GORGE RESERVOIR FISH SURVEY 2006 REPORT

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Introduction

Gorge reservoir is one of three impoundments on the Skagit River created by Seattle city lights hydroelectric project. It is the smallest, narrowest, most downstream reservoir with the lowest water retention time. In fact water moves through the upper reaches in a riverine manner.

The 1991 relicensing agreement for the Seattle city light Skagit hydroelectric project provided for the development of a Ross Lake rainbow brood stock program to enhance the rainbow trout fisheries above the project including gorge reservoir. As part of the implementation of this program Washington department of fish and wildlife conducted a baseline survey to assess fish populations and gorge reservoir.

Methods

One WDFW biologist and two scientific technicians surveyed Gorge Reservoir during August 15 through August 17, 2006. Fish were captured using two sampling techniques: horizontal and vertical gill netting. Two configurations of horizontal experimental gill nets were deployed. One type (45.7 m long × 2.4 m deep) was constructed of four sinking panels (two each at 7.6 m long and 15.2 m long) of variable-size (13, 19, 25, and 51 mm stretched) monofilament mesh, and the other (two each 2.4 m deep x 33 m long) was constructed of three sinking panels (each 10.3m long of variable size (15, 21, 32 mm stretched) monofilament mesh. Three vertical gll net sets composed of panels (all 33 m deep x 2.4 m wide) of variable size (15, 21, and 32 mm stretched) were attached with clips every 4 m with PVC spreaders and suspended from the surface mooring buoys.

Sampling locations were selected by dividing the shoreline into five geographically distinct regions; the deep pelagic region directly behind the dam, the middle region below Stetattle Creek, and the Skagit River reach below the Diablo powerhouse (Figure 4). Those regions were then divided into consecutively numbered sections of about 400 m each as determined from a 1:24,000 USGS map. From those sections, sample sites were then chosen systematically to maximize spatial independence and geographic coverage.

Horizontal net types were randomly assigned, and vertical net sets were deployed near the centroids of major basins. Two gill nets of each horizontal type were set perpendicular to the shoreline and one set of three-panel vertical gill nets were set for each of three nights for a standardized 2:2:1 ratio. For sinking horizontal nets, the small-mesh end was attached onshore and the large-mesh end was anchored offshore. Maximum effective depth was about 30 m for horizontal nets, though a range of shallower depths were sampled. Vertical nets were suspended from mooring buoys to fish the top 33 m of the pelagic zone. Although larger fish were observed with a hydro-acoustic fish finder near the bottom at greater depths, we decided not to risk losing a sinking net where course woody debris could be an issue.

All fish captured were identified to species, with the exception of native char, which could not be more specifically identified based solely on meristics. Fish were measured to the nearest mm and assigned to 10-mm size classes based on total length (TL). Fish were weighed to the nearest 0.5 g. Scales and otoliths were removed from up to 5 fish from each size class for aging. Scale samples were mounted, pressed, and the fish aged according to Jearld (1983) and Fletcher et al. (1993). Scales were also measured for standard back-calculation of growth. Otoliths were cleaned and read under a standard dissecting microscope. Tissue samples, taken from the pelvic fin, were collected from all species and stored in alcohol for future MtDNA analysis.

Data analysis

Evaluations of species composition, size structure, growth, and condition (plumpness or robustness) of fish provide useful information on population age class structures, relative species abundances and interaction, and the adequacy of the food supplies for various foraging niches (Ricker 1975, Kohler and Kelly 1991). This information also aids in the development of responsible fish management strategies and forms the basis for sound adaptive management. The balance and productivity of the fish community may also be assessed based upon these evaluations (Swingle 1950; Bennett 1962).

Species composition was determined by weight (kg) of fish captured using procedures adapted from Swingle (1950). The species composition by number of fish captured was determined using procedures outlined in Fletcher et al. (1993). While young-of-year or small juveniles are often not considered because large fluctuations in their numbers may distort results (Fletcher et al. 1993), we would have included them had any been collected, since their relative contribution to total species biomass would have been small. Moreover, the overall length frequency distribution of fish species indicate successful spawning, lentic habitat use and initial survival during a given year, as demonstrated by a preponderance of fish in the smallest size classes. Although many of these fish would be subject to natural attrition during their first winter (Chew 1974), resulting in a different size distribution by the following year, the presence of these fish in the system relates directly to fecundity and interspecific and intraspecific competition at lower trophic levels (Olson 1997).

Catch per unit effort (CPUE) by gear type was determined for each fish species (number of fish/net night). CPUE was calculated for each species based on all fish and based only on stock- size fish and larger. Stock length, which varies by species (see Table 1 and discussion below), refers to the minimum size of fish having recreational value. Although sample locations were systematically selected based on habitat type in order to minimize variability due to habitat differences within the lake, 80% confidence intervals (CI) were determined for each mean CPUE by species and gear type. CI was calculated as the mean ± $t_{(\forall, N\text{-}1)} \times SE$, where t = Student's t for ∀ confidence level with n-1 degrees of freedom (two-tailed) and SE = standard error of the mean. Since it is standardized, CPUE is a useful index for comparing relative abundance of stocks between lakes and confidence intervals express the relative uniformity of species distributions throughout the lakes.

The size structure of each species captured was evaluated by constructing a stacked length frequency histogram (percent frequency of fish captured in a given size class by age class). Although length frequencies are generally reported by gear type, length frequency of Diablo fish are reported with combined gear types. Selectivity of gear types not only biases species catch based on body form, and behavior, but also based on size classes within species (Willis et al. 1993). Therefore, an unbiased assessment of length frequency is unlikely under any circumstance. A standardized 1:2:2 gear type ratio adjusts for differences in sampling effort between sampling times and locations. Furthermore, differences in size selectivity of gear types may in some circumstances, result in offsetting biases (Anderson and Neumann 1996).

The proportional stock density (PSD) of each fish species was determined following procedures outlined in Anderson and Neumann (1996). PSD, which was calculated as the number of fish∃quality length/number of fish∃stock length×100, is a numerical descriptor of length frequency data that provides useful information about size class structure. Stock and quality lengths, which vary by species, are based on percentages of world-record lengths. Again, stock length (20-26% of world-record length) refers to the minimum size fish with recreational value, whereas quality length refers to fish that are from 36 to 41% of world-record in length.

The relative stock density (RSD) of each fish species was examined using the five-cell model proposed by Gabelhouse (1984). In addition to stock and quality length, Gabelhouse (1984) introduced preferred, memorable, and trophy length categories (Table 2). Preferred length refers to fish 45-55% of world-record length, memorable length refers to fish 59-64% of world-record length, whereas trophy length refers to fish 74-80% of world-record length. Like PSD, RSD can provide useful information regarding size class structure, but is more sensitive to changes in year-class strength. RSD was calculated as the number of fish∃specified length/number of fish∃stock length×100. For example, RSD P was the percentage of stock length fish that also were longer than preferred length, RSD M, the percentage of stock length fish that also were longer than memorable length, and so on. Eighty-percent confidence intervals for PSD and RSD were selected from tables in Gustafson (1988).

TABLE 1. Proportional and relative stock density values for species collected from Diablo Reservoir in August 2005. Fish length thresholds are expressed in millimeters.

Species	Stock	PSD	RSD-P	RSD-M	RSD-T
Eastern brook trout	200	300	400	500	600
Bull trout	300	500	650	800	1000
Rainbow trout	250	400	500	650	800

Age and growth of fishes in Diablo Reservoir were evaluated using the direct proportion method (Jearld 1983; Fletcher et al. 1993) and Lee's modification of the direct proportion method (Carlander 1982). Using the direct proportion method, total length at annulus formation was back-calculated as $L_n = (A \times TL)/S$, where A is the radius of the fish scale at age n, TL is the total length of the fish captured, and S is the total radius of the scale at capture. Using Lee's modification, L_n was back-calculated as $L_n = a + A{\times}(TL - a)/S$, where a is the species-specific standard intercept from a scale radius-fish length regression. Mean back-calculated lengths at age n for all species are reported in the respective species sections. Mean back-calculated lengths at age n for rainbow trout are also presented in graphic form for easy comparison of growth between year classes, as well as with rainbow trout collected from two tributaries of Ross Lake, Dry and Roland Creeks.

A relative weight (W_r) index was used to evaluate the condition of fish in the lake. A W_r value of 100 generally indicates that a fish is in good condition when compared to the national standard (75th percentile) for that species. Furthermore, W_r is useful for comparing the condition of different size classes within a single population to determine if all sizes are finding adequate forage or food (ODFW 1997). Following Murphy et al.(1991), the index was calculated as $W_r = W/W_s \times 100$, where W is the weight (g) of an individual fish and W_s is the standard weight of a fish of the same total length (mm). W_s is calculated from a standard $\log_{10}$weight-$\log_{10}$length relationship defined for the species of interest. The parameters for the W_s equations of many coldwater fish species, including the minimum length recommendations for their application, are listed in Anderson and Neumann (1996). The relative weight equation used for native char was adopted from Hyatt and Hubert (2000) who developed a relative weight equation for bull trout. Relative weight (W_r) values from this study were compared to the national standard ($W_r = 100$).

Results

Native char, Eastern Brook trout, and rainbow trout were sampled throughout the reservoir (Figure 1). Rainbow trout accounted for 34% of the catch by weight and 60% of the catch by number and range in size from 103 mm two 320 mm and total length. Eastern Brook trout accounted for 7% of the catch by weight, 14% of the catch by number, and ranged in size from 158 mm to 290 mm and total length. Native char accounted for 60% of the catch by weight 18% of the catch by number and ranged in size from 130 mm to 751 mm in total length.

Catch per unit effort was highest for rainbow trout averaging for fish per net per night in the horizontal small mesh gill nets and nearly 14 fish per net per night in the horizontal large mesh gill nets. Eastern Brook in native char were caught in similar numbers in both net types ranging from 1.5 to 2.5 fish per net per night.

Proportional and relative stock densities were zero for both rainbow trout and Eastern Brook trout. WDFW sampled five stock length native char which produced a PSD of 80 and an RSD-P of 40.

Rainbow trout in Gorge Reservoir ranged from age 1 to age 4 with age 2 and age 3 fish dominating the population (Table 4). Condition of rainbow trout, expressed in terms of relative weight, averaged about 80 and showed no trend with respect to total length.

Eastern Brook sampled from gorge reservoir consisted entirely of age 2 and age 3 fish (Table 5) who. Condition of Eastern Brook expressed in terms of relative weight was generally above 80.

Native char sampled from gorge reservoir ranged from age 2 to age 5 with age 2 and 3 fish dominating the population (Table 6). Condition of native char expressed in terms of relative weight was generally above 100.

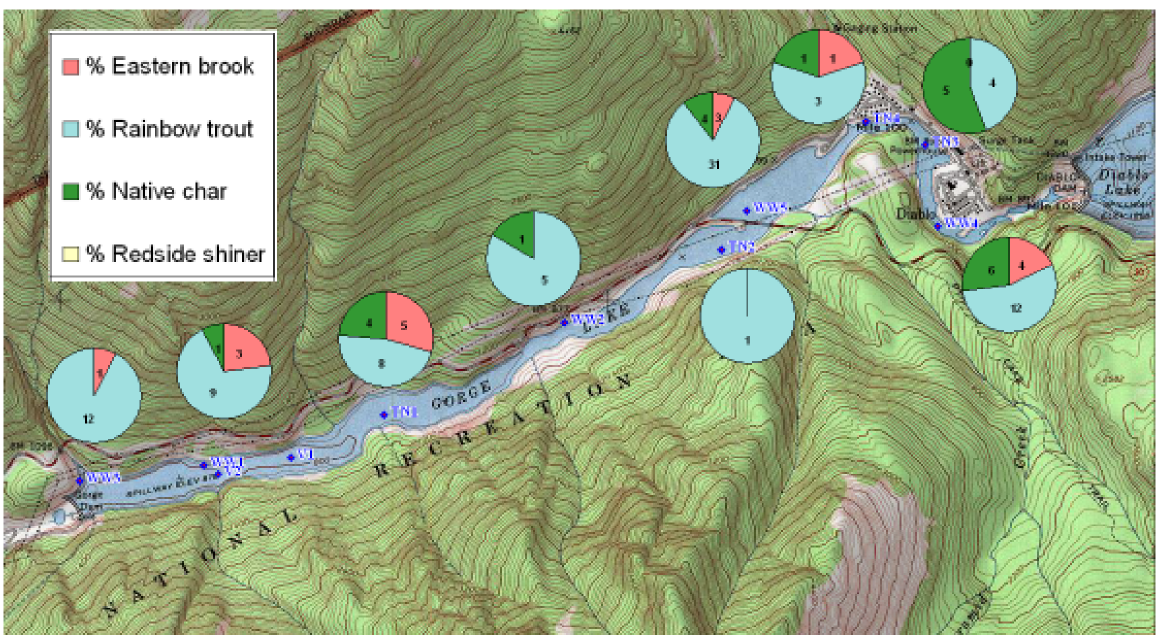

Figure 1. Species composition for sites sampled on Gorge Reservoir in August 2006.

Table 2. Species composition of fish captured on Gorge Reservoir in August 2006.

	Species composition					
	by weight		by number		Size range (mm TL)	
Species	(kg)	(%) wt	(#)	(%) n		
Rainbow trout (Oncorhynchus mykiss)	8635	0.340	85	0.685	103	320
Eastern brook trout (Salvelinus fontinalis)	1720	0.068	17	0.137	158	290
Native char (Salvelinus spp)	15059	0.593	22	0.177	130	751
Red side shiner	0	0.000	0	0.000	0	0
Total	25414	1.000	124	1.000		

Table 3. Catch per unit effort for fish captured on Gorge Reservoir in August 2006.

Species	Small mesh gill net (fish/night)		n (net nights)	Large mesh gill net (fish/night)		n (net nights)	Vertical gill net (fish/night)		n (net nights)
All fish									
Rainbow trout	4	±1.89	4	13.8	±5.75	5	0	_	2
Eastern brook	1.5	a	4	2.2	±0.94	5	0		2
Native char	2.5	±1.53	4	2.4	±1.44	5	0	_	2
Stock length fish					_			_	2
Rainbow trout	0.5	±0.37	4	3.2	±2.85	5	0	_	2
Eastern brook	1	±0.91	4	1.4	±0.65	5	0		2
Native char	0.25	_a	4	0.8	±0.48	5	0	_	2

Table 4. Proportional and relative stock densities for fish captured on Gorge Reservoir in August 2006.

Species	n	PSD	RSD-P	RSD-M	RSD-T
Rainbow trout	#	0 _	0 _	0 _	0 _
Eastern brook	#	0	0	0	0
Native char	5	80 ±22.93	40 ±28.08	0 _	0 _

Rainbow Trout

Table 5. Age and growth of rainbow trout sampled from Gorge Reservoir in August 2006.

	Age				
	1	2	3	4	5
TL(avg)	119.0± 15.4	204.6± 26.3	278.8± 24.3	267.8± 14.4	ND
n	4	39	13	4	0

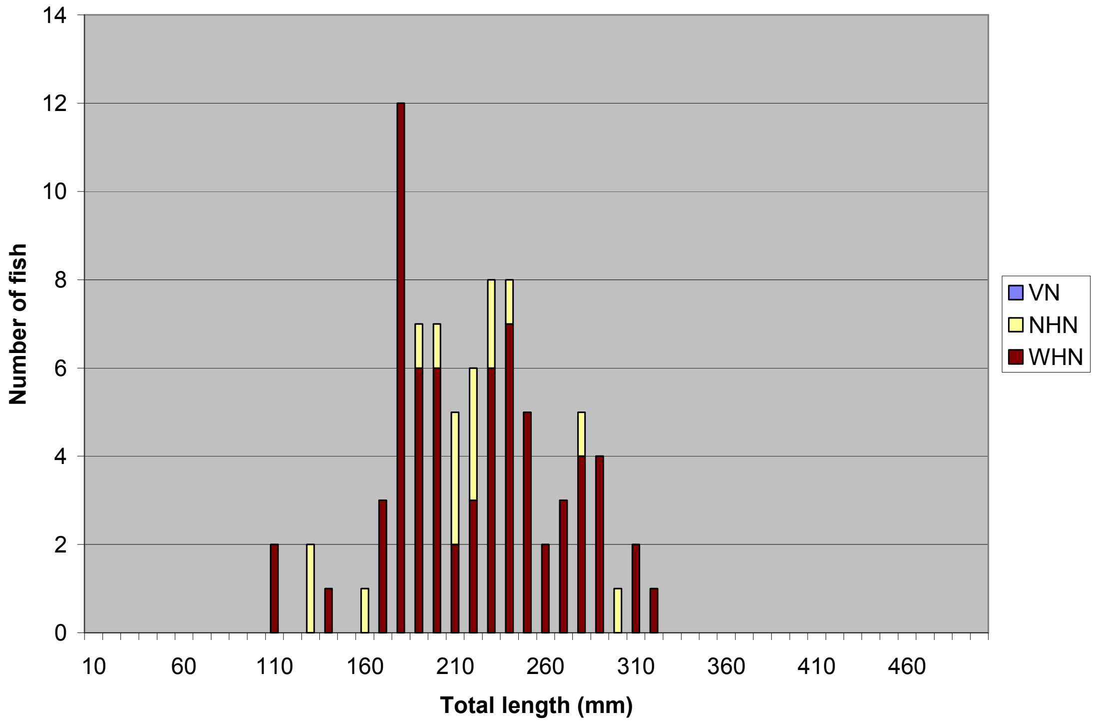

Figure 2. Length frequency distribution of rainbow trout sampled from Gorge Reservoir in August 2006.

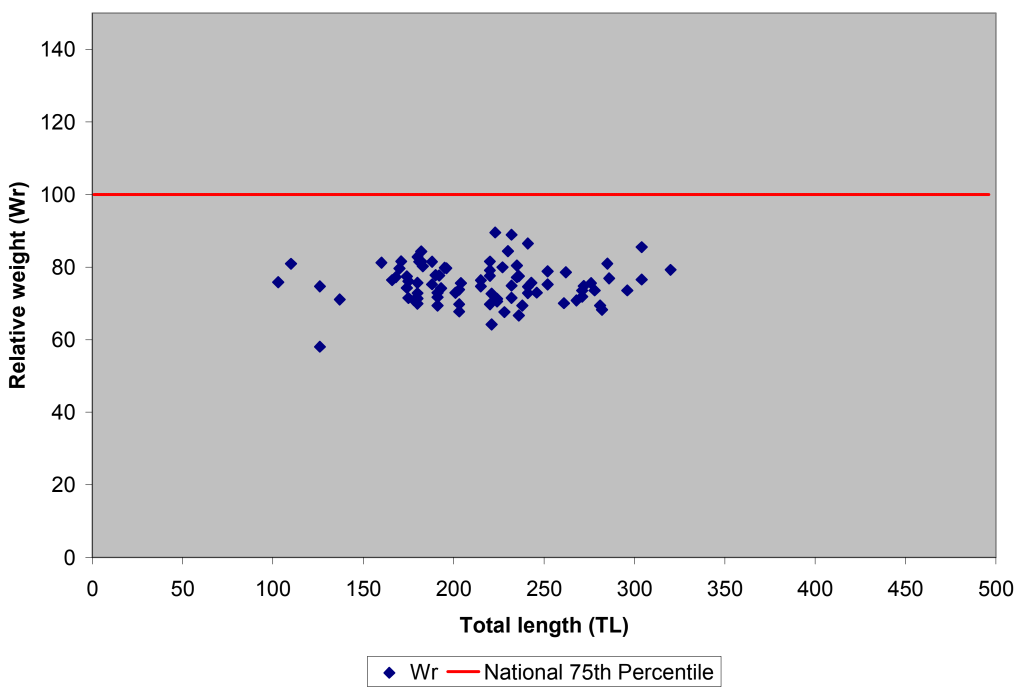

Figure 3. Relative weight for rainbow trout sampled from Gorge Reservoir in August 2006.

Eastern Brook Trout

Table 6. Age and growth of rainbow trout sampled from Gorge Reservoir in August 2006.

	Age				
	1	2	3	4	5
TL(avg)	ND_	208.3$\pm$ 17.1	242.5$\pm$ 7.8	ND_	ND_
n	0	7	2	0	0

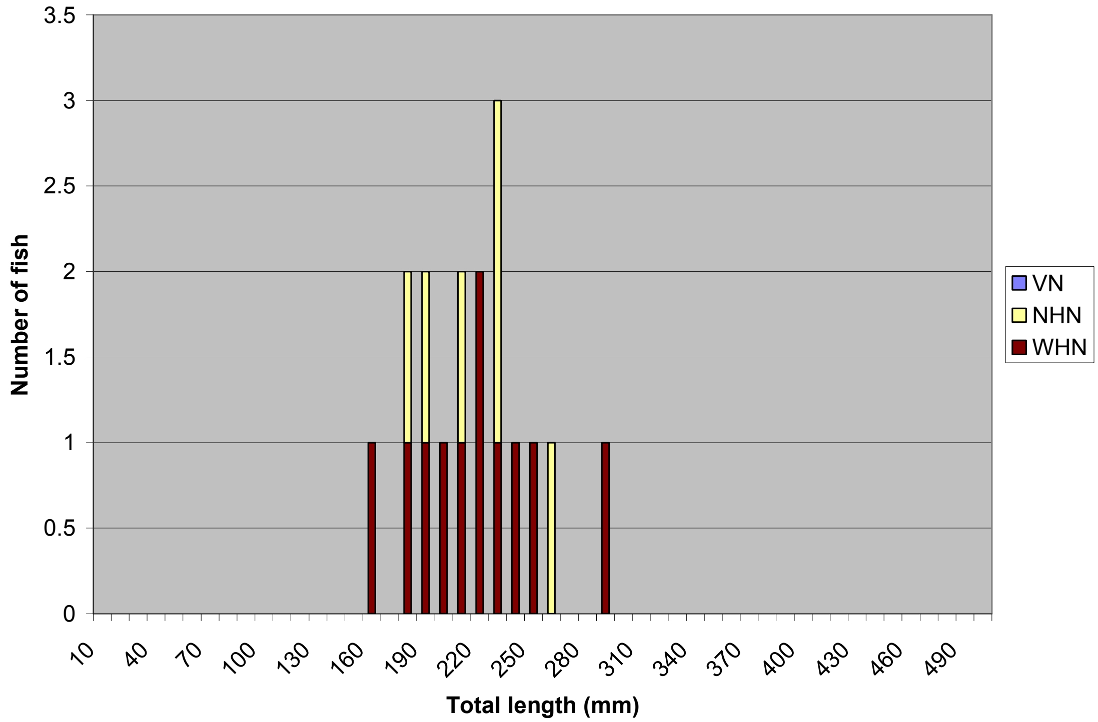

Figure 4. Length frequency distribution of eastern brook trout sampled from Gorge Reservoir in August 2006.

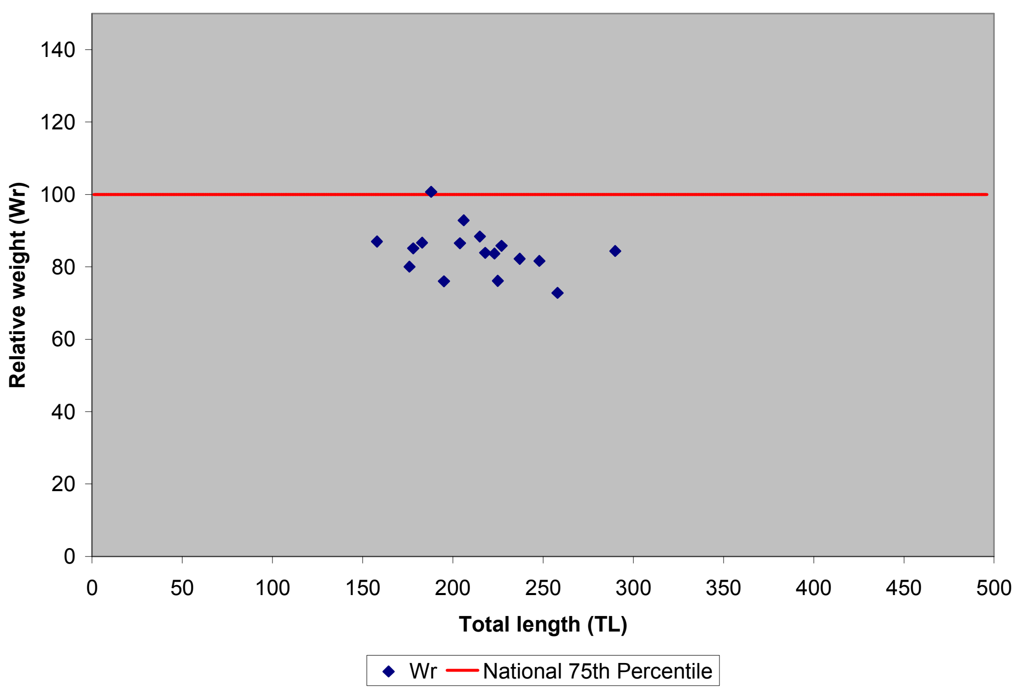

Figure 5. Relative weight for eastern brook trout sampled from Gorge Reservoir in August 2006.

Native Char

Table 7. Age and growth of native char sampled from Gorge Reservoir in August 2006.

	Age				
	1	2	3	4	5
TL(avg)	ND	165.3± 23.0	206.3± 16.4	577.3± 266.9	639.5± 14.8
n	0	7	6	3	2

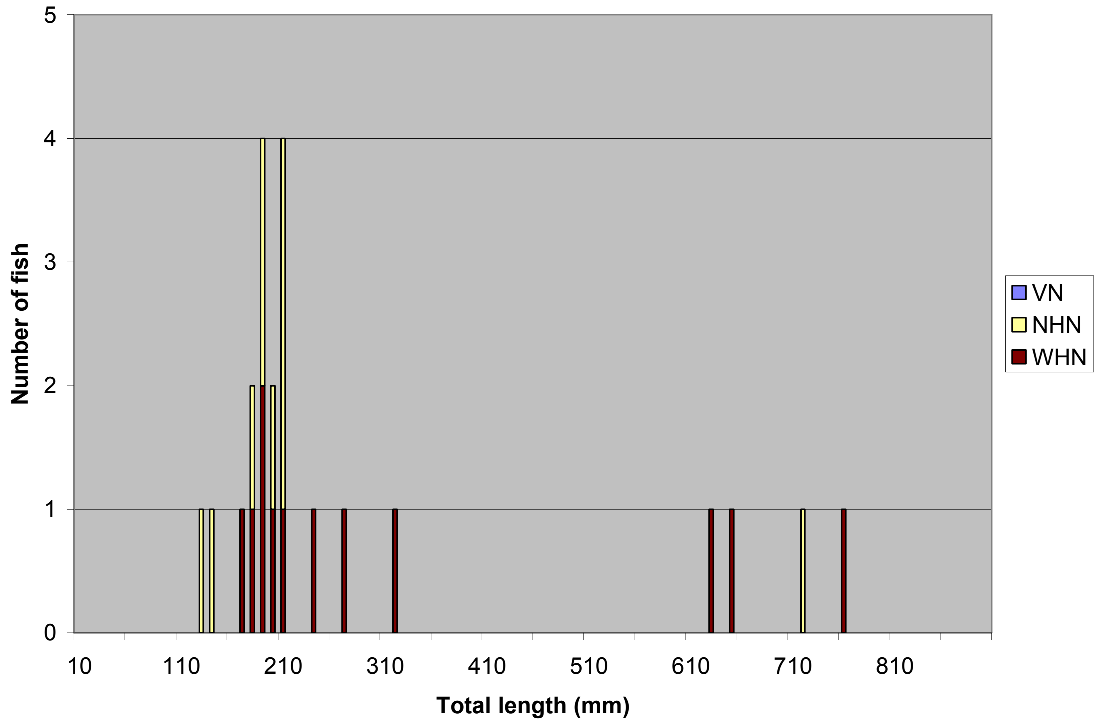

Figure 6. Length frequency distribution of native char sampled from Gorge Reservoir in August 2006.

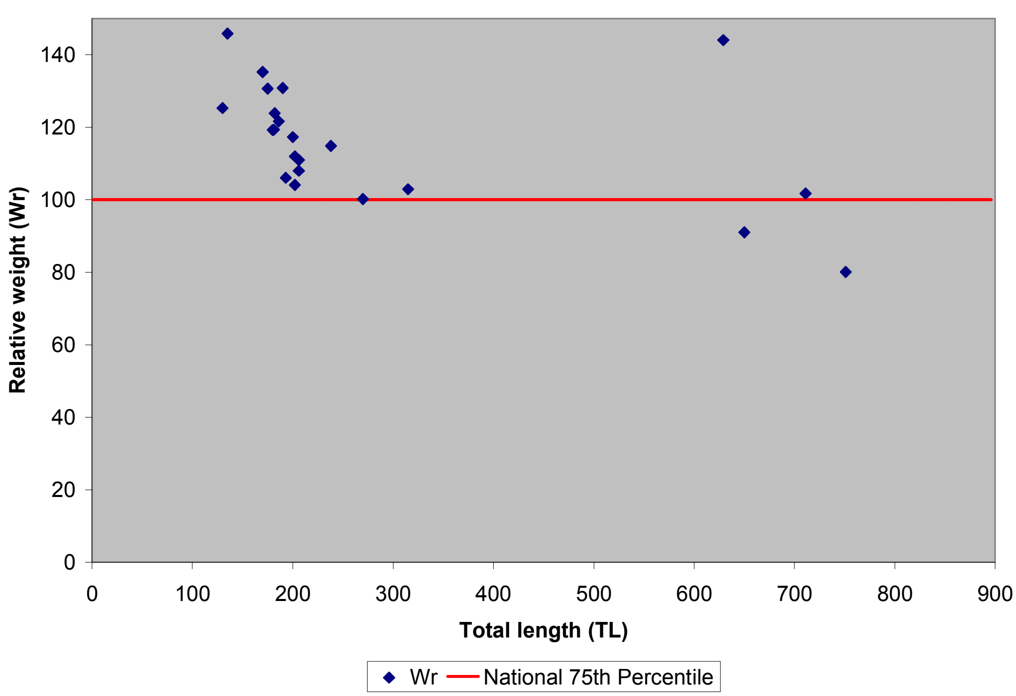

Figure 7. Relative weight for native char sampled from Gorge Reservoir in August 2006.