Bureau of Reclamation **Southern Ute Indian Tribe**

Animas River Fisheries Database Synthesis and Analysis

Final Report - July 2008

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ANIMAS RIVER FISHERIES DATABASE SYNTHESIS AND ANALYSIS
(Phase I)

by

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for

Bureau of Reclamation
and
Southern Ute Indian Tribe

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This Animas River fisheries database synthesis and analysis was conducted by SWCA, Inc. with assistance from the Southern Ute Indian Tribe (SUIT) and Bureau of Reclamation (Reclamation), Durango Office. This document provides a description and characterization of this fisheries database, as well as preliminary analyses that help describe fish populations of the Animas River.

Thanks to Steve Whiteman and Ben Zimmerman of the SUIT for providing the database and for assisting with synthesis and analysis. Thanks also to Michael Francis of Reclamation for administering the work and for helping to identify issues of importance for data analysis. Kirk Lashmett, formerly of Reclamation coordinated most of the field work and was instrumental in collecting much of the field data that went into this database. Jim White and Mike Japhet of the Colorado Division of Wildlife provided stocking data and mark-recapture data from the Animas River.

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EXECUTIVE SUMMARY

The U.S. Bureau of Reclamation and the Southern Ute Indian Tribe (SUIT) have jointly conducted fisheries studies of the Animas River since 1997. The data collected from these studies provide a valuable baseline of information to characterize fish populations and to assess the impact of the Animas-La Plata Project (ALP). The ALP will withdraw water from the Animas River, and understanding the response by the fish populations to that action must rely on precise and accurate data with sufficient sensitivity to reasonably detect changes in fish numbers and health. The most common fish species of the Animas River include bluehead sucker (*Catostomus discobolus*, 37%), flannelmouth sucker (*Catostomus latipinnis* 21%), brown trout (*Salmo trutta*, 14%), rainbow trout (*Oncorhynchus mykiss*, 14%), Snake River cutthroat trout (*Oncorhynchus clarkii* sp., 7%), mottled sculpin (*Cottus bairdi*, 3%), and white sucker (*Catostomus commersonii*, 1%).

The Animas River Fisheries Database consists of over 43,000 records stored in 11 worksheets in a Microsoft Excel platform. Each record (i.e., line of information) contains 30 column-specific data entries with numeric and alphanumeric information specific to each fish captured. This data structure allows for easy access to data and for sorting of data partitions and analyses. The data contained in the database were collected through four principal study types including trout population estimates, sucker tagging, longitudinal sampling, and larval surveys. Data for the first three study types consist of individual fish information (e.g., date and location of capture, fish length, weight, tag numbers, etc.) from large-bodied fish captured with raft electrofishing. The larval data were collected with beach seines and small nets.

Trout population estimates were conducted in each of three reaches within the SUIT lands. These estimates were based on marking brown trout, rainbow trout, and Snake River cutthroat trout with fins punches and resampling the area within a period of 2 weeks to recapture marked fish. Petersen-Lincoln estimates showed that rainbow trout had the highest densities in all reaches with over 298 fish per mile for fish greater than about 135 mm total length (TL). Brown trout density was up to 165 fish per mile for fish greater than about 150 mm TL, and Snake River cutthroat trout were up to 200 fish per mile for fish greater than about 200 mm TL. The precision of these estimates was moderate to good, as measured by coefficient of variation (CV = standard deviation/mean). A suitable CV should be less than about 0.15. Coefficient of variation ranged from 0.05 to 0.47 for brown trout, 0.13 to 0.43 for rainbow trout, and 0.05 to 0.88 for Snake River cutthroat trout where numbers of marks and recaptures were sufficient for an estimate. The precision of this statistic can be improved through a more robust sampling design that focuses on smaller sub-reaches of river.

A preliminary analysis was conducted of all the data to determine precision, accuracy, and sensitivity to detecting change. Catch rate estimators were computed as the numbers of large-bodied fish captured with raft electrofishing per hour of effort. This statistic is often used to characterize the status and trends of fish populations, but requires a comprehensive analysis of precision and sensitivity to insure that it can reliably be used to document change in fish populations with a high degree of confidence (generally 95%). Preliminary analyses showed that these catch rate data have a moderate to low level of precision, as measured by coefficient of variation (CV = 0.34 to 4.90). This level of precision only allowed for detecting a catch rate change of 75% or greater; detection level should be less than about 40%. These data provide the opportunity to develop a sampling design that will reduce variability and yield sufficient precision to detect change. This preliminary analysis also showed a low level of accuracy for catch rate data when regressed against simultaneous mark-recapture estimators (R^2 = 0.05-0.52), indicating that the current catch rate data do not reflect true fish abundance.

Growth rate and condition of the three trout species were comparable to other healthy populations. Relative condition for total length ranged 0.98-1.21 for brown trout, 0.95-1.02 for rainbow trout, and 0.97-1.00 for Snake River cutthroat trout. This metric of condition had high precision and length-weight relationships generally showed an R^2 of >0.90. This metric may be one of several that can be used to assess health and condition of the fish under different management actions. The variability in weight measurements in the field should be reduced through more stringent measurement techniques and reliable weighing procedures.

The von Bertalanffy growth parameter $L\infty$ predicted maximum total lengths for brown trout, rainbow trout, and Snake River cutthroat trout in the Animas River of 720 mm (28 in.), 678 mm (27 in.), and 667 mm (26 in.), respectively. Based on length-weight relationships, predicted weights for these lengths are 4,049 g (9 lb.), 2,996 g (7 lb.), and 3,674 g (8 lb.), respectively. These estimated sizes were reasonable, given that actual maximum sizes of brown trout, rainbow trout, and Snake River cutthroat trout from the Animas River fisheries database were 680, 646, and 631 mm TL, respectively.

The Animas River supports a quality trout fishery with brown trout and rainbow trout that reach 5 to 6 years of age. The majority of Snake River cutthroat trout that are stocked in the Animas River apparently survive only 1 to 2 years. Survival of brown trout after 1 to 6 years in the river was 73%, 53%, 38%, 28%, 20%, and 15%, respectively, and survival of rainbow trout was 62%, 38%, 24%, 15%, 9%, and 6%, respectively. These are good survival rates, but it is noted that few fish live past about 7 years in the river. Proportional stock density (PSD, proportion of quality fish >406 mm TL to stock fish 252 mm TL) was high for brown trout with a PSD >50 in all years. The PSD for rainbow trout was more variable with a maximum of 66, and the PSD for Snake River cutthroat trout was generally below 40.

Available data do not indicate a negative impact from stocking of trout in the Animas River on the riverine populations. Fish length, weight, condition, growth rate, and PSD show that the population is healthy and provides a quality fishery. Overall, the SUIT stocked an average of 10,956 trout per year over the 12-year period (1996-2007), and the CDOW stocked an average of 64,389 trout per year over the 10-year period (1998-2007). Brown trout were stocked in 2003 and 2006 as small fish by the SUIT and annually by the CDOW from 2000 to 2007. These stockings appear to have had little effect on the natural reproducing population in the river which remained relatively stable. Conversely, rainbow trout were stocked in nearly all years by the SUIT and every year by the CDOW, and these stockings apparently helped to maintain and augment the riverine population which has low natural reproduction. Based on changes in abundance after stockings, it appears that sufficient numbers of rainbow trout stocked by CDOW moved downstream into SUIT waters to augment that population. The Snake River cutthroat trout population declined to zero after stocking stopped in the SUIT section in 2001, despite continued stocking in the CDOW section through 2004. This species is sustained entirely by stocking, does not appear to disperse downstream, and stocked fish live for only 1-2 years after stocking.

The viability of the flannelmouth sucker and bluehead sucker populations is not well understood. The fish appear to be reproducing but levels of survival and recruitment are unknown. Furthermore, two irrigation diversion dams impede movement of fish and may be affecting viability of these upstream populations. These diversion dams have been in place since the 1950's and the persistence of native sucker populations upstream is strong evidence that successful reproduction and recruitment continues. However, the effect of these dams—as well as future management of river flows—to the long-term viability of these populations is inconclusive. An age-specific recruitment model is necessary to assess the viability of these populations. This will provide an opportunity to simulate population trajectories under different survival, recruitment, and movement scenarios.

A modification of the current sampling design is recommended that will reflect the information needs of managers when evaluating the impacts of the ALP. Discussions should be held among managers, fish biologists, and statisticians to identify desired precision and accuracy of data, as well as the sensitivity of the data to detect change, and the level of acceptable risk. The appropriate monitoring plan should be structured to address the information needs at the specified levels of precision, accuracy, sensitivity, and risk.

1.0 INTRODUCTION

1.1 Background

The U.S. Bureau of Reclamation (Reclamation) is presently constructing the Animas-La Plata Project (ALP), a water project that will withdraw water from the Animas River in southwestern Colorado (Figure 1). The Southern Ute Indian Tribe (SUIT) manages a valuable trout fishery on the Animas River through tribal lands downstream of the ALP pumps near Durango, Colorado. This fishery is comprised of rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), and Snake River cutthroat trout (*Oncorhynchus clarkii* sp.).

The Animas River upstream of SUIT lands is also managed as a gold medal trout fishery by the Colorado Division of Wildlife (CDOW). The Animas River downstream of Durango also contains populations of bluehead sucker (*Catostomus discobolus*), flannelmouth sucker (*Catostomus latipinnis*), and roundtail chub (*Gila robusta*). These native fish are conservation species under a 2004 Range-Wide Conservation Agreement among the states of Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming. Information on fish of the Animas River is a necessary and valuable baseline for assessing impacts of water depletions by the Animas-La Plata Project.

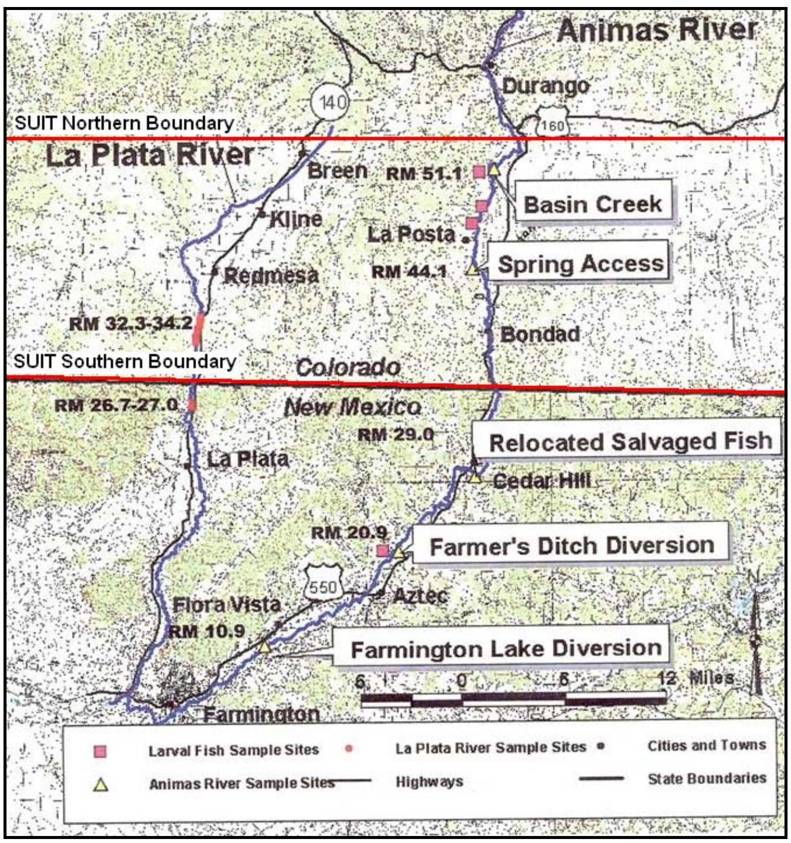


Figure 1. Principal locations along the Animas River in Colorado and New Mexico.

1.2 Purpose and Objectives

This is Phase I of a synthesis and analysis of the Animas River Fisheries Database which was compiled by the SUIT and Reclamation since 1997 (Whiteman 1999, 2000, 2002; Zimmerman 2003, 2005). The purpose of this phase is to assimilate and synthesize the fisheries data for the Animas River in electronic format, and to provide a preliminary analysis of those data. Phase II will be conducted to provide more detailed and directed analyses that will help the SUIT and Reclamation develop a reliable, precise and sufficiently sensitive monitoring program for fish populations of the Animas River.

The objectives of Phase I are to:

1. Develop an accurate and reliable electronic database for fish in the Animas River from data collected by the SUIT and Reclamation for use as baseline data for future impacts evaluation of the ALP;

2. Estimate annual population size of rainbow trout, brown trout, and Snake River cutthroat trout using mark-recapture estimators and compare across the years of data collection to assess trends in fish populations of the Animas River through SUIT lands;

3. Estimate annual catch rates of brown trout, rainbow trout, Snake River cutthroat trout, bluehead sucker, and flannelmouth sucker and compare years to assess trends in fish populations of the Animas River through SUIT lands;

4. Characterize length-weight and age-growth of rainbow trout, brown trout, and Snake River cutthroat trout using length-frequency analysis;

5. Characterize length-weight and age-growth of flannelmouth sucker and bluehead sucker using length-frequency analysis and aging of opercles;

6. Evaluate the effect of stocking on trout populations in the Animas River and evaluate species and numbers of fish stocked and their survival.

7. Evaluate data suitability, utility, strengths and weaknesses, and data gaps for the Animas River Fisheries Database;

8. Provide insight into a fish monitoring strategy for the Animas River to evaluate effects of the ALP.

1.3 Study Area

The Animas River originates in the San Juan Mountains of southwestern Colorado and flows into the San Juan River in northwestern New Mexico. Fish collections for this database were taken from a 56-mile reach of the Animas River from the northern boundary of the Southern Ute Indian Reservation to the confluence of the San Juan River near Farmington, New Mexico (Figure 1).

Locations along the Animas River are designated by river miles upstream of the San Juan River confluence (Table 1). The Animas River flows for 19.1 miles within SUIT lands from just downstream of Purple Cliffs (RM 56.2) to the Colorado-New Mexico state line (RM 37.1).

The Animas River within the SUIT lands was divided into four reaches for the purposes of sampling fish. These reaches include:

1. Reach 1: Purple Cliffs (RM 56.4) to Basin Creek (RM 52.1),
2. Reach 2: Basin Creek (RM 52.1) to Weaselskin Bridge (49.5),
3. Reach 3: Weaselskin Bridge (RM 49.5) to Bondad (RM 41.9), and
4. Reach 4: Bondad (RM 41.9) to Colorado Stateline (RM 37.1).

Purple Cliffs is located just upstream of the northern boundary of the SUIT lands, and Basin Creek is the tributary that drains Ridges Basin and will be used to return water released from Nighthorse Reservoir, the major storage unit for ALP. The Animas River flows beneath Weaselskin Bridge at 214 Road and Highway 550 crosses the river at Bondad. The southern boundary of the SUIT lands is the same location on the Animas River as the Colorado-New Mexico state line.

Table 1. Key locations along the Animas River indicated by river miles upstream from the confluence of the San Juan River near Farmington, New Mexico.

Location	River Mile
CDOW “Animas 1” Reach (Durango HS footbridge)—upper end	62.2
CDOW “Animas 1” Reach (9th Street Bridge)—lower end	60.6
CDOW “Animas 2” Reach (BMX Park) —upper end	58.5
CDOW “Animas 2” Reach (High Bridge) —lower end	57.4
Purple Cliffs	56.4
Northern Boundary—Southern Ute Indian Reservation	56.2
Basin Creek	52.1
Weasel Skin Bridge	49.5
Spring Access	45.7
Bondad	41.9
Southern Boundary—Southern Ute Indian Reservation	37.1
Farmer’s Ditch Diversion	21.9
Aztec—Highway 550 Bridge (Riverside Park)	17.7
Farmington Lake Diversion	11.9
Flora Vista	9.2
San Juan River confluence	0.0

2.0 METHODS

2.1 Database Development and Quality Control

An electronic database was transferred from the SUIT to SWCA that included data collected from 1997 to 2005 and 2007. This electronic database was quality checked for data accuracy and consistency. All codes were evaluated and numerical data were screened for aberrant entries. Aberrancies were cross checked against field data sheet to insure that the correct data had been entered. A clean master fishery database was provided to the SUIT and Reclamation for use in a baseline evaluation of the ALP.

2.2 Estimates of Abundance

Numbers of brown trout, rainbow trout, and Snake River cutthroat trout were estimated using the following Chapman modification of the Petersen-Lincoln estimator (Seber 1982; Hayes et al. 2007):

$$\tilde{N} = \frac{(n_1 + 1)\,(n_2 + 1)}{(m_2 + 1)} - 1$$

Where: $\tilde{N}$ = population estimate,
n_1 = number of fish caught, marked, and released in pass 1,
n_2 = total number of fish caught in pass 2, and
m_2 = number of marked fish that are recaptured in pass 1.

The variance of this estimator was approximated as (Seber 1982; Hayes et al. 2007):

$$V(\tilde{N}) = \frac{(n_1 + 1)\,(n_2 + 1)\,(n_1 - m_2)\,(n_2 - m_2)}{(m_2 + 1)^2\,(m_2 + 2)} - 1$$

All trout mark-recapture data were short-term (less than 2 weeks between mark and recapture events). Variances estimators and 95% confidence intervals were computed for each estimate. Mark-recapture data provided by the CDOW were also used in the same estimator model to standardize fish population estimates and to make all estimates comparable. Stocking records were procured from the SUIT and CDOW to evaluate the effect of stocking on trout populations.

Mark-recapture data from bluehead sucker and flannelmouth sucker were not reconciled for this phase of the project but will be used for population estimates in Phase II. Catch rates of large-bodied bluehead sucker and flannelmouth sucker were estimated as numbers of fish per hour of electrofishing. Variances estimators and 95% confidence intervals were computed for each average catch rate. Numbers and percentage composition of flannelmouth sucker, bluehead sucker, and roundtail chub were computed for each year using the catch rate index (i.e., number of fish per hour of electrofishing). Coefficient of variation (CV) was computed for catch rate indices and for population estimators as measures of precision for each statistic. The CV for catch rate indices was computed as standard deviation divided by the mean, whereas CV for population estimators was computed as standard error divided by the estimate.

Proportional stock density (PSD) was assessed for brown trout, rainbow trout, and Snake River cutthroat trout according to the following (Neumann and Allen 2007):

$$PSD = (P_q/P_s) \times 100$$

Where: P_q = number of fish ≥ quality length; and
P_s = number of fish ≥ stock length.

Quality length was considered as fish ≥ 406 mm TL (16 in.) as used by the SUIT in their angler regulations (i.e., bag and possession limit is 2 trout ≥ 16 in.; all other fish must be released alive). Stock length was considered as ≥ 252 mm TL, or 10 in. which was the most common size of fish stocked.

2.3 Length-Weight and Condition

The relationship of length to weight of fish is important for assessing the health and condition of individuals and the population. The following power function was used to express the relationship of fish length to weight (Pope and Kruse 2007):

$$W = aL^b$$

Where: W = predicted weight,
L = fish total length,
a = coefficient that describes the Y intercept,
b = rate of increase.

The above power function was log transformed to the following to facilitate computation of predicted weights and to express the relationship in the standard format:

$$\log W = \log a + b \log L$$

An important metric for assessing condition or health of a fish is condition factor taken as the relationship of total length to weight (K_{TL}). The coefficients 'a' and 'b' derived from the above length-weight relationship for each species were used to express the metric of "relative condition" as follows:

$$K_{TL} = W/aL^b$$

Where: (K_{TL}) = relative condition based on total length,
W = fish weight,
a = coefficient 'a' derived from length-weight relationship, and
b = coefficient 'b' derived from length-weight relationship.

A relative condition of 1.00 indicates that the fish included in the analysis comply with a fundamental principle of fish growth, the "cube law," in which the weight of a fish is the cube of its length; e.g., if a fish 1 foot long weighs 1 pound, a fish 2 feet long is expected to weigh 8 pounds ($2^3 = 8$). Clearly, adherence to this principle is species-specific and varies considerably with body shape and growth characteristics. Nevertheless, most trout species conform to the "cube law" and trout in good condition are expected to have a condition index of 1.00 or better (Carlander 1969). Adherence to this principle is also reflected as a 'b' coefficient of 3.00 in the length-weight relationship.

2.4 Age and Growth

Age information was not available from scales or otoliths of trout from the Animas River and age of trout could only be surmised from length-frequency analysis. Length-frequency analysis and modal progression were used to estimate growth with the aid of the routine ELEFAN (Electronic Frequency Analysis) in the program FiSAT II (Gayanilo et al. 2005). ELEFAN uses subsequent length modes to develop the following von Bertalanffy growth function (VBGF):

$$L(t) = L\infty * [1 - \exp(-K*(t-t_o))]$$

Where:
$L\infty$ = the maximum predicted size of fish,
K = rate of growth at which fish approach $L\infty$,
t_o = time in years at which fish length in zero, and
t = time in years to for length L(t).

The VBGF provides an estimate of the rate of growth (K) and the maximum possible length of a fish from the population sampled ($L\infty$). Understanding this relationship over time is valuable for assessing the effect of management actions on the rate of growth of individuals in the population.

Unlike trout species, length-frequency analysis could not be used to characterize age composition of flannelmouth sucker and bluehead sucker because of overlapping lengths of same age fish. Opercles from flannelmouth sucker and bluehead sucker were examined to develop length-at-age relationships and estimated mean length and growth of each cohort (Scoppettone et al. 1986). Carlander's third degree polynomial was used to describe the relationship of fish length to opercular radius (Lagler 1956; Chugunova 1963; Bagenal and Tesch 1978) as:

$$TL = Ax + Bx^2 + Cx^3 + a$$

Where:
TL = total length,
A, B, C = coefficients,
x = opercular radius, and
a = y-intercept.

The above relationship assumes that the y-intercept (a) represents fish size at time of formation of the opercular bone. The y-intercept was specified for bluehead sucker at 14 mm TL and for flannelmouth sucker at 15 mm TL, based on the size of the fish at the mesolarval stage of development (Snyder and Muth 1990).

2.5 Survival

Tag data were insufficient for computing surviving of either the trout species or the sucker species. Therefore, Bhattachayra's modal progression in FiSAT II (Gayanilo et al. 2005) was used to estimate survival by tracking mean length of age group modes from the same cohort over several years. The survival function applied was the Beverton and Holt model (1957) that generates Ricker 'Z' from progression of modal mean lengths. The basic Ricker survival model (Ricker 1975) is expressed as:

$$N_t = N_o e^{-Zt}$$

Where: N_t = individuals in the population at time 't';
N_o = estimated number of individuals at start of time 't'; and
Z = instantaneous mortality rate, slope of line.

2.6 Data Evaluation

An evaluation was provided of how suitable the data are for evaluation of project effects, its usefulness, strengths and weaknesses, as well as data or information gaps that are necessary for a more effective project evaluation. Insight was provided for a long-term fish monitoring strategy of the Animas River to evaluate effects of the Animas-La Plata Project on native and sport fish.

3.0 RESULTS

3.1 Schedule of Studies

The Animas River fisheries database consists of data collected primarily for four study types, including (1) trout population estimates, (2) larval surveys, (3) sucker tagging, and (4) longitudinal sampling (Table 2). Trout population estimates were done every other year in 2001, 2003, 2005, and 2007. Larval sampling was done annually in 2000, 2001, and 2002. Sucker tagging was started in 2001 and done annually to 2005, and longitudinal sampling was done in 1997, 1998, and 1999.

Table 2. Schedule of primary studies for the Animas River fisheries.

Year	Trout Population	Larval Survey	Sucker Tagging	Longitudinal
1997				X
1998				X
1999				X
2000		X		
2001	X	X	X	
2002		X	X	
2003	X		X	
2004			X	
2005	X		X	
2006	No sampling			
2007	X			

3.2 Database Development

All field data were electronically stored in Excel worksheets and preliminarily quality controlled and checked by the SUIT. Additional quality control was performed during this phase and data errors were reconciled, where possible.

The Animas River Fisheries Database is stored in an Excel platform in column-specific format consisting of unique numeric and alphanumeric codes. The database file is entitled "MASTER-Animas Fish Data." Three additional files are provided that contain the analyses performed for this data evaluation. These files are entitled "ANIMAS DATA 1 of 2," "ANIMAS DATA 2 of 2," and "ANIMAS ANALYSIS." Table 3 provides a description of each of these files.

The Master database contains all of the cleaned data without any analyses. Animas data files 1 and 2 are for a portion of the years with basic data summaries, length-frequency analyses, and length-weight analyses for each year. The Animas analysis file contains more advanced and comprehensive analyses that span across years.

Table 3. Description of each of the data files of the Animas River Fisheries Database.

Data File	Description
MASTER-Animas Fish Data	Master database, 11 worksheets: data for 1997, 1998, 1999, 2001, 2002, 2003, 2004, 2005, 2007, 2000-Larva, and Floy Tags
ANIMAS DATA 1 of 2	7 worksheets: data and analyses for 1997, 1998, 1999, 2001, 2002, 2000-Larva, and Floy Tags (duplicate of Master database)
ANIMAS DATA 2 of 2	4 worksheets: data analyses for 2003, 2004, 2005, 2007 (duplicate of Master database)
ANIMAS ANALYSIS	Summary analyses for all datasets; 11 worksheets

The master database file contains separate worksheets for each year of data collection, including 1997 to 2005 and 2007. No fisheries data were collected in 2006. The numbers of records (i.e., lines of data) in each worksheet are shown in Table 4. Each record is populated with column specific numeric or alphanumeric information consistent with pre-determined codes or measurement ranges. Missing data are designated by blank cells.

Table 4. Number of records (lines of data) in each worksheet of "MASTER-Animas Fish Data."

Spreadsheet	Number of Records
1997	3,005
1998	2,479
1999	6,095
2000	153
2001	3,410
2002	1,526
2003	10,082
2004	7,247
2005	6,275
2006	No Sampling
2007	2,949
Total:	43,221

Column designations and field names for MASTER-Animas Fish Data are provided in Table 5. Each record consists of 30 columns of data, designated by field names that relate to the type of data entered (e.g., Date, Type, etc.). The descriptions provided in Table 5 help to explain the type of information provided in the particular column. Each data entry is a unique code or measurement. Codes are predetermined so that files can be easily searched, and measurements are entered within specified ranges. Codes and measurements were originally recorded in the field on paper data sheets and entered electronically into the specified data files.

Each data entry was quality controlled by checking against the field data sheets and then through code and range checks which searched each file for unacceptable codes or data entries outside of the specified range. Additional quality control was conducted during data analysis when aberrant observations were checked against data sheets.

Table 5. Column designations and field names for MASTER-Animas Fish Data.

Column	Field Names	Description	Codes or Measurements
A	Date	Month, day, and year of sample.	MM/DD/YYYY; e.g., 09/21/1998
B	Type	Type of Sampling	T-POP=Trout Population Estimate, LARV=Larval, S-TAG=Sucker tagging, LONG=Longitudinal
C	Sample	Contains 2 digit year, 3 letters for river and 2 digits for sample number.	e.g., 01ANI03 = 2001, Animas River, Sample 03
D	RM	Approximate river mile of sampled fish	Measured upstream from San Juan River confluence
E	RO RM	Round-off river mile	Rounded off for purposes of data blocking
F	Species	3 letter species code	See Table 5 for species codes
G	TL_mm	Total length measured in millimeters	1 to 999
H	Wt_g	Weight of fish measured in grams	1 to 9,999
I	SL_mm	Standard length measured in millimeters	1 to 999
J	Count	Fish not measured or weighted - count in number	1 to 999
K	Reach	Specific to trout 2-pass mark recapture.	1 = Purple Cliffs to Basin Creek, 2 = Basin Creek to Weaselskin Bridge, 3 = Weaselskin Bridge to Bondad, 4 = Bondad to Colorado Stateline
L	Pass	Specific to trout 2-pass mark recapture.	Pass 1 = mark pass, Pass 2 = recapture pass
M	Status	Applies to both trout and native suckers.	M=marked trout, C=captured trout-not marked, R=recaptured trout, new= new FLOY Tag, recap=recapture FLOY tag
N	Lat.	Latitude	e.g., 36.78143
O	Long.	Longitude	e.g., -108.09953
P	Northing	UTM Northing in zone 13	e.g., 4075118
Q	Easting	UTM Easting in zone 13	e.g., 223390
R	Elec_min	Electro-fishing minutes	1 to 999
S	Tag_num	FLOY tag number	1 to 9,999
T	Tag_Color	FLOY tag color	B = blue, G = green, Y = yellow
U	Tag_Type	Type of tag	F = Floy, P = PIT, C = coded wire tag
V	Tag_Info	FLOY tag information	Responsible party; USBOR = Bureau of Reclamation, SUIT = Southern Ute Indian Tribe
W	Comments	Comments related to specific fish sampled	Text comments

Column	Field Names	Description	Codes or Measurements
X	Sex	Sex of specific fish sampled	M = male, F = female, m/milt = male with milt, f/eggs = female with eggs, TVB male = tubercled male, TVB female = tubercled female
Y	fsample	Field sample number	1 to 99
Z	Boat	Electro-fishing rafts.	SUIT = Southern Ute Raft, BOR = Reclamation raft
AA	GPS	GPS waypoint number	1 to 99
AB	Mile	Range of sample measured in river miles	0 to 99
AC	Report_Sample	Specific only to 2001 data	1.1 to 2.4
AD	Location	Description of specific location of sampled fish	Text description

3.3 Fish Species Composition

Large-bodied fish were collected with raft electrofishing in the Animas River from Purple Cliffs to the confluence of the San Juan River, and species composition was determined from the pool of all years of sampling (1997-2005, 2007). Bluehead sucker (37.12%) and flannelmouth sucker (20.99%) dominated fish composition (Figure 2, Table 6) followed by brown trout (14.32%), rainbow trout (13.72%), and Snake River cutthroat trout (6.59%).

Raft electrofishing captured primarily large-bodied fish and species composition does not include young of any species nor does it appropriately represent small-bodied forms such as mosquitofish, mottled sculpin, or speckled dace. These small-bodied forms are undoubtedly important to the Animas River ecosystem and their importance should not be discounted. Other sampling gears or methods should be employed to better account for these small-bodied fishes.

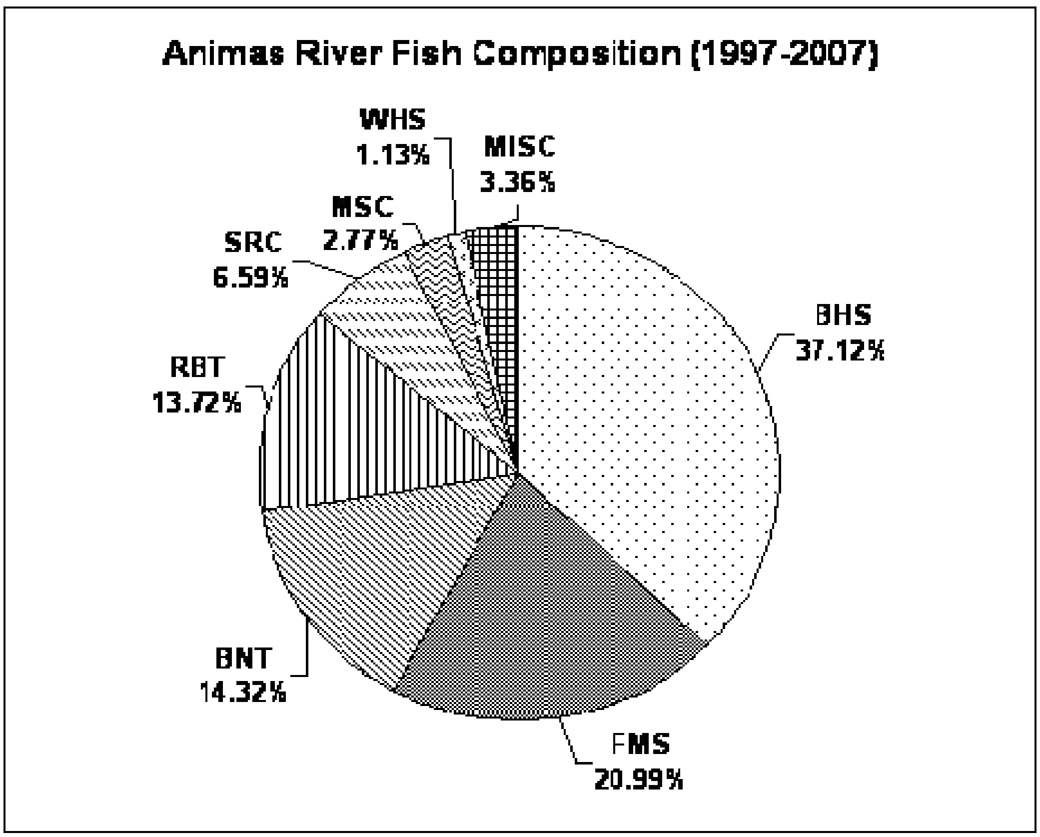


Figure 2. Fish composition of the Animas River between Purple Cliffs and the confluence of the San Juan River, 1997-2007 (see Table 6 for species codes; MISC = miscellaneous).

Table 6. Number and proportions of fish species captured in the Animas River between Purple Cliffs and the confluence of the San Juan River, 1997-2007.

Common Name	Scientific Name	Code	Number	Percent
Black bullhead	*Ictalurus melas*	BBH	185	0.43
Bluehead sucker	*Catostomus discobolus*	BHS	15,976	37.12
Bluehead x white hybrid		BW	168	0.39
Bluehead x flannelmouth		BF	15	0.03
Brown trout	*Salmo trutta*	BNT	6,162	14.32
Channel catfish	*Ictalurus punctatus*	CHC	2	0.00
Colorado pikeminnow	*Ptychocheilus lucius*	CPM	3	0.01
Common carp	*Cyprinus carpio*	CCP	276	0.64
Cutthroat x rainbow hybrid		CB	175	0.41
Fathead minnow	*Pimephales promelas*	FHM	105	0.24
Flannelmouth sucker	*Catostomus latipinnis*	FMS	9,033	20.99
Flannelmouth x white hybrid		FW	159	0.37
Green sunfish	*Lepomis cyanellus*	GSF	15	0.03
Largemouth bass	*Micropterus salmoides*	LMB	86	0.20
Mosquitofish	*Gambusia affinis*	GAM	28	0.07
Mottled sculpin	*Cottus bairdi*	MSC	1,194	2.77
Rainbow trout	*Oncorhynchus mykiss*	RBT	5,904	13.72
Roundtail chub	*Gila robusta*	RTC	4	0.01
Snake River cutthroat trout	*Oncorhynchus clarki*	SRC	2,837	6.59
Speckled dace	*Rhinichthys osculus*	SPD	220	0.51
Sucker-unidentified	*Catostomus sp.*	SU	3	0.01
White sucker	*Catostomus commersonii*	WHS	488	1.13
Grand Total			43,038	100.00

Of the 17 species captured in the Animas River between Purple Cliffs and the confluence of the San Juan River (about 91 km), only six were native, including bluehead sucker, Colorado pikeminnow, flannelmouth sucker, mottled sculpin, roundtail chub, and speckled dace. Only four roundtail chub were caught in 10 years of sampling, and the population in the Animas River is alarmingly low. The Colorado pikeminnow is an endangered species and three were captured on July 15, 2004 at RM 1.9 and 2.3. The fish were 226, 239, and 246 mm TL and had been previously marked as part of the U.S. Fish and Wildlife Service reintroduction program of Colorado pikeminnow in the San Juan River near Farmington. These fish had apparently moved upstream into the Animas River following their release in the San Juan River.

The remaining 11 fish species were nonnative forms that have been introduced into the Animas River by various means. Brown trout, rainbow trout, and Snake River cutthroat trout are introduced regularly as game fish. Channel catfish, largemouth bass, and green sunfish have been distributed variously for many years as game fish and are found primarily in the San Juan River and below the Farmington Lake Diversion. Fathead minnow and mosquitofish are common throughout the San Juan River Basin and the white sucker has established populations in various tributaries and occurs as small concentrations in the Animas River, where they hybridize with native suckers and where hybrid swarms are becoming evident.

Table 7. Number (No.) and percentage (Per.) of fish species captured in the Animas River, 1997-2007 (see Table 6 for species codes).

	1997		1998		1999		2001		2002		2003		2004		2005		2007	
Species	No.	Per.	No.	Per.	No.	Per.	No.	Per.	No.	Per.	No.	Per.	No.	Per.	No.	Per.	No.	Per.
BBH	0	0.00	0	0.00	0	0.00	2	0.06	1	0.07	1	0.01	181	2.50	0	0.00	0	0.00
BF	0	0.00	0	0.00	6	0.10	1	0.03	2	0.13	4	0.04	0	0.00	2	0.03	0	0.00
BHS	228	7.59	702	28.32	2132	35.14	893	26.19	616	40.37	2747	27.25	6537	90.20	1725	27.49	396	13.43
BNT	1048	34.88	381	15.37	849	13.99	716	21.00	8	0.52	1168	11.59	34	0.47	997	15.89	961	32.59
BW	0	0.00	2	0.08	63	1.04	10	0.29	8	0.52	58	0.58	6	0.08	13	0.21	8	0.27
CB	0	0.00	1	0.04	87	1.43	85	2.49	0	0.00		0.00	0	0.00	2	0.03	0	0.00
CCP	4	0.13	9	0.36	36	0.59	26	0.76	68	4.46	63	0.63	6	0.08	62	0.99	2	0.07
CPM	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	3	0.04	0	0.00	0	0.00
CHC	0	0.00	0	0.00	0	0.00	0	0.00	1	0.07	1	0.01	0	0.00	0	0.00	0	0.00
FHM	0	0.00	0	0.00	0	0.00	0	0.00	102	6.68	3	0.03	0	0.00	0	0.00	0	0.00
FMS	44	1.46	282	11.38	1235	20.35	483	14.16	448	29.36	4068	40.36	449	6.20	1730	27.57	294	9.97
FW	0	0.00	3	0.12	43	0.71	17	0.50	0	0.00	60	0.60	2	0.03	12	0.19	22	0.75
GAM	0	0.00	0	0.00	0	0.00	0	0.00	28	1.83		0.00	0	0.00	0	0.00	0	0.00
GSF	0	0.00	0	0.00	0	0.00	4	0.12	11	0.72		0.00	0	0.00	0	0.00	0	0.00
LMB	0	0.00	0	0.00	0	0.00	17	0.50	69	4.52		0.00	0	0.00	0	0.00	0	0.00
MSC	73	2.43	0	0.00	453	7.47	75	2.20	4	0.26	173	1.72	6	0.08	90	1.43	320	10.85
RBT	509	16.94	726	29.29	532	8.77	222	6.51	37	2.42	1452	14.41	10	0.14	1552	24.73	864	29.30
RTC	0	0.00	0	0.00	2	0.03	0	0.00	2	0.13		0.00	0	0.00	0	0.00	0	0.00
SPD	1	0.03	0	0.00	6	0.10	50	1.47	71	4.65	34	0.34	6	0.08	35	0.56	17	0.58
SRC	1087	36.17	320	12.91	500	8.24	777	22.79	6	0.39	123	1.22	0	0.00	22	0.35	2	0.07
SU	0	0.00	0	0.00	0	0.00	0	0.00	3	0.20		0.00	0	0.00	0	0.00	0	0.00
WHS	11	0.37	53	2.14	124	2.04	32	0.94	41	2.69	124	1.23	7	0.10	33	0.53	63	2.14
Grand Total	3005	100.00	2479	100.00	6068	100.00	3410	100.00	1526	100.00	10079	100.00	7247	100.00	6275	100.00	2949	100.00

3.4 Trout Population Size

3.4.1 Population Estimates—SUIT Waters

Population sizes of brown trout and rainbow trout were estimated in Reach 1 (Purple Cliffs to Basin Creek), Reach 2 (Basin Creek to Weasel Skin Bridge), and Reach 3 (Weasel Skin Bridge to Bondad) for 1997, 2001, 2003, 2005, and 2007. Numbers of Snake River cutthroat trout could not be estimated for Reach 3 in 2005 and for all reaches in 2007 because of small numbers of fish captured and recaptured. The last stocking of Snake River cutthroat trout in the Animas River was in 2001. Population estimates for brown trout were the most precise of the three trout species (Table 8, Figure 4). Coefficient of variation ranged from 0.05 to 0.47 where the numbers of marks were sufficient for reliable estimates. Precision of population estimates for rainbow trout ranged from 0.13 to 0.43 where numbers of marks were sufficient, and precision for Snake River cutthroat trout ranged from 0.05 to 0.88. Additional analyses of fish density and biomass will be computed for trout in Phase II.

Average numbers of brown trout per mile for all years in SUIT Reaches 1, 2, and 3 were 204, 186, and 139, respectively (Figure 3). Average numbers of rainbow trout per mile for all years in Reaches 1, 2, and 3 were 345, 454, and 118, respectively. Average numbers of Snake River cutthroat trout per mile for all years in Reaches 1, 2, and 3 were 38, 317, and 49, respectively.

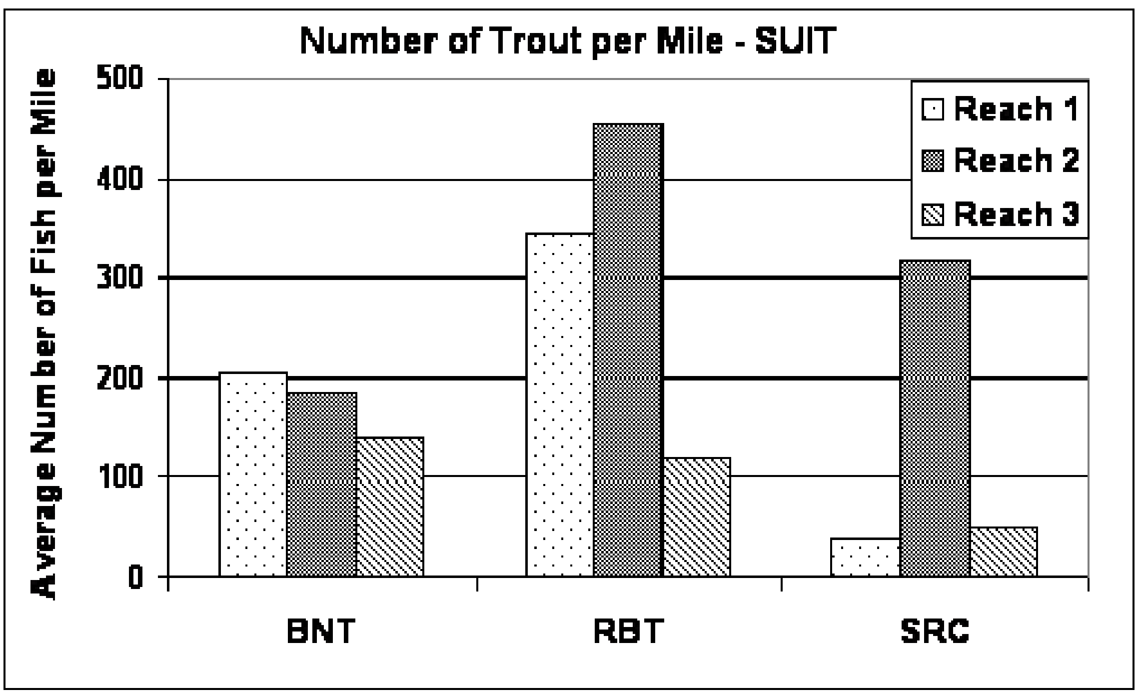


Figure 3. Average number of brown trout (BNT), rainbow trout (RBT), and Snake River cutthroat trout (SRC) per mile for all years in three reaches of the Animas River within SUIT lands.

Table 8. Population estimates of brown trout (BNT), rainbow trout (RBT), and Snake River cutthroat trout (SRC) from SUIT mark-recapture data. n1 = number of fish marked and released in pass 1, m2 = number of marked fish recaptured in pass 2, n2 = total number of fish captured in pass 2, N-hat = population estimate with Chapman modification of Petersen-Lincoln estimator, Var N-hat = variance of population estimate, 95% CI = 95% confidence interval, p-hat = capture probability, SE = standard error, CV = coefficient of variation.

Year	Reach 1 - Purple Cliffs to Basin Creek (RM 56.4-52.1 = 4.3 mi)			Reach 2 - Basin Creek to Weasel Skin Bridge (RM 52.1-49.5 = 2.6 mi)			Reach 3 - Weasel Skin Bridge to Bondad (RM 49.5-41.9 = 7.6 mi)		
1997	BNT	RBT	SRC	BNT	RBT	SRC	BNT	RBT	SRC
n1	149	128	47	45	21	115	226	70	305
m2	26	23	9	4	2	7	52	12	73
n2	205	178	79	55	27	140	368	84	401
N-hat	1143	961	383	514	204	2044	1579	463	1661
Var N-hat	33329	26097	9285	35908	8127	407877	30362	10651	22791
95% CI	358	317	189	371	177	1252	342	202	296
p-hat	0.13	0.13	0.11	0.07	0.07	0.05	0.14	0.14	0.18
SE	225.19	205.49	201.84	816.10	406.34	3577.87	134.94	154.36	74.97
CV	0.20	0.21	0.53	1.59	1.99	1.75	0.09	0.33	0.05
2001	BNT	RBT	SRC	BNT	RBT	SRC	BNT	RBT	SRC
n1	108	54	29	93	15	327	145	23	27
m2	17	3	5	17	2	39	23	7	14
n2	140	55	48	67	18	244	150	39	93
N-hat	853	769	244	354	100	2008	918	119	174
Var N-hat	27943	102101	6019	3945	1755	72323	23720	852	750
95% CI	328	626	152	123	82	527	302	57	54
p-hat	0.12	0.05	0.10	0.25	0.11	0.16	0.15	0.18	0.15
SE	261.15	1926.43	214.96	42.88	125.39	221.85	164.72	38.74	28.84
CV	0.31	2.51	0.88	0.12	1.25	0.11	0.18	0.33	0.17
2003	BNT	RBT	SRC	BNT	RBT	SRC	BNT	RBT	SRC
n1	188	291	36	64	205	17	132	228	12
m2	47	36	7	15	31	4	22	24	1
n2	198	333	35	70	187	16	96	115	5
N-hat	783	2635	166	287	1209	60	560	1062	38
Var N-hat	7092	141983	1877	2857	31108	317	8270	30346	285
95% CI	165	739	85	105	346	35	178	341	33
p-hat	0.24	0.11	0.20	0.21	0.17	0.25	0.23	0.21	0.20
SE	37.93	489.60	53.62	45.35	152.49	19.83	63.13	133.68	25.91
CV	0.05	0.19	0.32	0.16	0.13	0.33	0.11	0.13	0.68
2005	BNT	RBT	SRC	BNT	RBT	SRC	BNT	RBT	SRC
n1	157	234	7	36	201	3	117	194	1
m2	34	41	1	3	13	0	12	34	1
n2	207	358	5	43	182	2	106	273	4
N-hat	938	2008	23	406	2639	11	970	1526	4
Var N-hat	15856	68046	95	26861	399483	35	52670	46329	-1
95% CI	247	511	19	321	1239	12	450	422	--
p-hat	0.16	0.11	0.20	0.07	0.07	0.00	0.11	0.12	0.25
SE	101.64	292.04	15.83	767.46	1997.42	17.50	454.05	240.05	--
CV	0.11	0.15	0.69	1.89	0.76	1.59	0.47	0.16	--

Table 8. Continued

Year	Reach 1 - Purple Cliffs to Basin Creek (RM 56.4-52.1 = 4.3 mi)			Reach 2 - Basin Creek to Weasel Skin Bridge (RM 52.1-49.5 = 2.6 mi)			Reach 3 - Weasel Skin Bridge to Bondad (RM 49.5-41.9 = 7.6 mi)		
2007	BNT	RBT	SRC	BNT	RBT	SRC	BNT	RBT	SRC
n1	103	110	0	70	109	0	229	139	0
m2	22	15	0	5	9	0	61	20	0
n2	147	149	1	71	158	0	341	199	1
N-hat	668	1040	1	851	1748	0	1268	1332	1
Var N-hat	12274	48702	-1	87025	236909	-1	15278	61474	-1
95% CI	217	433	--	578	954	--	242	486	--
p-hat	0.15	0.10	0.00	0.07	0.06	--	0.18	0.10	0.00
SE	120.33	446.81	1.00	1261.23	2193.60	1.00	67.01	445.46	1.00
CV	0.18	0.43	1.00	1.48	1.25	--	0.05	0.33	1.00

The sums of estimates for all three reaches, averaged for the 5 years were: brown trout (2,419), rainbow trout (3,563), and Snake River cutthroat trout (1,364). An estimate by Nehring (1992) for brown trout (2,421) from Purple Cliffs to the New Mexico state line was strikingly similar to the average annual sum estimate from this analysis, but Nehring's estimate of 512 rainbow trout was considerably lower than this estimate of 3,563. In 1994, Miller et al. (1995) provided Lincoln-Peterson mark-recapture estimates of brown trout, rainbow trout, and Snake River cutthroat trout for approximately the same reaches of river. The sums of those estimates were brown trout (329), rainbow trout (277), and Snake River cutthroat trout (62). There is a wide disparity between the estimates of Nehring (1992) and the present estimates when compared with those of Miller et al. (1995) that cannot be explained. Further analysis is needed of the data collected by Nehring (1992) and Miller et al. (1995) together with the present database. This will require incorporating all data into electronic format to facilitate analysis.

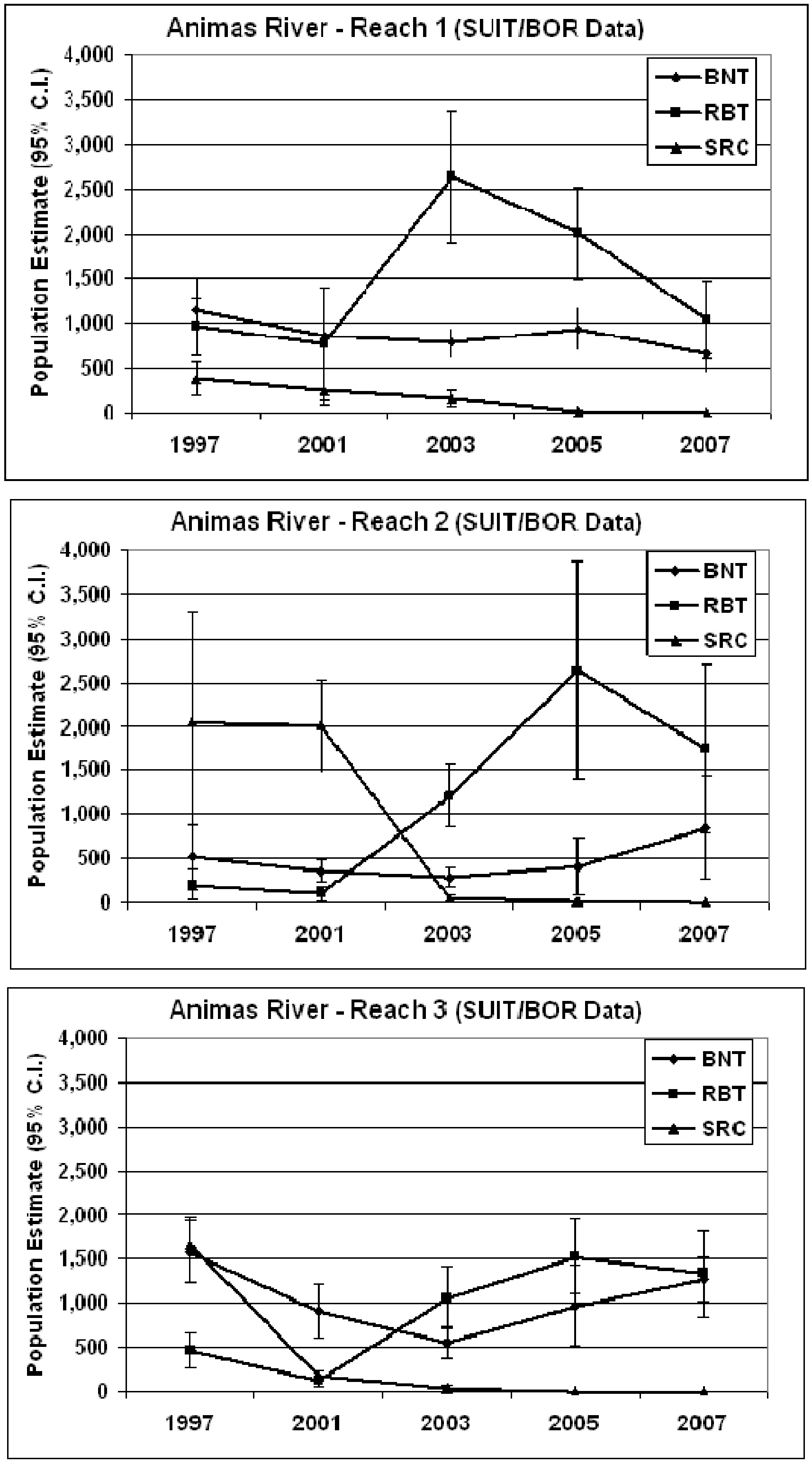


Figure 4. Population estimates of brown trout (BNT), rainbow trout (RBT), and Snake River cutthroat trout (SRC) from SUIT mark-recapture data in Reaches 1 (top), 2 (center), and 3 (bottom) within SUIT lands. Vertical bars are 95% confidence intervals around the mean.

3.4.2 Population Estimates—CDOW Waters

Population sizes were also estimated for brown trout, rainbow trout, and Snake River cutthroat trout from mark-recapture data collected by CDOW from two reaches near the City of Durango and upstream from SUIT lands (Table 9, Figure 5). Animas #1 represents the 'gold medal' section of the Animas River, and Animas #2 is a section with standard fishing regulations. Estimates of brown trout and rainbow trout were possible in both sections for 2002, 2004, and 2006, but estimates for Snake River cutthroat trout were not possible for Animas #1 in 2004 and 2006 because of small numbers of fish captured. The CV of these estimates for all three trout species ranged from 0.11 to 0.82.

Table 9. Population estimates of brown trout (BNT), rainbow trout (RBT), and Snake River cutthroat trout (SRC) from CDOW mark-recapture data. n1 = number of fish marked and released in pass 1, m2 = number of marked fish recaptured in pass 2, n2 = total number of fish captured in pass 2, N-hat = population estimate with Chapman modification of Petersen-Lincoln estimator, Var N-hat = variance of population estimate, 95% CI = 95% confidence interval, p-hat = capture probability, SE = standard error, CV = coefficient of variation.

Year	Animas #1 - BMX park to high bridge			Animas #2 - DHS footbridge to 9th St. bridge		
2002	BNT	RBT	SRN	BNT	RBT	SRC
n1	148	176	22	105	205	26
m2	19	24	5	13	12	2
n2	92	103	15	95	130	2
N-hat	692	735	60	726	2075	26
Var N-hat	15534	13602	247	26110	259754	-1
95% CI	244	229	31	317	999	--
p-hat	0.21	0.23	0.33	0.14	0.09	1.00
SE	105.67	77.72	11.77	251.06	1273.30	-0.04
CV	0.15	0.11	0.20	0.35	0.61	0.00
2004	BNT	RBT	SRC	LOC	RBT	SRC
n1	88	118	11	105	160	0
m2	11	16	0	11	16	0
n2	69	110	10	72	142	0
N-hat	518	776	--	644	1353	--
Var N-hat	14862	24345	--	23701	80301	--
95% CI	239	306	--	302	555	--
p-hat	0.16	0.15	--	0.15	0.11	--
SE	170.83	208.08	--	227.89	505.04	--
CV	0.33	0.27	--	0.35	0.37	--
2006	BNT	RBT	SRC	BNT	RBT	SRC
n1	62	83	0	111	206	0
m2	15	10	0	9	24	0
n2	85	124	0	106	180	0
N-hat	338	954	--	1197	1498	--
Var N-hat	4095	60179	--	107790	65461	--
95% CI	125	481	--	643	501	--
p-hat	0.18	0.08	--	0.08	0.13	--
SE	67.13	733.89	--	979.91	319.32	--
CV	0.20	0.77	--	0.82	0.21	--

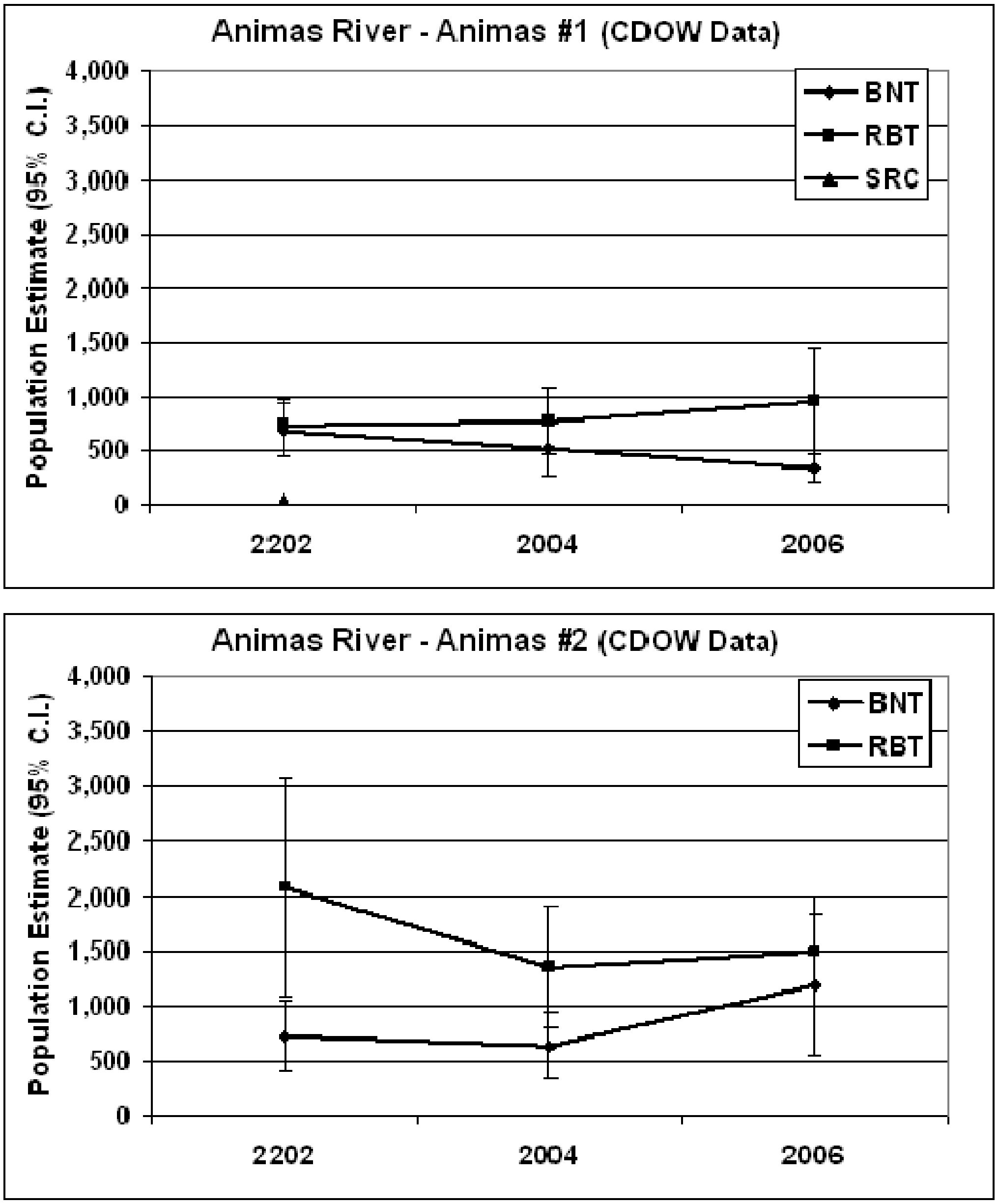


Figure 5. Population estimates of brown trout (BNT), rainbow trout (RBT), and Snake River cutthroat trout (SRC) from CDOW mark-recapture data in Animas 1 (top) and 2 (bottom). Vertical bars are 95% confidence intervals around the mean.

3.4.3 Proportional Stock Density

Proportional stock density (PSD) was computed for the three trout species on the basis of numbers of fish captured with raft electrofishing. The PSD for brown trout in SUIT waters was consistently above 50 in all years evaluated (Figure 6). This is a relatively high PSD and indicates that a large proportion of brown trout in the Animas River are of trophy quality (≥ 406 mm, 16"). The annual PSD for rainbow trout varied more than for brown trout and ranged from 14 to 66. This could be affected by stocking of fish where increased numbers of smaller stocked fish affect the PSD. For Snake River cutthroat trout, PSD ranged from 4 to 45. The highest PSD of 45 occurred in 2005 long after stocking of this species and when only large fish remained.

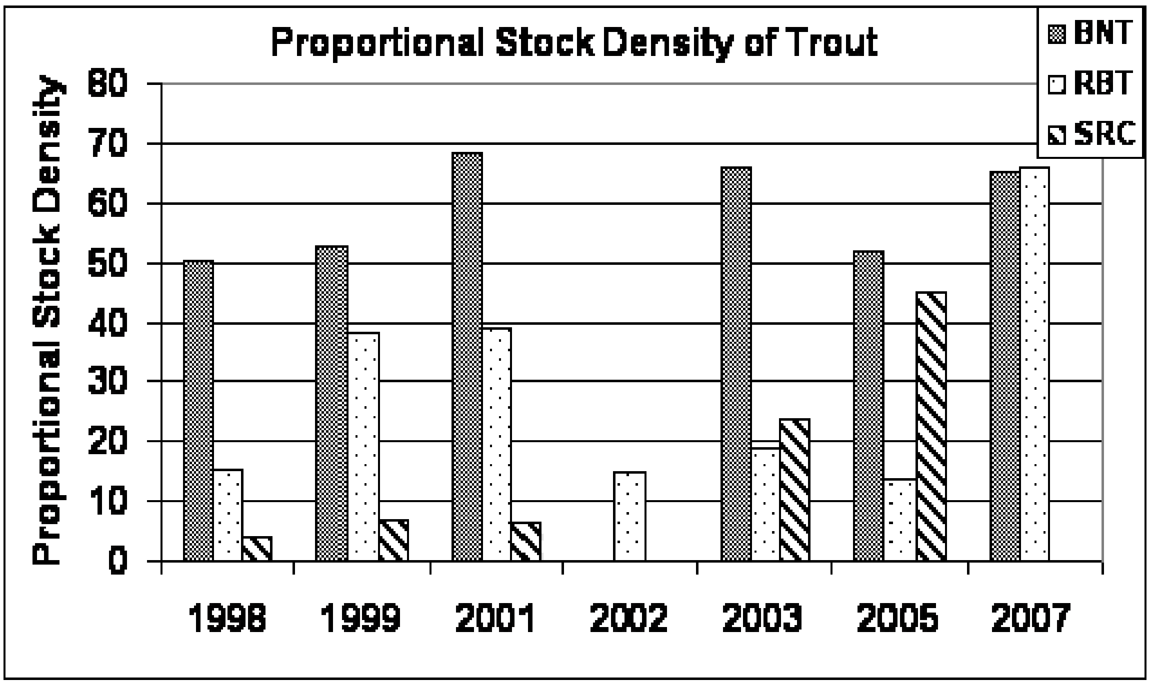


Figure 6. Proportional stock density of brown trout (BNT), rainbow trout (RBT), and Snake River cutthroat trout (SRC) in the Animas River within SUIT lands.

Nehring (1988) reported a PSD for brown trout in the Animas River upstream of Purple Cliffs (CDOW waters) that ranged from 24 to 61, which is similar to that reported in this analysis within the SUIT waters.

Proportional stock densities for the Animas River compare favorably with other top fisheries. The PSD for rainbow trout was 55 in the Kootenai River, Idaho (Walters 2005) and 16-68 in the South Fork Boise River, Idaho (Hebdon 2007), compared to 14-66 for the Animas River. Comparable PSDs for brown trout and Snake River cutthroat trout could not be found in literature. Nevertheless, the high PSDs for brown trout in the Animas River indicate a high proportion of trophy fish in the system.

3.5 Catch Rates of Trout and Suckers

Although fish sampling may have not been designed to specifically obtain and use catch rate data to characterize fish population size, these are the only comprehensive data for assessing numbers of large-bodied fish that may reflect long-term population size and trends. Catch rate indices were computed as numbers of large-bodied fish per hour of raft electrofishing (Figures 7 and 8). Small-bodied fish were not consistently and efficiently captured with raft electrofishing and are not included in this analysis. Nevertheless, it should be noted that small-bodied fish were abundant in the Animas River, but their numbers are not reflected in these catch rate data.

These catch rate indices were highly variable with low precision; CV ranged from 0.34 to 4.90. About 25% of all data distributions were not normally distributed with negative binomial distributions. Kruskal-Wallis ANOV and comparison of mean ranks were used to determine differences among means. Compatible groups that are not significantly different ($\alpha > 0.05$) are shown in Figures 7 and 8 as the same letters. Detailed descriptive statistics for these analyses are provided in the file "ANIMAS ANALYSIS."

These catch rate data have limited utility as a metric because they lack the sensitivity to detect changes in fish densities. Most means differed by about 75% or more before they were significantly different; hence fish density (and presumably population size) would have to change by at least 75% before it could be detected with the present data at a significance level of $\alpha \leq 0.05$. If catch rate data for the Animas River could be more precise, this index could be one valuable metric for tracking abundances of large-bodied fish populations as part of fish monitoring. Power analysis is recommended in Phase II to determine sample sizes necessary to reduce precision to CVs of less than 0.15.

These catch rate indices also lacked the accuracy to reflect population size when validated against simultaneous population estimates (Figure 9). Coefficient of determination (R^2) for brown trout and rainbow trout were 0.05 and 0.52. The high R^2 of 0.99 for Snake River cutthroat trout is probably not valid because it is attributed to three small catch rates and population estimates regressed with a single large catch rate and population estimate. Additional data collection is also need to validate catch rate indices against population estimates.

Numbers of white sucker and white sucker crosses with bluehead sucker and flannelmouth sucker appear to have increased from 1997 to 2007. The majority of these fish were between RM 30 and RM 57 (Table 10); sampling for these fishes did not occur above RM 57 and white suckers and their crosses may be present here as well. The white sucker is not native to the Colorado River Basin and readily hybridizes with the native suckers, sometimes forming hybrid swarms that threatened to dilute the genetic viability of the native suckers (Rees et al. 2005). Hybridization of native suckers by white suckers could be one of the most significant threats to the native sucker populations of the Animas River. Concentrations and sources of these nonnative white suckers should be identified and actions taken to reduce their numbers in the Animas River.

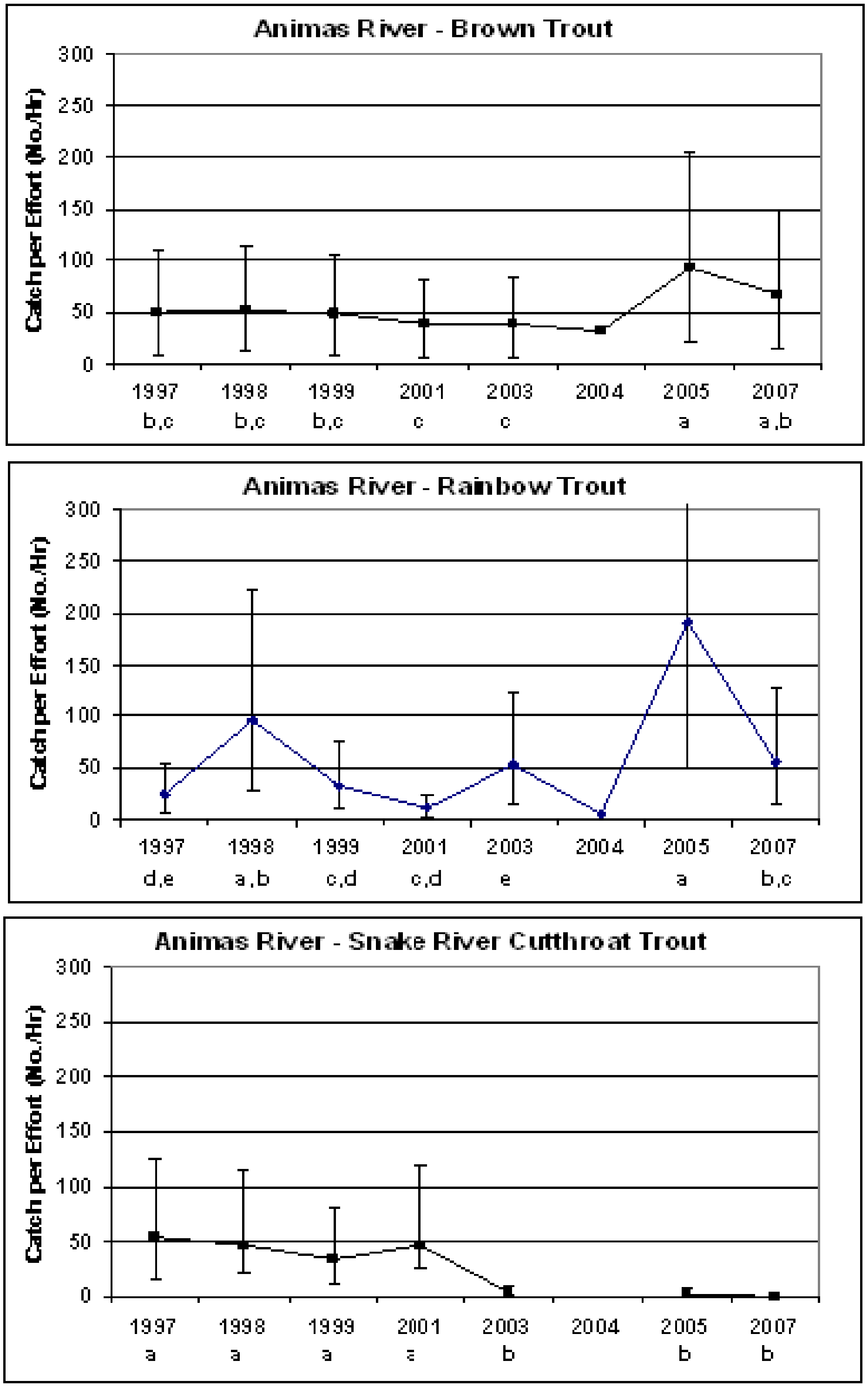


Figure 7. Annual electrofishing catch rate estimates for brown trout (top), rainbow trout (center), and Snake River cutthroat trout (bottom) from the Animas River within SUIT lands (RM 37-56). Vertical bars are 95% confidence intervals around the mean, and same letters beneath years indicate compatible groups with means that are not significantly different ($\alpha > 0.05$).

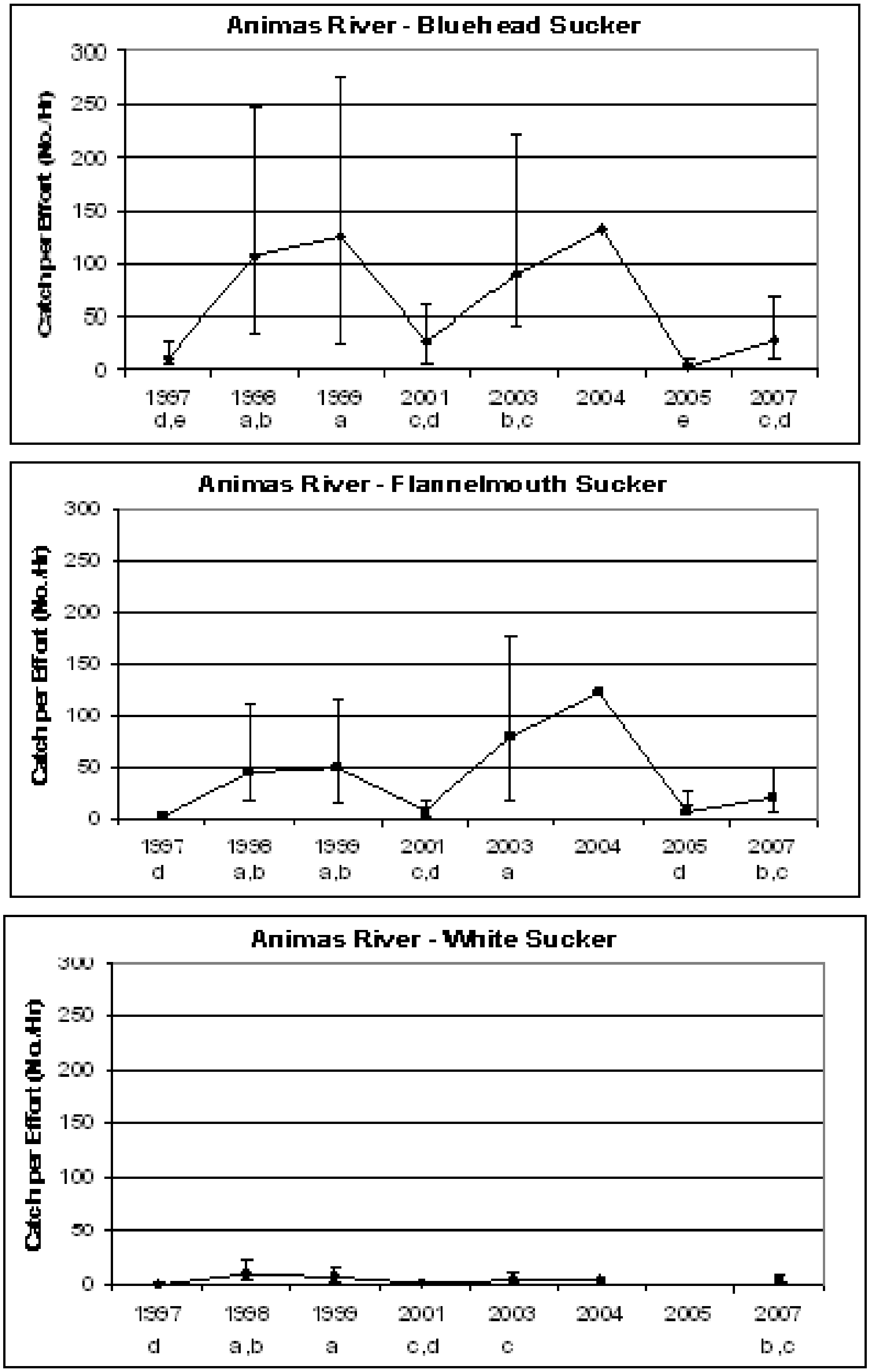


Figure 8. Annual electrofishing catch rate estimates for bluehead sucker (top), flannelmouth sucker (center), and white sucker (bottom) from the Animas River within SUIT lands (RM 37-56). Vertical bars are 95% confidence intervals around the mean, and same letters beneath years indicate compatible groups with means that are not significantly different ($\alpha > 0.05$).

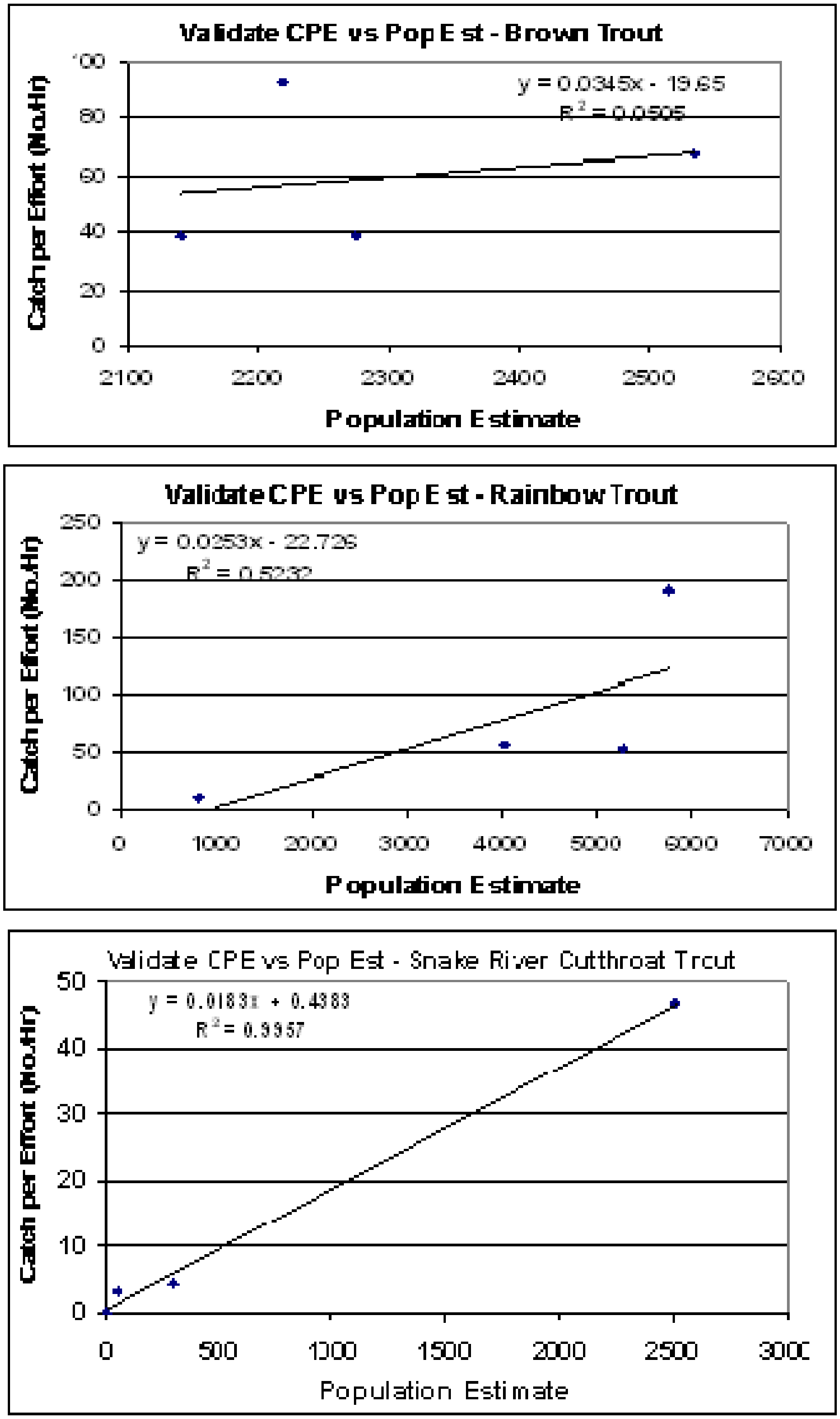


Figure 9. Catch rate indices regressed against simultaneous population estimates for brown trout (top), rainbow trout (center), and Snake River cutthroat trout (bottom) from the Animas River within SUIT lands (RM 37-56).

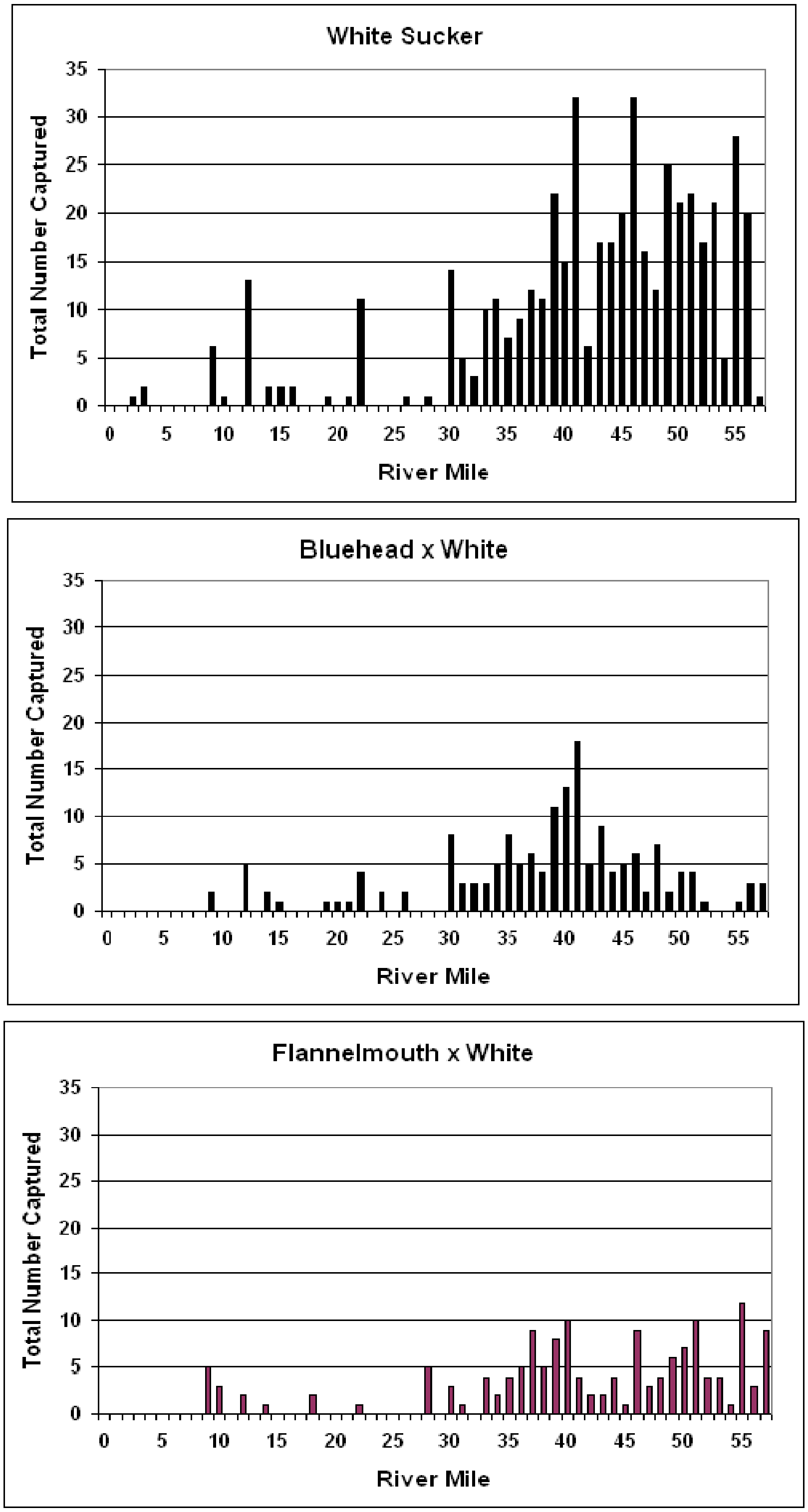


Figure 10. Total numbers of white sucker (top), bluehead x white crosses (center), flannelmouth x white crosses (bottom) captured by river mile in the Animas River within SUIT lands (RM 37-56), 1997-2007.

3.6 Length-Frequency Analyses

3.6.1 Length Distributions of Trout and Suckers

Nearly every fish captured was measured for total length and the data were good for generating length-frequency histograms for trout based on 10-mm bins. This length-frequency analysis helps to determine modes, medians, and means for lengths of most cohorts. Bhattacharya's modal separation and the routine NORMSEP found in FiSAT II were used to help distinguish cohorts of fish for each species. Cohort distinction was fair to good for the youngest two or three cohorts of brown trout, rainbow trout, and Snake River cutthroat trout (Figure 11). However, cohort separation was difficult for bluehead sucker, flannelmouth sucker, and white sucker because: (1) the 1- and 2-year old fish were rarely caught, and (2) growth of these species slows dramatically after maturity in about the 4th year of life leading to overlap in lengths of different age fish (Figure 12).

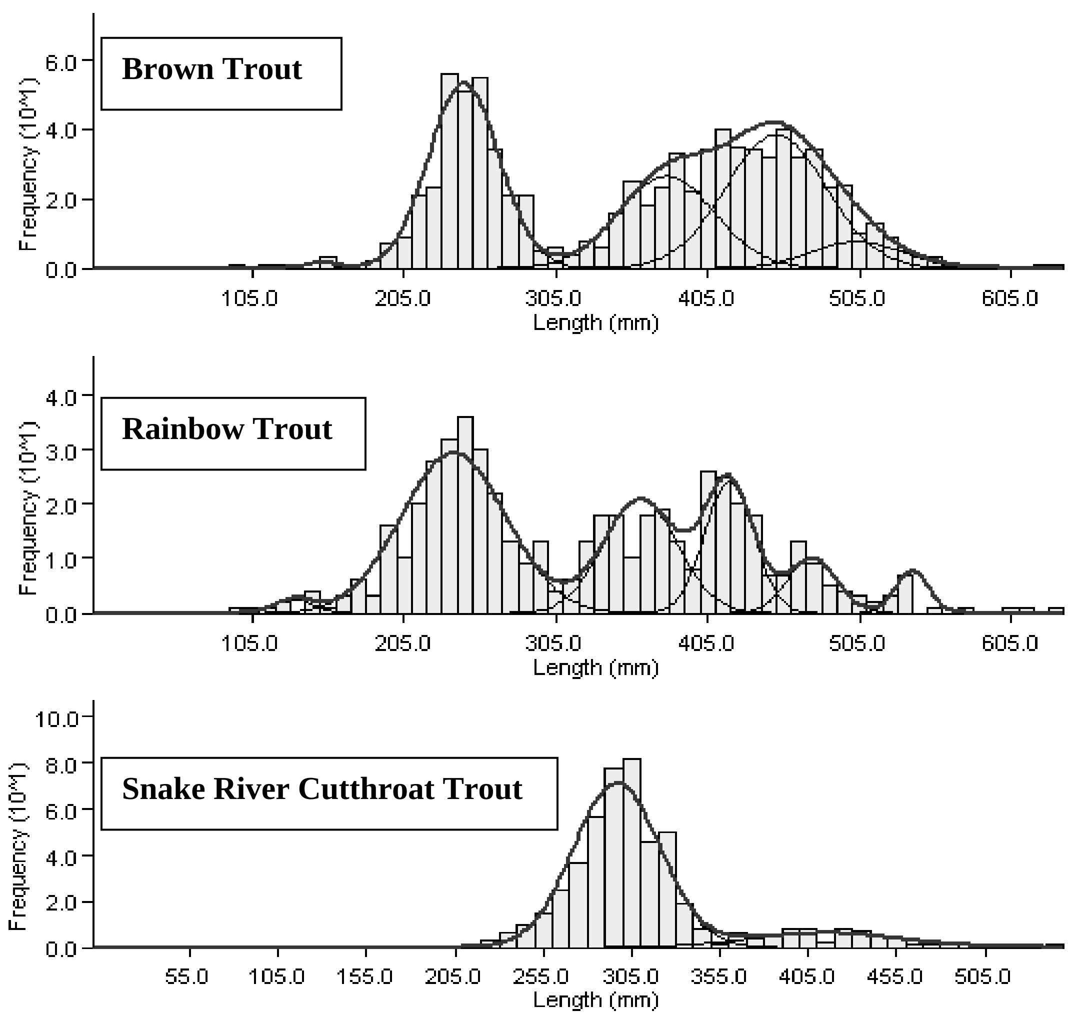


Figure 11. Modal separation of lengths showing five cohorts for brown trout (top), six for rainbow trout (center), and two for Snake River cutthroat trout (bottom) using Bhattachayra's modal separation and the routine NORMSEP found in FiSAT II.

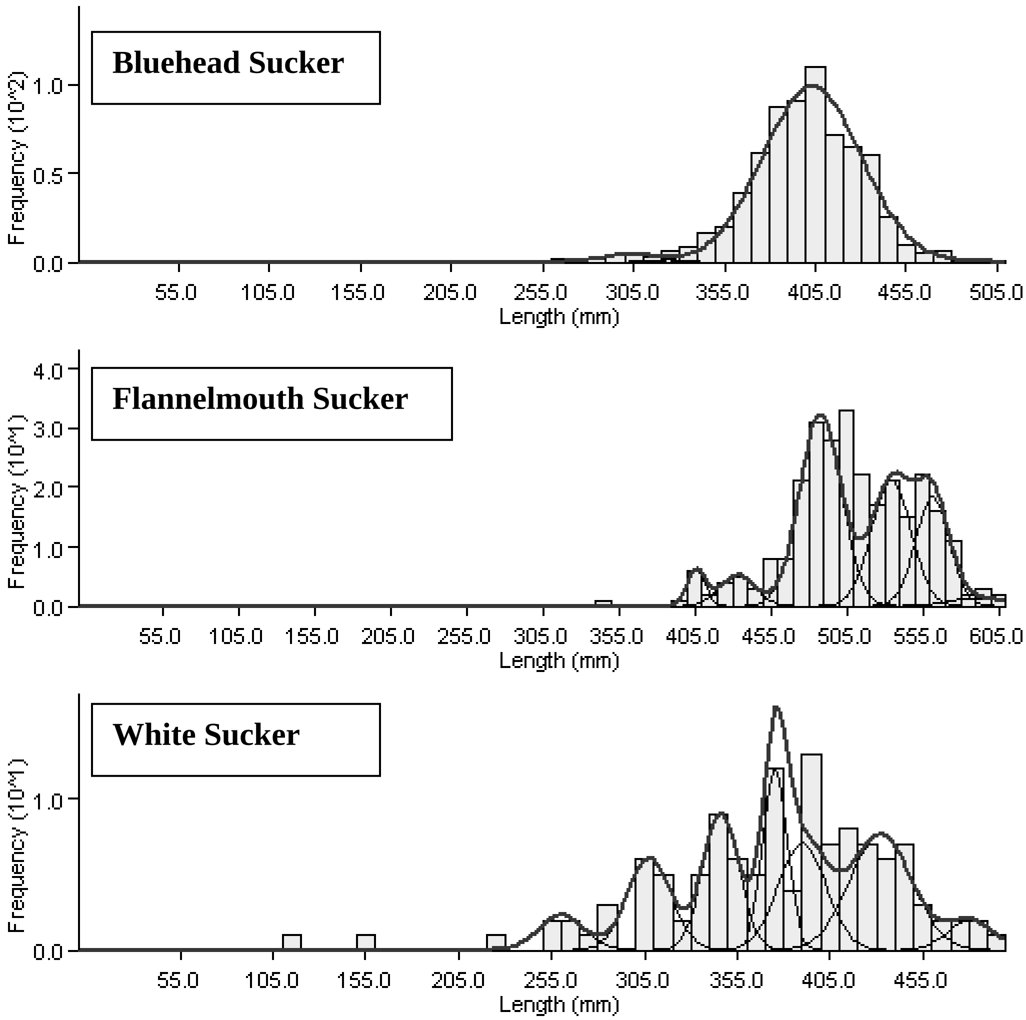


Figure 12. Modal separation of lengths showing two apparent cohorts for bluehead sucker (top), six for flannelmouth sucker (center), and seven for white sucker (bottom). Modal separation with Bhattachayra's modal separation and the routine NORMSEP found in FiSAT

Length-frequency histograms for the major fish species in each year are provided in the files "ANIMAS DATA 1 of 2" and "ANIMAS DATA 2 of 2." Cohort distinction using modal separation was adequate for estimating growth and survival of brown trout, rainbow trout, and Snake River cutthroat trout using additional analyses described below under section 3.6 (Length-Weight and Age-Growth of Trout) and section 3.8 (Survival of Trout). However, a length-at-age relationship is needed to validate cohort separation for these species using scales, otoliths, or other structures that exhibit annual growth rings.

The difficulty in distinguishing cohorts with length data of bluehead sucker, flannelmouth sucker, and white sucker was anticipated, and opercles were collected and analyzed to develop length-at-age relationships. This process and the results are described below under section 3.7 (Length-Weight and Age-Growth of Suckers).

3.6.2 Length Discrepancies in Native Suckers

Lengths of flannelmouth sucker and bluehead sucker were compared above and below the Farmer's Ditch Diversion at RM 21.9 (Figures 13 and 14). The Farmer's Diversion (RM 21.9) and the Farmington Lake Diversion (RM 11.9) are partial barriers to fish movement, and for the purpose of this discussion, data were partitioned with respect to the upper-most Farmer's Diversion. Comparable samples were taken above and below this diversion in 2001, 2002, 2003, 2004, and 2005. A prior analysis of fish passage at these diversions concluded that the diversion dams across the Animas River are partial barriers to upstream fish movement, but effects to the populations of native suckers were inconclusive (SWCA 2007).

The Kolmogorov-Smironov test was used to compare length-frequency distributions by species above and below the Farmer's Ditch Diversion for 2001-2005 (Table 10). Most samples were taken in July, August, and September, and samples in 2003 and 2004 were also taken in October and December. Time of year affected size distribution in that the young fish were larger later in the year. All paired length-frequency distributions within a year were significantly different (two-tailed test, $p<0.05$) indicating that lengths of fish differed above and below the diversion. Also, in all cases, minimum differences were significant (one-tailed test, $p<0.05$) meaning that above-diversion distributions contained fewer small fish than below-diversion distributions. Conversely, maximum differences were not significant (one-tailed test, $p>0.05$) such that numbers of large fish below and above the diversion did not differ.

Evidently, the two diversions in the lower Animas River impede movement of especially small fish and the length-frequency distributions show a larger proportion of small suckers below the diversions in most years. The numbers of small fish below the diversions may depend on time of year and flow conditions. Nevertheless, the effects to the sucker populations cannot be fully understood without a comprehensive analysis of long-term population trends through a recruitment model.

Table 10. Kolmogorov-Smirnov test comparing distributions above and below the Farmer's Ditch Diversion at RM 21.9 on the Animas River.

Year	Sample Size Above/Below	Two-Tailed Test Above <> Below	One-Tailed Above < Below	One-Tailed Above > Below
Bluehead Sucker				
2001	492/401	0.65 (p<0.0000)	-0.65 (p<0.0000)	0.00 (p=1.0000)
2002	300/312	0.15 (p<0.0017)	-0.15 (p<0.0008)	0.00 (p=1.0000)
2003	2,037/57	0.85 (p<0.0000)	-0.85 (p<0.0000)	0.00 (p=1.0000)
2004	1,367/5,169	0.82 (p<0.0000)	-0.82 (p<0.0000)	0.00 (p=1.0000)
2005	284/1,441	0.40 (p<0.0000)	-0.40 (p<0.0000)	0.00 (p=1.0000)
Flannelmouth Sucker				
2001	143/339	0.49 (p<0.0000)	-0.49 (p<0.0000)	0.00 (p=1.0000)
2002	209/235	0.34 (p<0.0000)	-0.34 (p<0.0000)	0.03 (p=0.8050)
2003	2,059/388	0.23 (p<0.0000)	-0.23 (p<0.0000)	0.00 (p=1.0000)
2004	269/179	0.64 (p<0.0000)	-0.64 (p<0.0000)	0.00 (p=1.0000)
2005	792/932	0.38 (p<0.0000)	-0.38 (p<0.0000)	0.00 (p=1.0000)

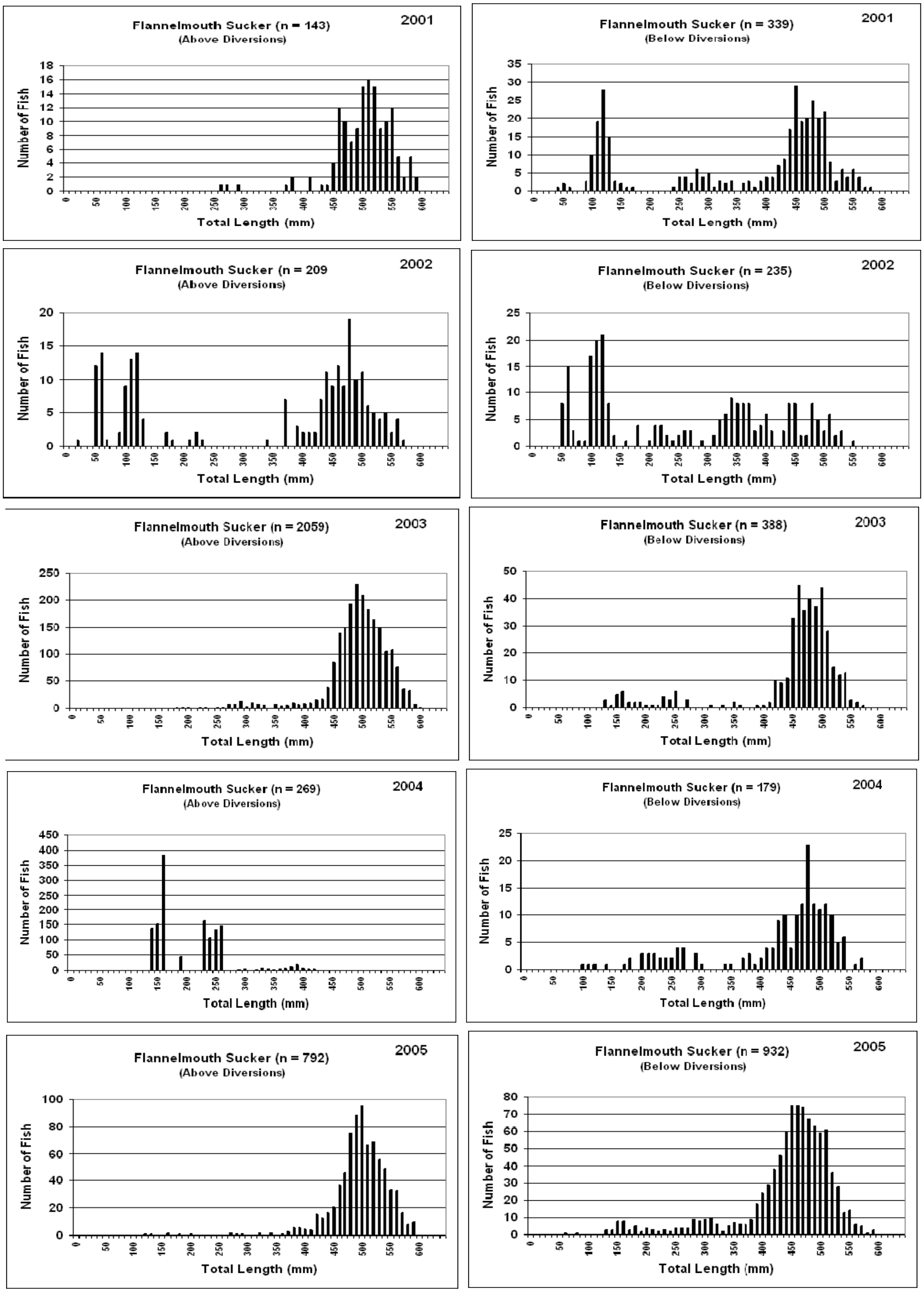


Figure 13. Length-frequency distributions for flannelmouth sucker in the Animas River above (left column) and below (right column) the two irrigation diversions.

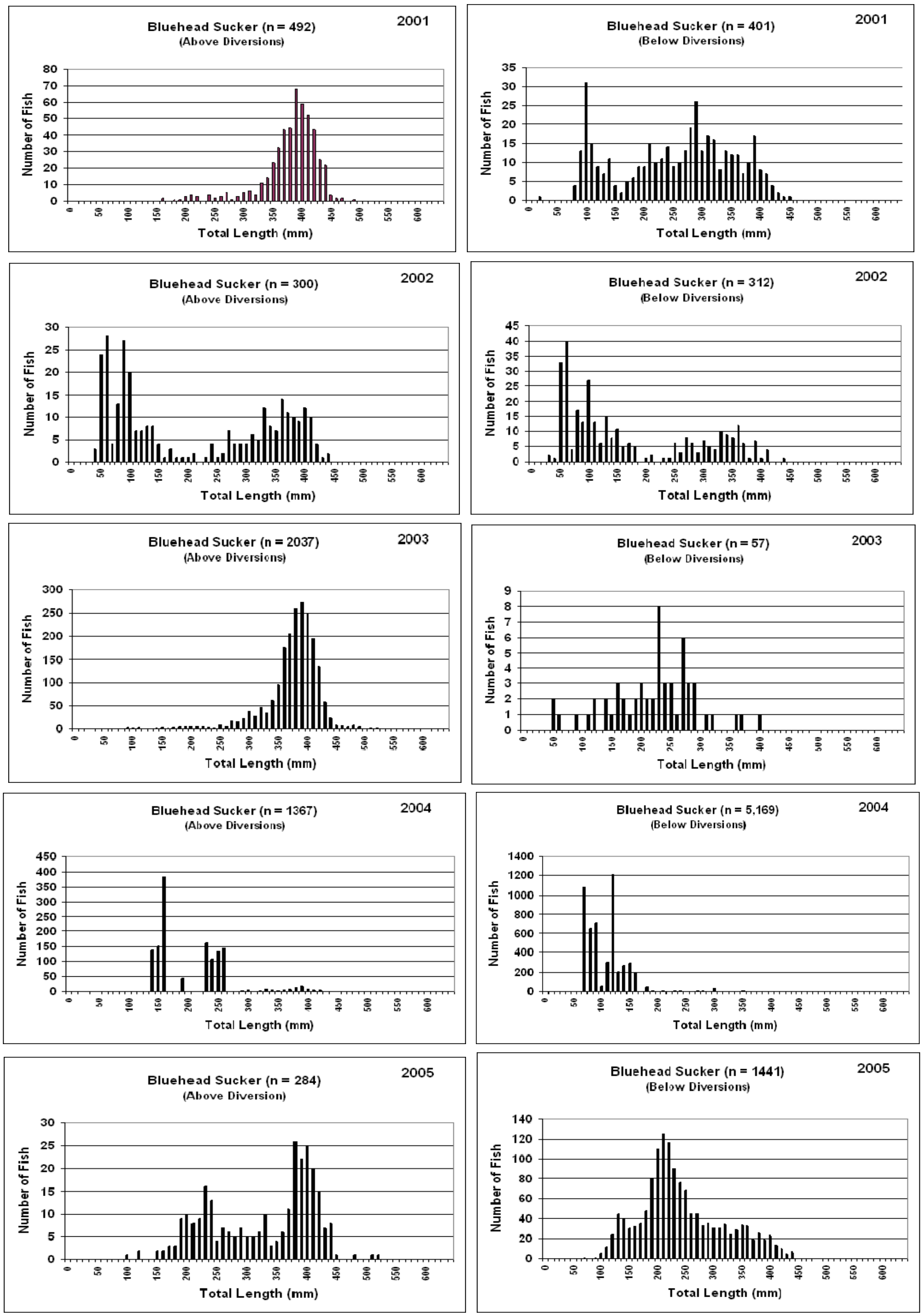


Figure 14. Length-frequency distributions for bluehead sucker in the Animas River above (left column) and below (right column) the two irrigation diversions.

3.7 Length-Weight and Age-Growth of Trout

3.7.1 Length-Weight and Condition

Length and weights were measured from between 25% and 30% of all fish handled. These data were sufficient to generate length-weight relationships for the principal species in some years (see "ANIMAS DATA 1 of 2" and "ANIMAS DATA 2 of 2"). A power function was used to describe the relationship between length and weight of the principal fish species (Figure 15) and condition factor was also computed for each species as an index of condition (Figure 16, Table 11).

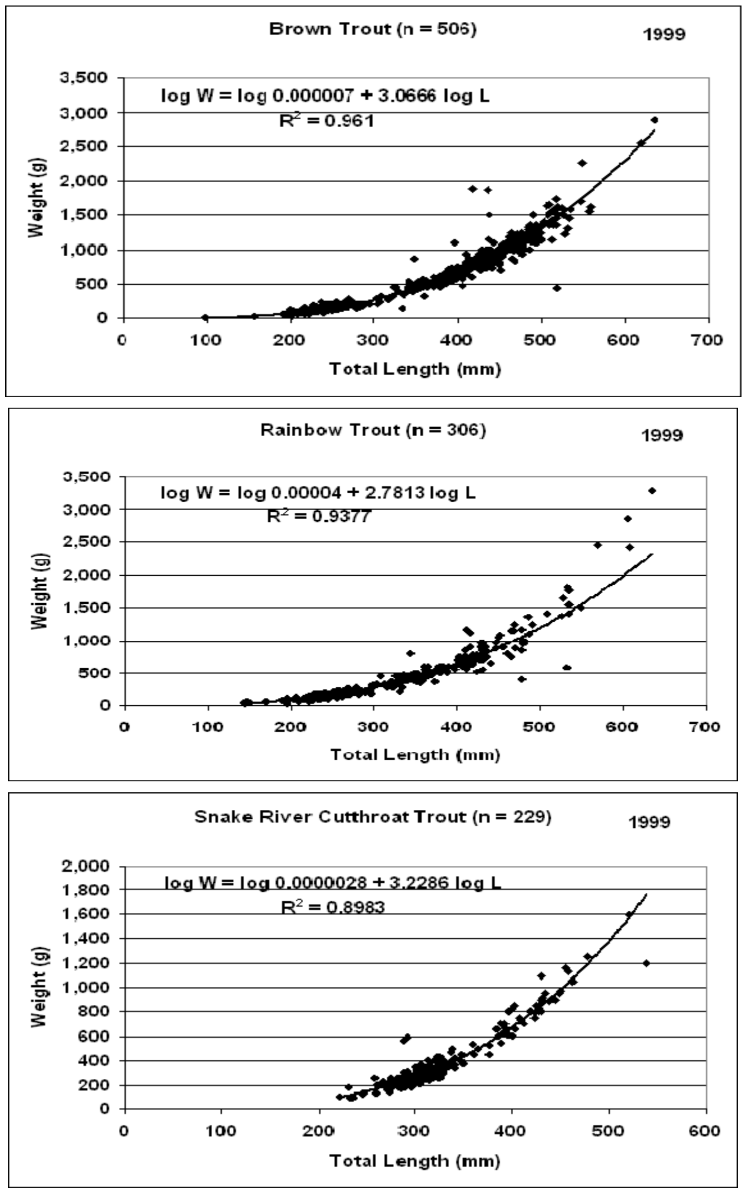


Figure 15. Length-weight relationships for brown trout (top), rainbow trout (center), and Snake River cutthroat trout (bottom) from the Animas River in 1999 within SUIT lands (RM 37-56).

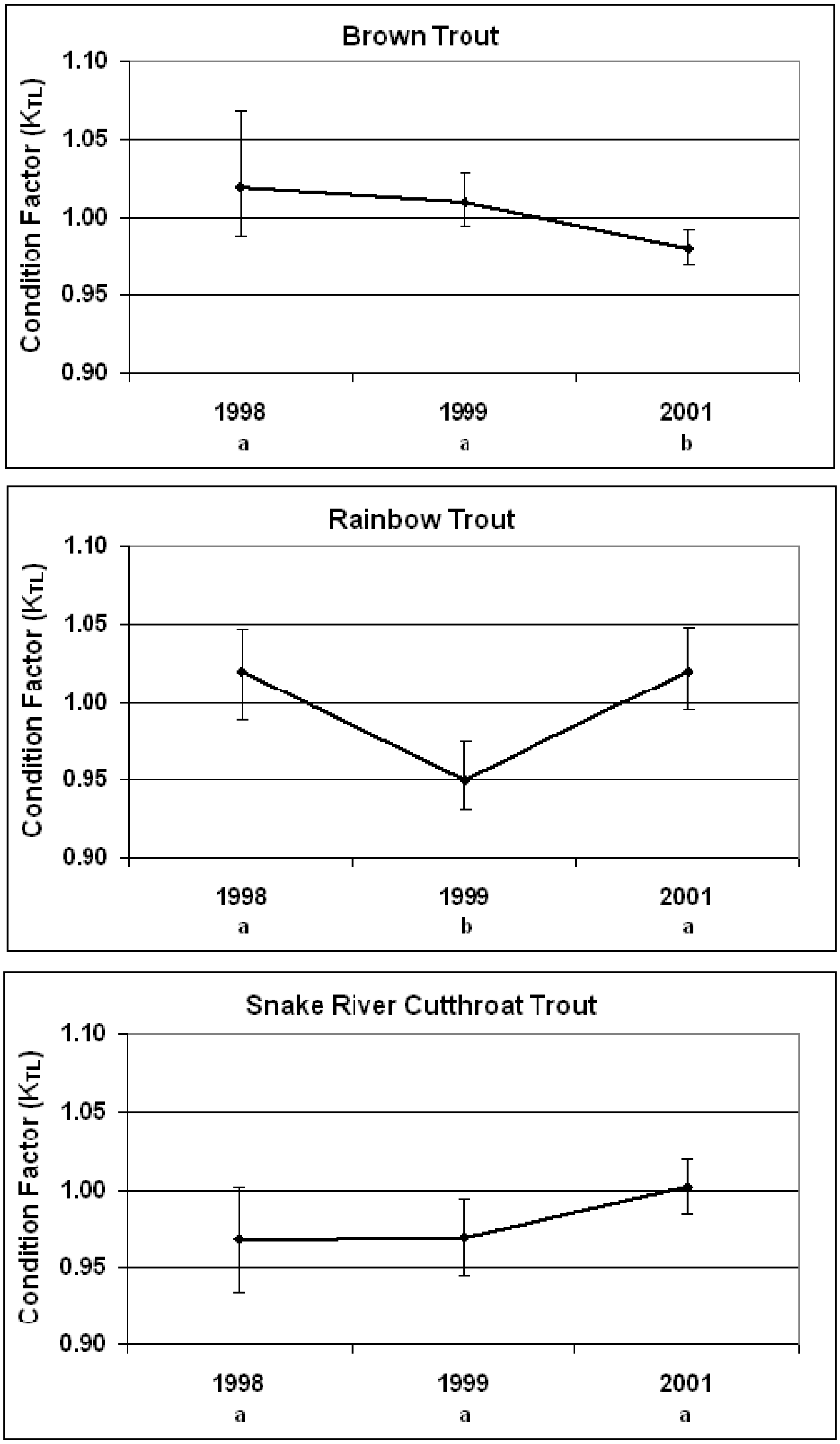


Figure 16. Relative condition of brown trout (top), rainbow trout (center), and Snake River cutthroat trout (bottom) of the Animas River within SUIT lands (RM 37-56). Vertical bars are 95% confidence intervals around the mean, and same letters beneath years indicate compatible groups with means that are not significantly different ($\alpha > 0.05$).

Table 11. Length-weight relationships and condition factors for brown trout, rainbow trout, and Snake River cutthroat trout of the Animas River within SUIT lands (RM 37-56).

Species (sample size)	Year	Length-Weight Relationship	Coefficient of Determination (R^2)	Condition Factor (K_{TL})
Brown trout (103)	1998	log W = -5.0969 + 3.0463 log L	0.91	1.21
(506)	1999	log W = -5.1549 + 3.0666 log L	0.96	1.01
(34)	2001	log W = -4.4949 +2.8163 log L	0.97	0.98
Rainbow trout (242)	1998	log W = -4.9586 + 2.976 log L	0.86	1.02
(306)	1999	log W = -4.3979 + 2.7813 log L	0.94	0.95
(92)	2001	log W = -4.4089 + 2.7807 log L	0.97	1.02
Snake River cutthroat trout (132)	1998	log W = -6.2218 + 3.4819 log L	0.80	0.97
(229)	1999	log W = -5.5528 + 3.2286 log L	0.90	0.97
(378)	2001	log W = -5.1549 + 3.0689 log L	0.91	1.00

3.7.2 Age and Growth

Based on length-frequency analyses, the majority of brown trout and rainbow trout in the Animas River live for 6-7 years with high mortality in the 5th and 6th years. Snake River cutthroat trout survive for 1-2 years after stocking. The von Bertalanffy growth functions (VBGF) were derived for each of the three trout species (Table 12, Figure 17). The VBGF is a logarithmic growth function that describes the rate of growth of a group of fish and predicts the maximum length. The VBGF yields two valuable parameters of growth, $L\infty$ and K.

The parameter $L\infty$ predicted maximum sizes for brown trout, rainbow trout, and Snake River cutthroat trout in the Animas River as 720 mm (28 in.), 678 mm (27 in.), and 667 mm (26 in.), respectively. Based on length-weight relationships (see Table 9), predicted weights for these lengths are 4,049 g (9 lb.), 2,996 g (7 lb.), and 3,674 g (8 lb.), respectively. These estimated sizes are reasonable, given that actual maximum sizes of brown trout, rainbow trout, and Snake River cutthroat trout from the Animas River fisheries database were 680, 646, and 631 mm TL, respectively. Weights were not recorded for these fish and predicted weights cannot be confirmed.

Table 12. The von Bertalanffy growth function (VBGF), maximum predicted size of fish ($L\infty$), and rate of growth (K) for the six principle fish species of the Animas River.

Species	VBGF	$L\infty$	K
Brown trout	L(t) = 719.78 [1 – exp (-0.160 (t – (-0.16)))]	720 mm TL (28 in.) 4,049 g (9 lb.)	0.16
Rainbow trout	L(t) = 677.78 [1 – exp (-0.110 (t – (-0.4)))]	678 mm TL (27 in.) 2,996 g (7 lb.)	0.11
Snake River cutthroat trout	L(t) = 667.28 [1 – exp (-0.130 (t – (-0.2)))]	667 mm TL (26 in.) 3,674 g (8 lb.)	0.13

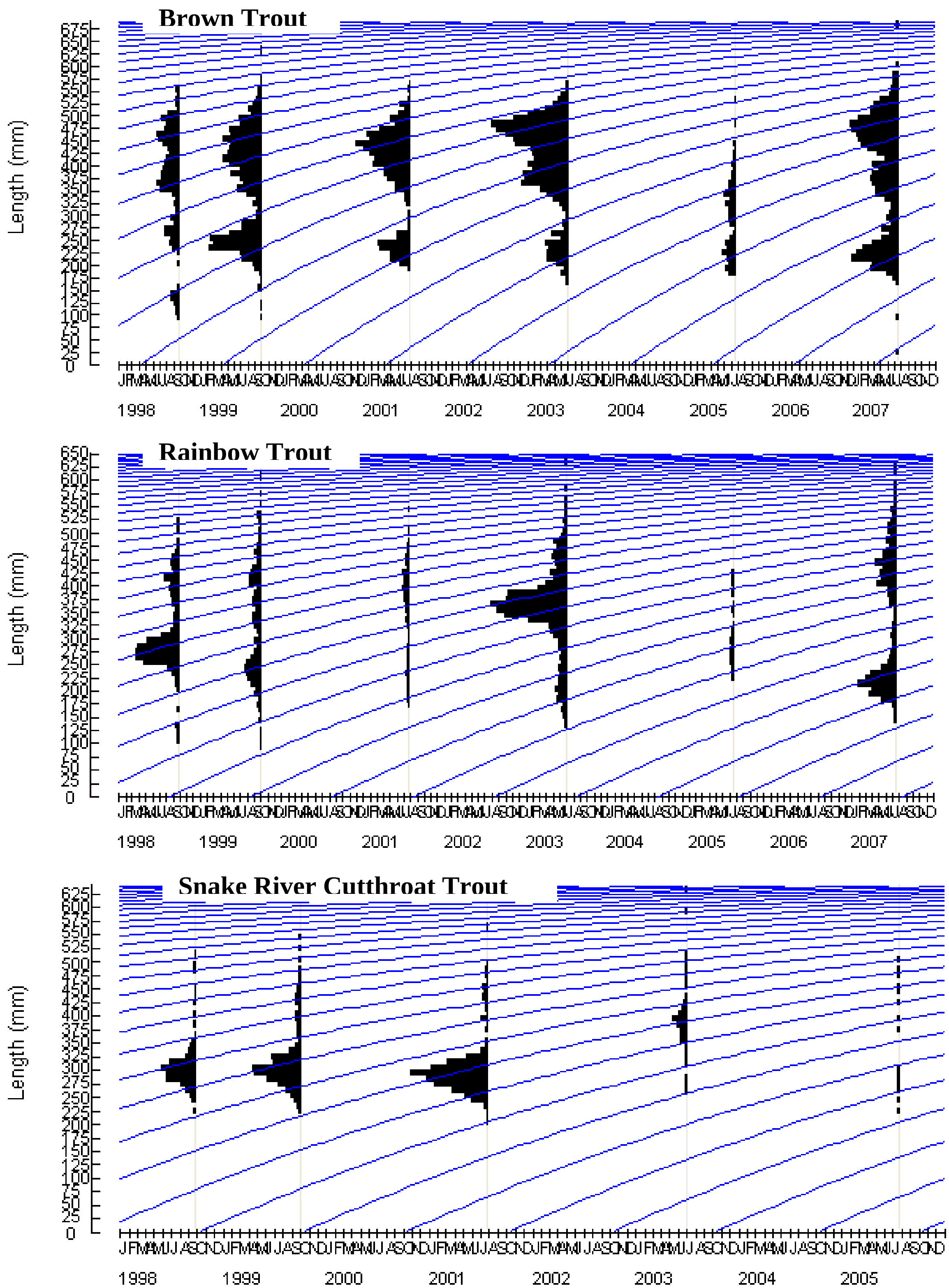


Figure 17. Growth rates of brown trout (top), rainbow trout (center), and Snake River cutthroat trout (bottom) using the routine ELEFAN in program FiSAT II to generate von Bertalanffy growth functions.

Average annual growth rates of brown trout, rainbow trout, and Snake River cutthroat trout were 0.16, 0.11, and 0.13, respectively (Table 13). These rates reflect average growth of each species for all ages; growth rates for each age can be computed from the VBGFs provided in Table 9. Annual percent increase in total length was similar for all three species with 72%, 62%, and 73% from year 1 to 2, and 36%, 34%, and 37% from year 2 to 3, respectively.

Average annual growth of brown trout for 8 years was 16%. Growth rate decreased with age and ranged from 41% in the first year to 6% in the seventh year. Growth of brown trout for the first 4 to 5 years was similar to growth of three other riverine populations; only the growth rate of fish from Pathfinder Lake was greater (Figure 18). However, growth of brown trout from the Animas River was lowest after 6 years of all populations compared. Lower growth rate of older fish in the Animas River is not readily explained, but may be a function of food supply or heavy metals contaminants.

Average annual growth rate of rainbow trout for 7 years was 11%. Like brown trout, growth rate decreased with age and size of fish. Growth rate of rainbow trout from the Animas River was lower than that of three other riverine populations and one lake population. No explanation is offered for the lower overall growth rate of rainbow trout in the Animas River, but heavy metals contaminants may be a factor.

Average annual growth rate of Snake River cutthroat trout for 6 years was 13%. Most fish survived only 1 or 2 years after stocking and average annual growth rate for the first 2 years was 35%. Growth rate of Snake River cutthroat trout from the Animas River was similar to that of fish from the Salmon River, Idaho.

Because only one sample was taken per year in every other year, estimates of fish growth in the Animas River may not be accurate. Sensitivity of these estimates can be assessed when the mark-recapture data are reconciled. Use of ELEFAN provided an estimate of growth based on length frequencies 1 to 2 years apart. Growth rate estimates of Animas River trout need to be refined for improved accuracy through age-growth analysis of scales, from close-order sampling, or from mark-recapture analyses.

Table 13. Total length at age and annual percent increase in length for brown trout (BNT), rainbow trout (RBT), and Snake River cutthroat trout (SRC) in the Animas River.

Age-→	1	2	3	4	5	6	7	8	Average
Total length (mm) at age									
BNT	122	210	286	350	405	451	491	525	--
RBT	97	157	211	260	304	343	377		--
SRC	96	166	227	281	328	369			--
Annual percent increase in total length									
BNT		72%	36%	22%	16%	11%	09%	7%	16%
RBT		62%	34%	23%	17%	13%	10%		11%
SRC		73%	37%	24%	17%	13%			13%

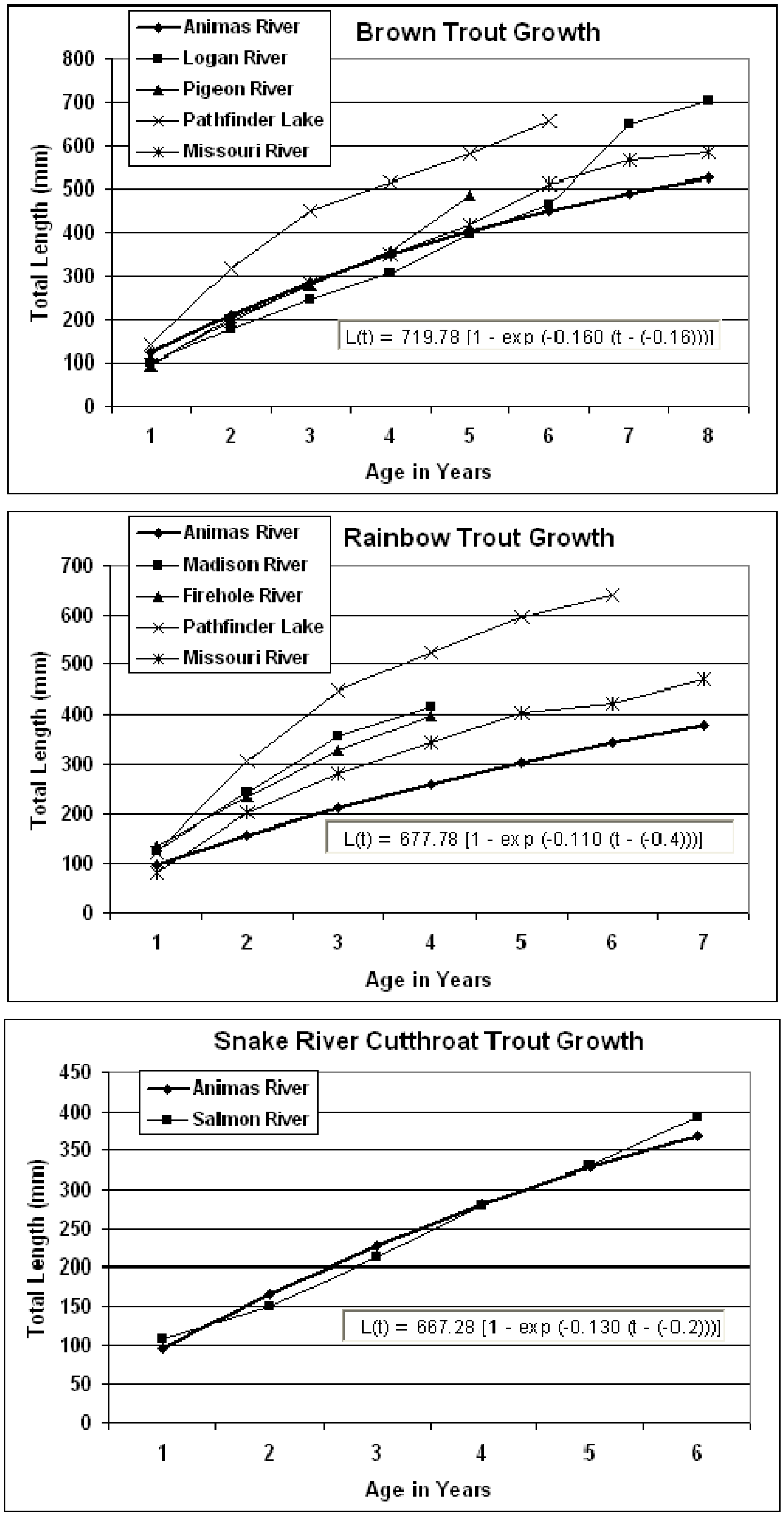


Figure 18. Growth rates of brown trout (top), rainbow trout (center), and Snake River cutthroat trout (bottom) from the Animas River based on von Bertalanffy's growth function derived with ELEFAN in the program FiSAT II and compared with growth rates from other populations.

3.8 Length-Weight and Age-Growth of Suckers

3.8.1 Length-Weight and Condition

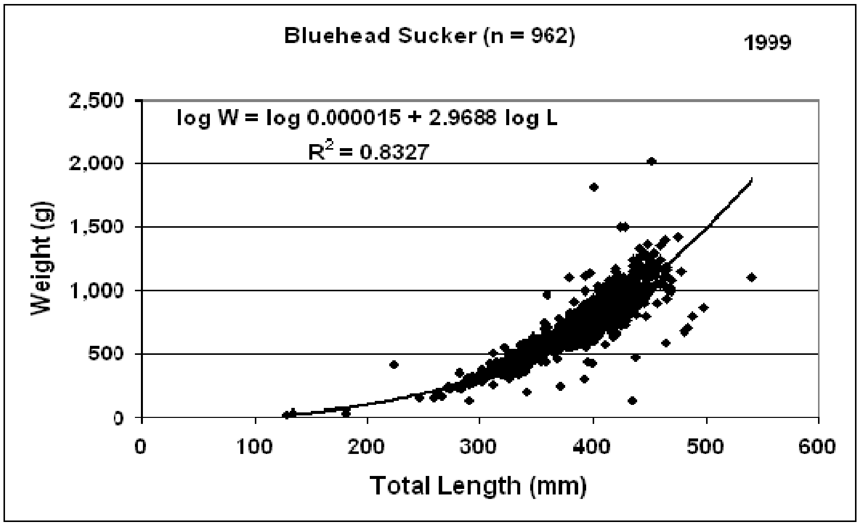
The length-weight relationships and condition factors for bluehead sucker, flannelmouth sucker, and white sucker in several years are presented in Table 14 and examples of these relationships are shown in Figure 19. Precision of length-weight relationships was variable (R^2 = 0.80-0.97 for trout; 0.44-0.94 for suckers). Precision was higher for trout because they are short-lived and generally adhere to predictable growth rates; however, suckers are long-lived and growth is more variable. Precision was also affected by several weight measures that were apparently in error. Weight measures that were apparent aberrancies were excluded from the database, but those measures that could have been legitimate were included in the analysis.

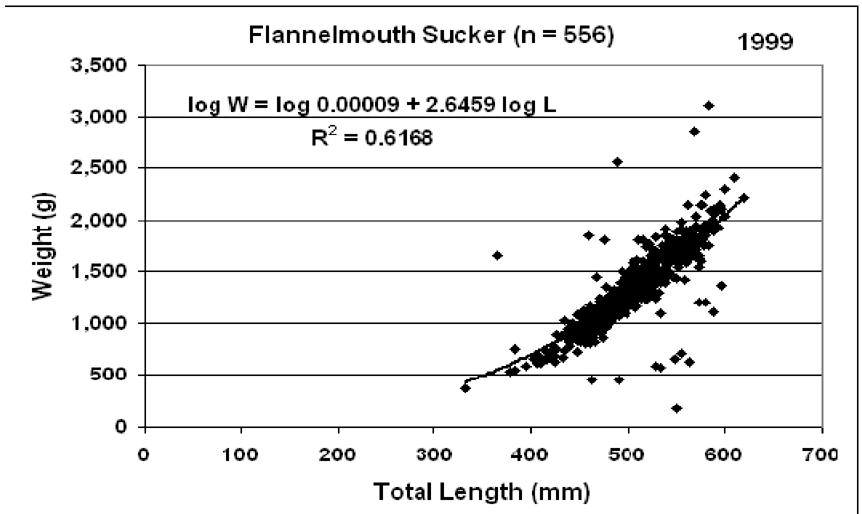
Given that weights were taken in the field by various personnel and under various weather conditions, an undetermined error rate is suspected. The only way to assess error would be to double weigh a sample of fish; i.e., two people weigh the same fish on separate scales. No weight data were available in 2005 and 2007, and insufficient numbers of weights were taken within SUIT lands in 2002, 2003, and 2004.

Table 14. Length-weight relationships and condition factors for bluehead sucker, flannelmouth sucker, and white sucker of the Animas River within SUIT lands (RM 37-56).

Species (sample size)	Year	Length-Weight Relationship	Coefficient of Determination (R^2)	Condition Factor (K_{TL})
Bluehead sucker (272)	1998	log W = -2.7447 + 2.1565 log L	0.64	1.02
(962)	1999	log W = -4.8239 + 2.9688 log L	0.83	0.98
(381)	2001	log W = -5.1079 + 3.0642 log L	0.94	1.01
Flannelmouth sucker (123)	1998	log W = -4.0000 + 2.6429 log L	0.77	0.98
(556)	1999	log W = -4.0458 + 2.6459 log L	0.62	1.03
(114)	2001	log W = -4.1675 + 2.6995 log L	0.76	1.00
White sucker (13)	1998	log W = -2.9281 + 2.2149 log L	0.44	1.03
(32)	1999	log W = -5.5376 + 3.2363 log L	0.88	1.05
(19)	2001	log W = -4.6990 + 2.9045 log L	0.80	1.05

Relative condition may be a useful metric to assess the health of trout or suckers in the Animas River under different management scenarios. Figures 20 and 21 show relative condition with 95% confidence intervals for the six principle fish species. Although sample size for trout was substantial in some cases (n = 92-506), CV varied from 0.11 to 0.23. This could be improved with increased sample size, but probably more profoundly through increased accuracy in weight measurements afield. Similarly, sample size for bluehead and flannelmouth suckers varied substantially (n = 114-962) and CV varied from 0.11 to 0.16; condition factor precision was better for these two sucker species than for trout.





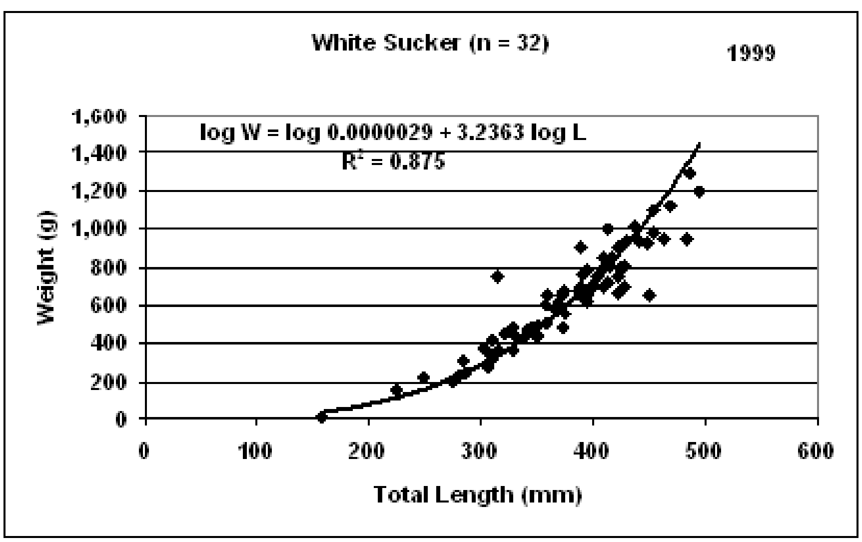


Figure 19. Length-weight relationships for bluehead sucker (top), flannelmouth sucker (center), and white sucker (bottom) from the Animas River in 1999 within SUIT lands (RM 37-56).

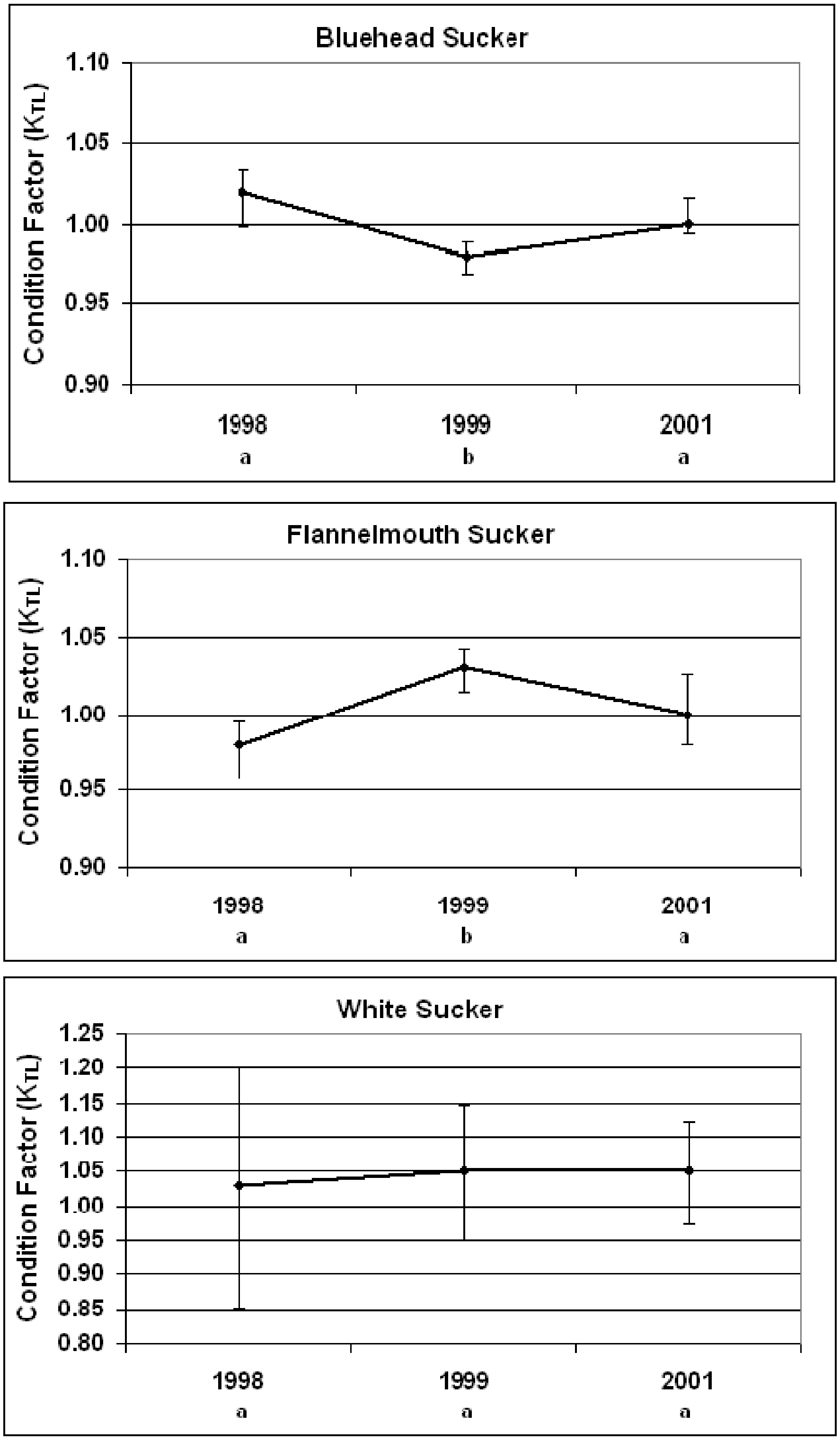


Figure 20. Relative condition of bluehead sucker (top), flannelmouth sucker (center), and white sucker (bottom) of the Animas River within SUIT lands (RM 37-56). Vertical bars are 95% confidence intervals around the mean, and same letters beneath years indicate compatible groups with means that are not significantly different ($\alpha > 0.05$).

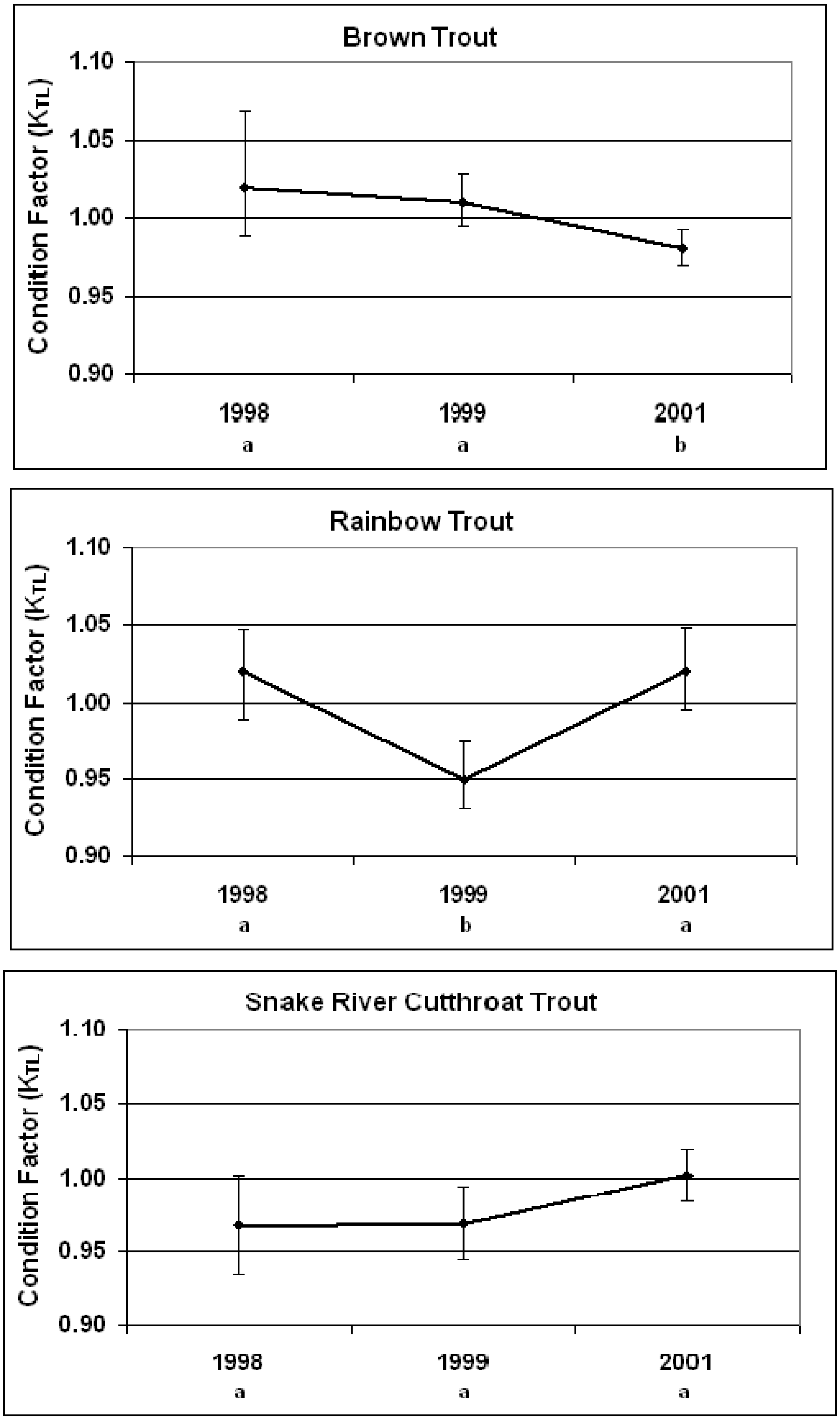


Figure 21. Relative condition of brown trout (top), rainbow trout (center), and Snake River cutthroat trout (bottom) of the Animas River within SUIT lands (RM 37-56). Vertical bars are 95% confidence intervals around the mean, and same letters beneath years indicate compatible groups with means that are not significantly different ($\alpha > 0.05$).

3.8.2 Age and Growth

The most direct way to assess age and growth of fish is through analysis of bony structures that show annual growth rings, such as scales, otoliths, or opercles. Age and growth of fish is specific to a population and body of water, and age and growth information from other populations is generally not applicable. This direct measure of age for fishes in the Animas River has been done only from interpretation of opercles from bluehead suckers and flannelmouth suckers (Zimmerman 2003).

Alternative methods for quantifying growth of fish are: (1) differences in measured lengths of marked and recaptured fish, and (2) progression of length modes. The mark-recapture data in this database have not been reconciled and hence, the modal progression technique was applied only to trout. This technique was not applicable to suckers because of the great overlap in lengths of same-age fish (see 3.7 Length-Frequency).

Opercles were examined for annual growth rings from 71 bluehead sucker and 25 flannelmouth sucker from the Animas River. Carlander's third degree polynomial best described the relationship of opercular radius to total length and length-at-age was computed for each year using standard back-calculation techniques (Figures 22 and 23). Although the paired data for opercular radius and total length are a good fit to the third degree polynomial model (R^2 = 0.92-0.97), additional opercles are needed to better define the relationship, especially for small to intermediate size fish. As is evident from Figure 19, there were five or fewer opercular pairs examined from fish less than 300 mm TL.

A more defined set of length-at-age relationships for bluehead sucker and flannelmouth sucker will help to better understand age composition of these populations, growth rates, and longevity. The oldest fish examined were 15 and 21 years of age for bluehead sucker and flannelmouth sucker, respectively. Information on age composition, growth, and longevity is also important for constructing population recruitment models, which are proposed for the next phase of work for the Animas River fisheries database analysis. These models are helpful for evaluating impacts of management actions where data are lacking or difficult to collect.

Cohort separation was difficult for bluehead sucker, flannelmouth sucker, and white sucker (Figure 12) because: (1) the 1- and 2-year old fish were rarely caught, and (2) growth of these species slows dramatically after they reach maturity in about the 4^{th} year of life leading to overlap in lengths of different age fish. When compared with the length-frequency mode separation for trout using NORMSEP (Figure 11), using sucker length information for cohort determination, growth, and survival is clearly problematic.

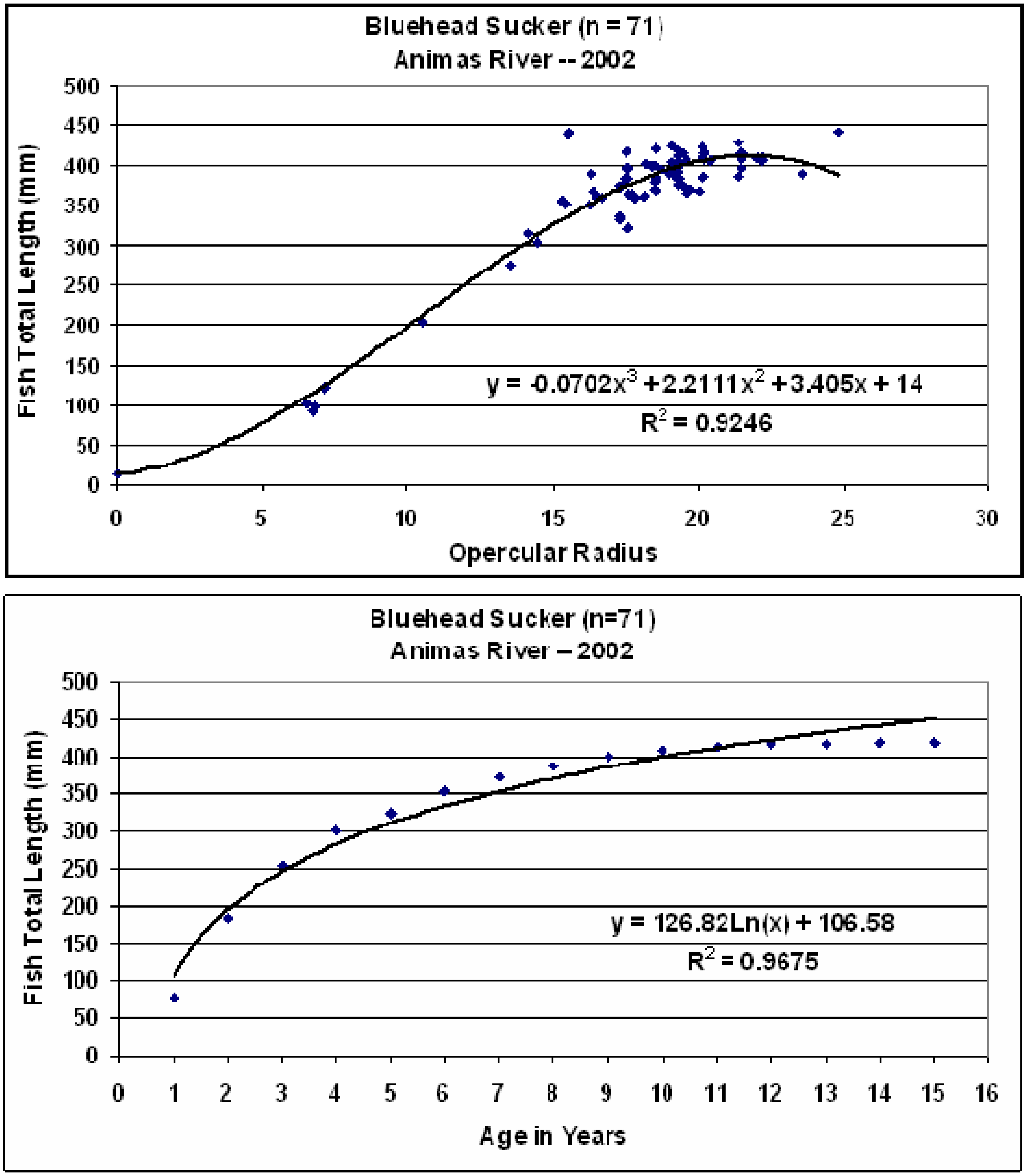


Figure 22. Relationship of opercular radius to total length (top) and length-at-age relationship (bottom) for bluehead sucker in the Animas River.

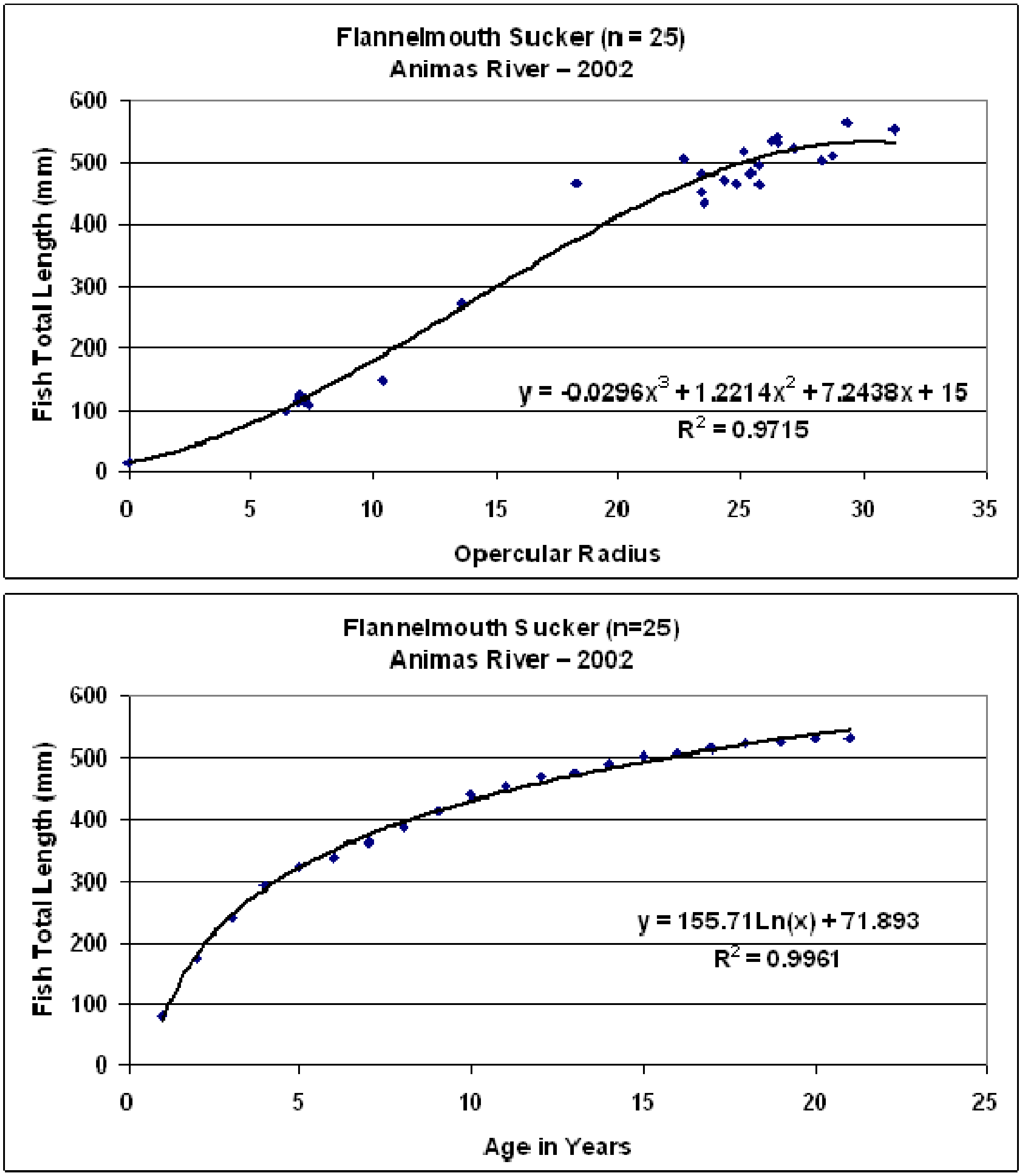


Figure 23. Relationship of opercular radius to total length (top) and length-at-age relationship (bottom) for flannelmouth sucker in the Animas River.

3.9 Survival of Trout

Survival of fish is generally estimated by tracking population size over time by marking samples of fish and recapturing them in a single event, two recapture events, or from multiple mark-recapture events called the Jolly-Seber model (Ricker 1975; Seber 1982; summarized by Miranda and Bettoli 2007). The trout tagging portion of the Animas River Database is a mark-recapture design with mark and recapture efforts spaced generally less than 2 weeks apart. The next mark-recapture effort occurs 2 years later and because the fish are fin-clipped, marks do not remain visible or unique on fish. These data are inadequate for survival estimates of trout.

An alternative but less precise way to estimate survival is with Bhattachayra's model progression routine in Program FiSAT II which tracks mean lengths of age group modes over time. This routine generated Ricker's 'Z' function from mean lengths using the Beverton and Holt model (Table 15, Figure 24).

Table 15. Survival of brown trout (BNT), rainbow trout (RBT), and Snake River cutthroat trout (SRC) from the Animas River.

Species	Size	N	Z value	Percent Survivors After Specified Years						
				1	2	3	4	5	6	7
BNT-all	All	1000	0.32	72.61	52.73	38.29	27.80	20.19	14.66	10.65
RBT-all	All	1000	0.478	62.00	38.44	23.84	14.78	9.16	5.68	3.52
RBT-200+	200+	1000	0.416		43.52	28.71	18.94	12.49	8.24	5.44
RBT-404+	406+	1000	0.921			39.81	15.85	6.31	2.51	1.00
SRC-all	All	1000	1.462	23.18	5.37	1.25	0.29	0.07	0.02	0.004

Because all three trout species are stocked in the Animas River, survival is not indicative of age, but rather years in the river. For rainbow trout, there is little apparent natural reproduction and survival reflects hatchery fish that are in the river for 1 to 7 years. This analysis indicates that 62% of stocked fish survive after 1 year in the Animas River, 38% after 2 years, 24% after 3 years, 15% after 4 years, 9% after 5 years, 6% after 6 years, and less than 4% after 7 years in the river, respectively.

There is natural reproduction of brown trout in the Animas River and the species was stocked annually from 2000 to 2007 by the CDOW, and in 2003 and 2006 by the SUIT. Hence, survival of this mixed stock is difficult to estimate without mark-recapture data. Modal progression showed that survival of brown trout was 73%, 53%, 38%, 28%, 20%, 15%, and 11% after 1 to 7 years in the river. Because of the mixed stock, it is difficult to determine if this greater survival rate by brown trout is for the same age fish as for rainbow trout.

There is no natural reproduction of Snake River cutthroat trout in the Animas River and most fish do not survive after their second year in the river. Only 23%, 5%, and 1% of stocked fish remained after 1 to 3 years in the river, respectively.

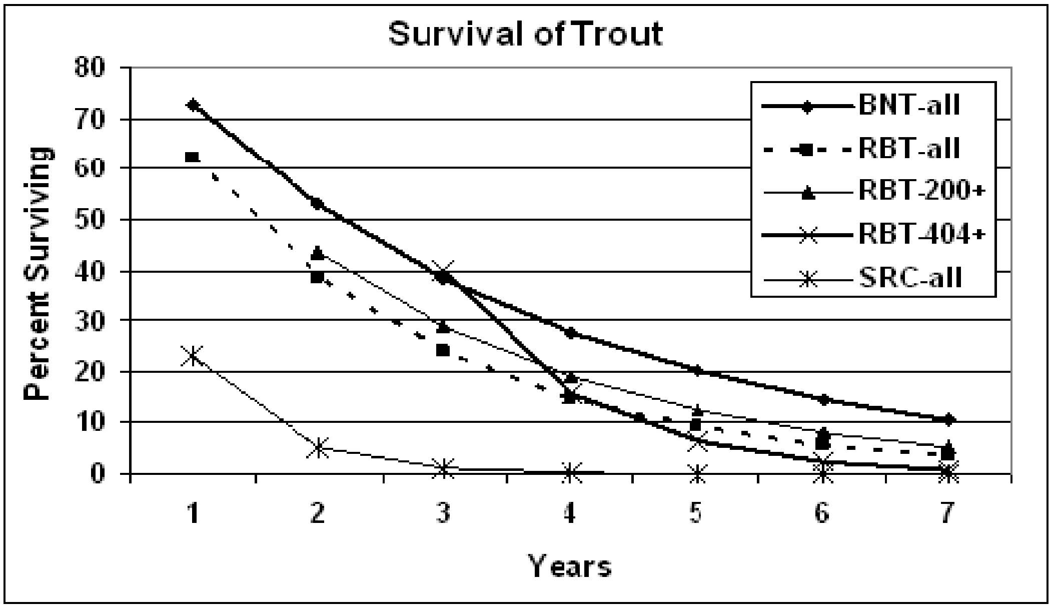


Figure 24. Survival of brown trout (BNT), rainbow trout (RBT), and Snake River cutthroat trout (SRC) from the Animas River.

These survival estimates are approximations for fish in the river after they have been stocked. These estimates do not represent survival of stocked fish. In order to estimate survival of stocked fish, it will be necessary to batch-mark the fish with coded wire tags. This will enable estimates of survival to be made for the entire time that the fish are in the river.

A more reliable, precise, and accurate method is needed to estimate survival of fish in the Animas River. The most accurate is a multiple mark-recapture estimator such as the Jolly-Seber model used on an annual basis. Increased precision is needed in this parameter to increase sensitivity of detecting a change in survival from management actions.

3.10 Trout Stocking Protocols and Patterns

Trout stocking records were provided by the SUIT for the Animas River during 1996-2007 (Table 16) and by the CDOW during 1998-2007 (Table 17). Fish stocked by the SUIT are released within the SUIT lands between river miles 56.2 and 37.1, usually at key access locations, such as Basin Creek. The SUIT stocked primarily Snake River cutthroat trout through 2001, and then stocked primarily rainbow trout with smaller, infrequent releases of brown trout. The CDOW has released seven strains of fish (see Table 17), which were consolidated into the three principal species (brown trout, rainbow trout, Snake River cutthroat trout) for this analysis, since field distinctions are not made among strains (Table 18, Figure 25). The net effect of stocking on the riverine trout population is difficult to assess because: (1) stocked fish were not marked, (2) survival and movement at stocking are not known, (3) different size and age fish were stocked.

Table 16. Dates, sizes, strains, and sources of fish stocked in the Animas River by the SUIT within SUIT lands (RM 37.1-56.2) during 1996-2007.

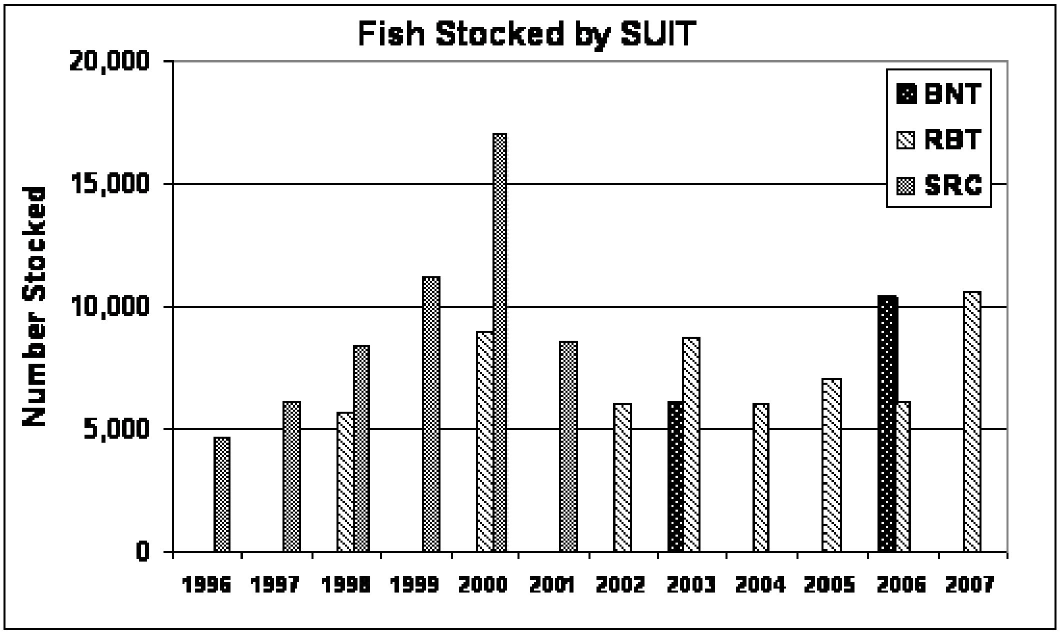
Year	Date	Number Stocked	Size, Strain, and Source of Fish Stocked
1996	15-May	1,000	8-12" Snake R. cutthroat trout from William's Creek NFH
	11-Jun	905	8-12" Snake R. cutthroat trout from William's Creek NFH
	9-Jul	1,714	8-12" Snake R. cutthroat trout from William's Creek NFH
	21-Aug	1,000	8-12" Snake R. cutthroat trout from William's Creek NFH
	Total	**4,619**	
1997	13-May	2,000	8-12" Snake R. cutthroat trout from William's Creek NFH
	10-Jun	1,500	8-12" Snake R. cutthroat trout from William's Creek NFH
	14-Jul	1,512	8-12" Snake R. cutthroat trout from William's Creek NFH
	28-Aug	1,128	8-12" Snake R. cutthroat trout from William's Creek NFH
	Total	**6,140**	
1998	22-Apr	430	12" Snake R. cutthroat trout Lake Capote transplant fish
	2-Jun	3,500	8-12" Snake R. cutthroat trout from William's Creek NFH
	11-Aug	5,700	8-12" Rainbow trout from Mescalero NFH
	27-Oct	4,500	4" Snake R. cutthroat trout
	Total	**14,130**	
1999	3-May	3,500	8-12" Snake R. cutthroat trout from William's Creek NFH
	15-Jun	2,800	8-12" Snake R. cutthroat trout from William's Creek NFH
	14-Jul	4,900	8-12" Snake R. cutthroat trout from William's Creek NFH
	Total	**11,200**	
2000	10-May	7,500	8-12" Snake R. cutthroat trout from William's Creek NFH
	29-Jun	3,500	8-12" Snake R. cutthroat trout from William's Creek NFH
	19-Jul	6,000	8-12" Snake R. cutthroat trout from William's Creek NFH
	17-Oct	9,000	4" Rainbow trout from Mescalero NFH
	Total	**26,000**	
2001	19-Jun	4,100	8-12" Snake R. cutthroat trout from William's Creek NFH
	1-Oct	4,500	4" Snake R. cutthroat trout
	Total	**8,600**	
2002	5-Jun	6,000	10" Rainbow trout from Alchesay NFH
	Total	**6,000**	
2003	14-May	8,700	Catchable Rainbow trout from Silver Springs, Kamloop Strain
	3-Dec	6,000	6" Brown trout from Alchesay NFH
	Total	**14,700**	
2004	8-Apr	6,000	5" Rainbow trout from Hotchkiss NFH, Irving Strain
	Total	**6,000**	
2005	6-Jun	3,556	10-11" Rainbow trout from Silver Springs, Kamloop Strain
	5-Aug	3,500	10-11" Rainbow trout from Silver Springs, Kamloop Strain
	Total	**7,056**	
2006	8-Jun	10,304	3" Brown trout Jones Holes
	30-Jun	4,135	10.8" Rainbow trout Mescalero TFH Erwin Strain
	21-Sep	4,200	3" Rainbow trout Jones Hole
	30-Aug	1,959	10.3-11.6" Rainbow trout Mescalero TFH Erwin Strain
	Total	**18,639**	
2007	28-Jun	5,300	8" Rainbow trout Hotchkiss
	26-Jul	2,128	10" Rainbow trout Crowther's Freshwater Trout
	31-Jul	1,065	10" Rainbow trout Crowther's Freshwater Trout
	9-Aug	2,130	10" Rainbow trout Crowther's Freshwater Trout
	Total	**10,623**	

Table 17. Numbers of trout stocked in the Animas River by the CDOW in the gold medal and standard regulations waters near Durango, Colorado (RM 57.4-62.2). CR1=Colorado River rainbow, CRR=Colorado River rainbow, LOC=brown trout, RBT=rainbow trout, RXN=rainbow x cutthroat hybrid, SRN=Snake River cutthroat trout, WEM=Weminuche Colorado River cutthroat trout.

Year	CR1 (RBT)	CRR (RBT)	LOC (BNT)	RBT	RXN (RBT)	SRN (SRC)	WEM (RBT)	Grand Total
1998				37766				37,766
1999				31992				31,992
2000		15,002	20,038			20,004		55,044
2001		20,000	20,154	32010		27,361		99,525
2002		24,309	28,361		10,497	20,026		83,193
2003		19,998	18,284	1667	833	18,285		59,067
2004		20,004	46,902	900	2,126	25,070		95,002
2005	19,996	20,004	17,882	2500				60,382
2006		20,004	22,509	2500			21,069	66,082
2007		32,810	20,144	2880				55,834
Grand Total	19,996	172,131	194,274	112,215	13,456	110,746	21,069	643,887

Table 18. Summary of trout stocked annually by the Southern Ute Indian Tribe (SUIT) and the Colorado Division of Wildlife (CDOW) in the Animas River (RM 37.1-56.2). BNT=brown trout, RBT=rainbow trout, SRC=Snake River cutthroat trout.

Year	SUIT				CDOW			
	BNT	RBT	SRC	Totals	BNT	RBT	SRC	Totals
1996			4,619	4,619				
1997			6,140	6,140				
1998		5,700	8,430	14,130		37,766		37,766
1999			11,200	11,200		31,992		31,992
2000		9,000	17,000	26,000	20,038	15,002	20,004	55,044
2001			8,600	8,600	20,154	52,010	27,361	99,525
2002		6,000		6,000	28,361	34,806	20,026	83,193
2003	6,000	8,700		14,700	18,284	22,498	18,285	59,067
2004		6,000		6,000	46,902	23,030	25,070	95,002
2005		7,056		7,056	17,882	42,500		60,382
2006	10,304	6,094		16,398	22,509	43,573		66,082
2007		10,623		10,623	20,144	35,690		55,834
Grand Totals	16,304	59,173	55,989	131,466	194,274	338,867	110,746	643,887



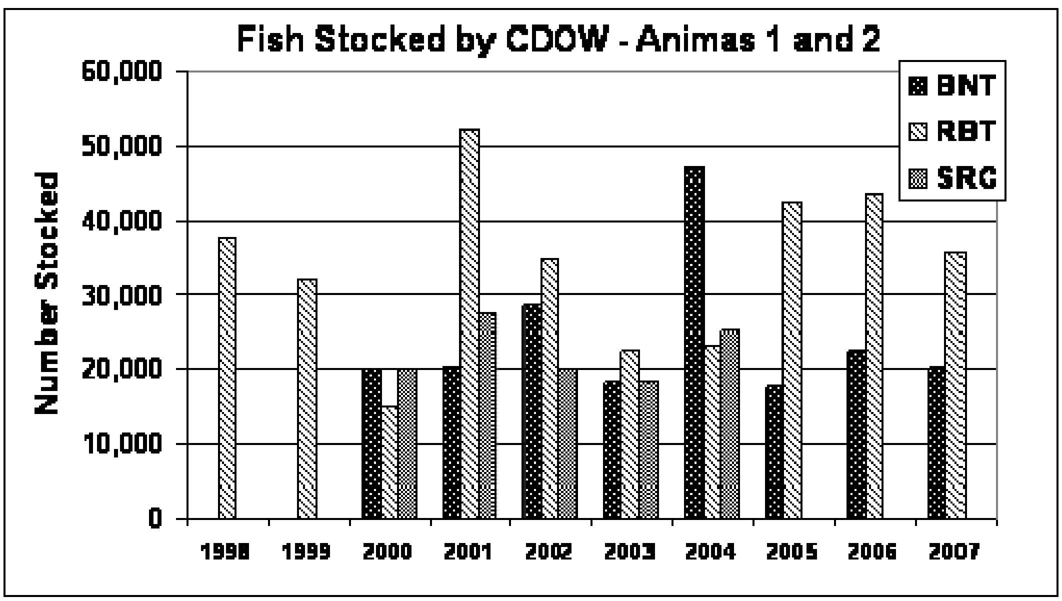


Figure 25. Numbers of brown trout (BNT), rainbow trout (RBT), and Snake River cutthroat trout (SRC) stocked by the SUIT during 1996-2007 (top) and CDOW during 1998-2007 (bottom).

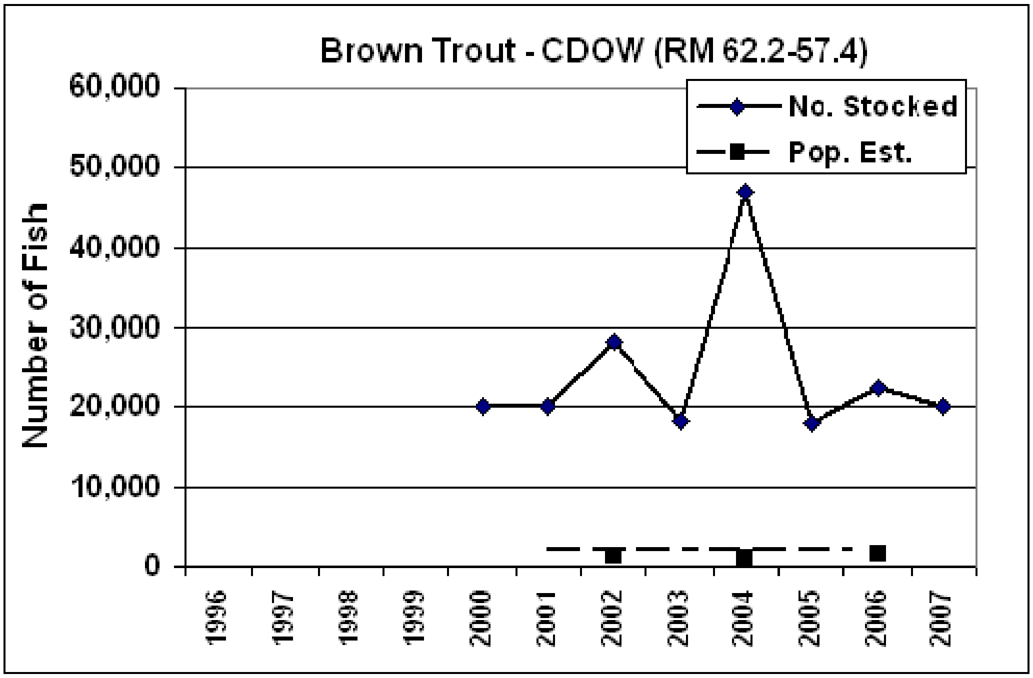
Overall, the SUIT stocked an average of 10,956 trout per year over the 12-year period (1996-2007), and the CDOW stocked an average of 64,389 trout per year over the 10-year period (1998-2007). None of these stocked fish were marked so their survival, movement, and ultimate destiny cannot be traced. Based on behavior of stocked trout in other streams, it is expected that large numbers of these stocked fish moved downstream, some perhaps for many miles. Many fish stocked by the CDOW near Durango likely move downstream into SUIT waters, and fish stocked by SUIT in their lands also distribute downstream, although high water temperatures and low flows in the lower Animas River probably restrict downstream movement or result in low survival.

How well these stocked fish do in the Animas River cannot be determined with certainty because of the lack of marked fish and post-stocking monitoring. Hence, the numbers of fish that survive the initial stockings into the river are unknown. However, because there appears to be little reproduction by rainbow trout and no reproduction by Snake River cutthroat trout, measures of the growth, survival, and abundance of these species in the river are largely for stocked fish that survived the initial release.

A comparison of fish stocked by the CDOW and SUIT to population estimates was made for the three trout species to evaluate the effect of stocking on riverine populations. Trout stocked by the CDOW are released in “Animas #1” and “Animas #2” which are the gold medal and standard fishing regulations sections near Durango, Colorado, and extend from river mile 62.2 to 57.4. The total numbers of fish stocked annually by species were totaled for this evaluation as well as the total population estimates derived from mark-recapture data. Trout stocked by the SUIT were also totaled for Reaches 1, 2, and 3 and population estimates were summed for the three reaches as well, which extend from river mile 56.4 to 37.1.

The brown trout population in the CDOW section (RM 62.2-57.4) remained stable at 1,162 to 1,535 fish (242 to 320 fish/mile) despite variable numbers stocked in that section (Figure 26). The numbers of brown trout in the SUIT section (RM 56.4-37.1) also remained relatively stable at 2,141 to 3,189 fish (111 to 165 fish/mile) despite only two stockings of 6-inch fish in 2003 and 3-inch fish in 2006. This relative population stability for brown trout may be the result of natural reproduction and habitat limitation. It is unclear if the brown trout population is sustained—or even affected—by stocking.

The rainbow trout population in the CDOW section remained stable at 2,129 to 2,810 fish (444 to 585 fish/mile) despite variable stockings of about 15,000 to 52,000 fish (Figure 27). The numbers of rainbow trout in the SUIT section increased from 807 fish in 2001 to 5,761 in 2005 (42 to 298 fish/mile) despite a fairly even number of fish stocked annually. In the case of rainbow trout, the higher numbers of fish stocked in the CDOW section may affect the net numbers in the river in the SUIT section from fish moving downstream. Clearly, stocking helps to sustain the riverine population of rainbow trout. The Snake River cutthroat trout population declined to zero after stocking stopped in the SUIT section in 2001, despite continued stocking in the CDOW section through 2004 (Figure 28). This species is sustained entirely by stocking and the fish live for only 1-2 years.



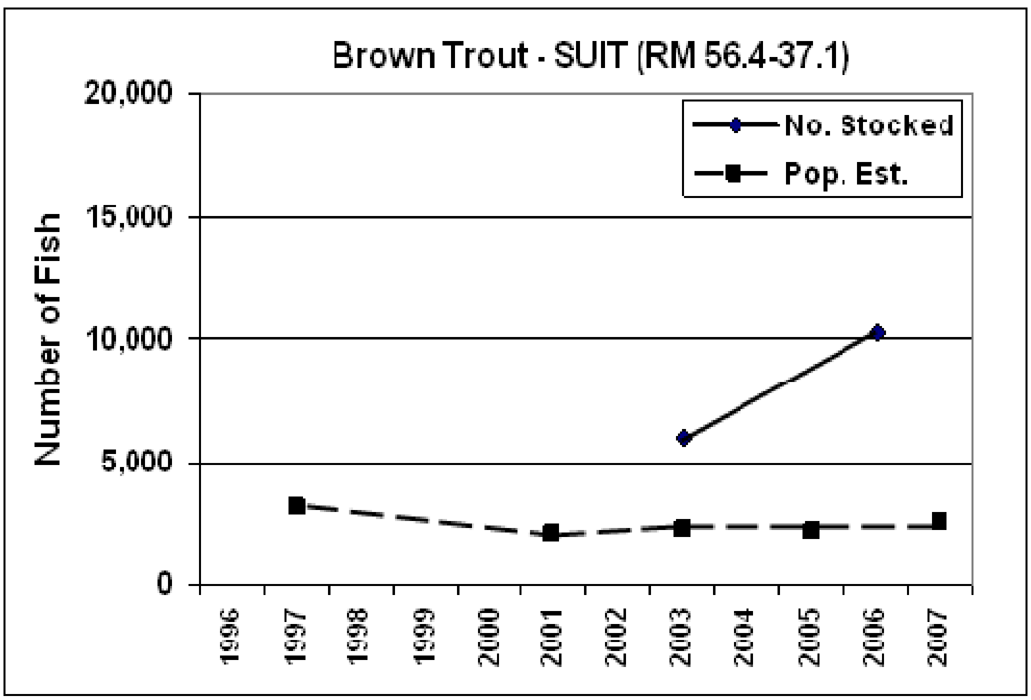
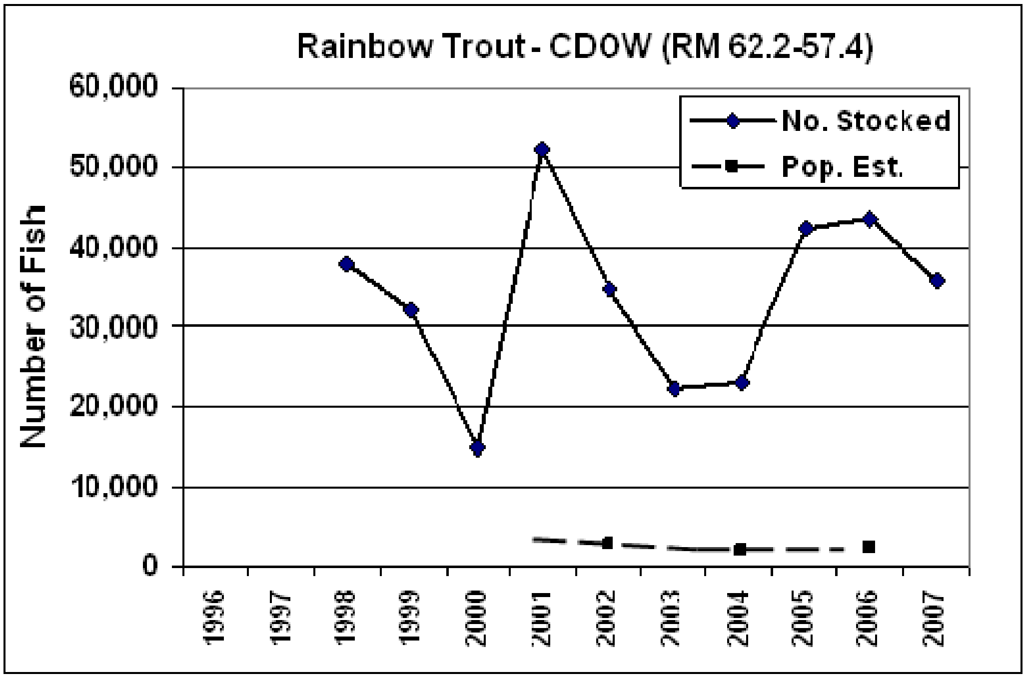


Figure 26. Numbers of brown trout stocked in the Animas River compared to population estimates for CDOW waters (top) and SUIT waters (bottom).



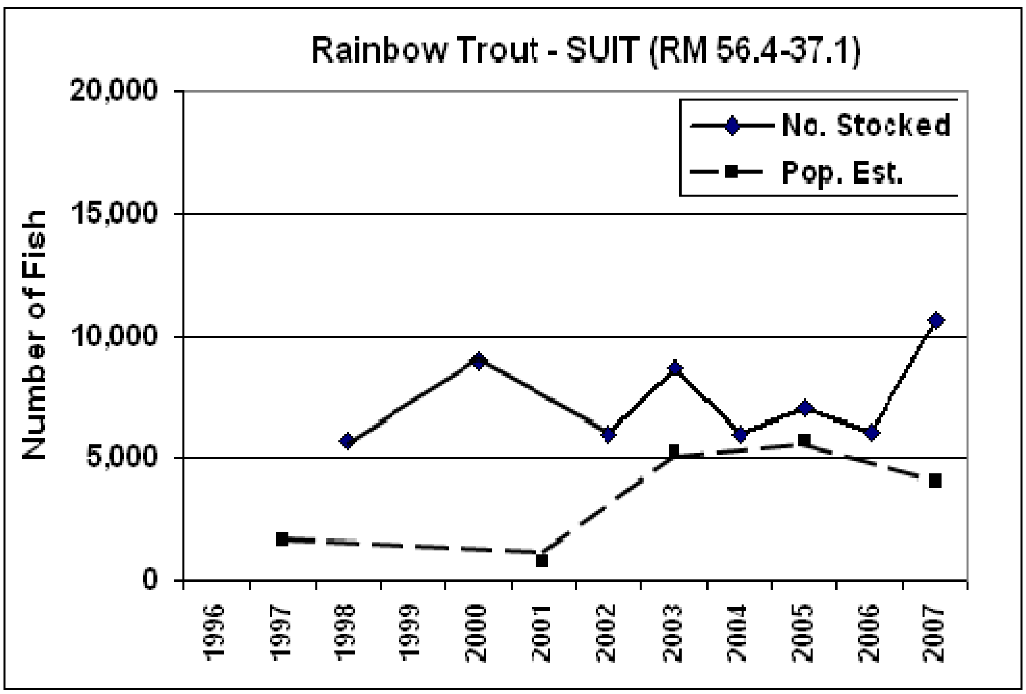


Figure 27. Numbers of rainbow trout stocked in the Animas River compared to population estimates for CDOW waters (top) and SUIT waters (bottom).

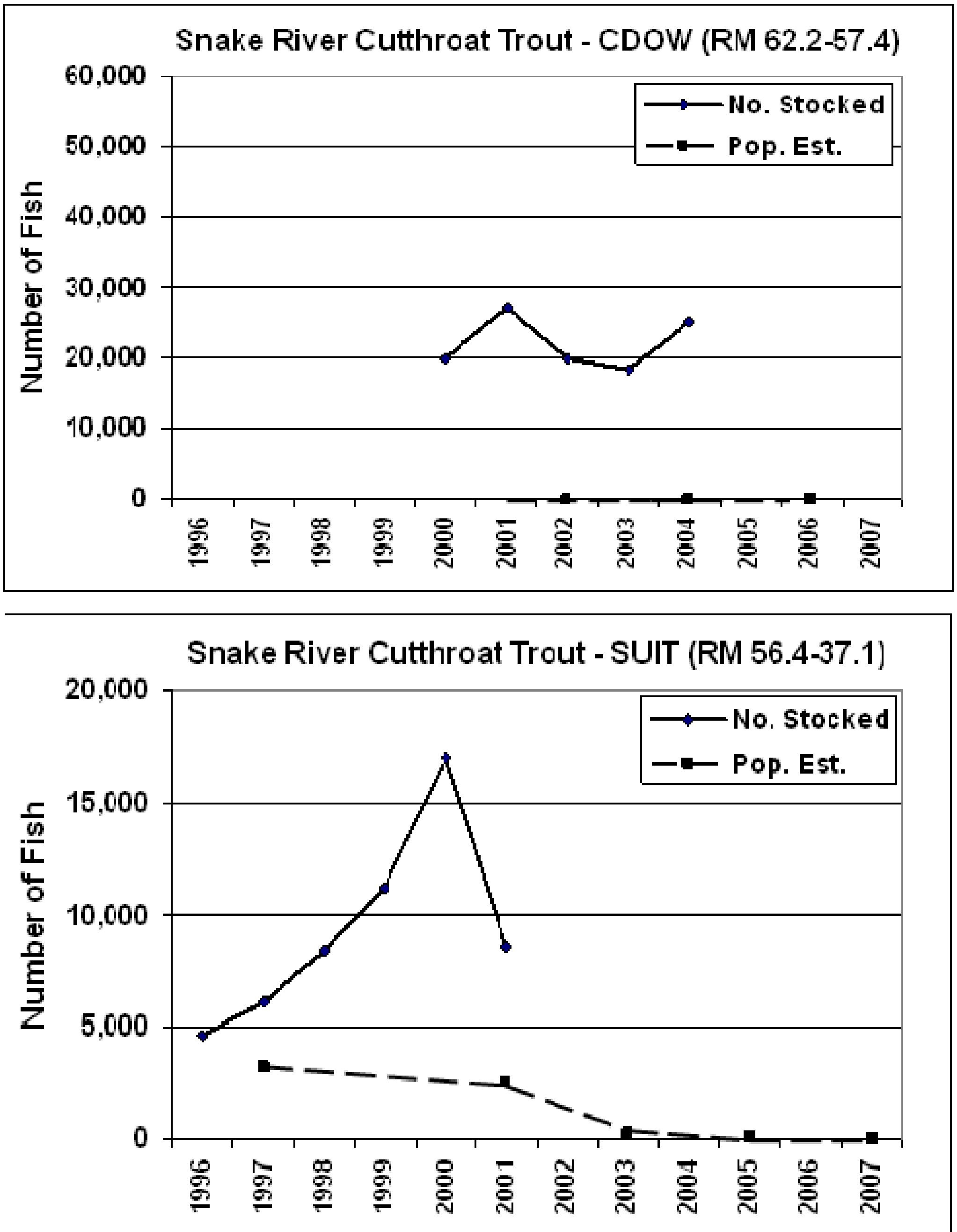


Figure 28. Numbers of Snake River cutthroat trout stocked in the Animas River compared to population estimates for CDOW waters (top) and SUIT waters (bottom).

4.0 DISCUSSION

4.1 Data Suitability and Utility for Fish Demographic Parameters

The Animas River fisheries database is stored in an Excel platform with column-specific data consisting of unique numeric and alphanumeric codes. This format facilitates data entry and analyses. Some data may be available from data sheets that were not previously entered, such as fish weights for 2005 and 2007. Data sheets should be reviewed to determine if additional data are available that could enhance analyses.

The Animas River fisheries database is suitable for evaluation of lengths and weight and is limited for evaluation of age and growth, abundance, and survival. The length-weight data lack some precision, which can be rectified through cross checks with data sheets and deletion of apparent aberrant measures. Future collection of fish lengths and weights should be done in a more precise and accurate manner.

The length data for trout were mostly suitable for determination of age and growth, but this information should be supplemented with aging of fish from scales and/or otoliths. Age determinations of fish will greatly enhance population age-structure evaluation and is necessary for development of a trout age-specific recruitment model.

The length data for native suckers was, as expected, not suitable for determination of age and growth because of the large overlap in size of different age fish. In anticipation of this limitation, opercles were collected and aged from bluehead sucker, flannelmouth sucker, and white sucker. Additional opercles are needed from small and medium-size fish for a more robust assessment of age and growth of these species. This information is also vital for development of a sucker age-specific recruitment model.

Demographic parameters such as length-weight, condition, age-growth, survival, and proportional stock density may be valuable measures of fish health when monitoring effects of the Animas-La Plata Project.

Historic fish collection data for 1934 to 1993 were presented by Miller et al. (1995). These data should be incorporated into the present database to provide the opportunity to expand analyses and provide more insight into historic fish populations and trends.

4.2 Suitability and Utility of Fish Abundance Estimates

Although the data were not specifically collected to use for catch rate estimates as a metric of fish abundance, existing data for brown trout, rainbow trout, bluehead sucker, and flannelmouth sucker provide the longest and most consistent record of fish capture information available for the Animas River. Although the precision of current data is low, these data help provide insight into fish abundances and distributions. These data will also help to determine the most appropriate sampling design for precise and accurate assessment of fish populations. This can be accomplished through either increased sample size or a stratified random sampling design that reduces sample variability.

A second drawback of the current catch rate data is that these estimates of numbers of fish per hour of electrofishing apparently have little relationship to mark-recapture abundances estimates. These catch rate estimates should reflect true population abundance if they are to be used as indices of population status and trends. As discussed above, an appropriate sampling design will be necessary to achieve better precision and accuracy, and to improve detection of changes in fish populations.

Population estimates for trout are based on close-order mark and recapture events that are spaced less than two weeks apart. These are fairly robust estimates with reasonable precision. However, these data cannot be used to estimate survival because the mark and recapture events are closely spaced, the marks are temporary fin clips, and the estimates are spaced two years apart. If population estimates of trout or native suckers are desirable or necessary, a better sampling strategy will be annual estimates for three consecutive years with two intervening years of no sampling. Marks on fish will need to be permanent (e.g., PIT tags, Floy tags, etc.) in order to procure across-year estimates and survival.

More precise fish population estimates may be possible through marking and releasing fish in short river subreaches rather than on a river-wide scale. Sampling can be restricted to pools and runs with distinct geomorphic breaks, such as long shallow riffles that minimize escapement of marked fish. Estimates from these short subreaches would need to be expanded for an estimate of the entire reach.

4.3 Effectiveness of Trout Stocking Program

The effect of stocking trout on the population of fish in the Animas River could not be fully evaluated because of the lack of marked stocked fish and annual population estimates. The fish of at least one year of stocking should be marked with coded wire tags in order to follow their survival in the river as well as their movement. Based on the available data, there was no apparent negative effect of stocking on the population of trout in the river. All three trout species were robust with good condition and populations appeared to be maintained with brown trout and rainbow trout living up to 6-7 years of age.

Snake River cutthroat trout did not appear to survive longer than 1 or 2 years after stocking. Their short longevity in the river following stocking cannot be explained, although the longevity of all trout species in the Animas River may be affected by elevated levels of heavy metals from historic mining activity in the upper watershed. The Snake River cutthroat trout is considered a “novelty fish” by anglers seeking an unusual catch. Periodic stocking of this species, when available could help to attract anglers to the Animas River on the chance of catching one of these attractive fish.

It is unclear if stocking of small brown trout helps to sustain the wild population or if that population is entirely sustained by natural reproduction. This uncertainty should be further evaluated in light of the large numbers of brown trout stocked in the Animas River. Stocking of rainbow trout appears to be vital to maintenance of the riverine population, although the amount of natural reproduction is not known. Snake River cutthroat trout survive for only 1 to 2 years after stocking, although a few individuals survive longer and become truly trophy fish.

The numbers of fish stocked and the frequency of stocking do not appear to be detrimental to the population and survival of brown trout and rainbow trout for the first 5 years in the river is high. Few Snake River cutthroat trout survive 2 years after stocking. Length-weight relationships and condition of all three trout species are comparable to other populations of similar species (Carlander 1969). Proportional stock density with fish greater than 16 inches long is exceptional for all three trout species, especially for brown trout. Also, the numbers of fish per mile is not excessive and could be several times higher in other comparable rivers.

It appears that rainbow trout stocked by the CDOW move downstream in sufficient numbers to supplement and maintain the population in SUIT waters. This is most apparent for rainbow trout, but cannot be determined for brown trout. It is noted that the population of Snake River cutthroat trout virtually disappeared in SUIT waters after stocking ceased in those waters in 2001, despite over 20,000 fish per year being stocked in upstream sections by CDOW. This evidence shows little or no downstream movement by Snake River cutthroat trout after stocking.

4.4 Population Projections for Native Suckers

The numbers of flannelmouth sucker and bluehead sucker in the Animas River appear to be large in some reaches when compared to populations in other rivers of the Upper Colorado River Basin. However, many of the fish are old adults and it is unknown if the numbers of young fish are sufficient to sustain the population long-term. These species are long-lived with successful reproduction and recruitment occurring sporadically. Capture information of these populations in the Animas River shows a disproportionate number of large, old adults and fewer numbers of small juveniles. This apparent age distribution may be a function of sampling gear; i.e., raft electrofishing captures primarily large-bodied fish. However, it is unlikely that juveniles of both species are present but not captured with raft electrofishing because crews do not report sighting many small fish during electrofishing. Alternatively, the small fish may be using habitats not sampled by raft electrofishing. This is also unlikely since the Animas River is primarily a single channel system with few side channels or embayments. Furthermore, young native suckers show up in raft electrofishing samples downstream of the Farmer’s Ditch diversion and the Farmington Lake diversion.

The viability of the flannelmouth sucker and bluehead sucker populations is not well understood. The fish appear to be reproducing but levels of survival and recruitment are unknown. Furthermore, two irrigation diversion dams impede movement of fish and may be affecting viability of these upstream populations. These diversion dams have been in place for 40 to 50 years and the persistence of native sucker populations upstream is strong evidence that successful reproduction and recruitment is occurring. Flannelmouth sucker and bluehead sucker live for 15-20 years and if recruitment had been significantly affected, the populations would be expected to be severely depleted or extirpated. Nevertheless, even a moderate reduction in recruitment could, over time, cause the population to slowly decline. Hence, the effect of these dams—as well as future management of river flows—on the long-term viability of these populations is inconclusive. An age-specific recruitment model is the best way to assess the viability of these populations. This will provide an opportunity to simulate population trajectories under different survival, recruitment, and movement scenarios.

4.5 Drift of Young Native Suckers

Flannelmouth suckers and bluehead suckers are broadcast spawners that scattered semi-adhesive eggs on cobble and gravel substrates in the main river channel. Spawning occurs in spring on the descending limb of spring runoff. The eggs incubate for 5-7 days and the larvae emerge and are swept downstream by river currents. The larvae are 14-16 mm long, without fully developed fins, and rely on a yolk sac for nutrition for about the first 2-3 weeks of their life. These larvae become entrained in eddies, shoreline embayments, and floodplains where they develop functional fins and a mouth and become active feeders of tiny zooplanktors and insects. Many larvae become entrained a short distance from their natal areas, but some may drift for many miles downstream, depending on channel geomorphology and complexity.

Reproduction and the presence of large numbers of larval suckers have been documented and the data are part of this database (see ANIMAS DATA 1 OF 2—2000 Larva). It is unknown how far these larvae drift in the Animas River and it is also unknown if enough larvae are retained upstream of the two diversion dams to provide sufficient recruitment to the populations for long-term sustainability. The relationship of young-of-year nursery habitat for native suckers to river stage should be quantified and modeled in order to predict how flow variation in the Animas River can affect this habitat.

4.6 Insights into Developing a Fish Monitoring Program

This Phase I was not intended to develop a monitoring program for fish in the Animas River. A monitoring program should be developed under Phase II and in collaboration with managers and biostatisticians. The following provides insight into a fish monitoring program.

The first step in developing a fish monitoring program for the Animas River will be to identify the needs of the program. These needs should be identified by the managers in collaboration with fish biologists and biostatisticians as a series of questions. These needs drive the sampling design and help to determine the types of data to be collected, the timing of those collections, as well as the frequency.

The second step of developing a monitoring program is to develop acceptable levels of precision, accuracy, sensitivity, and risk. Precision is the variability around the sample statistics that describe the goodness of the estimates. Precision can generally be improved through an appropriate sampling design (to control resource variability), appropriate sample methods (to control sampling variability), and a sufficient number of samples. Precision determines one's ability to detect changes with some specified degree of confidence (usually 95%). Managers need to recognize that high precision may not be achievable with certain resources, and alternative means of impact evaluation may be necessary. The expected precision from monitoring can be approximated by using the existing data and performing simulations; these analyses are proposed under Phase II.

Accuracy is a reflection of how well the sample data portray the real population size and dynamics. As was demonstrated above, the existing catch rate data bear little relationship to population size. Any metric used to portray the status and trends of fish populations should have some known relationship to true abundance.

Sensitivity refers to the ability to detect a change in a metric, such as population size or a catch rate estimator. The sensitivity for detecting a change in brown trout catch rate was 75% or greater; in other words, catch rate (and presumably population size) would have to change by at least 75 % before it could be detected with the present data at a significance level of $\alpha \leq 0.05$. Acceptable sensitivity levels need to be established by managers and the sample design and cost need to be determined in advance.

Finally, it is important to understand the risk associated with monitoring of certain resources and what contingencies, if any, need to be implemented if a particular sampling design does not yield desired information. The degree of risk is greatly reduced when a database exists, such as the Animas River Fisheries Database, from which one can draw inferences about the expected characteristics and behavior of certain types of data.

5.0 RECOMMENDATIONS

1. Maintain the Animas River Fisheries Database and record and enter all future fisheries data in compatible format.

2. Cross check data inconsistencies, discrepancies, and missing data in electronic database against field data sheets.

3. Reconcile tag numbers and colors for native suckers so that data can be used for population estimates.

4. Conduct population estimates for three consecutive years with two intervening years of no sampling in order to procure more precise and reliable estimates of abundance and survival.

5. Use long-term tags for population estimates (e.g., PIT tags, Floy tags).

6. Improve accuracy and precision of fish weight measurements in the field.

7. Improve accuracy and precision of native sucker tagging and documentation procedures.

8. Collect scales and/or otoliths from all trout species in the Animas River in order to develop age-growth relationships

9. Continue to collect opercles and otoliths from all sucker species in the Animas River in order to refine age-growth relationships.

10. Develop age-specific recruitment models for native suckers and for trout; i.e., one model for flannelmouth sucker and bluehead sucker, and one model for brown trout, rainbow trout, and Snake River cutthroat trout.

11. Procure prior fisheries data from the Animas River to incorporate into the existing database; e.g., Nehring, Miller.

12. Conduct a more thorough evaluation of the trout stocking program for the Animas River with coded wire tagged fish and the use of age-specific recruitment models; e.g., determine if stocking of brown trout is necessary.

13. Continue to stock Snake River cutthroat trout, as available, to provide a novelty fish for anglers.

14. Quantify species composition and abundances of small-bodied fishes of the Animas River through different gears and sampling methods.

15. Convene a workshop of ALP administrators, managers, biologists, and statisticians to define information needs and design a monitoring program accordingly.

16. Develop a formal monitoring plan that defines information needs, sampling design, sample sizes, and desired precision, accuracy, and acceptable levels of detectable change.

17. Translocate flannelmouth sucker and bluehead sucker upstream of the Farmer's Ditch and Farmington Lake Diversion during low river flows.

18. Remove and euthanize nonnative white sucker and their hybrids from the Animas River.

19. Locate sources of white sucker to the Animas River, and if possible, implement measures to reduce escapement.

20. Evaluate habitat of young-of-year flannelmouth sucker and bluehead sucker at the full flow range of the Animas River.

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APPENDIX A: Photographic Record

Photo Set 1. Electrofishing raft in operation on the Animas River (top) and navigating past the Farmer's Ditch diversion (bottom).

Photo Set 2. Bluehead sucker (top), flannelmouth sucker (center), and white sucker (bottom) from the Animas River.

Photo Set 3. Brown trout (top), rainbow trout (center), and Snake River cutthroat trout (bottom) from the Animas River.

Photo Set 4. Farmer's Ditch diversion during low flow (top), during medium flow (center), and Farmington Lake diversion (bottom).