ISSN 1330–061X
CODEN RIBAEG

UDK 591. 1: 597. 553. 2](78)
Original scientific paper

GROWTH, MORTALITY AND PRODUCTION OF BROWN AND RAINBOW TROUT IN NEW MEXICO STREAMS

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Summary

Thirty–two representative trout sites in 15 high elevation New Mexico streams (1,661 — 2560 m above sea level) were sampled in 1988 and 1989. Fish was captured by consecutive removal via electrofishing in net–blocked segments from 65 to 160 m long. Maximum estimated trout length (L_{max}) was related inversely to yield (r^2 = 0.351; p = 0.055). Instantaneous rate of mortality was also marginally related to yield (r^2 = 0.294). The production index ranged from 1,38 to 32.02 g/m^2/year. Varitation in production was highly correlated to trout biomass (r^2 = 0.910). Trout growth and production were best defined by the relationships where: cover, stream width, water temperature, yield by anglers, L_{max}, and nitrate–nitrogen concentration were included.

Key words: Salmo trutta m. fario, Oncorhynchus mykiss, streams, growth, production, mortality, New Mexico, management

INTRODUCTION

Stream trout management routinely relies on estimates of standing stock (concentration of biomass) as an index to fishery management needs (Everhart et al., 1975). Other reserachers have emphasized the importance of certain habitat attributes in predicting rainhow and brown trout biomass and production. Wesche and Goertler (1987) predicted standing crop of brown trout for Wyoming streams from measures of cover and flow regime. Lewis (1969) documented that the cover was the most important factor for brown trout, *Salmo trutta*, and current velocity for rainbow trout, *Oncorhynchus mykiss*, in a Montana stream. Heggenes (1988) found that the brown trout were associated with deeper and faster water with diverse substrate an plentiful cover. Kondolf et al. (1991) argued that periodic mobility of gravel may favor brown trout abundance over rainbow trout in

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the eastern Sierra Nevada because of seasonal reproductive differences. Predictive variables in a model developed in small Rocky mountain streams were dominant by geomorphologic features (Lanka et al., 1987). Combined brown and rainbow trout biomass in New Mexico streams was simply correlated to nitrate–nitrogen concentration, zoobenthic biomass, and zoobenthic diversity; while the brown trout biomass was positively correlated with cover and negatively correlated with fishing intensity (Leiner, 1992).

Other trout species also have been investigated. In Colorado's small streams, brook trout, *Salvelinus fontinalis, Salmo spp.* production and biomass were related inversely to elevation and directly to substrate diversity, conductivity, alkalinity, and water hardness (Scarnecchia and Bergersen, 1987). Mesick (1988) found that to maintain residency of Apache trout, *Oncorphynchus apache*, and brown trout, overhead cover in the form of concrete blocks had to be placed in previously unoccupied stream sections.

This study was conducted to evaluate the roles that fishing intensity play in determining the mortality and production of brown and reinbow trout in representative streams of New Mexico. For comparability included among the streams were several sections closed to public fishing.

METHODS

Stile Selections

Data were collected from 32 sites on 15 streams in New Mexico from June 1988 to November 1989. Eleven of the streams drained from the north–central mountains into the Rio Grande including the upper Rio Grande, Red River, Rio Pueblo de Taos, East Fork of the Jemez River, San Antonio, Cebolla, Rio de Las Vacas, Guadalupe River, Jaramillo Creek, Pecos River, and the Rio Penasco (Table 1). Of streams selected in the southwestern Gila Mountains, the Mimbres River flows to a closed basin and the West Fork of the Gila River and Mogollon Creek eventually contribute to the Colorado River. The Cimarron River drains eastward from Eagle Nest Reservoir, in the north–central mountains, to the Canadian River, a tributary of the largest river in the world, the Mississippi River.

The streams and sites were chosen to represent the widest range of trout habitat types, potentially available to trout anglers, including sites presently closed to public access. Some of the study sites were subject to drought and flooding particularly in the southern mountains. During this study, sites on Mogollon Creek and the Mimbres River became intermittent between permanent pools during early summer months. Nearby, the West Fork of the Gila River flooded in spring 1989.

Table 1. Site locations on fifteen study streams in New Mexico
Tablica 1. Uzorkovane postaje na 15 vodotokova države New Mexico

Site code number	Stream name (U/M/L)[a]	County (land status)[b]		Trout species (B/R)[c]	No. samples
1	Cebollar R. (U)	Sandoval	(NF)	B	1
2	Cebolla R. (U)	Sandoval	(NF)	B	1
3	Cimarron (U)	Colfax	(WA)	B	1
4	Cimarron (M)	Colfax	(WA)	B	1
5	Cimarron (L)	Colfax	(WA)	B,R	1
6	Jemez R. E. Fork (sp)[d]	Sandoval	(P)	B,R	1
7	Jemez R. E. Fork (bsp)[e]	Sandoval	(P)	B,R	1
8	Jemez R. E. Fork (U)	Sandoval	(NF)	B,R	7
9	Jemez R. E. Fork (L)	Sandoval	(NF)	B,R	6
10	Guadalupe R	Sandoval	(NF)	B	1
11	Jaramillo Cr. (U)	Sandoval	(P)	B,R	1
12	Jaramillo Cr. (L)	Sandoval	(P)	B,R	1
13	Rio de Las Vacas (U)	Sandoval	(NF)	B	1
14	Rio de Las Vacas (L)	Sandoval	(NF)	B	1
15	Mimbres R. (U)	Grant	(NF)	R	3
16	Mimbres R. (L)	Grant	(NF)	R	9
17	Mogollon Cr.	Grant	(P)	B,R	1
18	Pecos R (U)	San Miguel	(NF)	B	1
19	Pecos R (L)	San Miguel	(NF)	B,R	1
20	Rio Pueblo de Taos	Taos	(SP)	B,R	1
21	Red R. (U)	Taos	(NF)	B,R	1
22	Red R. (L)	Taos	(NF)	B,R	1
23	Rio Grande (U)	Taos	(SP)	B,R	1
24	Rio Grande (M)	Taos	(SP)	B,R	1
25	Rio Grande (L)	Taos	(SP)	B,R	1
26	Penasco R.	Chaves	(NF)	B,R	1
27	San Antonio R. (Baca)[f]	Sandoval	(P)	B	1
28	San Antonio R. STW (U)[g]	Sandoval	(NF)	B	4
29	San Antonio R. STW (U)	Sandoval	(NF)	B	5
30	San Antonio R. bSTW[h]	Sandoval	(NF)	B	2
31	Gila R. West Fork (U)	Catron	(NM)	B,R	5
32	Gila R. West Fork (L)	Catron	(NM)	B,R	6

a Sites: Upper/Middle/Lower; [b] NF=national forest, P=privates, WA=state wildlife area, SP=state park, NM=national monument; [c] B=brown, R=rainbow; [d] spring; [e] downstream of spring; [f] the most upper site on Baca Ranch; [g] special trout water (STW); [h] downstream of STW.

Physical and Chemical Characteristics

Using the transect system described by Platts et al. (1983), stream physical features were measured at each of the surveyed sites, including mean stream width, mean depth, annual stream flow variation (ASFV), and mean water velocity (Table 2).

Table 2. Physical and chemical characteristics of study streams

Tablica 2. Fizikalne i kemijske značajke istraživanih vodotokova

STREAM	ELEVATION (m)	DEPTH (m)	WIDTH (m)	WATER VELOCITY (m/s)	MAXIMUM WATER TEMP (°C),	ASFV*	NITROGEN (mg/1)	COVER (%)
CIMARRON	2,382	0.27	8.8	0.48	18.8	2000	0.13	43
LAS VACAS	2,250	0.19	6.8	0.38	25.0	25	0.01	64
GUADALUPE	2,012	0.26	6.2	0.37	18.0	27	0.01	84
MIMBRES	2,109	0.16	6.0	0.32	17.0	550	0.07	37
PECOS	2,414	0.29	13.4	0.52	12.0	49	0.01	31
PUEBLO	1,890	0.33	7.8	0.39	22.0	8	0.25	73
RIO GRANDE	1,833	0.47	23.0	0.74	23.0	11	0.23	38
EAST FORK,OF JEMEZ	2,560	0.18	7.1	0.28	19.5	34	0.01	60
SAN ANTONIO	2,532	0.21	5.1	0.37	24.0	34	0.01	42
RED R.	2,158	0.32	7.2	0.54	18.0	5	0.26	51
CEBOLLA	2,275	0.16	3.2	0.34	16.0	27	0.01	23
RIO PENASCO	1,926	0.18	9.9	0.62	16.0	25	0.32	10
MOGOLLON	1,661	0.18	7.8	0.25	18.0	808	0.01	29
W. F. GILA	1,737	0.18	7.9	0.20	22.0	13	0.01	16
JARAMILLO	2,676	0.23	1.9	0.47	16.9	20	0.01	15

*ASFV RATIO = ANNUAL MAXIMUM FLOW / ANNUAL MINIMUM FLOW

Nitrate–nitrogen concentration were determined by the Soil and Water Testing Laboratory at New Mexico State University according to APHA (1975) procedure. Data on discharge fluctuation were determined from the United States Geological Survey (USGS) reports at sites nearest to the sampling locations. Water temperature was measured when temperatures reached their peak in afternoon. Cover was estimated according to Platts et al. (1983).

Population Measurements and Analysis

Fish were progressively captured and removed during three to four passes with a Type VII or Type XI Smith–Rooth DC–current electroshockers in net–blocked segments from 65 to 160 m long.

At San Antonio River and East Fork of the Jemez River, all captured trouts were marked with fingerling or dart tags (Wydoski and Emery, 1983) during May and August 1989.

Otoliths were removed from up to five trouts in easch 20–mm category, stored dry and examined for age determination in water and glycerin, generally as described by Caillet et al. (1986). Von Bertalanffy (1938) growth parameters were derived from a least squares fit to the sample data (Ricker, 1975) for those streams where sufficient numbers of trout allowed reasonable estimates. No otoliths were taken at several sites located on private land, closed to public, including the upper San Antonio, upper East Fork of the Jemez River, Jaramillo Creek, and Mogollon Creek.

For all fish caught, the length–weight relationship was calculated (Bagenal and Tesch, 1978) separately for brown and rainbow trout.

Trout survival was estimated as described by Chapman and Robson (1960) and Robson and Chapman (1961) based on age structure of captured fish. Use of the procedure assumes that survival rate is constant at all ages, that all age–classes are recruited at the same abundance, and that all ages are equally accessible to the sampling gear. Sufficient fish were caught to estimate survival of brown trout in 10 studied streams and rainbow trout in two streams. In this manner, age groups that were not fully recruited into the sampled population were eliminated from the survival estimate after applying the test by Robson and Chapman (1961).

Trout weights were derived from length–weight relationship models, which were used to calculate the mean instantaneous rate of growth for the year classes that were fully recruited into a sample (Robson and Chapman, 1961). Production was calculated according to Ricker (1975).

Relationships between production, biomass, and physical and chemical attributes were investigated by using simple and multiple regressions (Snedecor and Cochran, 1967). The adjusted coefficient of multiple determination (R^2_a) and the coefficient of simple determination (r^2) were used as suggested by Neter et al. (1989).

RESULTS

For those populations numerous enough to estimate L_{max} (Table 3), it ranged from 225 mm in the Pecos River to 441 mm in the Red River. Brown trout in the closed for fishing Red River stood out exceptionally among all rivers sampled. Because L_{max} is determined by growth rate and by mortality, the Red River population was exceptional because the river sustained both low instantaneous rate of mortality and relatively high instantaneous rate of growth (Table 4). Instantaneous rate of mortality, ranging between 0.42 in the Mimbres River and 0.88 in the Cimarron River, generally was greatest where fishing impact was most intense and lowest where fishing pressure was least intense. The Mimbres population, although fished lightly, was also slow growing and had few fish in harvestable sizze ranges (over 200 mm). Stream sections closed to fishing universally had higher survival rates (Table 5). The correlation between number of caught fish by anglers and mortality was high (r^2 = 0.478; p = 0.018), explaining where most of the variation in instantaneous rate of mortality occured.

Table 3. The von Bertalanffy (1938) growth equation for trout population in New Mexico streams: $L_t = L_{max} /1-exp((-K(t-t_o))/^*$

Tablica 3. Jednadžbe rasta (Bertalanffy, 1938) za populacije pastrva u vodotokovima države New Mexico: $L_t = L_{max} /1-exp((-K(t-t_o))/^*$

STREAM	PARAMETERS L_{max} (mm)	K	t_o	TROUT	AGE RANGE (N)[a]
CIMARRON /0/[b]	281.8	0.787	1.036	BROWN	II–V (55)
LAS VACAS /0/	3935	0.368	0.630	BROWN	I–III (28)
GUADALUPE /0/	335.3	0.277	0.329	BROWN	II–V (20)
MIMBRES /0/	376.3	0.080	–1.630	RAINBOW	II–VII (41)
PECOS /0/	224.5	0.612	0.508	BROWN	I–IV (49)
PUEBLO /0/	312.2	0.968	–0.295	BROWN	I–III (24)
RIO GRANDE /0/	291.7	0.742	0.332	BROWN	I–V (66)
E. J. JEMEZ /0/	260.4	0.490	–0.140	BROWN	I–V (65)
S. ANTONIO /0/	298.3	0.431	–0.790	BROWN	I–IV (64)
RED /C/	440.9	0.430	0.700	BROWN	I–IV (21)
RED /C/	291.3	0.390	–0.360	RAINBOW	0–IV (24)

* L_{max} = the mathematical asymptote of the curve (often referred to as the »final« or »maximal« size).
K = a measure of the rate at which the growth curve approaches the asymptote.
t_o = the hypothetical starting time at which the fish would have been zero length if they had always grown according to growth equation.
a N = number of fisht and age classes used in growth equation.
b /0/ = open to public fishing; /C/ = closed to public.

Along with the Mimbers population, instantaneous rate of growth was low for populations in San Antonio, Cimarron, and Jemez rivers, and high for the Rio de Las Vacas, Guadalupe, and Red rivers. The estimated maximum length obtained, L_{max}, was a function of growth. Streams with lowes L_{max} typically had slowly growing trouts (Table 4). High biomass was not a good predictor of high growth rate. Among the streams with highest biomass, growth varied between extremes for all of the streams studied.

Tabele 4. Trout length, instantaneous mortality rate, specific growth rate, biomass, and production in New Mexico streams

Tablica 4. Dužina, trenutačna stopa smrtnosti, specifični rast, biomasa i produkcija pastrva u vodotokovima države New Mexico

STREAM	L_{max}* (mm)	MORTALITY	GROWTH	BIOMASS (g/m²)	PRODUCTION (g/m²/yr)	TROUT
CIMARRON /0/[a]	281.8	0.880	0.48	5.80	2.78	BROWN
LAS VACAS /O/	393.5	0.762	2.21	2.65	5.87	BROWN
GUADALUPE /O/	335.3	0.571	1.59	3.93	6.25	BROWN
MIMBRES /O/	376.3	0.421	0.34	4.02	1.28	RAINBOW
PECOS /O/	224.5	0.757	1.22	2.43	2.97	BROWN
PUEBLO /O/	312.2	0.750	1.28	7.22	9.26	BROWN
RIO GRAND /O/	291.7	0.672	0.75	3.99	2.99	BROWN
E.F. JEMEZ /O/	260.4	0.518	0.51	4.33	2.21	BROWN
S. ANTONIO /O/	298.3	0.743	0.44	3.25	1.43	BROWN
RED /C/	440.9	0.465	1.67	18.61	31.02	BROWN
RED /C/	291.3	0.464	0.99	6.41	6.35	RAINBOW

[a] O=Open to public; C=Closed to public.
* =Maximum length predicted by Von Bertalanffy equation.

Table 5. Survival statistics of trout populations in New Mexico

Tablica 5. Statistika preživljavanja populacija pastrva u državi New Mexico

STREAM	SURVIVAL (S)	MOR-TALITY (1–9),	V	STD. ERROR	95% C. I.	TROUT	AGE* CLASSES
CIMARRON /O/[a]	0.120	0.880	0.004	0.066	0.01–0.25	B	I, II, III
LAS VACAS /O/	0.238	0.762	0.009	0.095	0.05–0.43	B	I, II
GUADALUPE /O/	0.429	0.571	0.009	0.095	0.24–0.62	B	I, II
MIMBRES /O/	0.579	0.421	0.003	0.055	0.47–0.69	R	I
PECOS /O/	0.243	0.757	0.005	0.070	0.10–0.38	B	I, II
PUEBLO /O/	0.250	0.750	0.010	0.099	0.05–0.45	B	I
RIO GRANDE /O/	0.328	0.672	0.004	0.066	0.20–0.45	B	I
E. F. JEMEZ /O/	0.482	0.518	0.002	0.044	0.39–0.57	B	I
S. ANTONIO /O/	0.257	0.743	0.006	0.075	0.11–0.61	B	I, II
RED /C/	0.535	0.463	0.006	0.075	0.38–0.69	B	
RED /C/	0.536	0.464	0.009	0.096	0.34–0.63	R	

[a] = Open to public/Closed to public
* = Not fully recruited

Mean daily length and weight increments of marked and recaptured brown trout (22% recaptured of 162 marked) varied seasonally at San Antonio and East Fork of the Jemez River, the two sites where supplemental data were gathered to analyze seasonal growth. The mean daily increase in length and weight for the 148–day period from May to October for the San Antonio River was 0.132 mm and 0.214 g. For the East Fork of the Jemez River it was 0.247 mm and 0.110 g. Growth from Augutst to October was greater for brown trout in the San Antonio River; the daily increase in length and weight was 0.163 mm/day and 0. 163 g/day. For the sam period, a negative mean weight increment occurred in the oper segments of the East Fork of the Jemez River (–0.024 g/day).

Table 6. Trout length–weight relationship in 14 New Mexico streams during the period of study. W=weight in grams, L=length in millimeters, B=brown trout, R=rainbow trout, r^2=coefficient of simple determination (Neter et al. 1989), w=mean fish weight. N= number of fish used to establish the relationships

Tablica 6. Dužinsko–težinski odnos pastrva u 14 vodotokova države New Mexico u razdoblju istraživanja

		RELATIONSHIP			
Stream	sp.,		r^2	w(g)	N
Cebolla	B	log W = –2.629 + 2.593 (log L)	0.944	34.5	56
Las Vacas	B	log W = –4.785 + 3.915 (log L)	0.982	72.1	45
Guadalupe	B	log W = –4.634 + 2.842 (log L)	0.998	81.2	23
S. Antnio	B	log W = –4.303 + 2.707 (log L)	0.975	111.1	162
Jemez	B	log W = –4.214 + 2.662 (log L)	0.972	47.9	262
Pueblo	B	log W = –5.022 + 3.014 (log L)	0.995	187.7	26
Penasco	B	log W = –3.569 + 2.387 (log L)	0.748	32.0	35
Red	B	log W = –4.687 + 2.891 (log L)	0.986	108.3	80
	R	log W = –4.377 + 2.736 (log L)	0.940	28.0	157
Rio Gr.	B	log W = –3.765 + 2.472 (log L)	0.869	112.3	145
	R	log W = –4.698 + 2.880 (log L)	0.969	182.8	16
Pecos	B	log W = –5.010 + 3.000 (log L)	0.987	41.5	59
	R	log W = –5.687 + 3.304 (log L)	0.985	180.0	8
Cimarron	B	log W = –4.621 + 2.837 (log L)	0.969	157.3	98
Mogollon	B	log W = –5.061 + 3.020 (log L)	0.994	35.0	14
	R	log W = –5.000 + 2.991 (log L)	0.973	11.0	35
GWF	B	log W = –5.356 + 3.155 (log L)	0.988	96.6	17
Mimbres	R	log W = –4.589 + 2.848 (log L)	0.933	27.5	120
Average	B	log W = 4.435 + 2.817 (log L)	0.955	86.0	79
relati–	R	log W = –4.870 + 2.952 (log L)	0.960	85.9	67
onship	B+R	log W = 4.555 + 2.855 (log L)	0.956	86.0	73

The growth in weight was calculated from length–weight relationships (Table 6) and a production index was calculated as the product of the estimated stream biomass (g/m^2) and the specific growth rate. The production index ranged from 1.38 to 31.02 g/m^2/year. Trout in the closed Red River section were three times as productive as the second most productive trout population sampled in the open Rio Pueblo de Taos (Table 4). High production at closed Red River site, was a consequence of both high growth rate and high biomass. Lowest production occurred where growth and biomass were both low, such as the open San Antonio and Mimbres. Simple linear regression showed that variation in production was most highly related to biomass (r^2 = 0.910: $p < 0.01$); instantaneous growth rate explained much less of the trout production variation (r^2 = 0.270; p = 0.10).

No significant simple relationship ($p \leq 0.05$) was discovered between growth or production and physical–chemical characteristics in the studied streams, although nitrate–nitrogen concentration was marginally related to production (r^2 = 0.280; p = 0.07) and mean instantaneous growth variation was marginally related to the stream cover availability (r^2 = 0.290; p = 0.065). Fishing intensity had marginal relation to trout mortality (r^2 = 0.294; p = 0.06) and was negatively related to the trout maximum length variation, L_{max} (r^2 = 0.351; p = 0.055). Consequently, fishing intensity indicated negative relation to the trout biomass variation (r^2 = 0.128; p = 0.370).

Multiple regression models explained the greatest variation in growth and production, and were defined by the following relationships:

GROWTH = 0.872 + 0.03/COVER/ + 0.03/STREAM WIDTH/ — 0.08/WATER TEMPERATURE/ where R^2 = 0.462; R^2_a = 0.232

PRODUCTION = –30.406 + 0.098/L_{max}/ + 0.0002/FISHING INTENSITY/ + 33.940/NITROGEN CONCENTRATION/ where R^2 = 0.647; R^2_a = 0. 496.

Based only on physical and chemical characteristics in the streams, a multiple regression model that explained the greatest variation in trout production was defined by the following relationship:

PRODUCTION = 16.855 + 50.69/NITROGEN CONCENTRATION/ — 0.58/WATER TEMPERATURE/ — 0.55/STREAM WIDHT/ where R^2 = 0.430; R^2_a = 0.185.

DISCUSSION

Estimated trout production in selected streams of New Mexico was slightly lower than reported by Scarnecchia and Bergesen (1987) for high elevation streams in Colorado (*Salvelinus* and *Salmo spp.)*. Those streams were both smaller and colder than most of the streams sampled in New Mexico and were either lightly fished or unfished.

Fishing had direct impact on fish mortality, biomass and, to some extent, production in the New Mexico investigated streams. Beside fishing, the most important other factors are stream fertility, available cover for fish, water temperature, and stream witdh. Lewis (1969) documented cover to be an important factor for trout populations in Montana streams. Small streams with unreliable spring-water contribution throughout the year were among the least productive trout habitats. Large rivers, such as Rio Grande, Cimarron, and Pecos, also had low to moderate productivity despite high nutrient concentrations and moderate fishing intensity. The most productive waters had intermediate widths with dependable flows. The negative effect of increasing stream width above a certain width is not understood, but may relate to the depressive effect of water depth on light transmission and benthic productivity, and to the lowered input/m^2 of allochthonous terrestrial organic matter.

Results in fished streams of New Mexico and elsewhere (Bowlby and Roff, 1986) indicate that predictive models developed for unfished streams (e. g., Binns and Eiserman, 1979) are of limited utility for management purposes in fished streams. This seems particularly true where management is species-specific as it often is for rainbow and brown trout, which respond differently to cover, flow regimes, food sources, and fishing intensity.

ACKNOWLEDGEMENTS

I extend my sincere thanks to the following people: Dr. R. A. Cole for proffesional remarks and Dr. Leigh Murray for statistical control. Dr. R. Tafanelli, Mr. Brent Bristow, Mr W. U. Yoele and Mr. A. Montoya for their assistance in the field and laboratory. This study was funded by New Mexico State University, Federal Aid for Sport Fisheries distributed by New Mexico Department of Game na Fish and funds provided through the New Mexico Water Resources Research Institute and by Sigma Xi, the Scientific Research Society that granted me a Research award.

Sažetak

RAST, SMRTNOST I PRODUKCIJA POTOČNE I DUŽIČASTE PASTRVE U VODOTOKOVIMA DRŽAVE NEW MEXICO

Tijekom godina 1988. i 1989. uzorkovanje riba provedeno je na 32 reprezentativne postaje smještene na 15 visokoplaninskih vodotokova (nadmorska visina 1.661 do 2.560 m). Pastrve su lovljene uzastopnim izlovima elektroagregatom unutar mrežama blokiranih segmenata u dužini od 65 do 160 m. Maksimalno procijenjena dužina pastrva (L_{max}) bila je u negativnom odnosu prema ulovu (r^2 = 0,351; p = 0,055). Marginalna pozitivna veza dokazana je između trenutačne stope smrtnosti i sportskog ribolova (r^2 = 0,294). Indeks produkcije procijenjen je između 1,38 i 31,02 g/m^2/godinu. Promjene u produkciji u najvećoj mjeri ovise o biomasi pastrva (r^2 = 0, 910). Prirast i produkcija najbolje su objašnjeni višestrukom regresijskom analizom sa sljedećim atributima sredine: sklonište, širina vodotoka, temperatura vode, sportski ribolov, L^{max} i koncentracija spojeva dušika.

Ključne riječi: Salmo trutta m. fario, Oncorhynchus mykiss, vodotokovi, produkcija, smrtnost, rast, New Mexico, gospodarenje

REFERENCES

APHA (1975): Standard Methods for the Examination of Water and Wastewater. New York, 15th ed APHA, Washington, D. C., 1193 pp.

Bagenal, T. B., Tesch, F. W. (1978): Age and growth. In T. Bagenal (ed.), Methods for Assessment of Fish Production in Fresh Waters. Blackwell Scientific Publications, Oxford, p. 101–136.

Bertalanffy, L. Von (1938): A quantitative thory of organic growth. Human Biology 10, 181–243.

Binns, N. A., Eiserman, F. M. (1979): Quantification of fluvial trout habitat in Wyoming. Trans. Am. Fish. Soc. 108, 215–228.

Bowlby, J. N., Roff, J. C. (1986): Trout biomass and habitat relationships in southern Ontario streams. Trans. Am. Fish. Soc. 115, 503–514.

Caillet, G. M., Love, M. S., Ebeling, A. F. (1986): Fishes: A Field and Laboratory Manual on their Structure, Indentification, and Natural History. Watsworth Publishing Co., Belmont, 194 pp.

Chapman, D. G., Robson, D. S. (1960): The analysis of a catch curve. Biometrics 16, 354–368.

Everhart, H. W., Eipper, W. A., Youngs, D. W. (1975): Principles of Fishery Sciences. Cornell University Press, Ithaca, 288 pp.

Heggens, J. (1988): Effects of short–term flow fluctuations on displacement of, and habitat use by, brown trout in a small stream. Trans. Am. Fish. Soc. 117, 336–344.

Kondolf, G. M., Cada, G. F., Sale, M. J., Felando, T. (1991): Distribution and stability of potential salmonid spawning gravel in steep boulder–bed streams of the eastern Sierra Nevada. Trans. Am. Fish. Soc. 120, 177–186.

Lanka, R. P., Hubert, W. A., Wesche, T. A. (1987): Relations of geomorphology to stream habitat and trout standing stock in small Rocky Mountain streams. Trans. Am. Fish. Soc. 116, 21–28.

Leiner, S. (1992): Brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*): population metrics and biomass prediction models in New Mexico streams. New Mexico State University, Las Crucs, NM, Dissertation, 149 pp.

Lewis, S. L. (1969): Physical factors influencing fish populations in pools of a trout streams. Trans. Am. Fish. Soc. 98, 14–19.

Mesick, C. F. (1988): Effects of food and cover on numbers of Apache and brown trout establishing residency in artificial stream channels. Trans. Am. Fish. Soc. 117, 421–431.

Neter, J., Wasserman, W., Kutner, M. H. (1989): Applied Linear Regression Models. 2nd edition. Irwin Inc., Homewood, p. 241–242.

Platts, W. S., Megahan, W. F., Minshall, G. W. (1983): Methods for evaluating stream, riparian, and biotic conditions. General Technical Report INT–138. Ogden Utah: U. S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, 71 pp.

Ricker, W. E. (1975): Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191, 1–382.

Robson, D. S., Chapman, D. G. (1961): Catch curves and mortality rates. Trans. Am. Fish. Soc. 90, 181–189.

Scarnecchia, D. L., Bergersen, E. P. (1987): Trout production and standing crop in Colorado's small streams, as related to environmental features. N. Am. J. Fish. Management 7, 315–330.

Snedecor, G. W., Cochran, W. G. (1967): Statistical Methods, 6th edition. The lowa State University Press, Ames, 593 pp.

Wesche, T. A., Goertler, C. M. (1987): Modified suitability index modeled for brown trout in southwestern Wyoiming N. Am. J. Fish. Management 7, 232–237.

Wydoski, R., Emery, L. (1983): Tagging and marking. In L. A. Nielsen and D. L. Johnson (editors): Fisheries Techniques. Southern Printing Company, Blacksbur, p. 215–238.

Received 13. 12. 1994.