Recaptured Date
85	green	22R	215	226	134	126	Corley Island shoal	7	Allied Signal	3	3/13/2003	4/3/2003
86	green	98G	220	230	140	155	Corley Island shoal	7	Saluda Shoals Park	2	3/12/2003	4/3/2003
87	green	L34	245	245	192	177	Corley Island shoal	7	Saluda Shoals Park	2	3/12/2003	4/3/2003
88	green	O00	215	270	108	220	above Sandy Beach (near shoal)	2	Saluda Shoals Park	2	3/12/2003	4/28/2003
89	green	N24	242	266	176	225	Sandy Beach	3	Lake Murray Dam	1	3/11/2003	4/28/2003
90	green	47G	238	265	173	203	Sandy Beach	3	Lake Murray Dam	1	3/11/2003	4/28/2003
91	green	81L	236	265	148	191	Upstream of Rawls Creek at shoal	5	Lake Murray Dam	1	3/11/2003	4/28/2003
92	green	O57	244	280	154	219	downstream of I-20 bridge	11	Quail Hollow	4	3/14/2003	5/1/2003
95	green	S64	280	300	255	327	downstream of I-20 bridge	11	Quail Hollow	4	3/14/2003	5/1/2003
93	green	91Y	246	278	177	222	downstream of I-20 bridge	11	Quail Hollow	4	3/14/2003	5/1/2003
94	green	37G	235	269	152	238	Honeywell Intake	9	Lake Murray Dam	1	3/11/2003	5/1/2003
95	green	Z21	237	285	215	301	Corley Island shoal	7	Saluda Shoals Park	2	3/12/2003	5/1/2003
96	green	30T	238	280	138	204	Quail Hollow, mile 3 to mile 4	12	Quail Hollow	4	3/14/2003	5/20/2003
97	green	H42	252	305	178	213.0	Honeywell Intake	9	Quail Hollow	4	3/14/2003	5/20/2003
98	green	11C	230	272	178	204.0	Honeywell Intake	9	Saluda Shoals	2	3/12/2003	5/20/2003
100	green	P34	281	326	252	366	BC Components intake	8	Quail Hollow	4	3/14/2003	5/20/2003
101	green	82R	230	272	186	189	asphalt plant, mile 4+	11	Quail Hollow	4	3/14/2003	5/20/2003

	Tag Color	Tag Number	Stocked Total Length (mm)	Recaptured Total Length (mm)	Stock Weight (g)	Recaptured Weight (g)	Location Recaptured	Location on Figure B-1 (blue except where noted)	Location Stocked	Location on Figure B-1 (Red unless noted	Stock Date	Recaptured Date
102	green	T65	216	284	167	216	upstream of I-20, ~mile 4.5	13	Quail Hollow	4	3/14/2003	5/20/2003
103	green	G41	300	334	360	372	BC Components intake	8	Lake Murray Dam	1	3/11/2003	5/20/2003
104	green	P89	235	285	145	286	Corley Island shoal, mile 7+	7	Saluda Shoals	2	3/12/2003	5/20/2003
105	green	09Y	225	272	155	186	Corley Island shoal, mile 7+	7	Lake Murray Dam	1	3/11/2003	5/20/2003
106	green	08R	210	262	134	209	Corley Island shoal, mile 7+	7	Lake Murray Dam	1	3/11/2003	5/20/2003
107	green	28B	193	213	88	74	tailrace boat ramp & upstream	1 (red)	Lake Murray Dam	1	3/11/2003	6/2/2003
108	green	G67	230	271	126	211.5	tailrace boat ramp & upstream	1 (red)	Lake Murray Dam	1	3/11/2003	6/2/2003
109	green	72Y	259	291	159	259.0	Sandy Beach (upstream of Saluda Shoals Park landing)	3	Lake Murray Dam	1	3/11/2003	6/2/2003
110	green	E35	250	284	157	213.0	Sandy Beach (upstream of Saluda Shoals Park landing)	3	Quail Hollow	4	3/14/2003	6/2/2003
111	green	N25	233	272	146	204.0	downstream of Saluda Shoals Park, above "Logan's Point"	5	Lake Murray Dam	1	3/11/2003	6/2/2003

Table B-3: **Median growth rate (n) for each of the fourteen combinations of release site and release date. Overall median (n) growth rates are shown for each site, each date, and for all 111 recaptured trout. Growth rates are g/g/day and the overall rate of 0.0071 g/g/day is 0.71 percent weight gain per day.**

	DEC.	**JAN.**	**FEB.**	**MAR.**	**ALL MONTHS**
Below Dam	0.0072 (2)	0.0070 (6)	0.0095 (11)	0.0048 (13)	**0.0075 (32)**
Saluda Shoals	0.0077 (11)	0.0083 (12)	0.0075 (9)	0.0063 (6)	**0.0076 (38)**
Allied Signal	0.0078 (6)	0.0065 (14)	No release	-0.0030 (1)	**0.0071 (21)**
Quail Hollow	0.0030 (4)	No release	0.0095 (6)	0.0055 (10)	**0.0056 (20)**
All Sites	**0.0071 (23)**	**0.0072 (32)**	**0.0083 (26)**	**0.0056 (30)**	**0.0071 (111)**

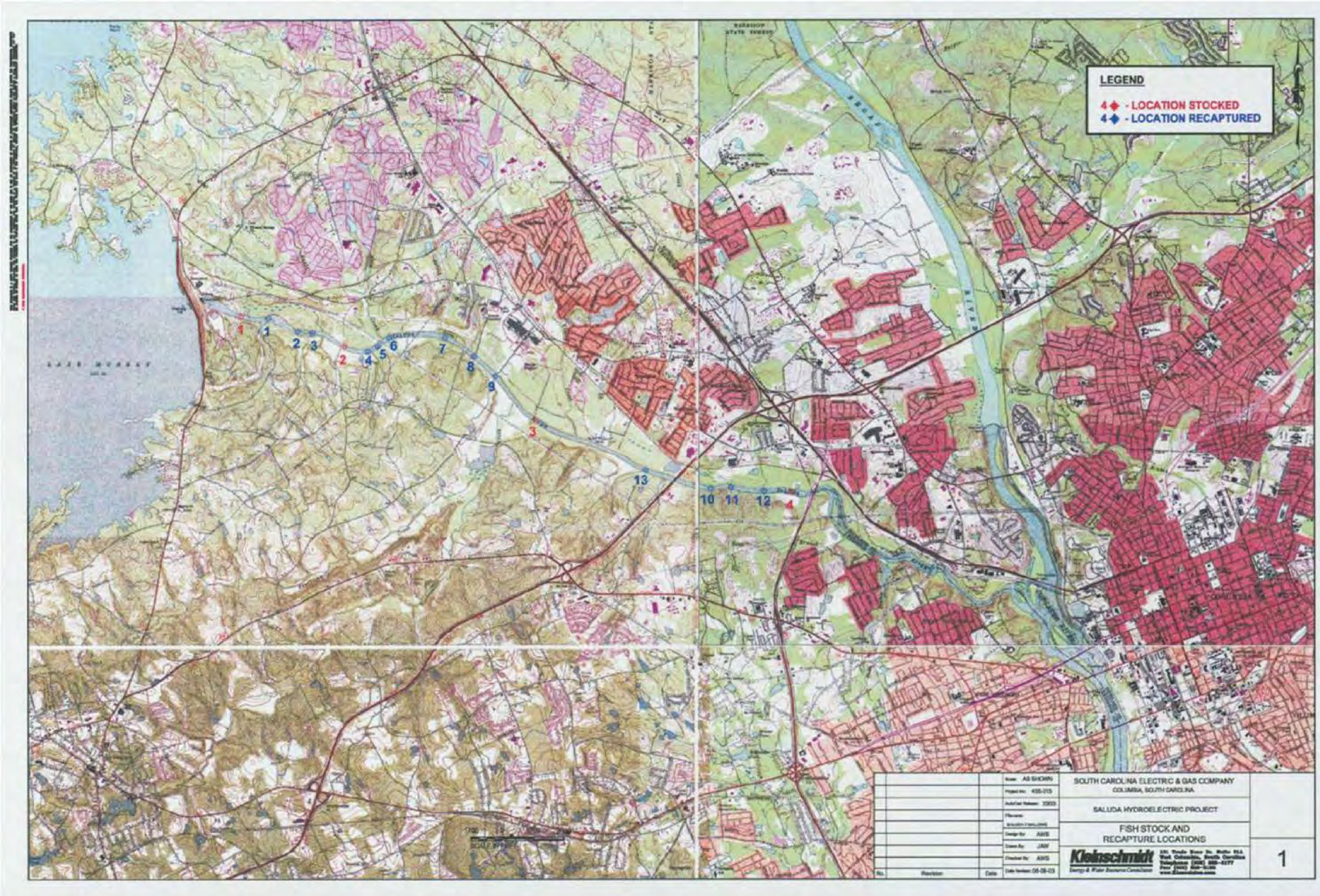


Figure B-1: **Fish Stock and Recapture Locations**

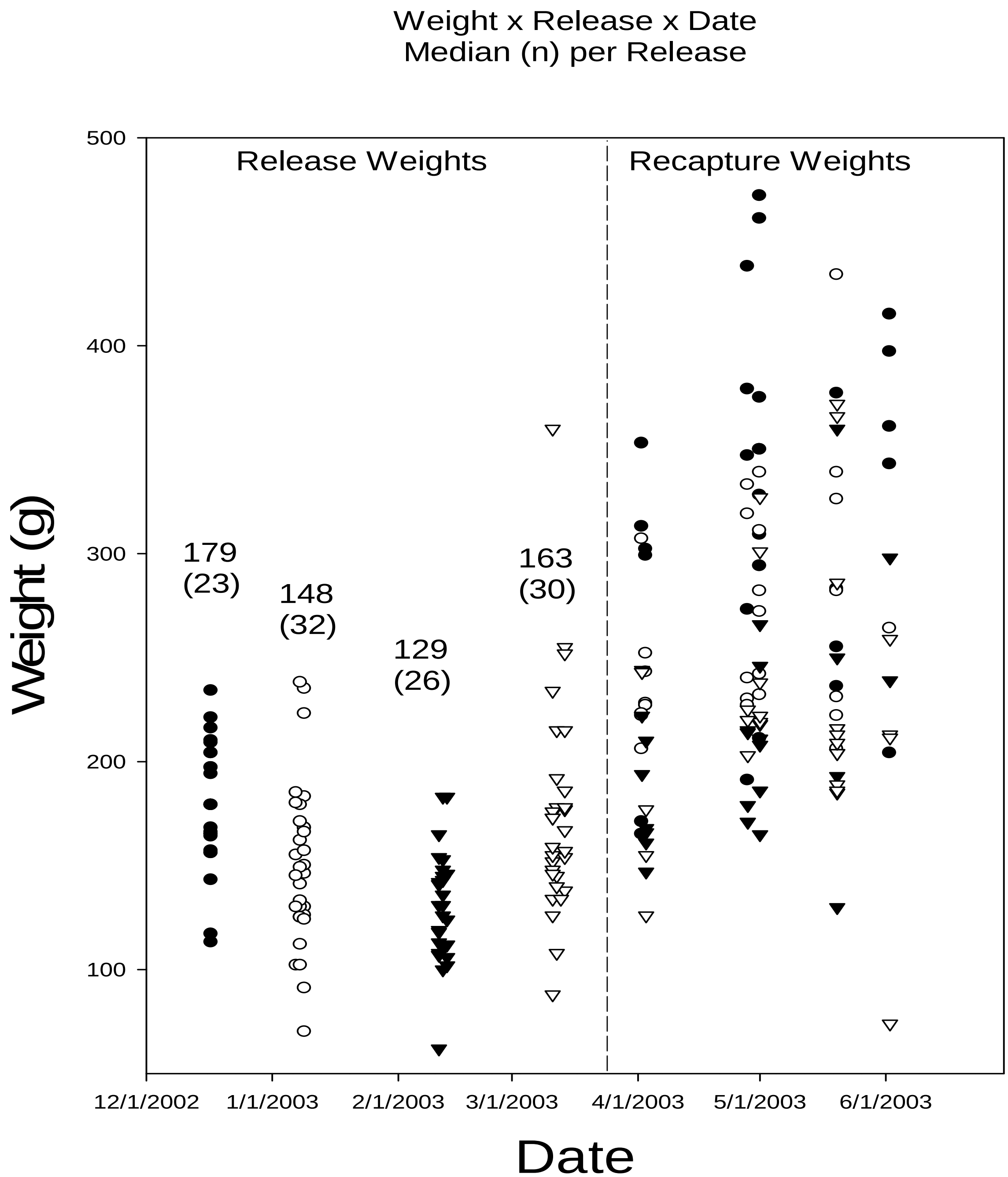
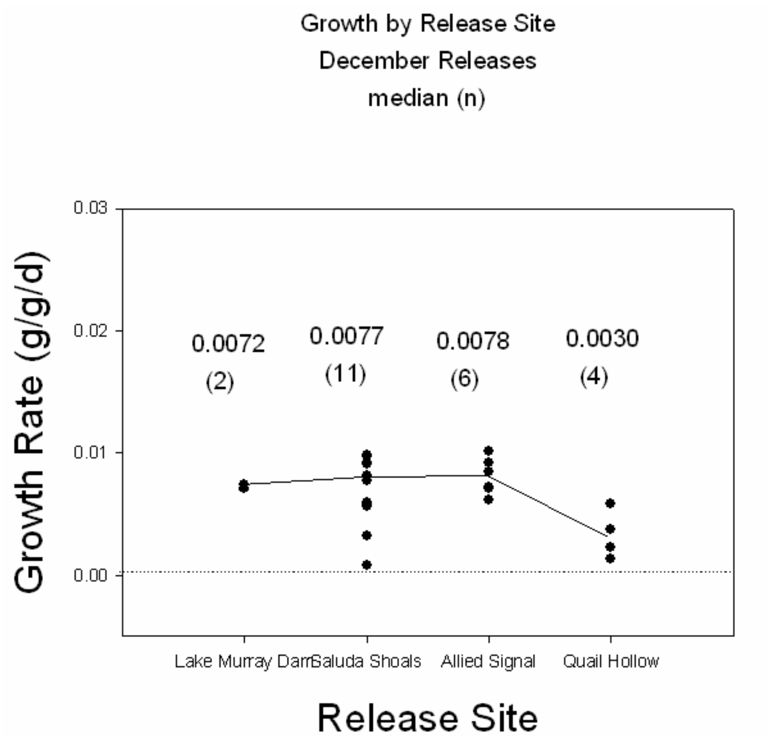


Figure B-2: Weight (g) of Recaptured Trout at Time of Release and Time of Recapture



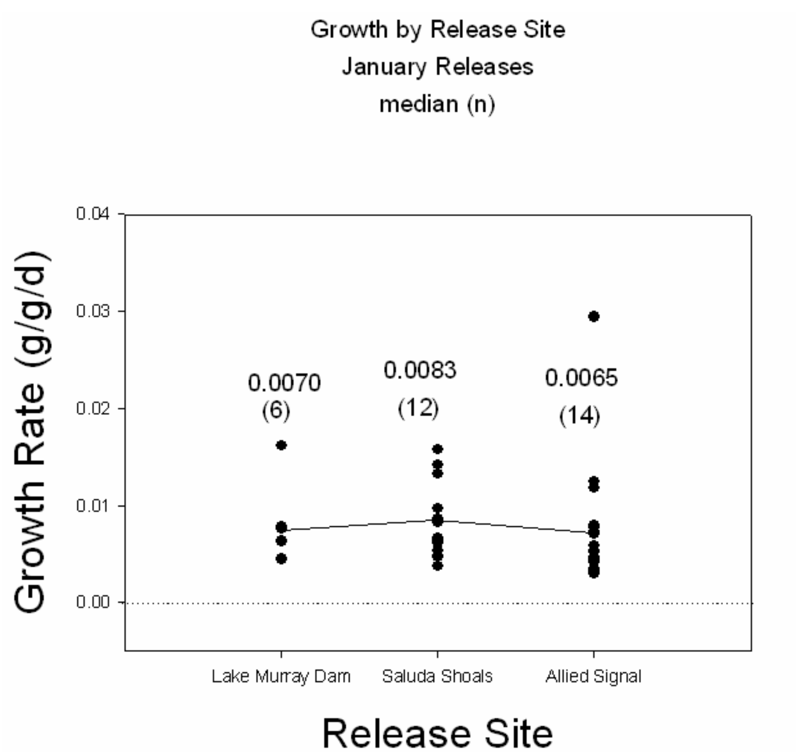
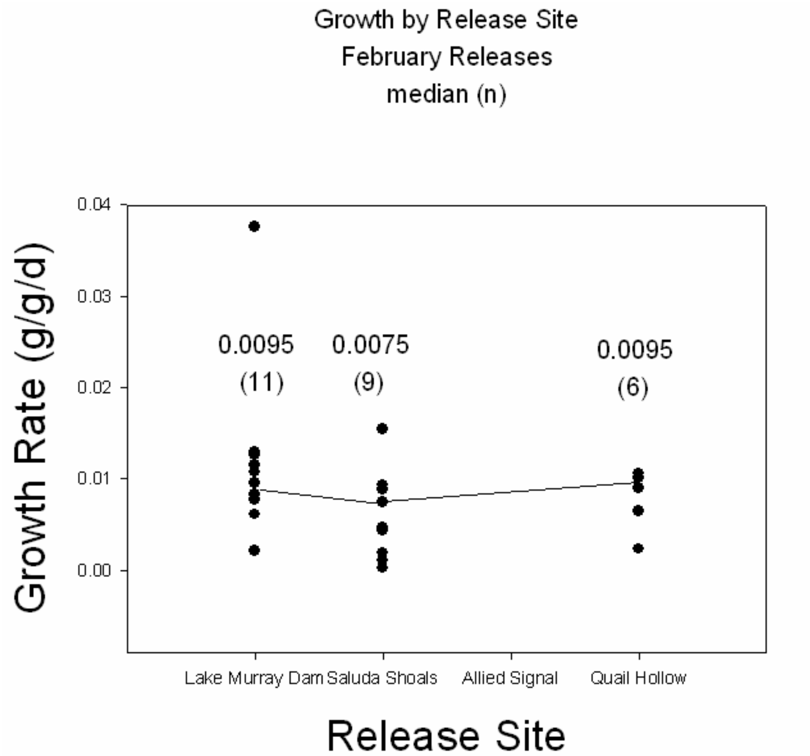


Figure B-2a: Growth Rate by Release Site for December and January Releases



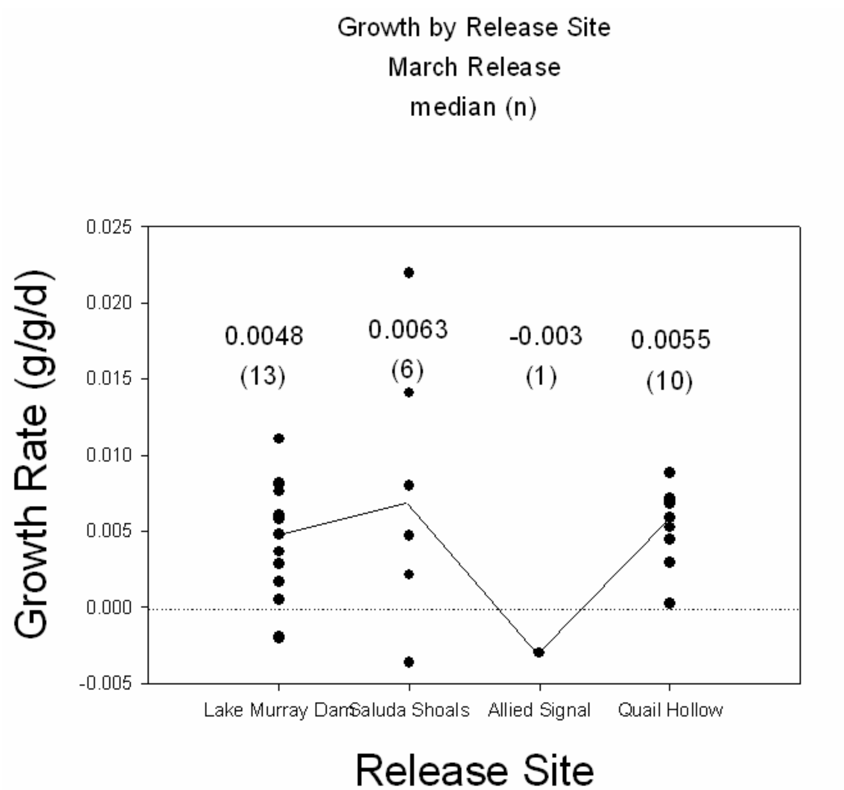


Figure B-2b: Growth Rate of Trout by Release Site for the February and March Releases

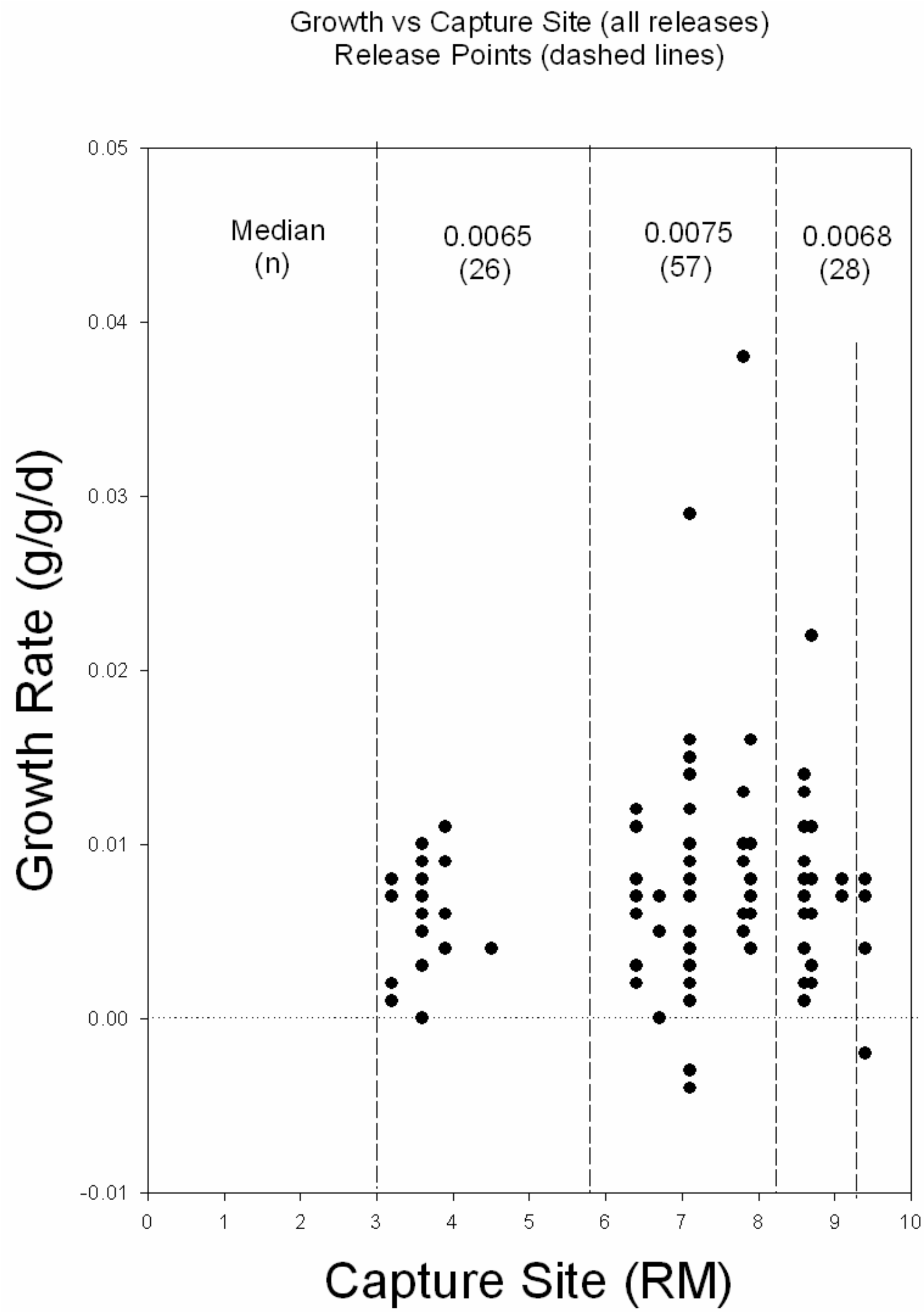


Figure B-3: Growth Rate is Shown as a Function of Recapture Location by River Mile. Release points are indicted by vertical dashed lines. From downstream to upstream these are Quail Hollow, Allied Signal, Saluda Shoals Park, and the immediate vicinity of the Lake Murray dam. No recapture efforts were made below the Quail Hollow release point (RM 3).

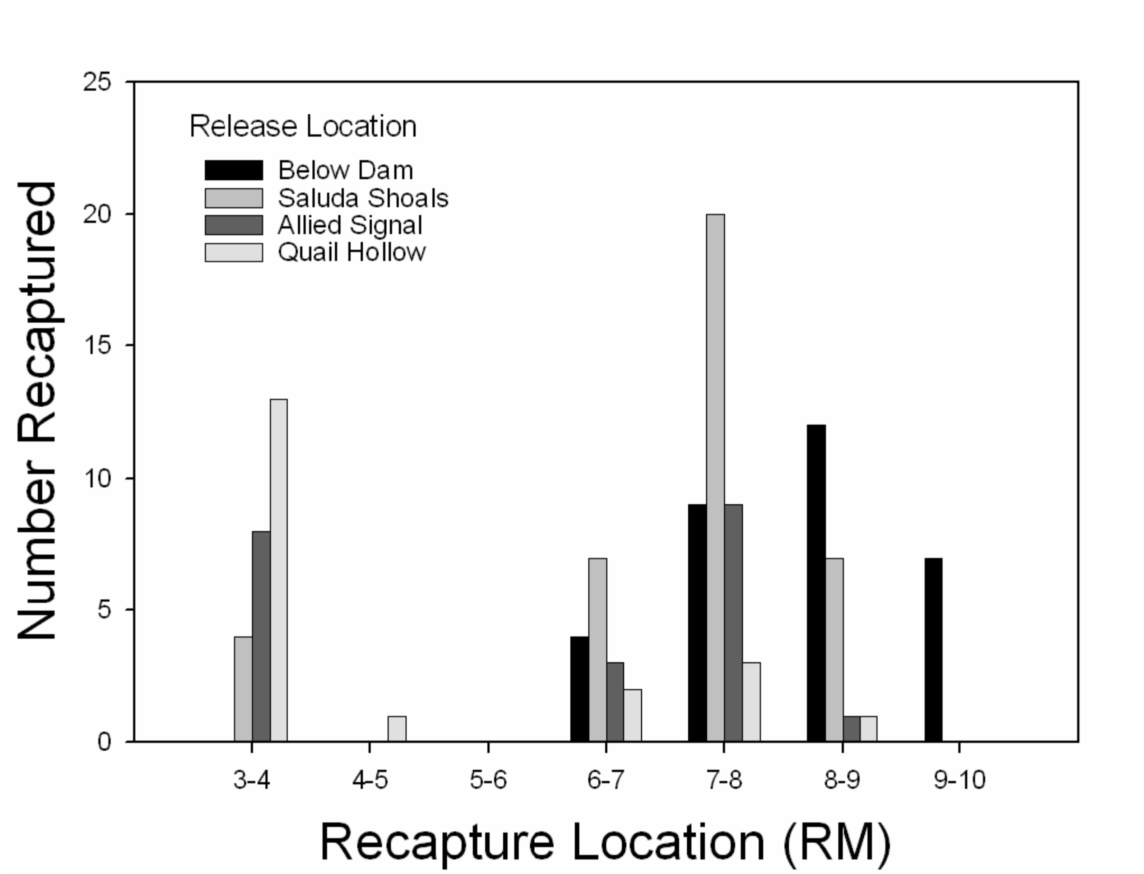


Figure B-4: Recapture Location (RM) and Site of Release. There was Limited Recapture Effort Between RM 4 and 6.

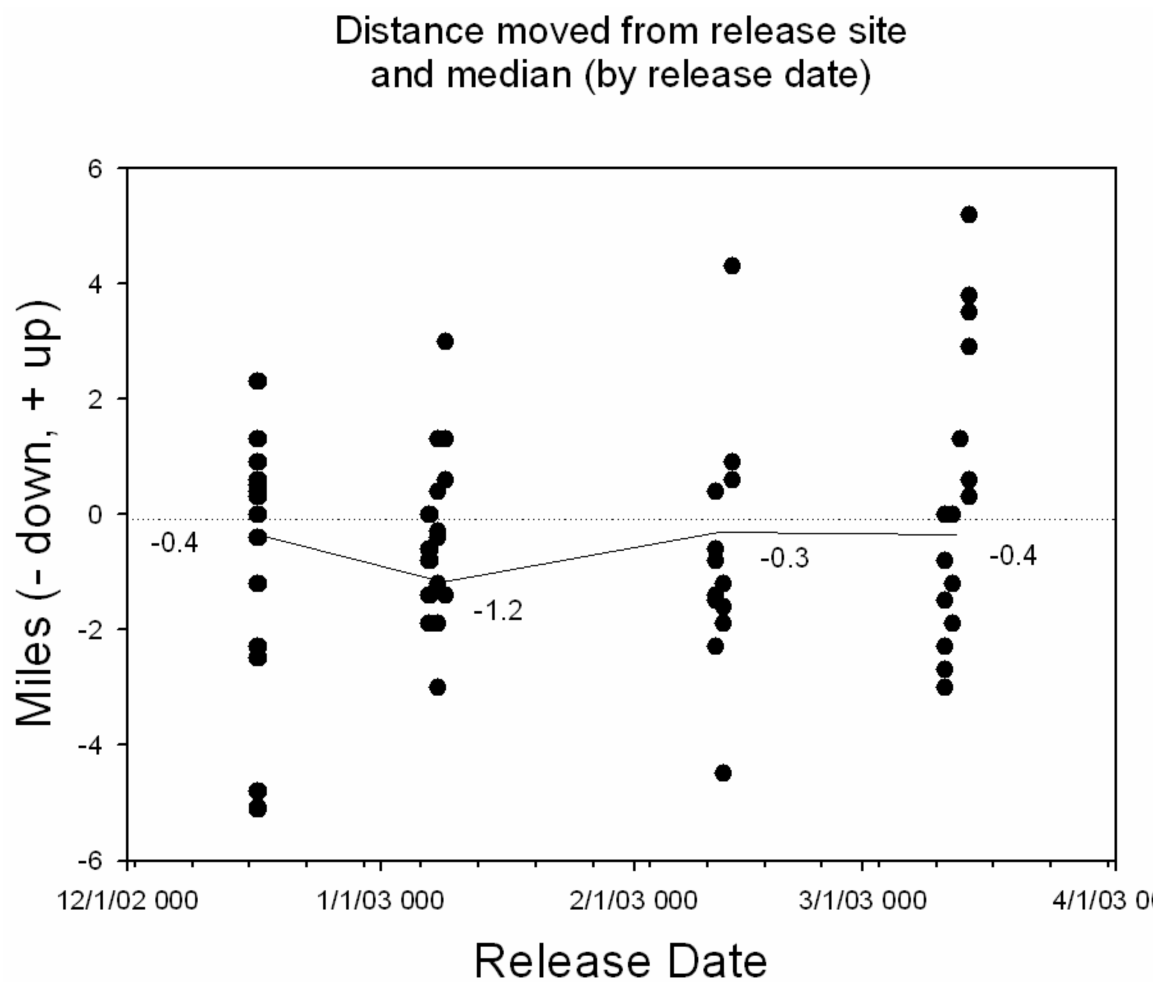


Figure B-5: Distance Moved from Release Site for Each Release Date. Median Distances are Shown on the Graph for each Release Date

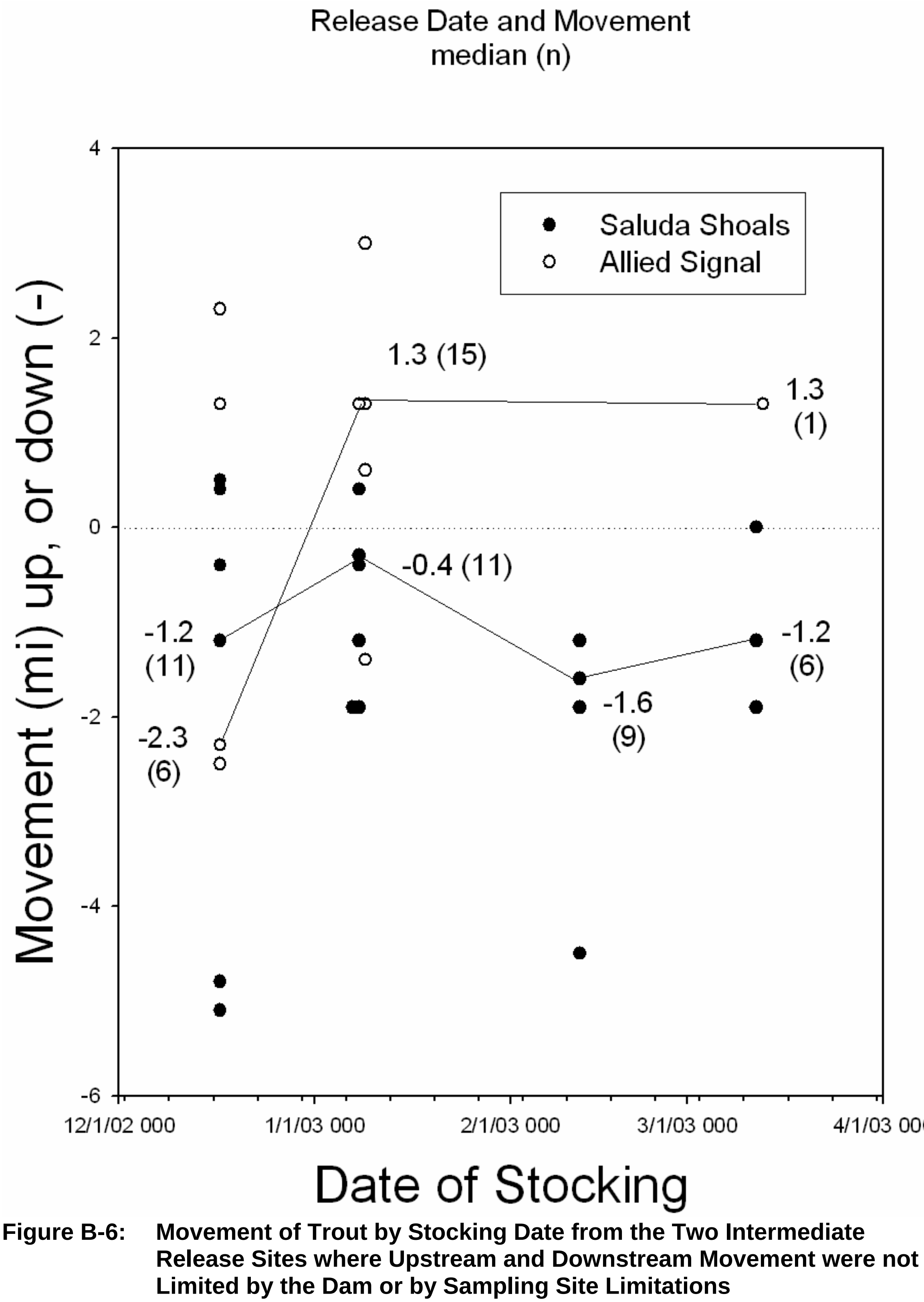


Figure B-6: Movement of Trout by Stocking Date from the Two Intermediate Release Sites where Upstream and Downstream Movement were not Limited by the Dam or by Sampling Site Limitations

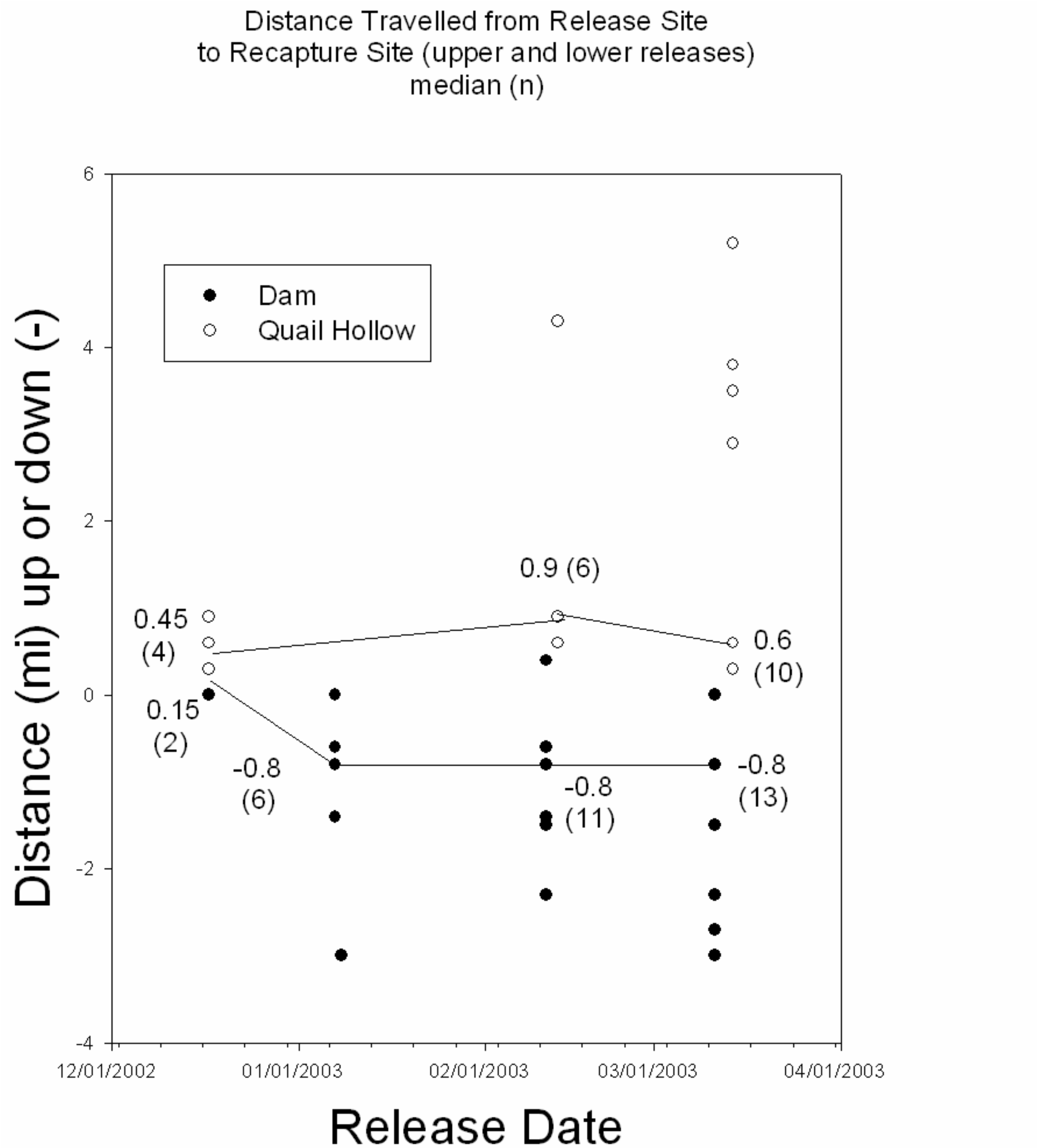


Figure B-7: Movement of Fish Following Release at Various Times at the Upstream Site Near Lake Murray Dam and at Quail Hollow

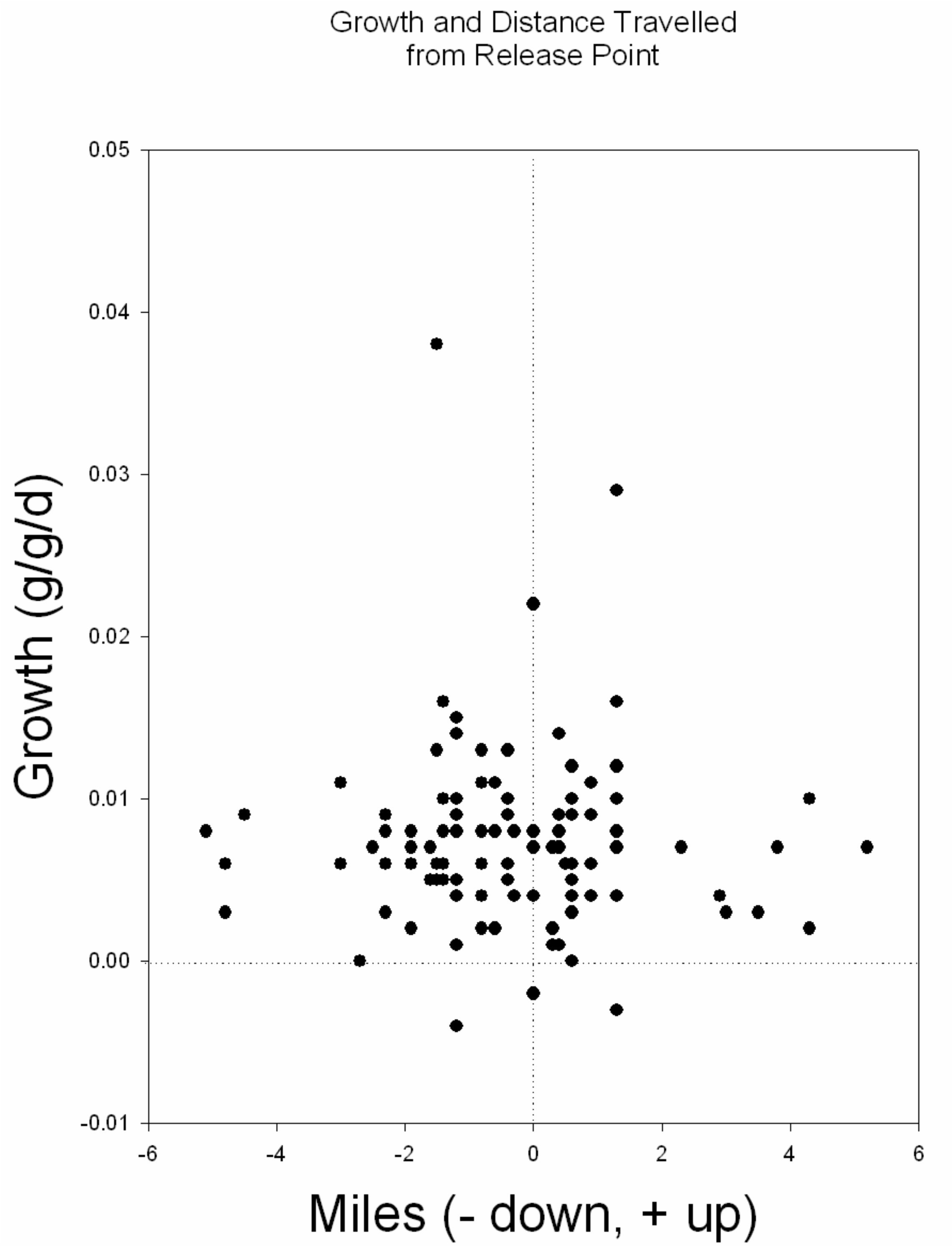


Figure B-8: This Figure Shows the Growth Rates for All 111 Fish as a Function of Their Movement Up or Downstream Following Release

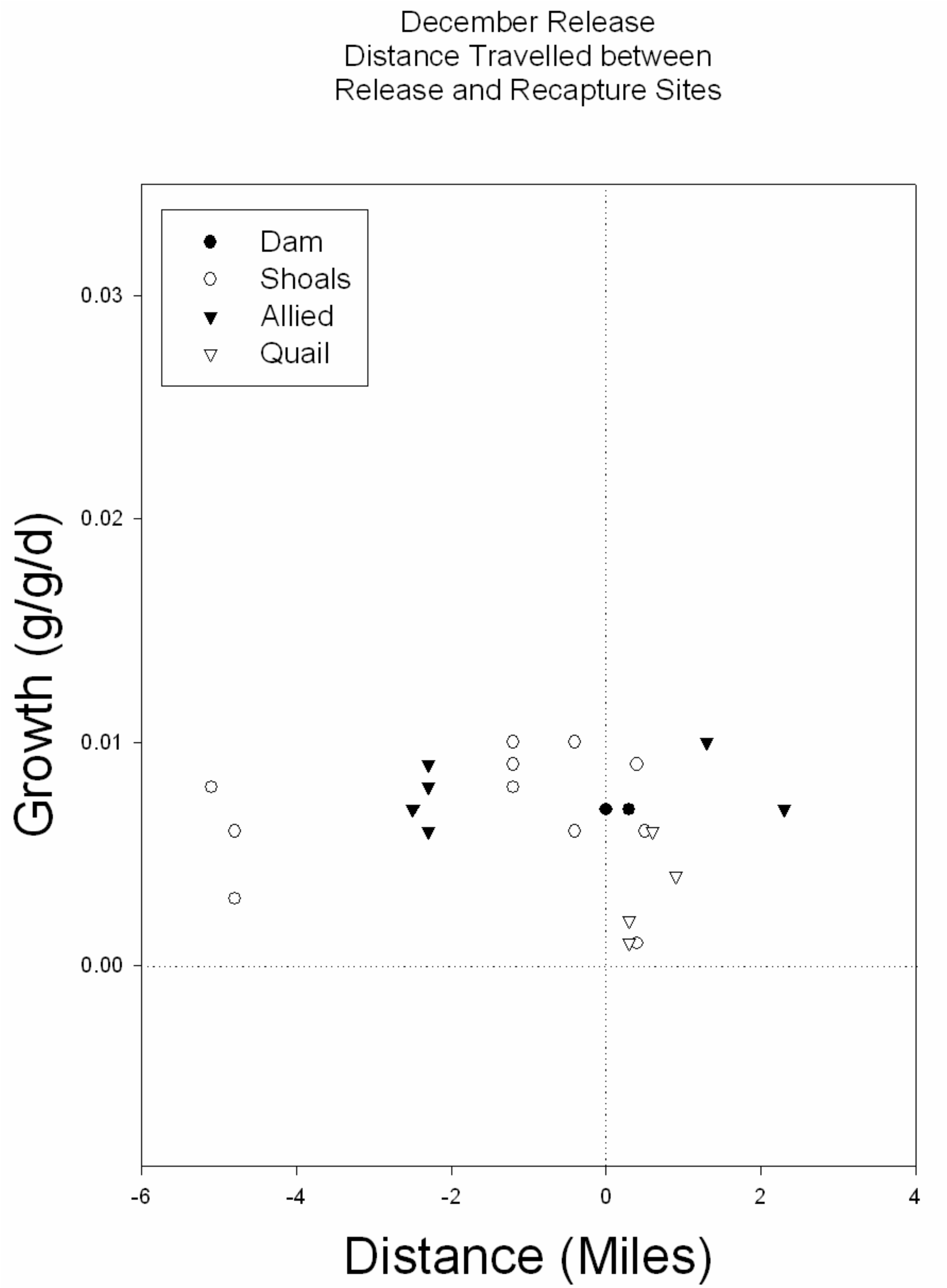


Figure B-9: Analysis of Growth Rate as a Function of Post-Release Movement for Fish Released in December at the Four Release Sites

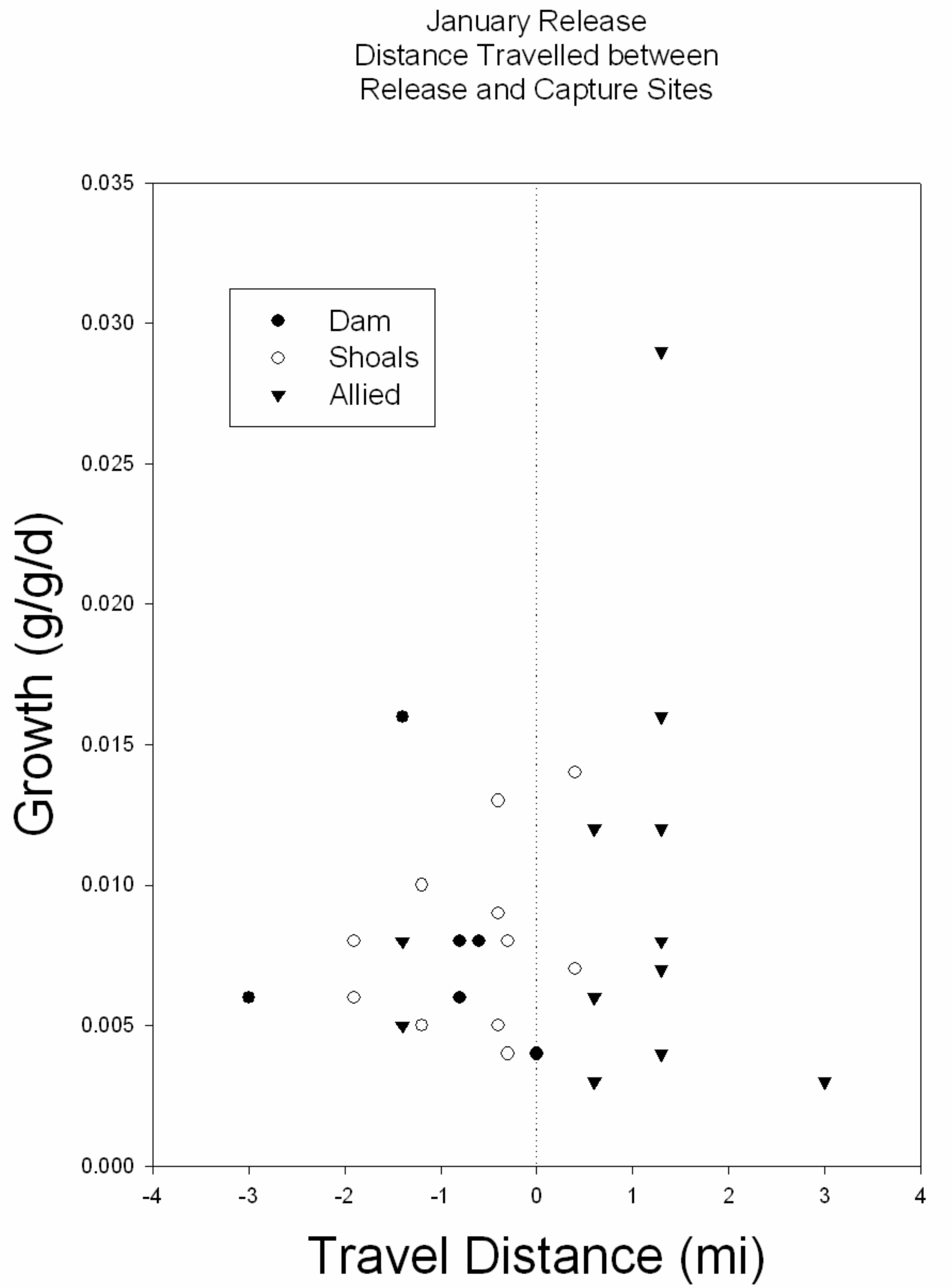


Figure B-10: Analysis of Growth Rate as a Function of Post-Release Movement for Fish Released in January at the Three Release Sites

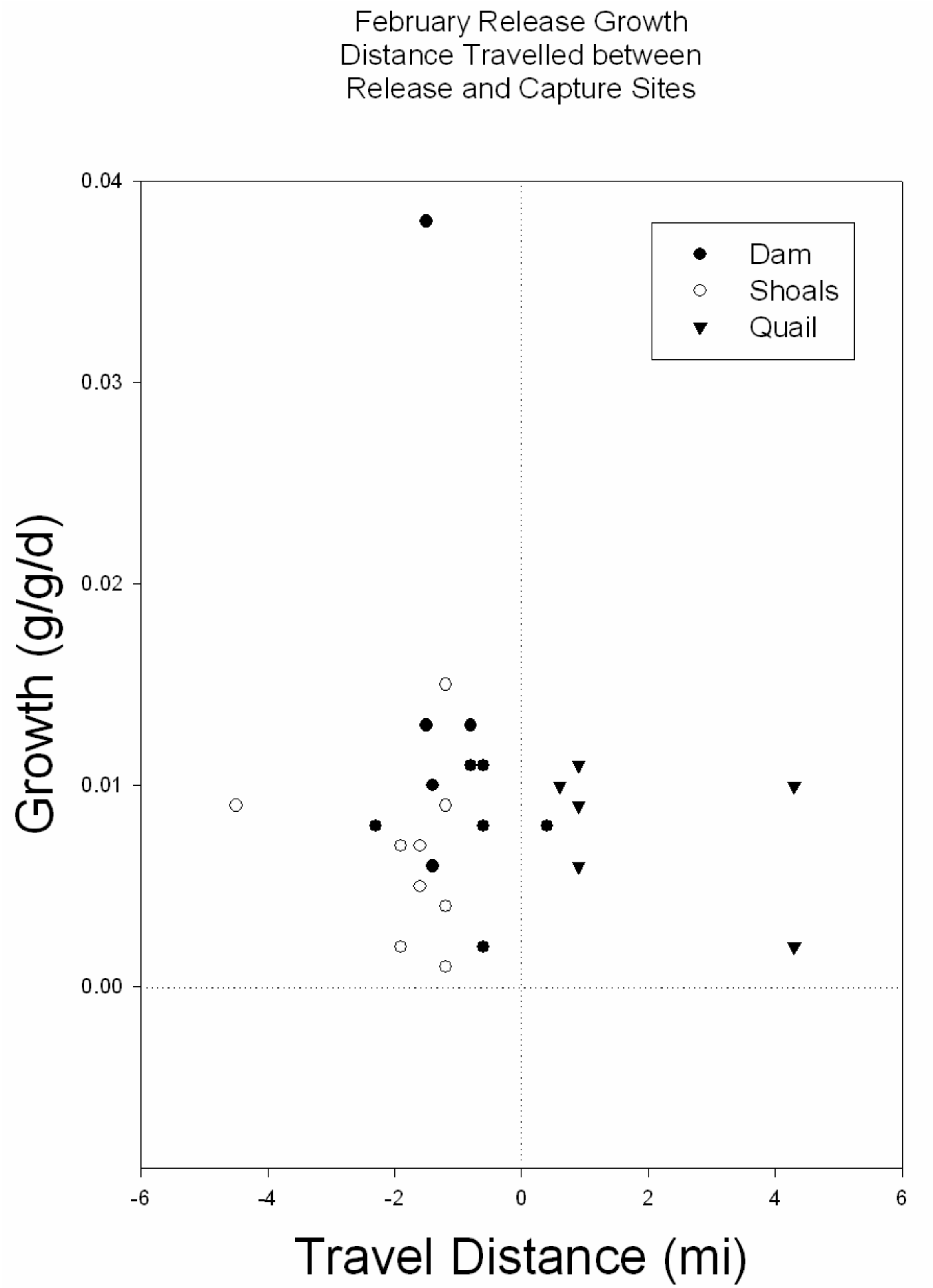


Figure B-11: Analysis of Growth Rate as a Function of Post-Release Movement for Fish Released in February at the Three Release Sites

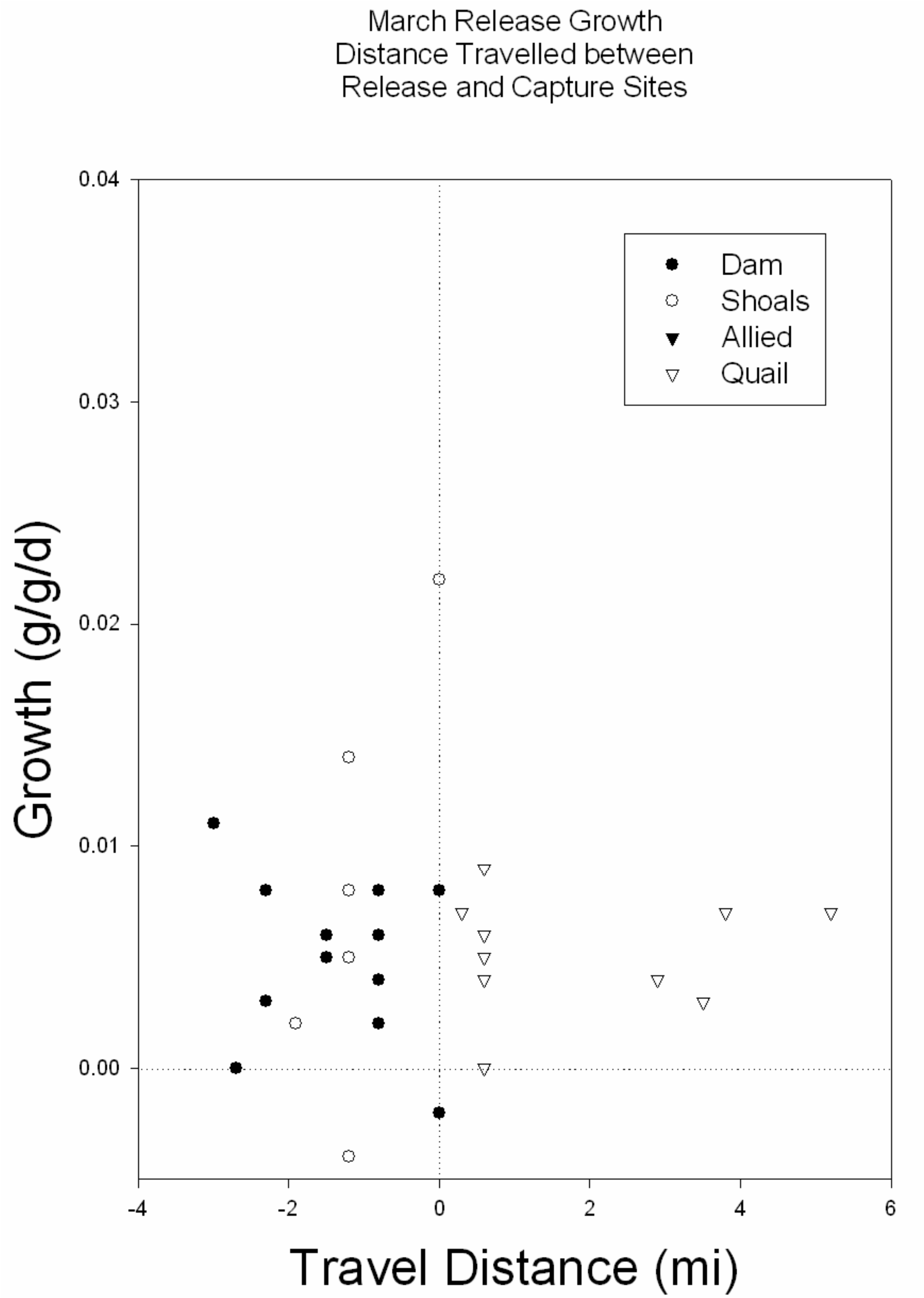


Figure B-12: Analysis of Growth Rate as a Function of Post-Release Movement for Fish Released in March at the Four Release Sites

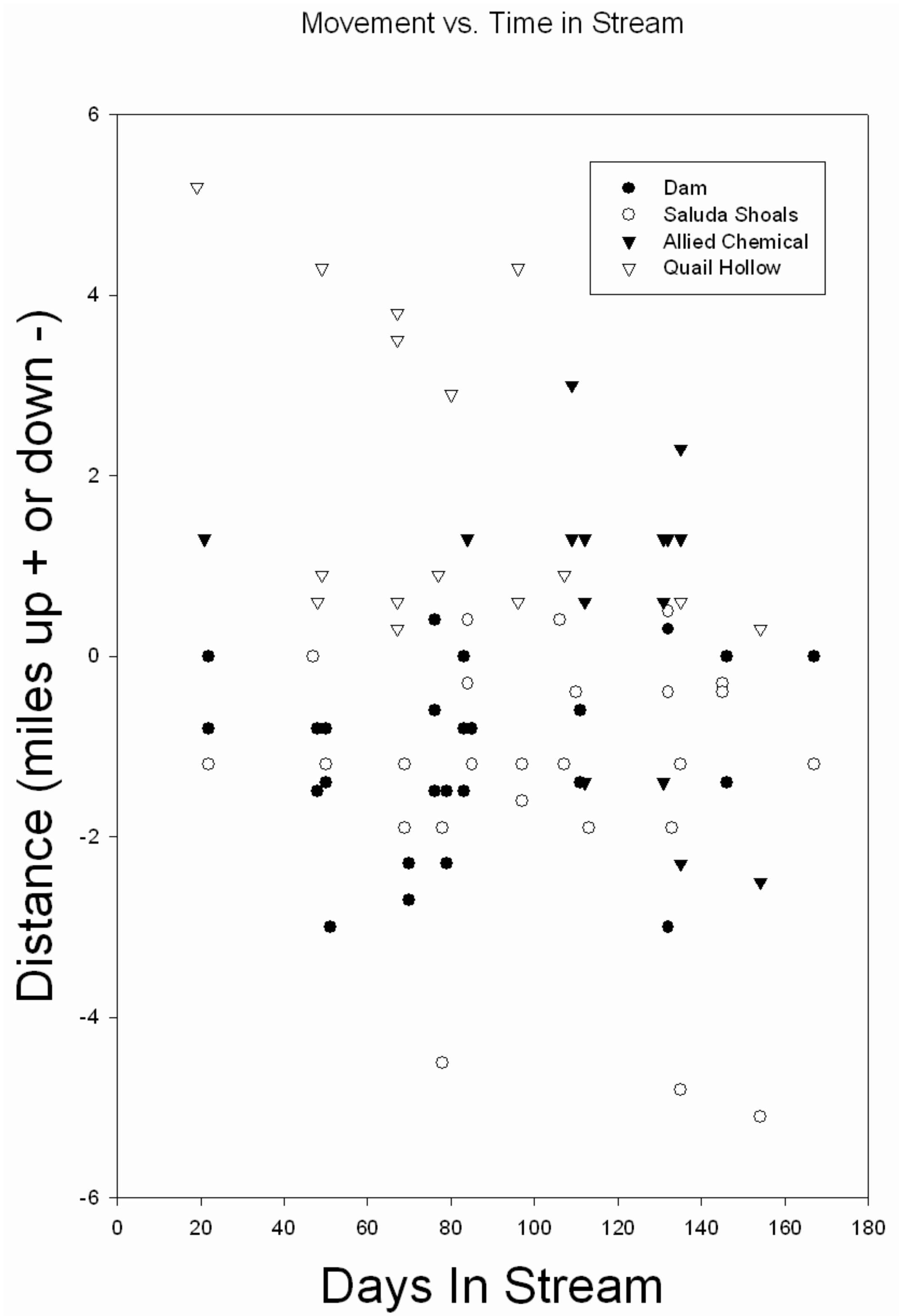


Figure B-13: Relationship Between Days in the Stream Between Release and Capture and the Distance Traveled from the Point of Release

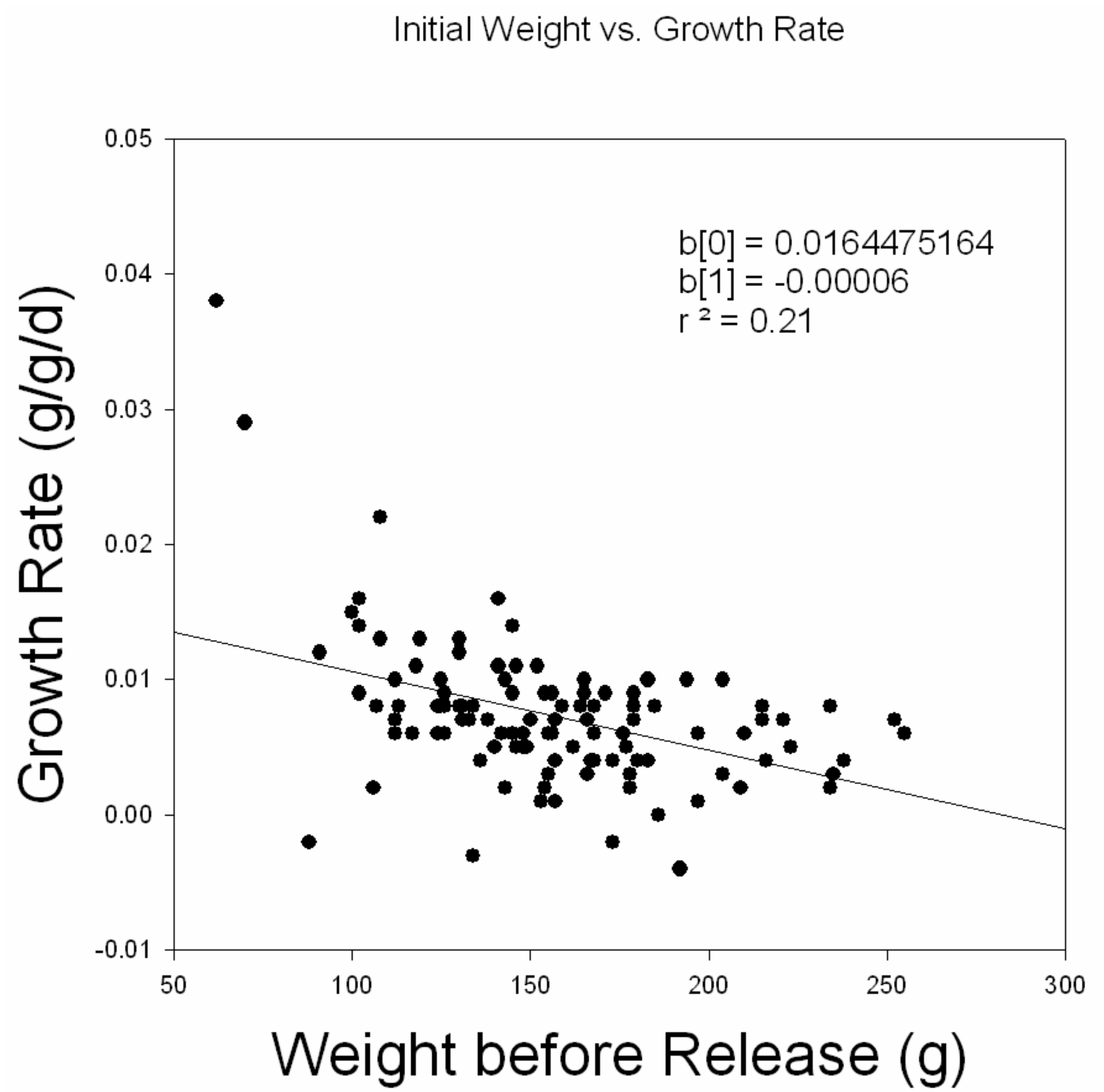


Figure B-14: The growth Rate of Trout in the LSR Showed a Slight Relationship with Size at Release

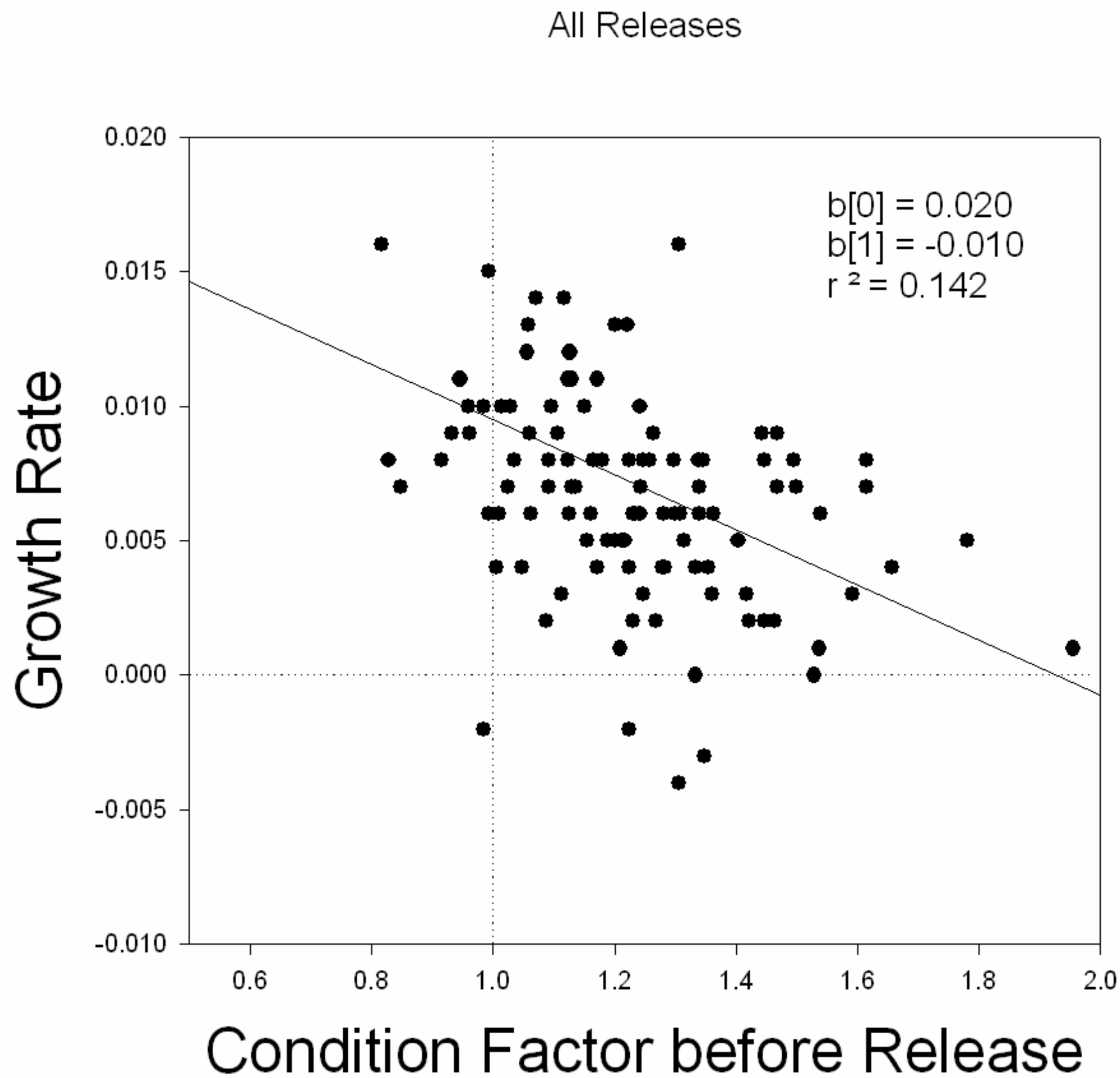


Figure B-15: Growth Rate was Greater in Fish with Lower Initial Condition Factors Following Release into the LSR

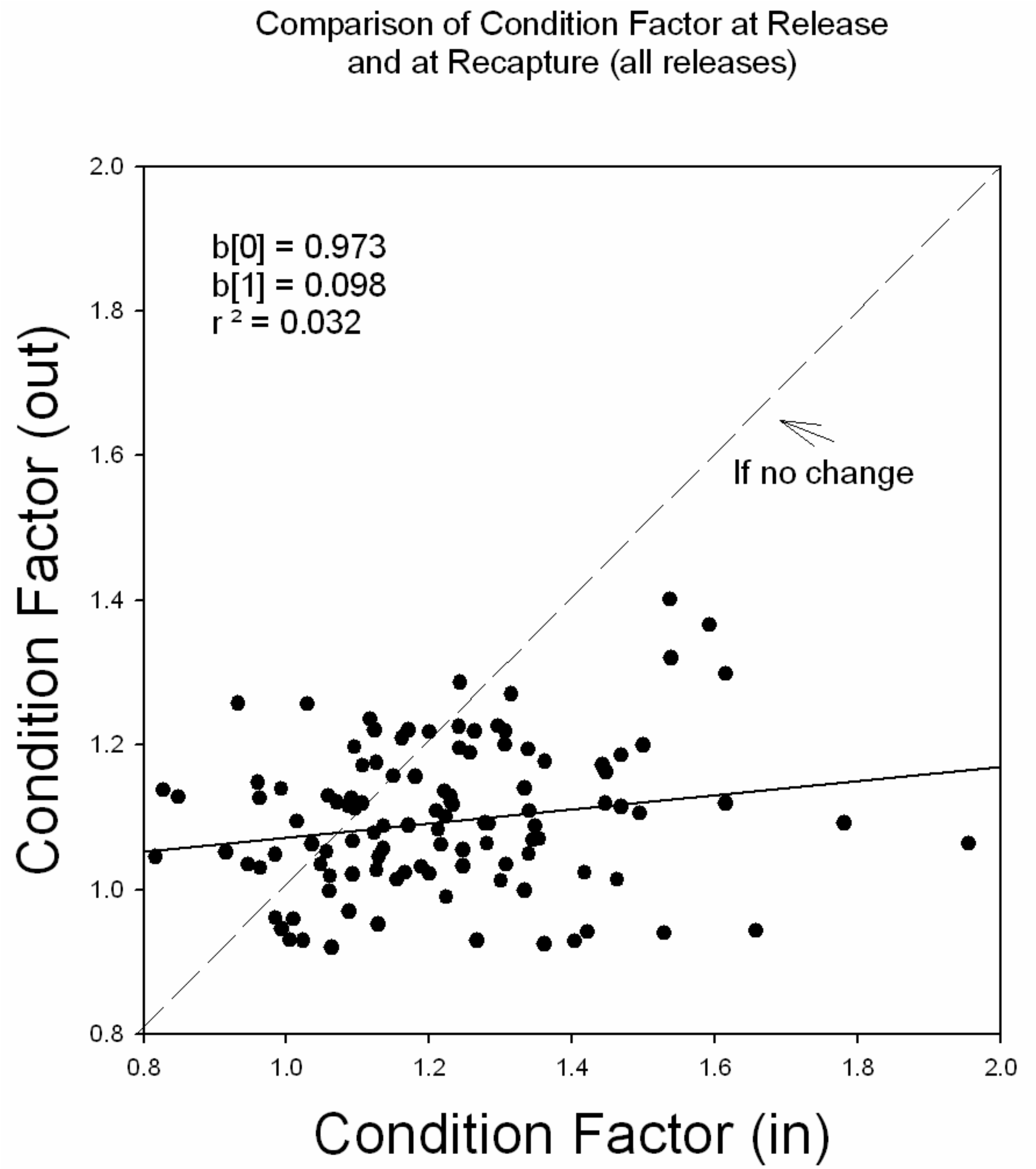
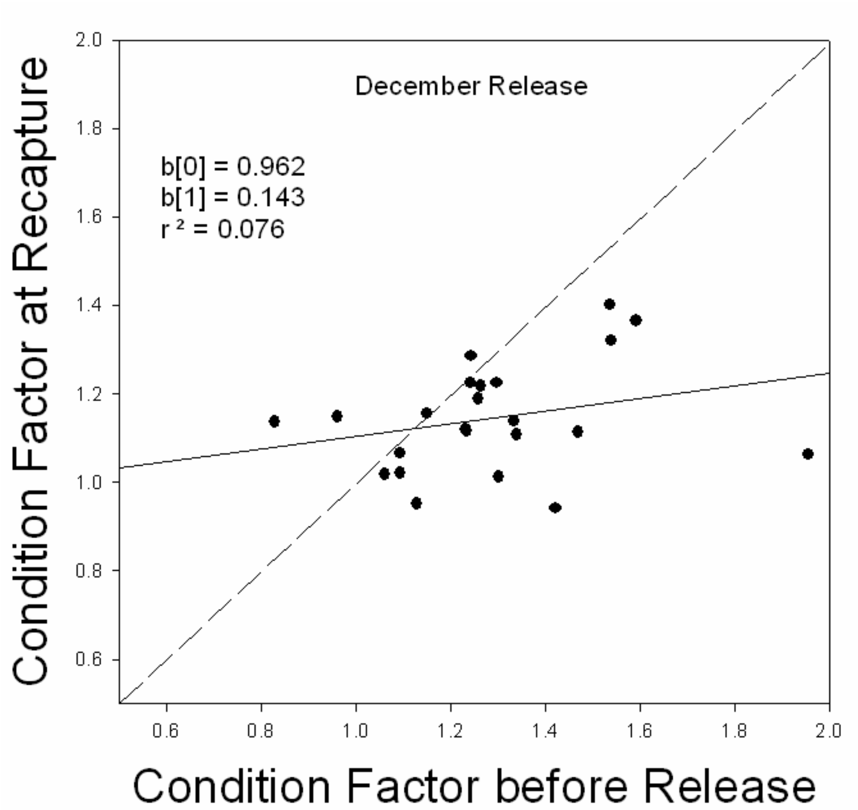


Figure B-16: The Condition of Trout in the LSR Became Much More Uniform Than That Seen at the Time of Release



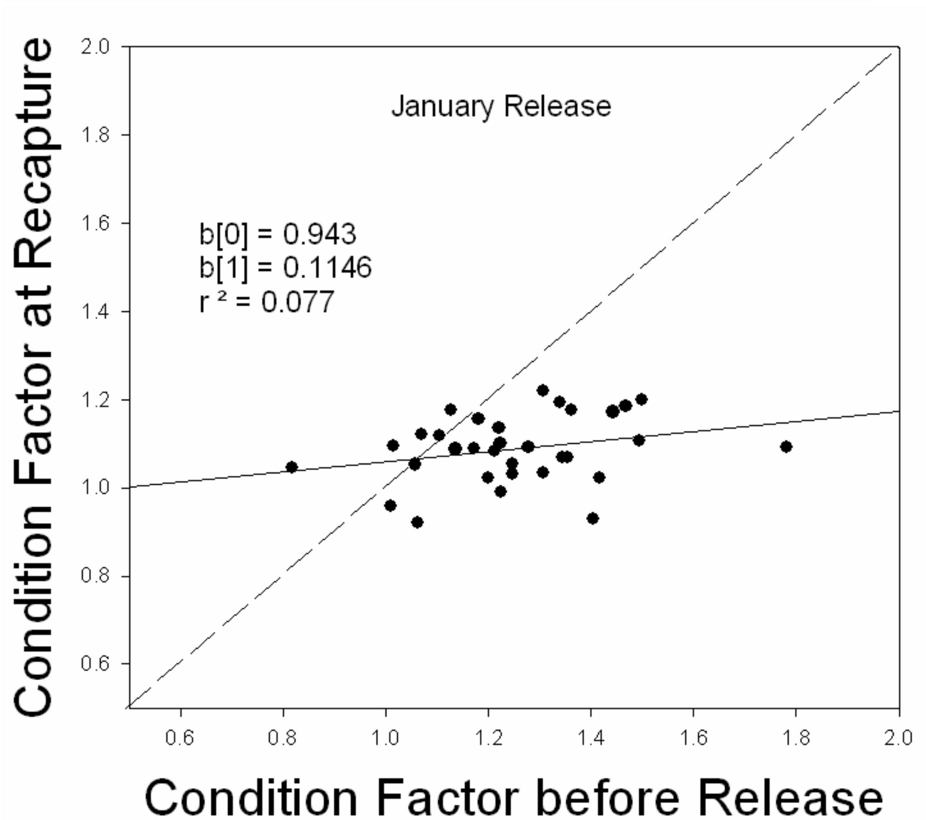


Figure B-17a: Condition Factor Change for December and January Releases

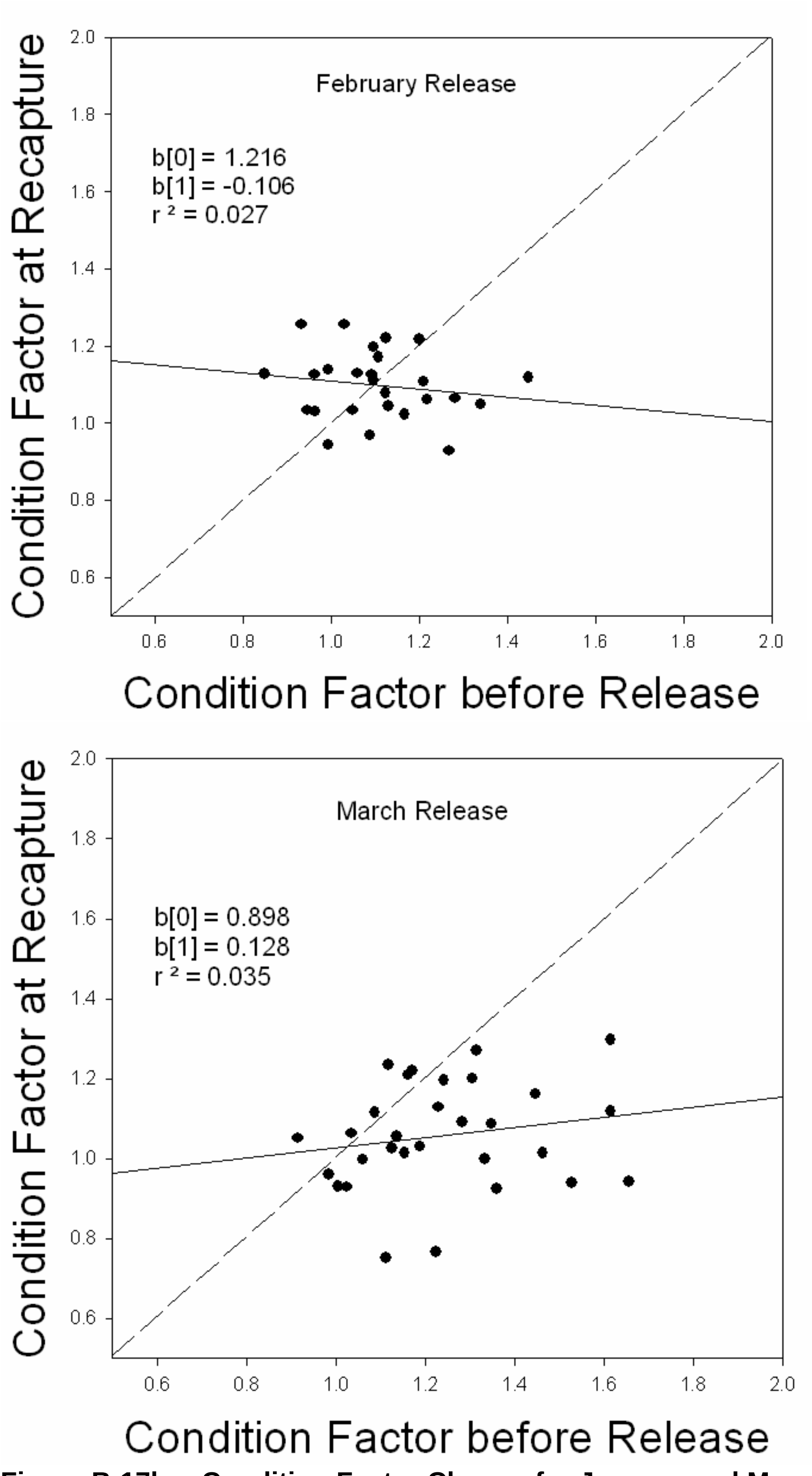


Figure B-17b: Condition Factor Change for January and March Releases

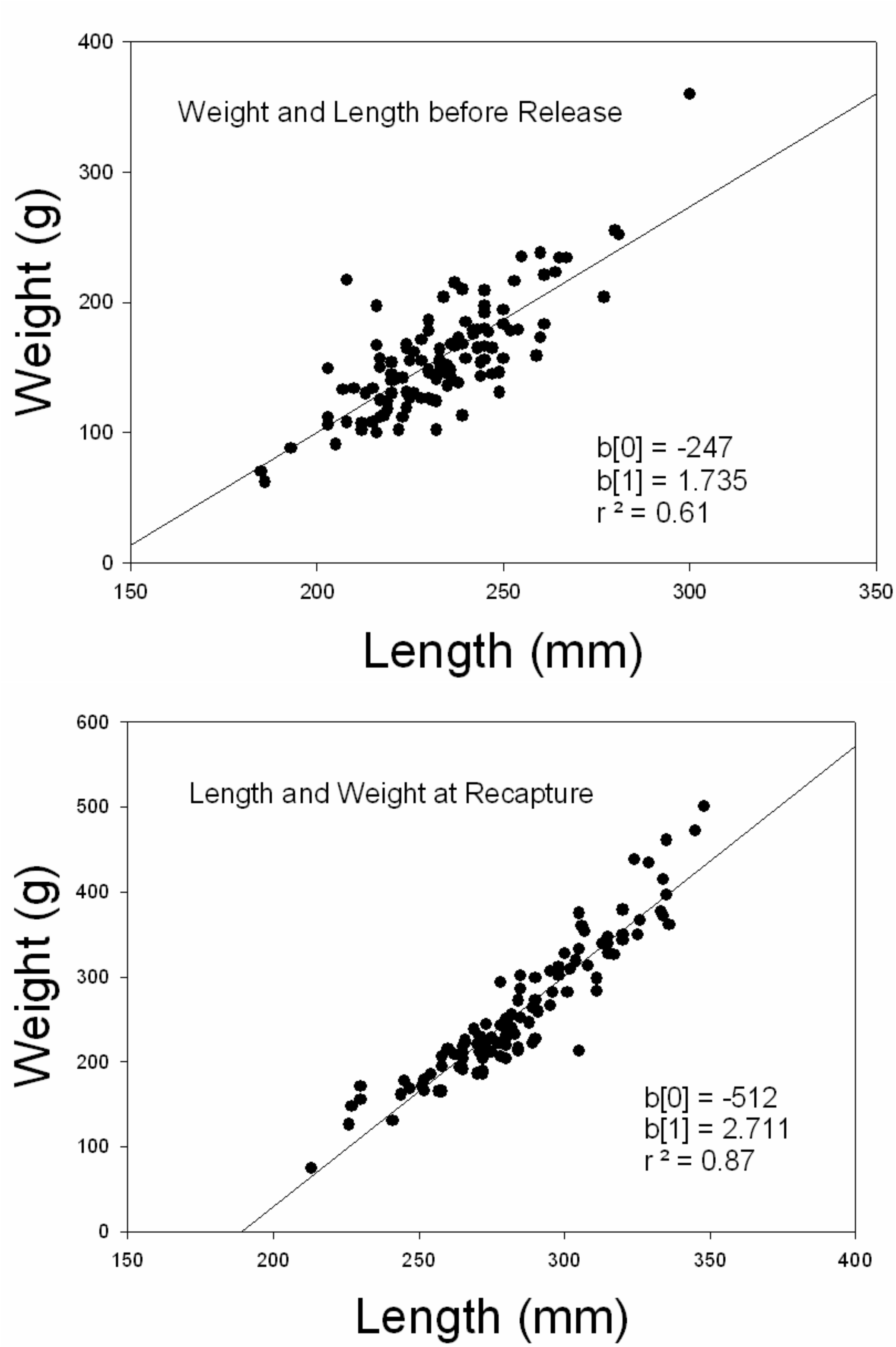


Figure B-18: Illustrating the Increased Uniformity of Trout Condition Following Release into the LSR

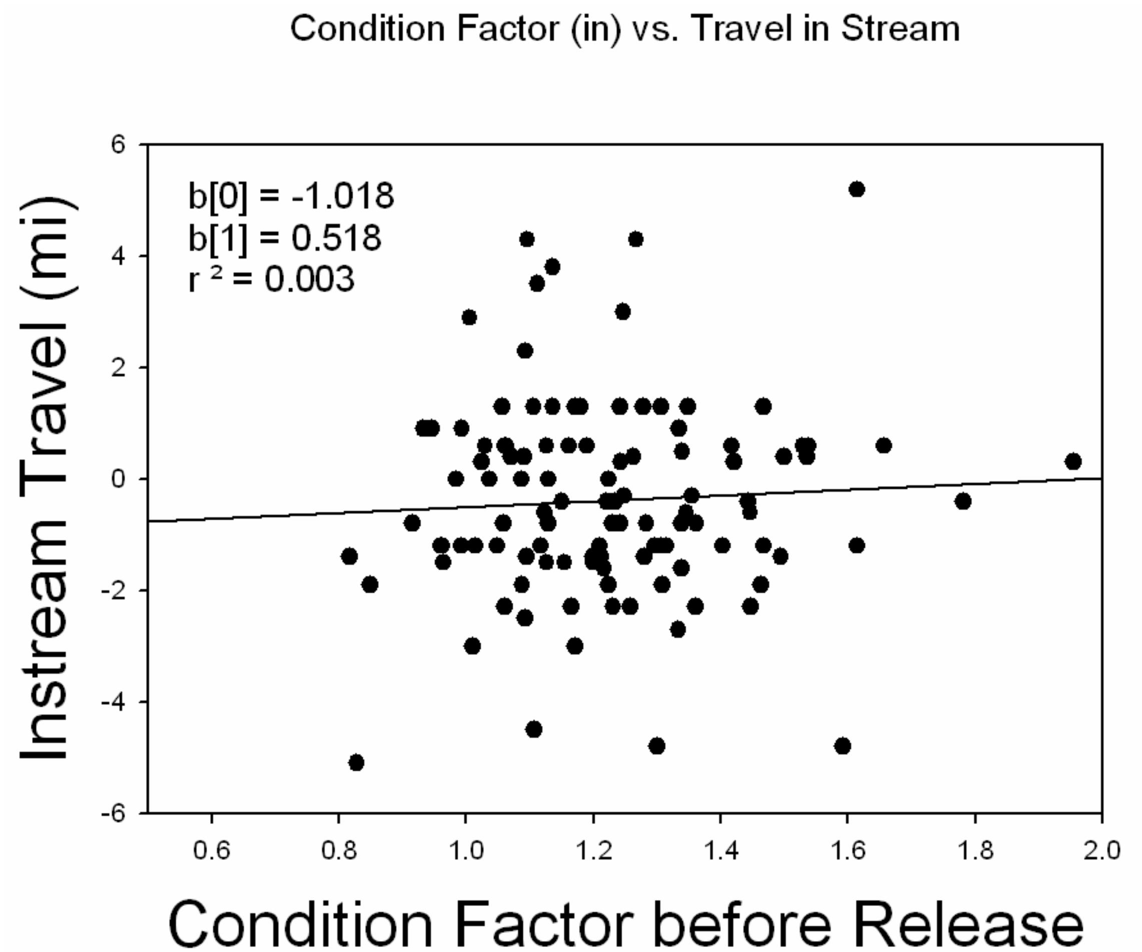


Figure B-19: There was No Significant Effect of Initial Condition Factor on the Tendency of Fish to Move Up or Downstream Following Release

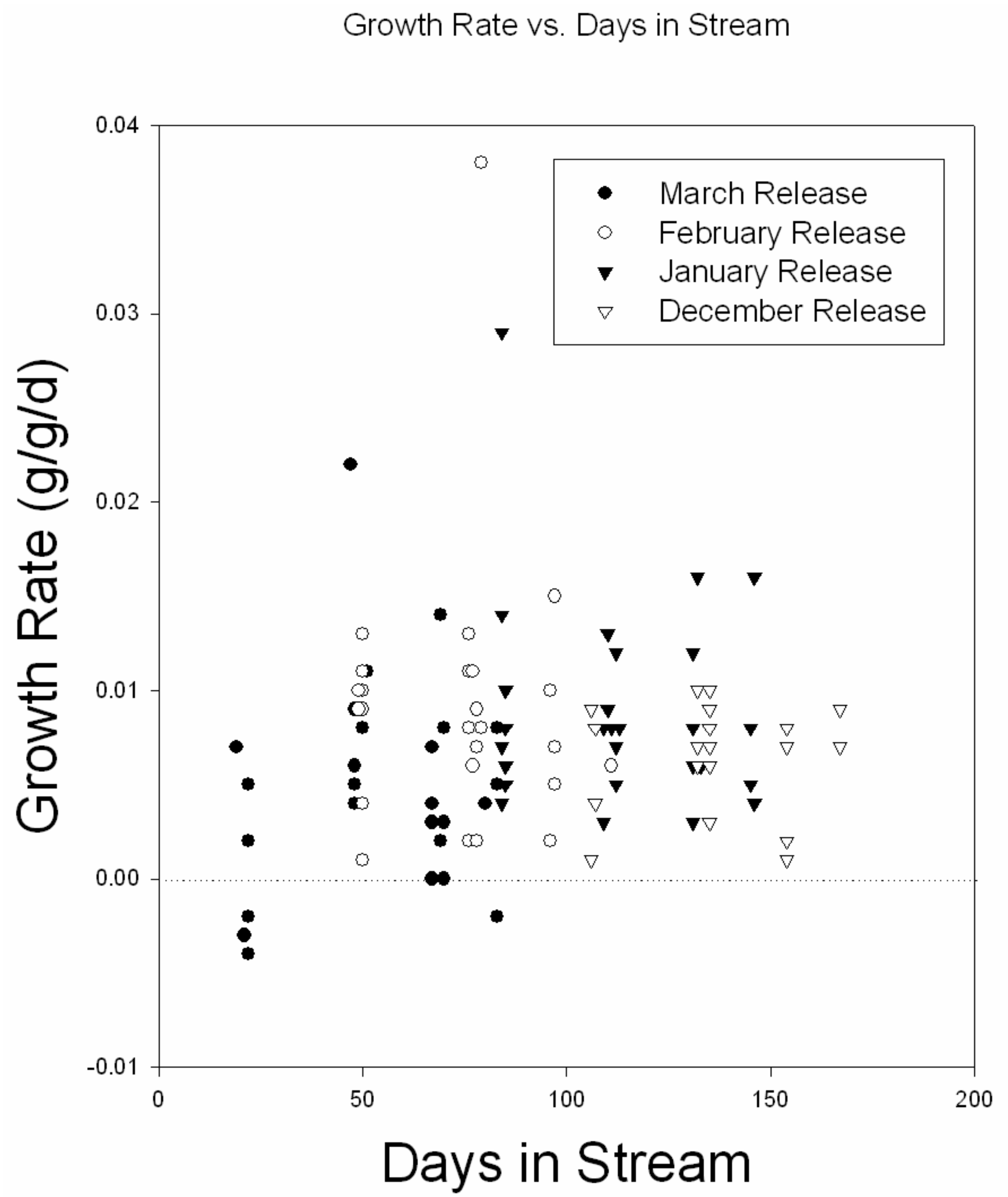


Figure B-20: There was No Appreciable Effect of Residency Duration on the Growth of Fish in the LSR

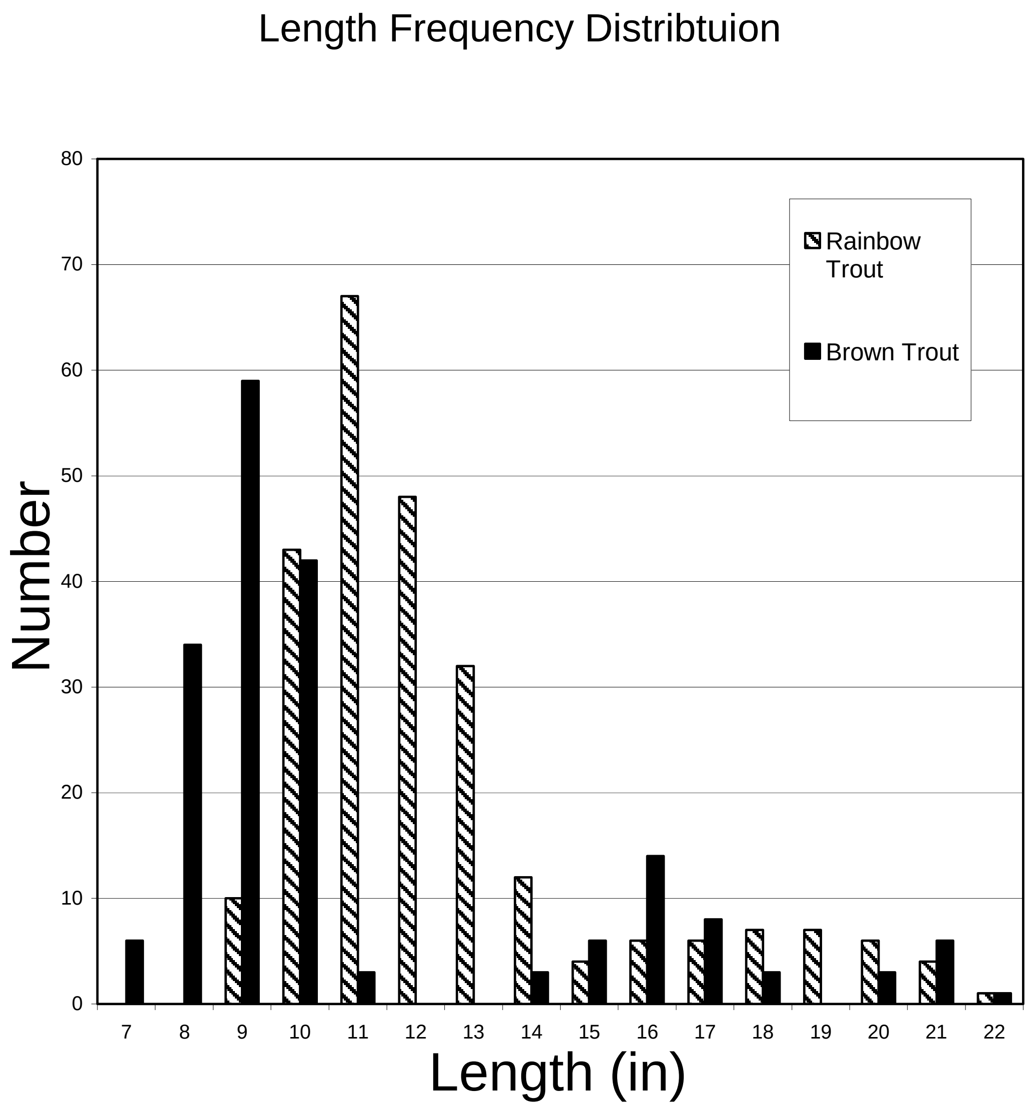


Figure B-21: Length Frequency Distribution of All Brown and Rainbow Trout Collected from the Lower Saluda River, April – June 2003