

Non-salmonid Fishes and Morphoedaphic Features Affect Abundance of Trouts in Wyoming Reservoirs

Abstract

Quantitative relations between the abundance of trout in reservoirs and chemical, physical, and biological factors are not well defined. We assessed standing stocks of trout in 22 reservoirs in Wyoming for their relation to the abundance of non-salmonid fishes and morphoedaphic features. Trout standing stocks were lower in reservoirs where non-salmonid fishes were abundant, but increased as total dissolved solids increased. A two-variable (non-salmonid fishes and total dissolved solids) multiple-regression model accounted for most variation ($R^2 = 0.56$) in trout standing stocks. Our results suggest the possibility of competition between trout and non-salmonid fishes in Wyoming reservoirs. They also indicate that total dissolved solids influence biological productivity and trout abundance in an asymptotic manner at concentrations between 54 and 14,442 mg/L.

Introduction

Factors governing the abundance of trout in reservoirs are poorly understood. We examined the standing stock of trout in small (≤ 890 surface hectares at full pool) reservoirs in Wyoming relative to the abundance of non-salmonid fishes that may compete for food or space and to chemical and physical features that have been related to fishery production in lakes. Quantitative relations among such variables can be useful in explaining their biological significance to trout and in managing impoundments of the Rocky Mountains for sport fisheries.

Non-salmonid fishes and trout in lakes or reservoirs can utilize similar food resources (Schneidervin and Hubert 1987). Evidence of possible competition for food resources between trout and non-salmonid fishes has been found in some lakes (Purych 1977, Fraser 1978, Barton and Bidgood 1980), but not in reservoirs (Marrin and Erman 1982). Johannes and Larkin (1961) demonstrated competition for food resources between a minnow and trout in a natural lake in British Columbia, but they emphasized that the observation could have been easily missed without comprehensive field work.

Several physical and chemical features influence fishery production (Rawson 1952, Murphy 1962, Hayes and Anthony 1964, Jenkins 1970).

The best known is the morphoedaphic index (MEI) which has been shown to be related to fishery production in numerous lakes (Ryder 1965, 1982). The MEI is computed as total dissolved solids (TDS) divided by mean depth of the lake.

Whitworth (1985) examined the relation of 24 physical, chemical, and biological parameters to trout abundance in small Wyoming reservoirs. He found the two best predictors of trout standing stock were maximum water depth at full pool and TDS, variables similar to those in the MEI. However, Whitworth did not evaluate the possible influence of non-salmonid fishes on trout abundance.

Guenther (1989) used 11 reservoirs sampled by Whitworth (1985) and 12 reservoirs that she sampled in Wyoming to assess factors influencing trout abundance. She found TDS, surface area, and MEI to be negatively correlated with trout standing stocks, while mean depth was positively correlated. Negative correlations for TDS and MEI seemed to have been due to the abundance of non-salmonid fishes in several reservoirs. When nine reservoirs with $< 20\%$ of the total fish biomass composed of non-salmonid fishes were assessed, a positive correlation between trout standing stocks and both TDS and MEI were found.

We know of no previous work on the interaction of the abundance of non-salmonid fishes and morphoedaphic features with standing stocks of trout in reservoirs. We hypothesize that the abundance of non-salmonid fishes reduces trout abundance, whereas certain chemical or physical features of reservoirs favor trout abundance.

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Methods

We studied 22 reservoirs in Wyoming that were ≤ 890 hectares surface area at full pool, 1253-3166 m above mean sea level, and constructed to store water for irrigation or municipal use. Spring runoff from melting mountain snow fills the reservoirs and they are drawn down during the remainder of the year. All of the reservoirs feature angling for trout. The Wyoming Game and Fish Department or private interests stock the reservoirs with various combinations of fingerling rainbow trout (*Oncorhynchus mykiss*), cutthroat trout (*Oncorhynchus clarki*), brown trout (*Salmo trutta*), and brook trout (*Salvelinus fontinalis*). Naturally reproducing populations of non-salmonid fishes, notably white suckers (*Catostomus commersoni*), longnose suckers (*Catostomus catostomus*), and yellow perch (*Perca flavescens*), were present in many of the reservoirs.

Mark and recapture techniques were used to estimate the abundance of trout in each reservoir during summer. Between 1981 and 1984, Whitworth (1985) sampled fish in 10 reservoirs of 50-890 hectares with trap nets (25-mm square mesh) and a 9 x 183 m purse seine (9-mm mesh). Trap nets were set at randomly assigned locations with leads extending perpendicular to the reservoir bank for approximately 24-h periods. Purse seining locations were randomly assigned from a grid system mapped for each reservoir. All captured trout were weighed, fin-clipped and then released near the point of capture during the initial capture period. A two-sample Schnabel estimator was used to estimate the number of the trout in the reservoir (Ricker 1975). Computations were made with Model Mo of program CAPTURE (White *et al.* 1983). All non-salmonid fishes were identified and enumerated. Two reservoirs sampled by Whitworth (1985) were omitted because the trout sampling techniques differed from the 10 reservoirs described here.

In 1987 and 1988, we sampled the fish in 12 reservoirs of 3-49 hectares with 8-9 trap nets (25-mm mesh) located around the periphery of each reservoir (Guenther 1989). All captured trout were weighed and marked with a caudal fin punch. A multiple-census Schnabel estimator was used with up to 10 mark and recapture episodes within a 2-week period to estimate the number of trout (Ricker 1975). All non-salmonid fish were identified and counted.

Trout standing stocks were computed for each species from the estimated number of trout in the reservoir multiplied by the mean weight of fish in the sample divided by the surface area of the reservoir. The proportion of non-salmonid fishes was computed from the number of non-salmonid fishes and trout captured in each reservoir.

Total dissolved solids (TDS) were determined gravimetrically from water samples taken at the time of fish sampling (APHA 1985). Mean water depth, maximum water depth, and surface area were measured from bathymetric maps at full pool. The morphoedaphic index (TDS/mean depth) was computed for each reservoir.

Statistix 3.1 (Analytical Software 1990) was used for correlation and multiple-regression analyses. The Wilk-Shapiro/Rankit Plots procedure was used to determine normality of individual variables. The distributions of all chemical and physical variables were transformed (\log_{10}) to normalize the distributions. Significance was determined at $P \leq 0.05$ for all procedures.

Results

The standing stocks of trout ranged from 0.2 to 139.2 kg/hectare among the 22 reservoirs (Table 1). Among the dependent variables, only the proportion of non-salmonid fishes was significantly correlated ($r = -0.61$) with trout standing stock. Multiple-regression analysis yielded only one two-variable model with both independent variables that were significant. Variation in standing stocks of trout was accounted for by the proportion of non-salmonid fishes and TDS ($R^2 = 0.56$):

$$SS = -4.3 - 9.498 NS + 23.5 \log_{10}TDS$$

where, SS is the standing stock of trout (kg/hectare), NS is the percentage of the total fish stock composed of non-salmonid fishes, and TDS is the total dissolved solids concentration (mg/L). Figure 1 illustrates the relationship between trout standing stock and TDS at three levels of abundance of non-salmonid fishes based on the multiple-regression model.

Discussion

The abundance of non-salmonid fishes and an index of biological productivity (TDS) accounted for variability in standing stocks of trout in small Wyoming reservoirs. The abundance of non-salmonid fishes was negatively related to trout abundance. However, our data are limited because 9 of 22

TABLE 1. Standing stocks of trout, relative proportion of non-salmonid fishes, and physical features of 22 small reservoirs in Wyoming, 1981-1988.

Reservoir	Standing stock of trout (kg/ha)	Proportion non-salmonid fishes (%)	Total dissolved solids (mg/L)	Mean depth (m)	Maximum depth (m)	Surface area (ha)
Twin Buttes	139	20.0	14442	3.7	9.2	135
Soda Lake, Fremont County	101	1.6	3391	7.3	13.4	120
Diamond	88	0	3964	1.8	9.1	102
East Lake	76	0	253	2.8	6.6	25
Greyhound	51	1.4	379	2.7	3.9	12
Cameahwait	51	89.3	364	4.9	11.3	168
Shirley Basin	48	0	2457	3.1	4.5	6
Kemmerer City	44	96.1	237	1.2	7.6	51
Harney	35	0	196	5.8	8.8	3
Miller	30	0	110	2.2	3.3	6
Chapman	29	0	54	4.4	6.6	8
Mortenson	20	76.9	646	1.8	3.0	29
Healy	10	96.8	479	11.5	29.6	600
LAK	9	93.6	1910	5.2	15.2	50
Sucker Lakes	6	0	84	1.2	2.6	5
Viva Naughton	5	97.4	940	11.3	37.2	890
Lower Sunshine	4	98.7	189	20.2	55.5	497
Upper Sunshine	3	98.0	158	14.0	36.6	469
Leazenby	2	99.3	273	0.6	1.6	13
Sand Lake	2	96.5	71	2.6	5.0	37
Nine Mile Lake	1	98.3	10112	2.2	3.7	49
Soda Lake, Albany County	<1	99.9	5246	3.2	4.4	26

reservoirs had ≤ 1.6 percent non-salmonid fishes and 11 had ≥ 89.3 percent non-salmonid fishes.

Use of the same food resources by non-salmonid fishes and trout has been shown to occur in reservoirs (Schneidervin and Hubert 1987), but competition for food resources has not been demonstrated. For example, Marrin and Erman (1982) found no evidence of competition between non-salmonid fishes and trout in a California reservoir. However, Gipson and Hubert (1991) found a negative relation between the body condition of rainbow trout and the abundance of non-salmonid fishes among 13 reservoirs in Wyoming.

Among natural lakes in Canada, evidence of competition between non-salmonid fishes and trout has been observed. Johannes and Larkin (1961) reported competition for food between redbside shiners (*Richardsonius balteatus*) and rainbow trout in a British Columbian lake. Purych (1977) ob-

served potential competition between non-salmonid fishes and native salmonids in an Ontario lake. A negative influence of white suckers and longnose suckers on growth of rainbow trout was suggested by Barton and Bidgood (1980) in an Alberta lake. Fraser (1978) provided evidence that yellow perch reduced the growth and survival of trout in an Ontario lake. Similarly, we observed a negative relation between the abundance of non-salmonid fishes and standing stocks of trout among Wyoming reservoirs, but the mechanism causing this relation was not defined.

Higher concentrations of TDS favored trout abundance. Fishery production has been related to TDS in other lakes and reservoirs (Jenkins 1968, 1982, Ryder 1982). The relation between TDS and trout standing stocks in Wyoming reservoirs is a function of not only biological productivity, but also stocking rates of fingerling trout. Experience

has taught managers which reservoirs are more productive, and these reservoirs subsequently have been stocked with larger numbers of trout fingerlings to increase the standing stocks.

The asymptotic relation between trout abundance and TDS in Wyoming reservoirs (Figure 1) is possibly a function of very high TDS (> 10,000 mg/L) in two of the reservoirs studied (Table 1). Trout production in saline waters can be limited by either physiological or toxic effects of dissolved

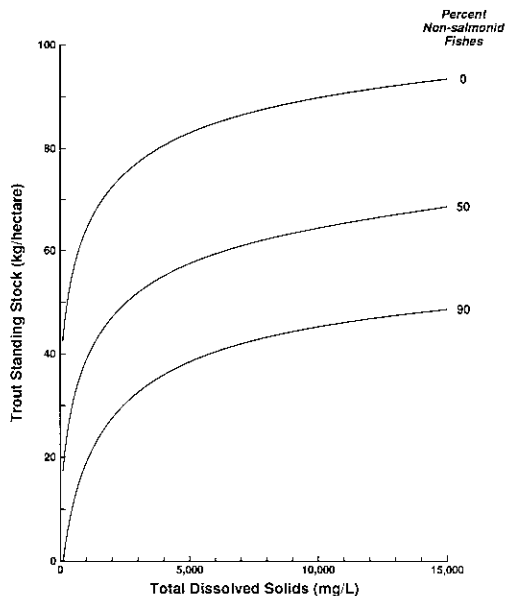


Figure 1. The relationships between trout standing stocks and total dissolved solids in Wyoming reservoirs at three levels of abundance of non-salmonid fishes.

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salts. Rainbow trout generally tolerate up to 7,000 mg/L TDS, but beyond this level survival, growth, and food conversion efficiency are reduced (Piper *et al.* 1982). It is also possible that these two reservoirs have been stocked with fewer fish than the reservoirs may be able to support.

The extent to which reservoirs are drawn down is also likely to affect the abundance of trout. The timing and magnitude of draw-down affect reservoir productivity, spawning success of fishes, and predator-prey interactions (Ploskey 1983). Among the reservoirs that we studied, water levels fluctuated from less than 1 m to more than 15 m annually. The extent to which water level fluctuations affected trout abundance in the reservoirs that we studied is unknown.

Our observations suggest that competition may occur between non-salmonid fishes and trout in Wyoming reservoirs. They also indicate that higher TDS concentrations, an index of biological productivity, enhance standing stocks of trout in reservoirs, but the effect may be less at very high levels of salinity (> 10,000 mg/L). The relations should be further evaluated because of the small sample size and limited geographic area of this study, but our results provide a base for future work.

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