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ABSTRACT

Hydroacoustic technology was used to estimate pelagic fish abundance and size structure in Anderson Ranch Reservoir, Black Canyon Reservoir, Cascade Reservoir, Deadwood Reservoir, Island Park Reservoir, Little Wood Reservoir, Mann Creek Reservoir, and Payette Lake. Intensive netting was conducted in concert with hydroacoustic surveys at all eight water bodies for species validation, which allowed for the estimation of abundance of individual species. Rainbow trout *Oncorhynchus mykiss* abundance was estimated at Cascade, Island Park, Little Wood, and Mann Creek reservoirs. Kokanee *O. nerka* abundance and cohort strength were estimated at Deadwood and Anderson Ranch reservoirs and Payette Lake. Hydroacoustics were also used to monitor the success of ongoing northern pikeminnow *Ptychocheilus oregonensis* removal efforts at Cascade Reservoir where the goal is to re-establish the popular yellow perch *Perca flavescens* fishery. Limnological data were collected at sites along the trophic gradient at most water bodies to assist in the understanding of fish distributions. Results from work conducted this year revealed that in water bodies with diverse species assemblages, useful population assessments should be limited to the most abundant pelagic species because confidence intervals are too large for species that occur infrequently during netting efforts.

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INTRODUCTION

Hydroacoustic technology has become an increasingly popular tool in fisheries management, and the applications are quite diverse. In lakes and reservoirs, hydroacoustic or sonar techniques have been frequently used to study fish abundance (Thorne 1979; Burczynski and Johnson 1986; MacLennan 1990; Bjerkeng et al. 1991), distribution (Maiolie and Elam 1996; Aku et al. 1997; Beauchamp et al. 1997), behavior (Levy 1991; Luecke and Wurtsbaugh 1993; Maiolie et al. 2001), and survival (Thiesfeld et al. 1999; Butts 2002). Sonar has also been used to estimate entrainment losses through hydroelectric facilities (Ransom and Steig 1994; Maiolie and Elam 1996; Ransom et al. 1996).

There are many advantages to incorporating hydroacoustics into traditional sampling methodologies such as trawling or gillnetting (Brandt 1996; Yule 2000). Hydroacoustic surveys are extremely cost effective in that a crew of two individuals can collect large quantities of data. In pelagic zones, hydroacoustics are also nonselective in comparison to trawls, seines, gillnets, or other traditional sampling gears. Additionally, multiple fish parameters can be estimated concurrently, and results are readily available.

Hydroacoustics are not limited to simply providing estimates of densities or spatial distributions. Hydroacoustics can be used to estimate individual fish length using equations that relate target strength (measured in decibels, dB) to fish length when fish are dorsal-ventrally oriented to a vertically aimed or downlooking transducer (Love 1971; Love 1977). Resulting length-frequency distributions may be valuable information for managers (e.g., monitor recruitment, estimating age structure and mortality, etc.).

Like any sampling methodology, hydroacoustic technology does not come without limitations. In shallow waters, fish abundance estimates obtained from downlooking transducers can be prone to bias, because sample volume is limited near the apex of the cone (Yule 2000). Recent development of horizontal or sidelooking hydroacoustics technology has enabled biologists to monitor fish in shallow water habitats (Kubecka 1996; Yule 2000; Teuscher 2001). Multiplexing between a downlooking and sidelooking transducer allows acoustic monitoring of surface-oriented fish in shallow waters (Yule 2000). However, in limnetic environments, target strength measurements are suspect, because there is no way to determine the horizontal orientation of a fish in relation to the acoustic beam axis (Kubecka and Duncan 1998; Yule 2000). Another limitation is that hydroacoustics require a high initial investment in equipment and training personnel to operate the equipment. Also, monitoring fish that are very close to boundaries, such as the surface or bottom, is difficult using hydroacoustics. Therefore, it is generally not possible to use hydroacoustic technology to examine fish in littoral, benthic, or near-surface habitats.

In shallow waters, fish abundance estimates obtained from downlooking transducers can be prone to bias, because sample volume is limited near the apex of the cone (Yule 2000). Recent development of horizontal or sidelooking hydroacoustics technology has enabled biologists to monitor fish in shallow water habitats (Kubecka 1996; Yule 2000; Teuscher 2001). Multiplexing between a downlooking and sidelooking transducer allows acoustic monitoring of surface-oriented fish in shallow waters (Yule 2000). However, in limnetic environments, target strength measurements are suspect, because there is no way to determine the horizontal orientation of a fish in relation to the acoustic beam axis (Kubecka and Duncan 1998; Yule 2000).

The inability to discern species is the primary limitation of using hydroacoustics to collect information that enhances the management of Idaho's flatwater fisheries (Butts 2004; Butts and Teuscher 2002). Many important fisheries in Idaho contain mixed species assemblages that overlap spatially and temporally. In these environments, hydroacoustics alone cannot provide enough information to assist in management decisions or activities, and thus, attempts to collect fish for target verification data should be made.

Fish sampling for hydroacoustic target verification can be designed to account for collection gear biases as well as vertical and horizontal environmental gradients in water bodies. More than one type of collection gear should be utilized for capturing fish, and collections should occur at a number of sites along hydroacoustic transects throughout a lake or reservoir.

Acoustic assessments of fish populations can also be enhanced by the collection of environmental data. Temperature and dissolved oxygen (DO) are critical variables that structure lake and reservoir habitats along both vertical and horizontal gradients. This in turn influences fish distribution and movement (Baldwin et al. 2002) and the structure of fish communities within a water body (Engel and Magnuson 1976; Jackson et al. 2001).

MANAGEMENT GOAL

1. Improve sportfishing and fisheries management in Idaho lakes and reservoirs.

OBJECTIVE

1. To determine during the 2004 field season whether hydroacoustic methods can be used to produce useable population estimates in complex fish communities.

2. To fulfill BOR grant agreement 1425-99FG1061030 by conducting surveys at remaining water bodies that were specified in the contract.

TASKS

1. Estimate the number of pelagic fish at Anderson Ranch Reservoir, Black Canyon Reservoir, Cascade Reservoir, Deadwood Reservoir, Island Park Reservoir, Little Wood Reservoir, Mann Creek Reservoir, and Payette Lake.

2. Describe the temporal aspects of susceptibility to sampling by sonar gear.

3. Develop fish sampling techniques to partition hydroacoustic abundance estimates by species, with reasonable error bounds (30-50%).

METHODS

Hydroacoustics

Hydroacoustic estimates of fish densities, lengths, and vertical depth distributions were obtained with a Hydroacoustic Technology, Inc. (HTI) Model 241-2 split-beam digital echo sounder. The 200 kHz sounder was equipped with two transducers: a 15° vertically aimed transducer (downlooking) and a 6° horizontally aimed transducer (sidelooking), which was set at a 6° angle below the surface. Transducers were suspended 1 m below the water surface using a retractable pole mounted on the port side of the boat. Boat speed during data collection ranged from 1 to 1.5 m/s. Sampling transects were determined prior to surveys and were followed using Global Positioning System (GPS) coordinates (Appendices).

Data were collected by fast multiplexing equally between both transducers at a sampling rate of 3.0-12.5 pings/s, which allowed for near-simultaneous data collection at 1.5-6.25 ping/s per transducer. A transmit pulse width of 0.2 milliseconds (ms) was used for both transducers.

Yule (2000) determined that the effective detection angle of the 15° transducer approached nominal beam width at 8 m of range and the 6° effective detection angle approached nominal beam width at 10 m of range. However, recent evaluations of this approach suggest that the nominal beam width of the 15° transducer may actually occur at 6 m of range. Therefore, the sidelooking transducer (6°) collected data in 0.5-6 m of the water column at a range of 10-42 m, which was manually adjusted *in situ* using an oscilloscope as a reference. The downlooking transducer (15°) collected data in the remaining water column. Downlooking ranges (depth), sidelooking ranges, and GPS coordinates were automatically recorded to data files at 10 s intervals during surveys.

Thresholds were generally established so that targets larger than –60 dB and –44 dB along the acoustic axis were accepted for the downlooking and sidelooking transducers, respectively. Thresholds corresponded to a minimum size acceptance of 19 mm fish targets for the downlooking transducer (Love 1977) and 132 mm for the sidelooking transducer (Kubecka and Duncan 1998). The bottom threshold was set at 2.0 V, and echoes within 1.5 to 2.0 m of the bottom were excluded from analysis (bottom window). However, in some instances, the bottom was tracked manually in efforts to detect fish closer to the bottom. In these instances, the bottom was manually traced using the returning echo strength and bottom editing functions within the software during fish tracking analyses.

Target tracking was used to classify returning echoes as fish and thus obtain fish density estimates. This method combines individual echo returns that meet specific criteria and records them as individual fish. Following methods described by Teuscher (2001), fish tracking criteria included: 1) a minimum of three echoes with a minimum acceptable change in range between echoes of 0.2 m, 2) a maximum difference in returning echo strength of 10 dB, 3) maximum swimming velocity of 3 m/sec, and 4) mean target strength for a tracked fish between a size range of –20 and –60 dB. During the survey, data were collected and processed, and fish were tracked and recorded using the HTI software, Digital Echo Processor (DEP). However, because the default tracking parameters may allow gas bubbles, bottom, or complex substrate to be counted as fish, we individually examined tracked fish using HTI's EchoScape software. The software allows the user to further examine individual echoes within a fish trace and thereby reduce errors associated with using the automatic tracking procedures, i.e. overestimating fish density.

Estimates of downlooking fish densities (>6 m deep) for each transect were obtained using a range weighting technique as described by Yule (2000). This method standardizes fish density estimates by accounting for expanding sampling volume with increasing range. Tracked fish are weighted back to a 1 m swath at the surface using the following formula:

$$F_w = \frac{1}{(2 * R * \tan(7.5°))}$$

where F_w is weighted fish,

R is range, and

7.5° equals half the nominal transducer beam width.

Fish densities (fish/m^2) for each transect were calculated by summing weighted fish and dividing that value by transect length (m). Fish detected by the downlooking transducer that were in the top 6 m of the water column were excluded from analysis to avoid double counting.

Sidelooking fish densities (<6 m deep) for each transect were estimated by dividing the number of fish detected by the volume of water sampled. The volume of water sampled (m^3) was estimated by multiplying transect length (m) by the average range sampled by the sidelooking transducer (m) by the average height of the cone (m). The first 10 m of range (near field) was not included in the sample volume estimate because of the effective detection angle of the sidelooking transducer (Yule 2000).

Because the distribution of fish density estimates from transects was not normal, the geometric mean density was calculated for expansion to population estimates. The geometric mean and 90% confidence intervals (CIs) for density estimates was computed using methods described by Elliott (1983). A log(x+1) transformation was used because density estimates sometimes contained zero values. Total fish abundance was estimated by multiplying the geometric mean sidelooking and downlooking fish density (fish/ha) by the surface area of the reservoir on the survey date and summing them together. The standard error for the total population estimate was calculated using the following equation (Elliot 1983):

$$SE = \sqrt{\frac{s^2{}_x}{n_x} + \frac{s^2{}_y}{n_y}}$$

where $s^2{}_x$ and $s^2{}_y$ are the variances of each estimate

n_x and n_y are the sample sizes of each estimate.

The Bureau of Reclamation (BOR) provided surface area and volume data for most of the reservoirs sampled during 2004. When data was not available, surface area estimates were obtained using ARCVIEW software. Ninety percent confidence intervals were calculated for population estimates using the methods described in Scheaffer et al. (1996). Regardless of transect length, each transect was considered a sample unit.

Vertical depth distributions of tracked fish were calculated for most 2004 surveys after accounting for transducer depths. Downlooking depth distributions were calculated by simply

summing the number of targets at each depth interval. Sidelooking vertical depths for each tracked fish were calculated using the following equation:

$$F_d = \sin(radians(6°) * R) - Y + T_d$$

where F_d is fish depth (m),

6° is the angle at which the horizontal transducer was aimed,

R is range,

Y is total distance (m) traveled vertically by the fish in the beam, and

T_d is the physical depth of the sidelooking transducer (m).

Fish were then summed across each 1 m depth interval to attain vertical depth distributions detected by the sidelooking transducer.

Target Verification

An array of net curtains were set at various depths in pelagic regions for target verification and species partitioning at Black Canyon Reservoir, Cascade, Deadwood, Island Park, Little Wood, and Mann Creek reservoirs during nighttime periods. Nets were not set during daytime periods because of poor catch rates observed the previous field season (Butts 2004). Nets were set at various sites along hydroacoustic transects using GPS; sites were spaced longitudinally from inlet to outlet. During most net nights, two 49 m x 6 m net curtains were suspended at various intervals between depths covered by sinking and floating gillnets to ensure that the entire water column was sampled. Each net curtain consisted of 3 m long panels of different mesh arrays that were randomly placed. One net curtain was comprised of 19, 25, 32, 38, 51, 76, and 102 mm stretch mesh, while the other net was comprised of 51, 57, 64, 76, 89, 102, 127, and 152 mm stretch mesh. Each net curtain was considered an individual sampling unit during our analyses.

Fish were identified to species, and total lengths (TL; nearest mm) and weights (nearest g) were measured and recorded. For each fish, capture depth (m) was estimated, and net mesh size (mm) was recorded. Total depth at each netting site was also recorded. In cases where fish lengths were converted to hydroacoustic target strengths or vice versa, total lengths were converted to standard lengths using species-specific conversion factors (Carlander 1969).

At Deadwood Reservoir, kokanee *Oncorhynchus nerka* were collected with gillnets to assess seasonal growth within each year class and if possible to run bioenergetic simulations to determine if the population was food limited. Length frequencies varied between sampling dates reflecting changes in size selectivity, fish behavior, and fish growth. In addition, the presence of larger stocked fish further complicated the ability to discern age classes.

Species proportions were calculated separately for day and night periods using the cluster sampling formulas described by Scheaffer et al. (1996):

$$\hat{p} = \frac{\sum_{i=1}^{n} a_i}{\sum_{i=1}^{n} m_i}$$

where $\hat{p}$ is an estimator of the population proportion p,

a_i is the total number of elements in cluster i that possess the characteristic of interest, and

m_i is the number of elements in the ith cluster, i = 1, 2, . . . , n.

The variance around the proportion estimates were calculated using the following equations (Scheaffer et al. 1996):

$$\hat{V}(\hat{p}) = \left(\frac{N-n}{Nn\bar{M}^2} \right) s_p^2$$

where *N* is the number of clusters in the population,

n is the number of clusters selected in a simple random sample,

$\bar{M}$ is the average cluster size for the population, and

s_p^2 is calculated as follows:

$$s_p^2 = \frac{\sum_{i=1}^{n} (a_i - \hat{p} m_i)^2}{n-1}$$

Relative abundance estimates for individual species were estimated by multiplying the species proportions obtained from gillnets by the total fish abundance obtained from hydroacoustics. Because abundance estimates for individual species were the products of two random variables, the error around these estimates was calculated using the following equation for the variance around the product of two independent variables (Goodman 1960):

$$v(\bar{x}\bar{y}) = \bar{x}^2 \frac{s^2(y)}{n(y)} + \bar{y}^2 \frac{s^2(x)}{n(x)} - \frac{s^2(x)s^2(y)}{n(x)n(y)}$$

where $v(\bar{x}\bar{y})$ is the variance of the product $\bar{x}\bar{y}$,

$s^2(y)$ and $s^2(x)$ are the variances of $\bar{y}$ and $\bar{x}$, and

$n(x)$ and $n(y)$ are the sample sizes for each estimate.

Obtaining an appropriate estimate of error, s_p^2, around the population proportion, $\hat{p}$, allows for the estimation of the required sample size for a desired error bound. The number of clusters that should be sampled to estimate p, within a bound of B units, can be calculated as follows (Scheaffer et al. 1996):

$$n = \frac{N\sigma_p^2}{ND + \sigma_p^2}$$

where $D = B^2\bar{M}^2 / 4$, and

σ_p^2 is estimated by s_p^2.

Because the total possible number of clusters N is unlimited, it was assumed that $N = \infty$ in our estimates. We used the above formula to calculate the appropriate number of clusters that should be sampled for rainbow trout at American Falls Reservoir and rainbow trout and northern pikeminnow at Cascade Reservoir.

Limnology

Limnological data were collected concurrently with most of the hydroacoustic surveys to help explain horizontal and vertical fish distributions. Limnological variables were measured at 1-3 sites along the longitudinal axis of each reservoir, from inlet to outlet. Vertical temperature (°C) and dissolved oxygen (mg/L) profiles were measured at 1 m intervals using a calibrated Hydrolab data logger (model Surveyor 4a) and depth probe (model MiniSonde 4a). Mean Secchi transparency was recorded at each site by two different observers using a 15 cm disc.

To describe gradients in forage availability for pelagic fish, we collected data on size structure and abundance of zooplankton communities in the lower, middle, and upper reaches of the reservoirs. Zooplankton was collected using three 50 cm diameter, Wisconsin-style plankton nets with 153, 500, and 750 μm mesh. Two samples were taken per site using each net so that six zooplankton samples were collected at each station. Vertical hauls were taken from the entire water column and samples were preserved in denatured ethyl alcohol, using a 1:1 (sample volume:alcohol) ratio. Zooplankton was analyzed and indices were calculated using methods described by Teuscher (1998), with the exception that indices were calculated at each sampling site instead of the entire reservoir. This allowed me to measure potential gradients in secondary production along a horizontal axis in addition to assessing the overall availability of zooplankton resources within a water body. The zooplankton ratio index (ZPR) was calculated by dividing the mean zooplankton biomass in the 750 μm net by the mean biomass collected in the 500 μm net (Yule and Whaley 2000). The zooplankton quality index (ZQI), which accounts for abundance, was calculated by multiplying the sum of the zooplankton weight collected in the 500 and 750 μm nets by the ZPR (Teuscher 1998).

At Deadwood Reservoir, a number of different tests were conducted to provide an overall picture of the nutrient composition of Deadwood Reservoir. Dissolved orthophosphate tests measure the filterable fraction of phosphorous, which phytoplankton use for growth. Thus, total phosphorous levels are good indicators of the trophic state of reservoirs (NALMS 1992). Given that nitrogen has such a complex cycling process, several nitrogen analyses including ammonia, nitrate, nitrite, and total Kjeldahl N were performed to obtain total nitrogen levels. In addition, chlorophyll a, the most common variable used to estimate algal biomass and often a major component of trophic state indices and water quality criteria, was also measured (EPA 2000; NALMS 1992).

Water nutrient sampling was conducted at three limnology sites using a modified sampler 9.1 m in length to obtain a sample of the entire photosynthetic portion of the water column. The tube was 1.5 cm in diameter and retrieved 1000 mL of water for analysis from each site. Samples were stored in transparent plastic bottles and put on ice immediately after retrieval. Samples were taken to Alchem Laboratories within 24 hours for analysis. A separate 1000 mL was retrieved for chlorophyll a analysis. These samples were stored in glass, amber colored bottles and were covered with tin foil to ensure the sample would be stored in complete darkness for accurate analysis. These samples were also put on ice immediately and taken to the laboratory within 24 hours. Samples were taken on June 15 and August 9, respectively. Samples were analyzed for total ammonia, nitrate, nitrite, dissolved orthophosphate, Kjeldahl nitrogen, total phosphorous, and chlorophyll a. Ratios of N:P were calculated by summing ammonia, nitrite, and nitrate as total nitrogen and total phosphorous. Common N:P ratios are 10:1, where living matter requires on average a 7:1 ratio for sustenance (Horne and Goldman 1994).

By conducting surveys at Black Canyon Reservoir, Island Park Reservoir, Little Wood Reservoir, and Mann Creek Reservoir, all water bodies specified in BOR grant agreement 1425-99FG1061030 have been completed.

RESULTS

Anderson Ranch Reservoir

Anderson Ranch Reservoir was surveyed using hydroacoustics during the evening of August 16, 2004. Twenty-one transects were sampled beginning near the inlet area and ending at the Anderson Ranch dam (Appendix A). Limnological data were also collected at three stations (Appendix A). Based on prior netting experience, all targets were considered kokanee.

The majority of tracked fish were less than 100 mm long, and older age classes were not discernable from the length-frequency histogram (Figure 1). The modal size of tracked fish was -50 dB, which is approximately 55 mm using the Love (1971) equation. The modal depth of tracked fish was 42 m, and most fish occupied a layer between 35 and 45 meters.

The highest fish densities of all size classes were observed at the lower end of the reservoir, near the dam, in areas that contained deeper water (Figure 2). Densities of fish <100 mm, presumably age-0 kokanee, were much higher than densities of older fish. Densities of fish >100 mm declined dramatically upstream from the confluence of Wood Creek, while densities of fish <100 mm were highest downstream from the Falls Creek confluence. The geometric mean density of fish <100 mm was 566.2 (396.4 to 808.6) fish/ha, while fish between 100 mm and 200 mm was 116.0 (77.9 to 172.6) fish/ha, and fish >200 mm was 47.2 (34.0 to 65.2) fish/ha (Table 1). The overall mean fish density estimate for kokanee at Anderson Ranch Reservoir was 754.9 (530.7 to 1,073.6) fish/ha.

The overall population of kokanee at Anderson Ranch Reservoir was estimated to be 916,469 (90% CI 644,251 to 1,303,492) in 2004 (Table 1). The population was comprised largely of age-0 fish, as 687,445 (481,273 to 981,718) fish were estimated for this age-class, accounting for approximately ¾ of the total population. Meanwhile, we estimated 140,843 (94,534 to 209,552) fish were 100-200 mm (age-1), and 57,253 (41,299 to 79,195) fish were >200 mm.

Anderson Ranch Reservoir was thermally stratified during the August 2004 survey (Figure 3). Water temperatures below 12°C were only available in the lower area of the reservoir where depths exceeded 30 m. Secchi depth increased by 1 meter, from 2.7 m at site 1 near the inlet, to 3.8 m at site 3 near the dam. Conversely, ZQI decreased eight-fold from the inlet area (3.2) to the dam area (0.4; Table 2). These results support the observed high densities of kokanee near the lower section of the reservoir.

We examined the annual late summer/early fall hydroacoustic estimates from Anderson Ranch Reservoir for the years 2000-2004 (Figure 4). The overall population estimate was highest in 2000 when numbers were close to 2,000,000 fish and were at their lowest in 2002 when fewer than 500,000 fish were estimated. The numbers have increased since 2002 to over 1.5 million in 2004. The 2004 estimate of age-0 kokanee was the highest observed during the 5-year period, despite the lower number of adults as compared to previous years. This suggests that density-dependent factors may be influencing growth and survival of age-0 kokanee at Anderson Ranch Reservoir.

Black Canyon Reservoir

Black Canyon Reservoir was sampled during the week of May 24, 2004. Twelve transects were sampled by hydroacoustics, during both day and night diel periods, beginning near the Anderson Creek tributary confluence where reservoir depth first allowed the boat to navigate safely and continuing towards the dam (Appendix B). Eight net curtains were set at randomly chosen sites along the longitudinal axis of the reservoir, and limnological data were also collected at three sites.

Size frequencies of hydroacoustic targets were quite similar between day and night periods (Figure 5). Targets ranged from 30 mm to nearly 600 mm SL, with the majority of targets below 100 mm. The modal length of targets was 40 mm for both day and night surveys. Depth distributions were not analyzed for Black Canyon Reservoir because the reservoir rarely contains depths >10 m.

Fish densities were similar between day and night periods but night transects did provide a higher total density estimate of 317.0 (206.9 to 485.4) fish/ha as compared to 287.9 (175.6 to 471.6; Figure 6; Table 3). Fish densities were higher below 6 m, as detected by the downlooking transducer, although the reservoir did not exceed 6 m during the first four transects. Using the night transects to estimate the population abundance, we estimated 141,070 (92,072 to 216,019) fish.

Net curtain catches were comprised of primarily largescale sucker *Catostomus macrocheilus* (53% ± 18%), northern pikeminnow *Ptychocheilus oregonensis* (15% ± 6%), yellow perch *Perca flavescens* (17% ± 13%), and chiselmouth *Acrocheilus alutaceus* (9% ± 4%). Black bullheads *Ictalurus melas*, black crappies *Pomoxis nigromaculatus*, and carp *Cyprinus carpio* were also encountered less frequently (Figure 7). Based on species proportions from gillnetting and abundance estimates from hydroacoustics, this resulted in population estimates of 75,456 ± 4,684 largescale suckers, 20,504 ± 1,576 northern pikeminnows, 23,785 ± 3,460 yellow perch, and 13,123 ± 1,044 chiselmouth. Yellow perch ranged from 76 to 225 mm with a mean of 164 mm (Table 4).

Black Canyon Reservoir was isothermal at the upper end of the reservoir (Site 1) where water temperature was approximately 10°C and ranged from 15°C (surface) to 10°C near the

dam (Site 3; Figure 8). Dissolved oxygen levels were habitable to fish throughout the reservoir except 1 m layer of anoxic water above the reservoir bottom at Site 3. Zooplankton, as measured by the ZQI index, ranged from 0.47 at Site 1 to 0.12 at Site 3 (Table 2). The values are ranked intermediate to extremely low, suggesting that forage resources are limited for zooplanktivorous species, particularly in the lower end of the reservoir where high fish densities were combined with low ZQI values.

This survey marked the first time that Black Canyon Reservoir was sampled with hydroacoustics gear. However, given the species composition and size of the game fish present, this reservoir does not appear to provide an important fishery.

Cascade Reservoir

Cascade Reservoir was surveyed during the week of July 26, 2004. Ten standardized transects, beginning at the northern portion of the reservoir, were sampled with hydroacoustics, and eight net curtains were set at random sites throughout the reservoir (Appendix C). Limnological sampling was also conducted at three sites.

Fish densities of all size classes were highest in transects 2-3 and densities of fish >250 mm were low throughout the survey (Figure 9). Fish density estimates for all sizes was highest in the top 6 m (sidelooking), where 138.2 (69.8 to 272.9) fish/ha were estimated (Table 5). The total density estimate for all size classes of fish was 158.7 (85.9 to 292.3) fish/ha. For fish >250 mm, 0.4 (0 to 1.0) fish/ha were estimated in the top 6 m, while 4.8 (3.2 to 7.0) fish/ha were estimated in depths >6m, resulting in a total density estimate of 5.4 (3.5 to 8.2) fish/ha. Expanding density estimates to abundance estimates, we estimated 54,348 (34,779 to 82,454) fish >250 mm, and 1,598,736 (865,550 to 2,945,840) total fish (Table 5).

Gillnet catches consisted primarily of largescale suckers (38% ± 26%), rainbow trout *O. mykiss* (35% ± 30%), northern pikeminnow (15% ± 10%), and brown bullheads *I. nebulosus* (8% ± 11%; Table 6). Rainbow trout ranged from 110-560 mm, with a mean total length of 277.6. Meanwhile, largescale suckers ranged from 395-660 mm ($\bar{x}$ = 540.3) and northern pikeminnow ranged from 310-560 mm ($\bar{x}$ =461.1; Figure 10).

In 2004, we estimated 553,752 (± 88,534) rainbow trout, where 18,824 (± 3,030) were >250 mm (Table 6). For northern pikeminnow, 241,150 (± 29,806) fish were estimated, of which 8,198 (± 1,025) were above 250 mm. Finally, 607,341 (± 78,226) largescale sucker were estimated, with 20,646 (± 2,688) fish >250 mm. Estimates for the less abundant fish species are located in Table 6.

Cascade Reservoir was thermally stratified throughout the reservoir during the survey. Water temperatures ranged vertically from 25-16.5°C (surface to bottom) at the northern end of the reservoir and 24-13.6°C near the dam (Figure 11). In addition, zones of poorly oxygenated water existed near the bottom at all three sites, where observed DO levels fell below 2 mg/L at depths >6m. ZQI increased from 5.4 at Station 1 to 14.5 at Station 3 (Table 2). These levels were among the highest measured at any reservoir in 2004, suggesting excellent forage for planktivores.

Hydroacoustic surveys have been conducted at Cascade Reservoir on an annual basis since 2000 (Figure 12). During this period, extensive removal efforts of northern pikeminnow and largescale sucker have also occurred. Hydroacoustic estimates were separated into two

groups: fish >250 mm and all fish. While physical removal efforts were most productive at removing adult fish that were >250 mm, hydroacoustic estimates did not show significant reduction in estimates of this size group. Estimates of fish >250 mm were relatively low, ranging from a low of 4,258 in 2001 to 88,289 in 2003. However, between 2001 and 2004, a dramatic increase in the estimate of all fish was observed. In 2001, we estimated 46,572 fish, which increased to 1,598,736 fish by 2004. Since the estimates of fish >250 mm were relatively stable during this period, this dramatic increase was comprised of primarily smaller fish.

Deadwood Reservoir

Deadwood Reservoir was sampled with hydroacoustics on June 22, 2004, one day prior to kokanee stocking, and on August 11, 2004. Sixteen transects were sampled with hydroacoustics in June and 15 were sampled in August (Appendix D). Netting was also conducted during these surveys with an additional netting event conducted on October 5, 2004. Otoliths were collected from a number of fish to assess growth within each year class. Limnological data were collected during all sampling events to assess forage availability and primary production.

Differences in target strength distributions between the two surveys were substantial (Figure 13). Fish ≤100 mm displayed a pronounced increase in August as a result of stocking, natural recruitment of age-0 kokanee, and thermal stratification, causing kokanee to reside in deeper waters where they were more detectable to sonar gear.

Density of age-0 kokanee increased from 127.9 (109.2 to 149.6) fish/ha in June to 441.6 (315.6 to 617.9) fish/ha in August (Table 7). Other size classes increased in density between the two time periods, albeit less substantially. The total density estimate for all size classes was estimated to be 652.4 (480.4 to 885.8) fish/ha in August.

We estimated the total abundance of kokanee to be 384,090 (346,064 to 426,277), of which 47% or 181,084 (154,691 to 211,939) were age-0 kokanee (Table 7). Fish that were between 100 and 200 mm were estimated at 120,951 (104,517 to 139,934), and kokanee >200 mm were at 66,791 (58,976 to 75,617).

Mean length at age during the three collection periods was calculated but results were confounded by small sample sizes and an inability to separate hatchery and wild-origin fish (Figure 14). Small sample sizes were a result of a large number of otoliths being destroyed during the sectioning process. The confounding results are best illustrated by the age-0 and age-1 size classes, where mean length at age estimates decreased between June and October from 150 mm to 94 mm (Table 8). Attempts to separate hatchery and wild-origin fish within year classes using both whole otolith length and the distance from the center of the otolith to the first annulus were also not successful. Using the distance between the otolith center to the first annulus did appear to offer better results as exemplified by age-3 fish in June and age-0 fish in August, and with a larger sample size within each age group, this method may have been successful (Figure 15). Therefore, without good estimates on growth within year classes, bioenergetic modeling of consumption was not possible.

Limnological data were collected at three sites at Deadwood Reservoir in June, August, and October. The reservoir had begun to thermally stratify in June and had cooled to isothermal conditions by October (Figure 16). ZQI levels were extremely high at all sites in June and dramatically decreased to levels where resource competition was evident by the August and

October sampling periods (Table 2). Mean zooplankton density varied between sites and was highest at sites 1 and 2 during the August sampling period. Mean *Daphnia* length was largest but most variable during the October sampling period and smallest during June (Figure 17). N:P ratios were high throughout the reservoir in June where we measured 26:1 ratio at site 1, 21:1 at site 2, and 19:1 at site 3. By August, N:P ratios had decreased to more moderate levels. On August 11, we measured N:P ratios of 9:1, 10:1, and 7:1 at sites one, two, and three respectively (Table 9).

The kokanee population at Deadwood Reservoir has been monitored with hydroacoustics since 2000, with the exception of 2001 (Figure 18). Total abundance estimates were lower in 2000 and 2002 where the estimates were below 225,000 but have since approached 900,000 in 2006. The increase has been noticeable in all size groups of fish and has likely been a result, in part, of stocking efforts from 2001-2005.

Island Park Reservoir

Island Park Reservoir was surveyed on July 7, 2004. Twelve transects, beginning at the inlet and ending at the dam, were sampled during both day and night periods (Appendix E). Limnological data were collected at three stations, but netting was not conducted because of time constraints. However, netting data from regional trend netting conducted from 2000-2002 was used to partition hydroacoustic estimates into species estimates.

A pronounced diurnal difference in size frequency of targets was observed (Figure 19). The night survey produced more targets and a more complete picture of the size distribution of fish in comparison to the day transects. Because of the shallow bathymetry of the reservoir, depth distribution was not plotted.

As suggested by size distributions, night transects produced a much higher count of targets than day transects (Figure 20). The exception to this was the shallow transects at the beginning and end of the surveys. During the day, mean densities were similar between sidelooking (0-6 m) and downlooking (>6 m) estimates (Table 10). However, during the evening, fish densities were much higher at depths >6 m (62.9 fish/ha) than in the top 6 m (12.7 fish/ha).

The estimate of total fish abundance increased six fold from day to night (Table 10). During the day, 53,939 (36,716 to 78,648) fish were estimated whereas 345,006 (271,883 to 437,588) were estimated at night.

Species proportions were calculated using netting data collected by regional personnel during 2000-03. The fish community was dominated by Utah chubs *Gila atraria* (52% ± 9%), followed by Utah suckers *C. ardens* (28% ± 27%), and rainbow trout (11% ± 13%). These proportions resulted in population estimates of 178,055 ± 3,826 Utah chub, 96,430 ± 11,127 Utah suckers, and 39,351 ± 5,120 rainbow trout (Table 11). Proportion and population estimates for species that occurred less frequently are in Table 11.

Despite a sampling date of July 7, temperature and dissolved oxygen profiles did not show stratification throughout most of the reservoir (Figure 21). At site 1, temperatures ranged from 19 to 14°C from surface to bottom respectively, and at site 3, near the dam, temperatures ranged from 19 to 17.5°C. Dissolved oxygen levels below 6 mg/L were not observed at any of the sampling sites in the reservoir. Secchi depths exceeded 4 m at all sites, with a depth of 4.3 m at site 1 and a maximum value of 5.6 m at site 3. The relatively high Secchi values

suggest low algal production or high grazing by planktivores. ZQI values ranged from 4.8 at site 1 to 11.2 at site 3, which supports the speculation that water transparency was a result of grazing by plankton (Table 2).

Little Wood Reservoir

Little Wood Reservoir was surveyed during the week of June 16, 2004. Fourteen hydroacoustic transects were sampled during the day, beginning near the inlet and ending along the dam (Appendix F). Eight net curtains were set overnight, and three limnological stations were sampled.

Tracked target strengths (dB) converted to standard lengths (mm) ranged from 31 to 590 mm with a median of 281 mm (Figure 22). Fish densities per transect ranged from a low of zero fish/ha at transect 5 to a high of 68.4 fish/ha at transect 9 (Figure 23). Transects 8-10 experienced the highest fish densities. Mean fish density for the top 6 m of the water column was 4.9 (3.4 to 6.9) fish/ha while 3.6 (1.6 to 7.3) fish/ha was estimated at depths >6 m (Table 12). Total fish density for Little Wood Reservoir was 11.2 (7.0 to 17.5) fish/ha. The total abundance estimate was 2,255 (1,417 to 3,527) fish (Table 12).

Gillnet catches were comprised of bridgelip suckers *C. columbianus* (71% ± 21%), rainbow trout (24% ± 18%), brook trout *Salvelinus fontinalis* (3% ± 5%), and speckled dace *Rhinichthys osculus* (2% ± 1%; Table 13). Bridgelip suckers averaged 189 m and ranged from 85 to 335 mm, rainbow trout mean length was 344 mm and ranged from 140 to 450 mm, and brook trout averaged 277 mm with a range of 245 to 364 mm (Figure 24).

Estimates of individual species abundance were 1,602 (± 87) for bridgelip sucker, 537 (± 74) for rainbow trout, and 78 (± 19) for brook trout (Table 13). The low population estimates were a result of the low density estimates.

Temperature and dissolved oxygen profiles were only collected at site 1 because of equipment malfunctions. Water temperatures ranged from 15.4°C at the surface to 12.8°C at the bottom while DO did not fall below 7 mg/L in the water column (Figure 25). ZQI values ranged from 1.1 near the inlet and 2.1 near the dam suggesting adequate forage for zooplanktivores throughout the reservoir (Table 2).

Mann Creek Reservoir

Mann Creek Reservoir was surveyed during the week of June 2, 2004. Fourteen hydroacoustic transects were sampled during the day beginning at the inlet and ending along the dam (Appendix G). Seven net curtains were set overnight at random sites across the reservoir, and three limnological stations were sampled as well.

Hydroacoustics detected 488 targets that met the criteria for fish. The majority of targets were small as the converted mean standard length was 58.6 mm and ranged from 18.8 to 462 (Figure 26). Density estimates were highest at the beginning and ending transects (Figure 27). The highest density was observed along transect 13 where 5,237.5 fish/ha were estimated. Nearly all fish were detected in the top 6 m of the water column where only one transect (3) contained fish below 6 m. Sidelooking density was 1,442.4 (1,085.1 to 1,917.2) fish/ha and downlooking density was 0.4 (0 to 1.1) fish/ha (Table 14). The total density estimate for Mann

Creek Reservoir was 1,449.9 (1,091.2 to 1,926.5) fish/ha which was expanded to a population estimate of 146,439 (110,206 to 194,575) fish.

Gillnet catches were comprised of rainbow trout (78% ± 21%), black crappie (19% ± 23%), and bridgelip sucker (3% ± 3%) (Table 15). Species population estimates for Mann Creek Reservoir were calculated from hydroacoustic abundance estimates and species proportions obtained from netting (Table 15). In Mann Creek Reservoir, we estimated 114,086 (± 5,406) rainbow trout, 27,245 (± 5,992) black crappie, and bridgelip sucker 5,108 (± 655). Rainbow trout lengths ranged from 110 to 536 mm, with a mean of 280 mm, black crappie lengths ranged from 101 to 131 mm with a mean 117 mm, and bridgelip sucker lengths ranged from 265 to 420 mm (Figure 28).

Temperature and DO profiles at Mann Creek Reservoir displayed stratification at the deeper sites of the reservoir (Figure 29). Near the inlet, temperatures ranged from 17.5 C at the surface to 13.5 C at the bottom, while near the dam they ranged from 17.5 C to 8.3 C. Dissolved oxygen levels were above 6 mg/L except near the dam where a 1 m layer of poorly oxygenated water (1.6 mg/L) was detected that may have excluded fish. ZQI values ranged from 1.1 to 20.5, which suggest excellent foraging conditions for zooplanktivores (Table 2).

Payette Lake

Payette Lake was surveyed with hydroacoustics in 2004 to continue annual efforts to monitor kokanee abundance. Thirteen transects were surveyed beginning in the east arm, traveling north and around Cougar Island, and south towards the boat ramp (Appendix H). In addition to hydroacoustics, temperature and DO profiles were also recorded (Appendix H). Fish were not collected for target verification or age information.

Kokanee age classes were not discernible from the target strength distribution (Figure 30). Therefore, kokanee age classes were separated using the same criteria as previous surveys conducted in 2000 (Teuscher 2001). Age-0 kokanee were identified as fish <-49 dB (77 mm), age-1 kokanee were fish between –49 dB and –42 dB (78 mm to 184 mm), and age-2+ fish were identified as fish between –41 dB and –33 dB (185 mm to 568 mm). All pelagic targets that fell within –49 dB and –33 dB were assumed to be kokanee.

Numbers of tracked kokanee varied across transects (Table 16). The highest overall density of kokanee was observed in transect 4 (534.1 fish/ha), which also had the highest densities of age-0 (245.8 fish/ha) and age-1 (235.2 fish/ha) fish. Age-0 kokanee had the highest observed densities with a mean density of 86.7 (67.9 to 110.6) fish/ha. The total density for all age classes of kokanee was 194.5 (160 to 236.4) fish/ha.

Population estimates were calculated for three size groups of kokanee along with total overall kokanee abundance (Table 16). We estimated 187,206 (146,624 to 238,857) age-0 kokanee, 156,770 (126,233 to 194,571) age-1 kokanee, and 61,962 (50,666 to 75,674) age-2+ kokanee. The estimate of total abundance for all age classes was 420,142 (345,611 to 510,646) fish.

Payette Lake was thermally stratified throughout the water body during the hydroacoustic survey (Figure 31). Water temperatures ranged from 22°C at the surface to 4°C at the deepest part of the lake. The thermocline occurred between 8 and 12 m depth. Dissolved

oxygen levels were adequate for fish except for a 1-m zone near the bottom measured at site 3, where levels fell below 2 mg/L (Figure 31).

Since 2000, the kokanee population has stayed relatively stable aside from a large year class of age-0 kokanee in 2003 (Figure 32). Age-1 and age-2 year classes, in particular, have shown little variation between years. Estimates of total kokanee abundance were not significantly different from one another but mean abundance reached its lowest value of 270,468 in 2002 and its highest value of 483,990 in 2003.

Lake Walcott

Lake Walcott was sampled with hydroacoustics on July 9, 2004 at night (Appendix I). However, fish sampling with gillnets was conducted on June 28, 2006 (Appendix I). In addition to hydroacoustics and gillnets, limnological data were collected at one station.

The majority of targets were below 100 mm and the median length was 239 mm (Figure 33). Fish densities were variable between transects with a low of 8 fish/ha in transect 12 and a high of 1,107 fish/ha in transect 6 (Figure 34). Despite the shallow bathymetry of Lake Walcott, mean density was higher at depths >6 m where 36.1 (16.2 to 78.8) fish/ha were estimated while 11.2 (5.9 to 20.5) fish/ha were estimated in the top 6 m (Table 17). Total abundance for the pelagic fish community at Lake Walcott was estimated to be 393,772 (231,114 to 668,669; Table 17).

Nine net curtains were set at random sites across Lake Walcott. Catches were dominated by Utah chub (75% ± 15%), Utah suckers (17% ± 15%), and rainbow trout (4% ± 3%; Table 18). Population estimates for individual species were calculated using hydroacoustic abundance estimates and species proportion values estimated from netting (Table 18). We estimated 294,518 ± 10,386 Utah chub, 67,467 ± 11,170 Utah suckers, and 16,218 ± 2,192 rainbow trout in Lake Walcott during the July 2004 survey. Utah chub ranged from 82 to 480 mm with a mean of 273 mm, Utah sucker ranged from 135 to 630 mm with a mean of 497 mm, and rainbow trout ranged from 322 to 587 mm with a mean of 392 mm. Smallmouth bass, bluehead sucker, common carp, redside shiner, and yellow perch were also encountered less frequently in nets.

Lake Walcott is a shallow reservoir that often experiences high winds, thus the reservoir was not stratified because it experiences frequent mixing (Figure 36). Water temperatures ranged from 19°C near the dam to 21°C at site 2. Dissolved oxygen values never fell below 6 mg/L at any of the limnology sites. ZQI ranged from 3 to 12, suggesting excellent forage availability for zooplanktivores (Table 2).

DISCUSSION

Nine hydroacoustic surveys were conducted in 2004, of which seven were accompanied by intensive netting so that population estimates of individual species could be calculated. Because of these surveys, there is a better understanding of the strengths and limitations of hydroacoustics in regards to species assemblage, fish behavior, and lake bathymetry. In addition to these findings, monetary costs can be estimated for a typical survey and for a

desired precision level. The latter will help IDFG biologists evaluate whether or not a complete population survey is warranted at any given water.

The validity of the use of hydroacoustics to estimate fish abundance is dependent upon many factors including community assemblage, fish behavior, habitat use, the bathymetry of the water body, and the seasonal influences upon these factors as well. Research on Cascade Reservoir illustrates how the influence of these factors can be minimized over time through the collection of hydroacoustic data and knowledge about the biology and behavior of the target species. Cascade Reservoir has been sampled at least once annually since 2000 with spring and fall sampling occurring in 2000 and 2001 in order to determine northern pikeminnow abundance and monitor the success of removal efforts. From that information, it was decided that August was the best month in which to conduct hydroacoustic sampling. During this period in 2002 and 2003, the reservoir has proven to be thermally stratified with a layer of anoxic water close to the bottom, which may increase the echo sounder's ability to detect fish because fish are inhibited from staying close to the reservoir bottom. To reduce the relatively large error bound around the overall population estimate, hydroacoustic transects were standardized by length beginning in 2002. This reduced the error around the hydroacoustic population estimate from 73% in 2001 to 47% and 40% in 2002 and 2003, respectively. Finally, using species proportion information collected using gillnets during 2002, it was determined that a minimum of 20 nets should be set to reduce the variance around proportion estimates (Butts 2004; Scheaffer et al. 1996). Proportion estimates were very similar between years, suggesting that these estimates can be used as a reliable indicator of relative abundance and will aide in partitioning hydroacoustic estimates into individual species estimates when variance is calculated. Although there is now a better understanding of the importance of seasonality on the timing of hydroacoustic assessments, there remains uncertainty about the seasonal impact upon species proportion estimates.

Estimates of species abundance, however, should be limited to species that occur frequently in nets. In a number of reservoirs, species were captured infrequently because either nets were set in nonpreferred habitats or the species are rare within a water body. In Cascade Reservoir, smallmouth bass comprised 1% of the total catch, which resulted in a population estimate of 17,863 ± 6,520. This estimate is unreliable, because smallmouth bass primarily inhabit littoral regions. Because hydroacoustics sampling is limited to pelagic regions, we only deployed nets within these habitats, and thus smallmouth bass were not sampled effectively with either methodology. Similar cases occur at all other reservoirs where multiple species were sampled. Therefore, it should be recognized that a hydroacoustic survey would generally only produce meaningful estimates for the most abundant, pelagically occurring species in a water body.

Measurements of environmental characteristics have enhanced the interpretation of fish distributions and aided in determining survey timing. For example, seasonal thermal differences between the June and August surveys at Deadwood Reservoir resulted in a two-fold increase in estimated fish abundance. In August, Cascade Reservoir approached anoxic conditions at depths >8 m, which should actually aid hydroacoustics by keeping fish away from the bottom where they are less detectable. As more water bodies are repeatedly surveyed through time, limnological parameters should aid in determining appropriate sampling periods and identifying potential sources of variability in results.

Another important factor in determining whether to use hydroacoustics as a tool to estimate fish population abundance is cost. In general, the relatively low cost of hydroacoustics in comparison to other methods such as mark-recapture estimates is often considered one of the primary advantages to hydroacoustics. However, managers must consider the relatively

intensive netting that must accompany hydroacoustics in most Idaho waters. These relationships that were developed based on the survey at Cascade Reservoir provide a good index for estimating the potential cost of conducting a hydroacoustic survey in concert with netting for species proportions at almost any given water body (Butts 2004). This also demonstrates the cost effectiveness of hydroacoustics in comparison to more labor intensive methods such as mark-recapture studies.

The use of the geometric mean instead of the arithmetic mean when expanding mean density estimates into population estimates resulted in numbers that are more conservative. In general, density estimates for individual transects are not normally distributed, as was the case for all of the surveys conducted in 2004. Perhaps this was because data collected from adjacent transects are more similar to one another, and changes in density estimates reflect changes along environmental gradients within the water body (i.e. inlet to outlet). Therefore, although the arithmetic mean has been used in all previous hydroacoustic population estimates conducted by this project, utilizing the geometric mean, when appropriate, should provide population estimates that are less biased by the often large variability between density estimates from individual transects.

Overall, the success of hydroacoustics to obtain fishery population estimates was good during 2004. A great deal has been learned over the past three years in regards to our ability to partition hydroacoustic estimates into estimates of individual species using gillnets for species verification and reduce the inherent variation. As illustrated by the Cascade Reservoir surveys from 2000 to 2004, hydroacoustics can provide a reasonable and stable population estimate for an individual species in water bodies containing complex species assemblages with a few caveats: 1) the target specie(s) must utilize pelagic habitats and must not be limited to the benthic region, 2) biologists should have some understanding of the biology and behavior of the target specie(s), 3) intensive fish collection efforts are crucial to obtaining reliable estimates of species proportions and the number of nets that are deployed should be based on the desired error bound for a proportion, 4) surveys that are repeated during different seasons are extremely helpful in determining the appropriate timing for the optimal population estimate, and finally 5) as with trend netting, every effort should be made to conduct future surveys during the same seasonal or environmental period as previous surveys so that behavioral biases are minimized. The costs in terms of time and labor can be high because of the required fish collection efforts. Therefore, the benefits and value of a survey should be carefully evaluated before deciding to proceed. However, in comparison to other methods such as creel censuses or mark-recapture methods, hydroacoustics is a cost effective alternative. The question as to whether these proposed methods underestimate or overestimate actual species abundance is likely irrelevant as long as they continue to provide a stable relative population estimate, which offers many of the same advantages as an absolute estimate (Thorne 1983; Yule 2000).

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Table 1. Kokanee densities (fish/ha) per transect and total fish abundance estimates calculated using both the arithmetic and geometric mean densities at Anderson Ranch Reservoir in 2004.

		Fish densities (number / ha)			
Transect	**Transect length (m)**	**<100 mm**	**100 mm-200 mm**	**>200 mm**	**Total**
1	419	1,244	468	139	1,851
2	1,060	1,193	403	158	1,754
3	809	2,199	254	75	2,528
4	812	1,910	318	81	2,309
5	763	2,559	306	80	2,945
6	883	3,027	451	121	3,599
7	844	1,459	220	55	1,735
8	993	948	243	82	1,272
9	1,654	550	161	99	810
10	1,479	716	207	109	1,032
11	684	1,205	487	189	1,880
12	772	767	354	133	1,253
13	995	665	335	126	1,126
14	1,251	67	15	16	98
15	1,097	82	6	9	97
16	755	85	12	5	102
17	877	64	22	9	94
18	609	137	18	27	182
19	1,242	538	52	12	602
20	557	765	50	8	824
21	945	229	70	25	323
	Arithmetic Mean (AM)	**971.8**	**212.0**	**74.2**	**1257.9**
	90% CI (AM)	**245.1**	**48.1**	**16.3**	**290.6**
	Abundance (AM)	**1,179,838 ± 297,537**	**257,368 ± 58,366**	**90,027 ± 19,735**	**1,527,233 ± 352,787**
	Geometric Mean (GM)	**566.2**	**116.0**	**47.2**	**754.9**
	90% CI (GM)	**396.4 to 808.6**	**77.9 to 172.6**	**34.0 to 65.2**	**530.7 to 1,073.6**
	Abundance (GM)	**687,445 481,273 to 981,718**	**140,843 94,534 to 209,552**	**57,253 41,299 to 79,195**	**916,469 644,251 to 1,303,492**

Table 2. Mean biomass (g/m), zooplankton ration index (ZPR), and zooplankton quality index (ZQI) values for water bodies sampled during the 2004 field season.

		Mean biomass (g/m)			ZPR	ZQI
Water	**Station**	**153 um**	**500 um**	**750 um**	**750 um / 500 um**	**(750 um + 500 um)ZPR**
Anderson Ranch	1	4.29	2.64	1.86	0.70	3.17
8/17/2004	2	2.87	1.21	0.51	0.42	0.72
	3	3.28	2.55	0.32	0.13	0.36
Black Canyon	1	0.675	0.13	0.19	1.46	0.47
5/24/2004	2	0.125	0.16	0.095	0.59	0.15
	3	0.14	0.115	0.075	0.65	0.12
Cascade	1	4.67	4.18	3.11	0.74	5.39
7/26/2004	2	9.09	6.05	5.17	0.85	9.54
	3	10.16	5.96	6.8	1.14	14.55
Deadwood	1	3.12	4.12	6.83	1.66	18.15
6/23/2004	2	8.55	11.47	8.88	0.77	15.75
	3	5.9	1.6	4.15	2.59	14.91
Deadwood	1	4.09	3.32	0.39	0.12	0.44
8/11/2004	2	5.79	3.02	0.45	0.15	0.52
	3	3.99	2.51	0.49	0.20	0.59
Deadwood	1	1.37	0.94	0.36	0.38	0.50
10/5/2004	2	1.44	0.59	0.23	0.39	0.32
	3	1.91	0.83	0.32	0.39	0.44
Island Park	1	7.2	4.74	2.94	0.62	4.76
7/6/2004	2	9.51	10.47	6.81	0.65	11.20
	3	8.1	7.51	6.1	0.81	11.02
Little Wood	1	9.92	5.34	0.965	0.18	1.13
6/15/2004	2	8.89	5.01	1.24	0.25	1.56
	3	8.18	5.55	1.63	0.29	2.08
Mann Cr	1	8.045	3.63	0.87	0.24	1.08
6/1/2004	2	13.625	3.33	6.77	2.03	20.50
	3	20.01	8.28	3.6	0.43	5.10
Payette	1	3.85	2.3	11.18	4.86	65.50
7/21/2004	2	14.88	2.19	3.68	1.68	9.86
	3	3.37	2.28	3.66	1.61	9.56
Walcott	1	4.74	0.91	1.25	1.37	2.96
6/29/2004	2	20.34	8.16	6.65	0.81	12.00
	3	3.78	5.04	3.31	0.66	5.50

Table 3. Day and night fish densities (fish/ha) per transect and total fish abundance estimates calculated using both the arithmetic and geometric mean densities at Black Canyon Reservoir in 2004.

Day				
		Fish densities (number / ha)		
Transect	**Transect length (m)**	**Sidelooking (0-6 m)**	**Downlooking (>6 m)**	**Total**
1	419	268.2	0.0	268.2
2	431	10.3	0.0	10.3
3	444	97.5	0.0	97.5
4	495	187.0	0.0	187.0
5	401	170.4	118.0	288.4
6	467	169.1	1108.7	1277.8
7	452	32.9	177.1	210.0
8	932	17.9	305.2	323.1
9	434	16.6	1273.9	1290.5
10	483	4.1	558.4	562.4
11	460	27.3	521.5	548.8
12	363	2.9	589.5	592.4
	Arithmetic Mean (AM)	**83.7**	**387.7**	**471.4**
	90% CI (AM)	**35.5**	**169.8**	**162.8**
	Abundance (AM)	**37,235**	**172,526**	**209,761**
		± 15,790	**± 75,546**	**± 72,459**
	Geometric Mean (GM)	**37.4**	**57.4**	**287.9**
	90% CI (GM)	**20.8 to 66.8**	**16.8 to 191.1**	**175.6 to 471.6**
	Abundance (GM)	**16,643**	**25,558**	**128,125**
		9,235 to 29,722	**7,464 to 85,042**	**78,154 to 209,868**
Night				
		Fish densities (number / ha)		
Transect	**Transect length (m)**	**Sidelooking (0-6 m)**	**Downlooking (>6 m)**	**Total**
1	419	574.1	0.0	574.1
2	431	30.8	0.0	30.8
3	444	96.9	0.0	96.9
4	495	74.6	0.0	74.6
5	401	124.8	248.8	373.7
6	467	131.5	695.4	826.9
7	452	35.0	279.2	314.1
8	932	22.2	936.0	958.2
9	434	2.1	819.2	821.4
10	483	4.6	852.3	856.9
11	460	2.2	430.5	432.8
12	363	15.4	259.6	274.9
	Arithmetic Mean (AM)	**92.8**	**376.8**	**469.6**
	90% CI (AM)	**61.4**	**140.3**	**128.4**
	Abundance (AM)	**41,315**	**167,656**	**208,971**
		±27,313	**±62,429**	**± 57,128**
	Geometric Mean (GM)	**32.2**	**61.6**	**317.0**
	90% CI (GM)	**16.8 to 60.8**	**17.9 to 205.7**	**206.9 to 485.4**
	Abundance (GM)	**14,308**	**27,395**	**141,070**
		7,476 to 27,034	**7,983 to 91,519**	**92,072 to 216,019**

Table 4. Abundance estimates for individual species from data collected during the 2004 fish assessment survey at Black Canyon Reservoir. Abundance was estimated as the product of a species proportion from gillnetting data and the total abundance estimate from hydroacoustics.

Day			
Species	**Proportion ± 90% CI**	**Abundance**	**90% CI**
Black Bullhead	0.02 ± 0.02	2,235	557
Black Crappie	0.01 ± 0.01	745	297
Bridgelip Sucker	0.01 ± 0.01	745	292
Chiselmouth	0.09 ± 0.04	11,919	948
Common Carp	0.03 ± 0.05	3,725	1,159
Largescale Sucker	0.53 ± 0.18	68,532	4,255
Northern Pikeminnow	0.15 ± 0.06	18,623	1,432
Yellow Perch	0.17 ± 0.13	21,603	3,142
Night			
Species	**Proportion ± 90% CI**	**Abundance**	**90% CI**
Black Bullhead	0.02 ± 0.02	2,461	613
Black Crappie	0.01 ± 0.01	820	327
Bridgelip Sucker	0.01 ± 0.01	820	322
Chiselmouth	0.09 ± 0.04	13,123	1,044
Common Carp	0.03 ± 0.05	4,101	1,276
Largescale Sucker	0.53 ± 0.18	75,456	4,684
Northern Pikeminnow	0.15 ± 0.06	20,504	1,576
Yellow Perch	0.17 ± 0.13	23,785	3,460

Table 5. Fish densities (fish/ha) per transect and total fish abundance estimates calculated using both the arithmetic and geometric mean densities at Cascade Reservoir in 2004.

A. Fish > 250 mm.

		Fish densities (number / ha)		
Transect	**Transect length (m)**	**Sidelooking (0-6 m)**	**Downlooking (>6 m)**	**Total**
1	2,483	0.0	2.6	2.6
2	2,537	12.7	10.2	22.8
3	2,510	0.0	7.2	7.2
4	2,513	1.0	2.7	3.8
5	2,565	0.0	5.9	5.9
6	2,559	0.0	0.0	0.0
7	2,573	0.0	12.1	12.1
8	2,489	0.0	9.4	9.4
9	2,570	0.0	5.2	5.2
10	2,456	0.0	4.9	4.9
	Arithmetic Mean (AM)	**1.4**	**6.0**	**7.4**
	90% CI (AM)	**1.7**	**1.6**	**2.7**
	Abundance (AM)	**13,778 ± 17,161**	**60,680 ± 16,305**	**74,458 ± 27,643**
	Geometric Mean (GM)	**0.4**	**4.8**	**5.4**
	90% CI (GM)	**0.0 to 1.0**	**3.2 to 7.0**	**3.5 to 8.2**
	Abundance (GM)	**3,965 0 to 9,971**	**48,227 32,140 to 70,444**	**54,348 34,779 to 82,454**

B. All fish.

		Fish densities (number / ha)		
Transect	**Transect length (m)**	**Sidelooking (0-6m)**	**Downlooking (>6m)**	**Total**
1	2,483	111.6	2.6	114.2
2	2,537	1,661.5	19.5	1681.0
3	2,510	787.8	15.5	803.3
4	2,513	190.0	2.7	192.8
5	2,565	233.7	9.6	243.4
6	2,559	6.8	4.9	11.7
7	2,573	47.8	12.1	59.9
8	2,489	25.5	16.5	42.0
9	2,570	122.5	6.1	128.6
10	2,456	330.0	8.3	338.3
	Arithmetic Mean (AM)	**351.7**	**9.8**	**361.5**
	90% CI (AM)	**219.9**	**2.5**	**221.5**
	Abundance (AM)	**3,544,373 ± 2,215,919**	**98,551 ± 25,656**	**3,642,924 ± 2,232,558**
	Geometric Mean (GM)	**138.2**	**8.2**	**158.7**
	90 % CI (GM)	**69.8 to 272.9**	**6.0 to 11.0**	**85.9 to 292.3**
	Abundance (GM)	**1,392,759 702,913 to 2,750,057**	**82,460 60,724 to 110,869**	**1,598,736 865,550 to 2,945,840**

Table 6. Abundance estimates for individual species from data collected during the 2004 fish assessment survey at Cascade Reservoir. Abundance was estimated as the product of a species proportion from gillnetting data and the total abundance estimate from hydroacoustics.

A. Fish > 250 mm.

Species	Proportion ± 90% CI	Abundance	90% CI
Northern pikeminnow	0.15 ± 0.10	8,198	1,025
Largescale sucker	0.38 ± 0.26	20,646	2,688
Rainbow trout	0.35 ± 0.30	18,824	3,030
Coho Salmon	0.01 ± 0.01	607	119
Mountain Whitefish	0.02 ± 0.01	1,214	118
Brown Bullhead	0.08 ± 0.11	4,251	1,159
Smallmouth bass	0.01 ± 0.02	607	222

B. All fish.

Species	Proportion ± 90% CI	Abundance	90% CI
Northern pikeminnow	0.15 ± 0.10	241,150	29,806
Largescale sucker	0.38 ± 0.26	607,341	78,226
Rainbow trout	0.35 ± 0.30	553,752	88,534
Coho Salmon	0.01 ± 0.01	17,863	3,496
Mountain Whitefish	0.02 ± 0.01	35,726	3,407
Brown Bullhead	0.08 ± 0.11	125,041	34,022
Smallmouth bass	0.01 ± 0.02	17,863	6,520

Table 7. Fish densities (fish/ha) per transect and total fish abundance estimates calculated using both the arithmetic and geometric mean densities at Deadwood Reservoir in 2004.

June

		Fish densities (number / ha)			
Transect	**Transect length (m)**	**<100 mm**	**100 mm-200 mm**	**>200 mm**	**Total**
1	468	176	195	111	482
2	479	67	68	75	211
3	494	36	77	25	137
4	520	145	91	54	289
5	509	77	137	77	290
6	513	164	138	46	348
7	490	145	68	35	248
8	483	153	107	37	297
9	441	129	58	40	228
10	500	228	50	53	331
11	490	165	126	51	342
12	538	113	61	50	224
13	525	210	79	47	335
14	470	168	117	36	321
15	467	92	35	30	156
16	475	164	87	43	294
	Arithmetic Mean (AM)	**139.5**	**93.3**	**50.5**	**283.3**
	90% CI (AM)	**17.1**	**13.6**	**7.1**	**27.6**
	Abundance (AM)	**197,524**	**132,130**	**71,564**	**401,218**
		± 24,181	**± 19,320**	**± 10,043**	**± 39,099**
	Geometric Mean (GM)	**127.9**	**85.4**	**47.2**	**271.2**
	90% CI (GM)	**109.2 to 149.6**	**73.8 to 98.8**	**41.6 to 53.4**	**244.3 to 301.0**
	Abundance (GM)	**181,084**	**120,951**	**66,791**	**384,090**
		154,691 to 211,939	**104,517 to 139,934**	**58,976 to 75,617**	**346,064 to 426,277**

August

		Fish densities (number / ha)			
Transect	**Transect length (m)**	**<100 mm**	**100 mm-200 mm**	**>200 mm**	**Total**
1	437	399	142	44	585
2	490	2,150	346	114	2,610
3	500	3,681	211	100	3,993
4	501	422	130	81	633
5	503	446	255	148	849
6	503	632	180	129	941
7	484	503	73	51	627
8	495	191	46	27	263
9	514	234	92	51	378
10	496	472	173	81	726
11	523	326	133	33	491
12	496	893	338	124	1,355
13	495	461	132	77	670
14	475	113	34	60	207
15	485	77	27	22	127
	Arithmetic Mean (AM)	**733.3**	**154.1**	**76.2**	**963.6**
	90% CI (AM)	**323.5**	**33.9**	**13.5**	**349.7**
	Abundance (AM)	**979,347**	**205,811**	**101,788**	**1,286,945**
		± 436,571	**± 45,682**	**± 18,201**	**± 471,930**
	Geometric Mean (GM)	**441.6**	**121.6**	**65.9**	**652.4**
	90% CI (GM)	**315.6 to 617.9**	**93.5 to 158.1**	**53.9 to 80.6**	**480.4 to 885.8**
	Abundance (GM)	**589,805**	**162,443**	**88,054**	**871,258**
		419,962 to 828,119	**124,561 to 211,724**	**71,951 to 107,695**	**641,586 to 1,182,976**

Table 8. Average size at age for kokanee during three collection periods at Deadwood Reservoir in 2004.

		# Annuli (Consensus)				
Month	**Data**	**0**	**1**	**2**	**3**	**4**
June	Mean fish length (mm)	150	150.6	200.7	322.9	440
	Std Dev	—	15.4	76.4	19.1	—
	n	1	11	6	13	1
August	Mean fish length (mm)	129.7	139.9	217.1	320.3	
	Std Dev	9.1	36.2	34.2	21.2	
	n	3	24	17	3	
October	Mean fish length (mm)	93.6	111.7	219.6	274.2	
	Std Dev	5.4	28.4	22.6	42.4	
	n	13	9	17	5	

Table 9. Results of nutrient analysis (in mg/L) at Deadwood Reservoir sample sites in 2004.

	Sites sampled on 6/22/2004			Sites sampled on 8/11/2004		
Analysis	1	2	3	1	2	3
Ammonia as N	<0.01	<0.01	0.01	0.02	<0.01	<0.01
Nitrate as N	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrite as N	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dissolved orthophosphate	0.01	0.009	0.014	0.022	0.025	0.041
Kjeldahl Nitrogen	0.13	0.11	0.14	0.19	0.25	0.11
Tot Phosphorous	0.013	0.016	0.018	0.038	0.034	0.052
Chlorophyll a	<0.1	<0.1	<0.1	2.1	n/a	4.4

Table 10. Fish densities (fish/ha) per transect and total fish abundance estimates calculated using both the arithmetic and geometric mean densities at Island Park Reservoir in 2004.

Day				
		Fish densities (number / hectare)		
Transect	**Transect length (m)**	**Sidelooking (0-6m)**	**Downlooking (>6m)**	**Total**
1	982	69.5	0.0	69.5
2	1,279	165.9	0.0	165.9
3	875	4.3	8.0	12.3
4	1,173	4.1	0.0	4.1
5	1,335	4.7	0.0	4.7
6	1,308	2.1	32.7	34.8
7	1,037	6.7	0.0	6.7
8	1,600	3.1	13.7	16.8
9	1,311	2.8	16.3	19.1
10	1,291	4.7	7.5	12.2
11	1,290	4.3	17.8	22.1
12	642	2.6	18.6	21.2
	Arithmetic Mean (AM)	**22.9**	**9.6**	**32.5**
	90% CI (AM)	**17.5**	**3.8**	**16.3**
	Abundance (AM)	**66,744**	**27,842**	**94,586**
		± 50,978	**± 10,956**	**± 47,625**
	Geometric Mean (GM)	**7.0**	**4.0**	**18.5**
	90 % CI (GM)	**4.1 to 11.6**	**1.2 to 7.4**	**12.6 to 27.0**
	Abundance (GM)	**20,510**	**11,646**	**53,939**
		12,034 to 33,792	**5,707 to 21,677**	**36,716 to 78,648**
Night				
		Fish densities (number / hectare)		
Transect	**Transect length (m)**	**Sidelooking (0-6m)**	**Downlooking (>6m)**	**Total**
1	982	51.1	0.0	51.1
2	1,094	52.7	17.8	70.5
3	1,392	74.8	152.5	227.4
4	1,296	8.0	26.9	34.8
5	1,375	18.8	146.7	165.4
6	1,590	11.1	232.5	243.5
7	1,309	5.0	159.8	164.8
8	1,296	3.3	161.6	164.9
9	1,276	8.7	84.2	92.9
10	622	1.0	181.7	182.7
	Arithmetic Mean (AM)	**23.4**	**116.4**	**139.8**
	90% CI (AM)	**9.4**	**28.3**	**26.2**
	Abundance (AM)	**68,316**	**339,111**	**407,427**
		± 27,267	**± 82,483**	**± 76,287**
	Geometric Mean (GM)	**12.7**	**62.9**	**118.4**
	90 % CI (GM)	**7.9 to 19.9**	**33.9 to 115.8**	**93.3 to 150.2**
	Abundance (GM)	**36,935**	**183,221**	**345,006**
		23,116 to 58,089	**98,915 to 337,328**	**271,883 to 437,588**

Table 11. Abundance estimates for individual species from data collected during the 2004 fish assessment survey at Island Park Reservoir. Fish proportion data was calculated from 2000-2003 regional netting data. Abundance was estimated as the product of a species proportion from gillnetting data and the total abundance estimate from hydroacoustics.

Day			
Species	**Proportion ± 90% CI**	**Abundance**	**90% CI**
Yellowstone cutthroat	0.001 ± 0.002	30	11
Rainbow trout	0.11 ± 0.13	6,152	801
Brook trout	0.01 ± 0.01	487	95
Kokanee	0.05 ± 0.06	2,589	355
Mountain whitefish	0.01 ± 0.01	274	37
Utah sucker	0.28 ± 0.27	15,076	1,741
Redside shiner	0.02 ± 0.03	1,188	202
Splake	0.01 ± 0.01	305	54
Utah chub	0.52 ± 0.09	27,838	617
Night			
Species	**Proportion ± 90% CI**	**Abundance**	**90% CI**
Yellowstone cutthroat	0.001 ± 0.002	195	72
Rainbow trout	0.11 ± 0.13	39,351	5,120
Brook trout	0.01 ± 0.01	3,117	607
Kokanee	0.05 ± 0.06	16,559	2,272
Mountain whitefish	0.01 ± 0.01	1,753	238
Utah sucker	0.28 ± 0.27	96,430	11,127
Redside shiner	0.02 ± 0.03	7,598	1,290
Splake	0.01 ± 0.01	1,948	348
Utah chub	0.52 ± 0.09	178,055	3,826

Table 12. Fish densities (fish/ha) per transect and total fish abundance estimates calculated using both the arithmetic and geometric mean densities at Little Wood Reservoir in 2004.

		Fish densities (number / ha)		
Transect	**Transect length (m)**	**Sidelooking (0-6 m)**	**Downlooking (>6 m)**	**Total**
1	341	0.0	22.0	22.0
2	426	0.0	6.2	6.2
3	485	14.3	12.3	26.6
4	381	18.6	10.5	29.1
5	410	0.0	0.0	0.0
6	408	0.0	1.9	1.9
7	408	0.0	8.8	8.8
8	431	41.1	4.5	45.6
9	370	55.1	13.3	68.4
10	416	29.3	1.5	30.8
11	437	7.0	2.8	9.8
12	445	0.0	4.1	4.1
13	413	9.6	3.7	13.3
14	318	0.0	3.8	3.8
	Arithmetic Mean (AM)	**6.8**	**12.5**	**19.3**
	90% CI (AM)	**2.1**	**6.3**	**6.9**
	Abundance (AM)	**2,525**	**1,377**	**3,902**
		± 1,274	**± 430**	**± 1,401**
	Geometric Mean (GM)	**4.9**	**3.6**	**11.2**
	90% CI (GM)	**3.4 to 6.9**	**1.6 to 7.3**	**7.0 to 17.5**
	Abundance (GM)	**991**	**724**	**2,255**
		689 to 1,395	**312 to 1,466**	**1,417 to 3,527**

Table 13. Abundance estimates for individual species from data collected during the 2004 fish assessment survey at Little Wood Reservoir. Abundance was estimated as the product of a species proportion from gillnetting data and the total abundance estimate from hydroacoustics.

Species	Proportion ± 90% CI	Abundance	90% CI
Bridgelip Sucker	0.71 ± 0.21	1,602	87
Brook Trout	0.03 ± 0.05	78	19
Rainbow Trout	0.24 ± 0.18	537	74
Speckled Dace	0.02 ± 0.01	39	4

Table 14. Fish densities (fish/ha) per transect and total fish abundance estimates calculated using both the arithmetic and geometric mean densities at Mann Creek Reservoir in 2004.

		Fish densities (number / hectare)		
Transect	**Transect length (m)**	**Sidelooking (0-6m)**	**Downlooking (>6m)**	**Total**
1	240	3367.2	0.0	3,367.2
2	247	4376.1	0.0	4,376.1
3	245	1210.3	91.4	1,301.7
4	182	1409.9	0.0	1,409.9
5	233	948.9	0.0	948.9
6	244	315.2	0.0	315.2
7	262	1496.7	0.0	1,496.7
8	244	907.3	0.0	907.3
9	245	409.5	0.0	409.5
10	271	1124.1	0.0	1,124.1
11	253	1564.4	0.0	1,564.4
12	267	1787.2	0.0	1,787.2
13	181	5237.5	0.0	5237.5
14	159	2442.5	0.0	2442.5
	Arithmetic Mean (AM)	**1,899.8**	**6.5**	**1,906.3**
	90% CI (AM)	**521.5**	**8.7**	**520.4**
	Abundance (AM)	**191,876**	**660**	**192,536**
		± 52,669	**± 878**	**± 52,558**
	Geometric Mean (GM)	**1,442.4**	**0.4**	**1,449.9**
	90 % CI (GM)	**1,085.1 to 1,917.2**	**0.0 to 1.1**	**1,091.2 to 1,926.5**
	Abundance (GM)	**145,680**	**39**	**146,439**
		109,595 to 193,634	**0 to 114**	**110,206 to 194,575**

Table 15. Abundance estimates for individual species from data collected during the 2004 fish assessment survey at Mann Creek Reservoir. Abundance was estimated as the product of a species proportion from gillnetting data and the total abundance estimate from hydroacoustics.

Species	Proportion ± 90% CI	Abundance	90% CI
Black Crappie	0.19 ± 0.23	27,245	5,922
Bridgelip Sucker	0.03 ± 0.03	5,108	655
Rainbow Trout	0.78 ± 0.21	114,086	5,406

Table 16. Fish densities (fish/ha) per transect and total fish abundance estimates calculated using both the arithmetic and geometric mean densities at Payette Lake in 2004.

		Fish densities (number / ha)			
Transect	**Transect length (m)**	**Age-0**	**Age-1**	**Age-2+**	**Total**
1	421	97.08	49.08	9.81	155.97
2	1583	59.96	44.17	17.47	121.61
3	1543	147.31	105.98	14.59	267.89
4	1425	245.76	235.24	53.14	534.13
5	923	183.04	92.40	51.35	326.79
6	1527	135.76	99.12	33.02	267.89
7	1392	38.57	29.57	16.28	84.43
8	1251	74.39	72.50	27.54	174.43
9	1562	19.53	38.07	31.55	89.15
10	1769	91.73	45.72	38.79	176.25
11	1725	74.93	76.76	30.93	182.62
12	1769	103.56	154.82	57.52	315.90
13	1618	13.9	0.0	0.0	0.0
	Arithmetic Mean (AM)	**103.3**	**85.5**	**32.3**	**221.2**
	90% CI (AM)	**22.8**	**20.9**	**5.7**	**45.4**
	Abundance (AM)	**223,212**	**184,787**	**69,751**	**477,750**
		± 49,263	**± 45,238**	**± 12,275**	**± 98,015**
	Geometric Mean (GM)	**86.7**	**72.6**	**28.7**	**194.5**
	90% CI (GM)	**67.9 to 110.6**	**58.4 to 90.1**	**23.5 to 35.0**	**160.0 to 236.4**
	Abundance (GM)	**187,206**	**156,770**	**61,962**	**420,142**
		146,624 to 238,857	**126,233 to 194,571**	**50,666 to 75,674**	**345,611 to 510,646**

Table 17. Fish densities (fish/ha) per transect and total fish abundance estimates calculated using both the arithmetic and geometric mean densities at Lake Walcott in 2004.

		Fish densities (number / hectare)		
Transect	**Transect length (m)**	**Sidelooking (0-6m)**	**Downlooking (>6m)**	**Total**
1	1,061	8.2	96.9	105.0
2	985	14.1	660.2	674.3
3	1,046	93.0	29.3	122.3
4	983	98.4	3.9	102.3
5	1,027	47.0	0.0	47.0
6	1,022	2.2	1,104.3	1,106.5
7	1,025	5.4	33.9	39.3
8	1,042	1.3	96.8	98.0
9	1,023	1.6	11.9	13.5
10	1,023	49.3	21.1	70.4
11	1,038	14.8	79.9	94.7
12	1,282	0.8	7.2	8.0
	Arithmetic Mean (AM)	**28.0**	**178.8**	**206.8**
	90% CI (AM)	**13.8**	**133.0**	**129.4**
	Abundance (AM)	**129,178**	**824,801**	**953,979**
		± 63,875	**± 613,547**	**± 596,864**
	Geometric Mean (GM)	**11.2**	**36.1**	**85.3**
	90 % CI (GM)	**5.9 to 20.5**	**16.2 to 78.8**	**50.1 to 144.9**
	Abundance (GM)	**51,605**	**166,531**	**393,772**
		27,243 to 94,597	**74,899 to 363,761**	**231,114 to 668,669**

Table 18. Abundance estimates for individual species from data collected during the 2004 fish assessment survey at Lake Walcott. Abundance was estimated as the product of a species proportion from gillnetting data and the total abundance estimate from hydroacoustics.

Species	Proportion ± 90% CI	Abundance	90% CI
Bluehead Sucker	0.01 ± 0.01	3,892	917
Common Carp	0.01 ± 0.01	3,892	427
Rainbow Trout	0.04 ± 0.03	16,218	2,192
Redside Shiner	0.01 ± 0.01	3,244	827
Smallmouth Bass	0.01 ± 0.01	3,892	921
Utah Chub	0.75 ± 0.15	294,518	10,836
Utah Sucker	0.17 ± 0.15	67,467	11,170
Yellow Perch	0.002 ± 0.003	649	230

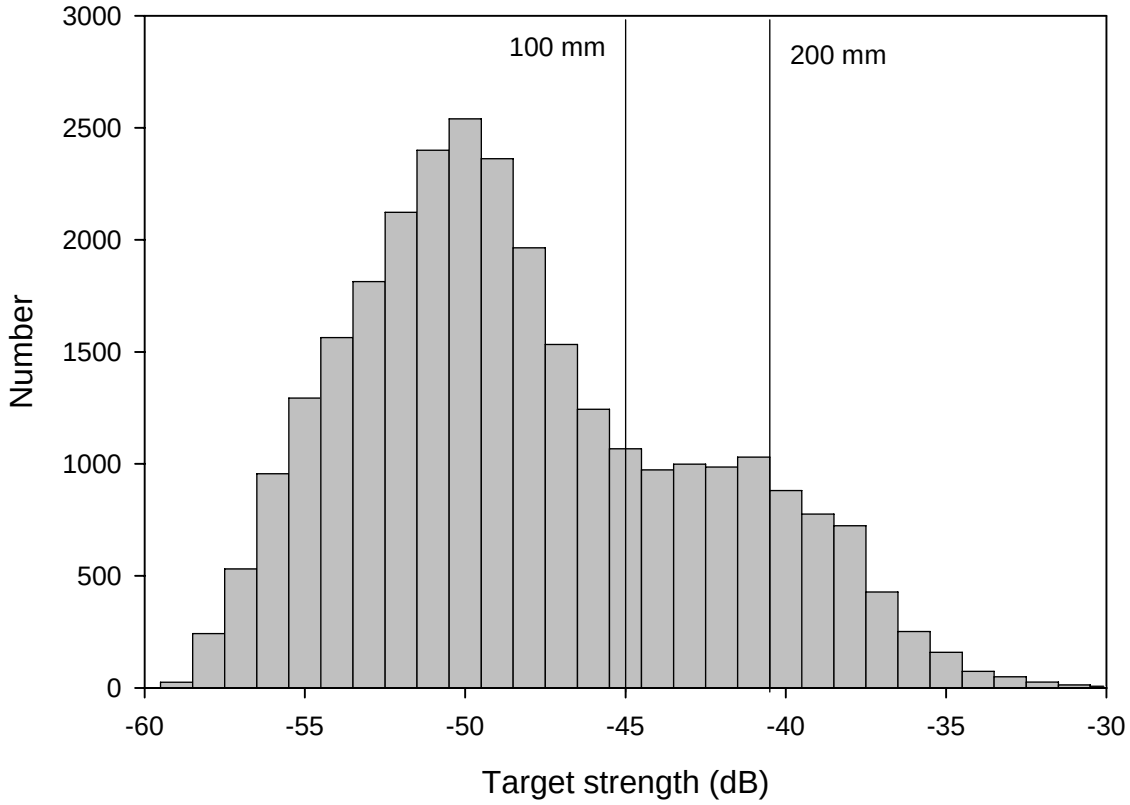


Figure 1. Target strength (dB) distribution of fish tracked during the 2004 survey at Anderson Ranch Reservoir.

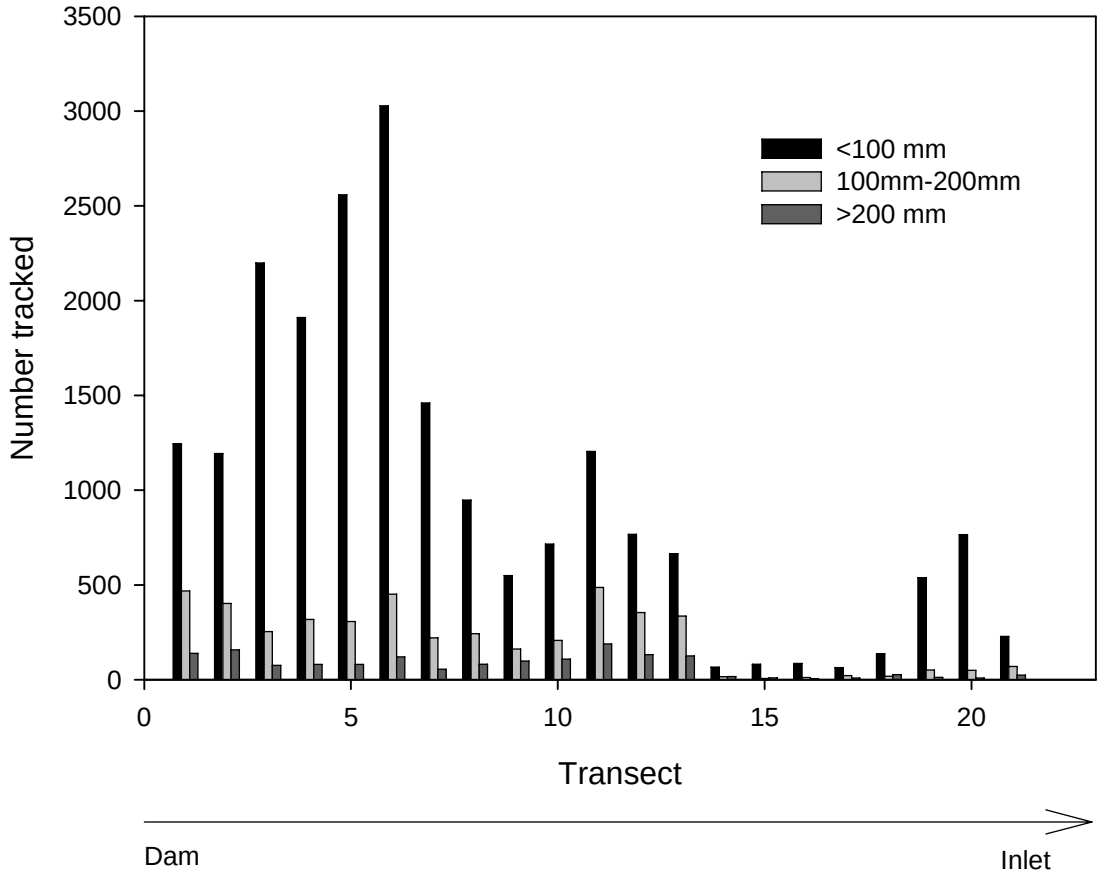


Figure 2. Number of fish tracked per transect at Anderson Ranch Reservoir in 2004.

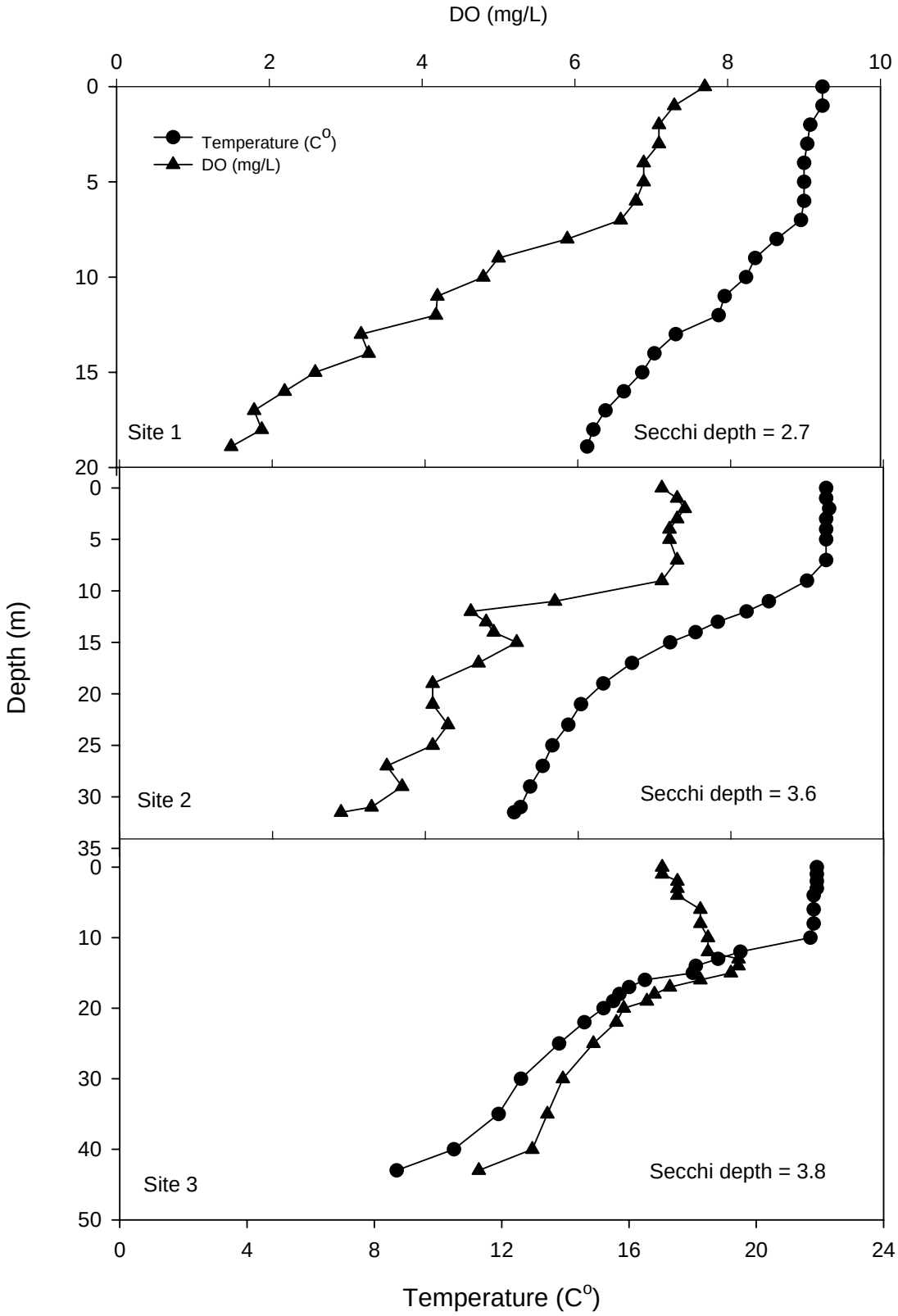


Figure 3. Vertical temperature (°C) and dissolved oxygen profiles (DO; mg/L) at three sites in Anderson Ranch Reservoir in 2004.

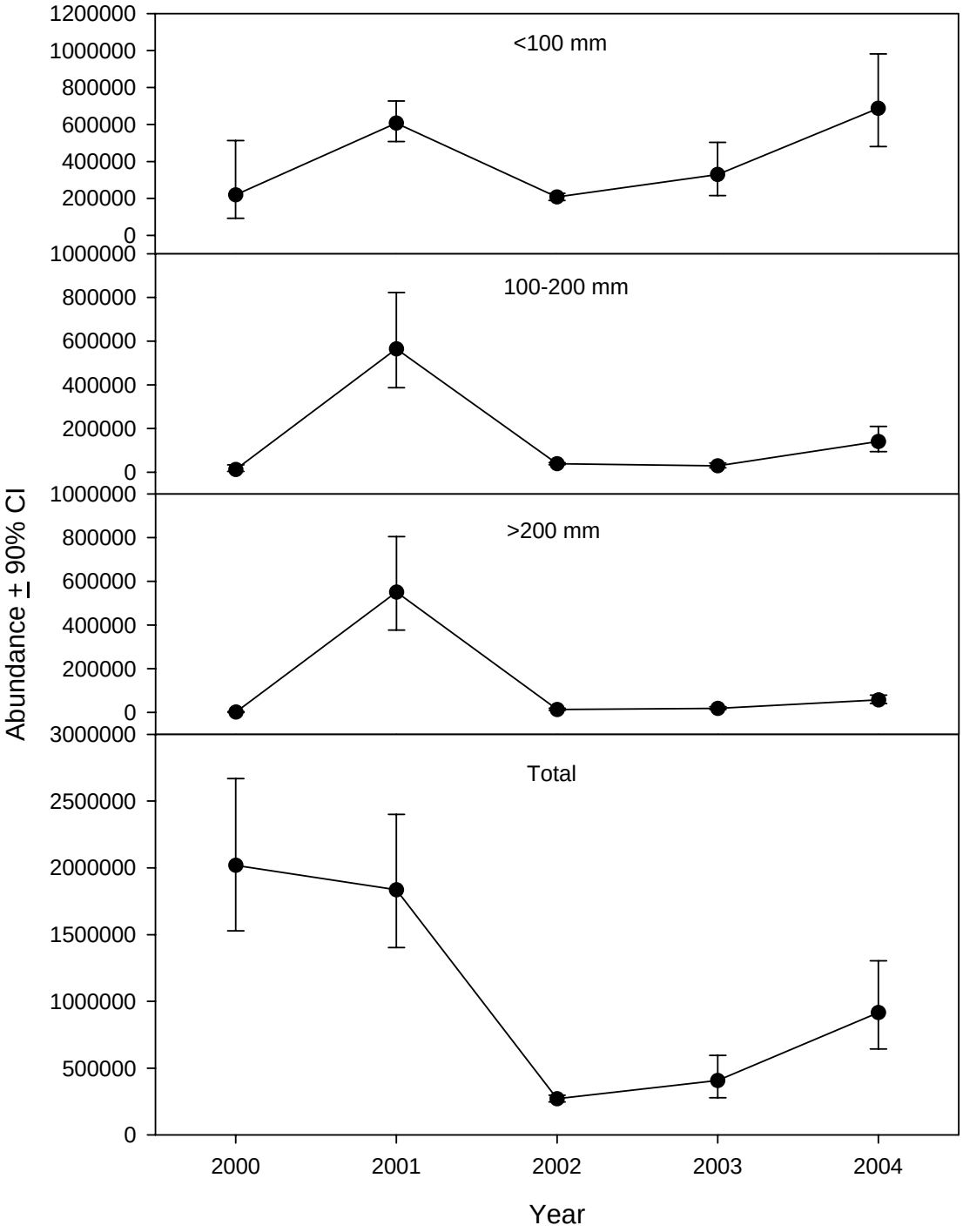


Figure 4. Trends in kokanee hydroacoustic abundance estimates at Anderson Ranch Reservoir during 2000-2004.

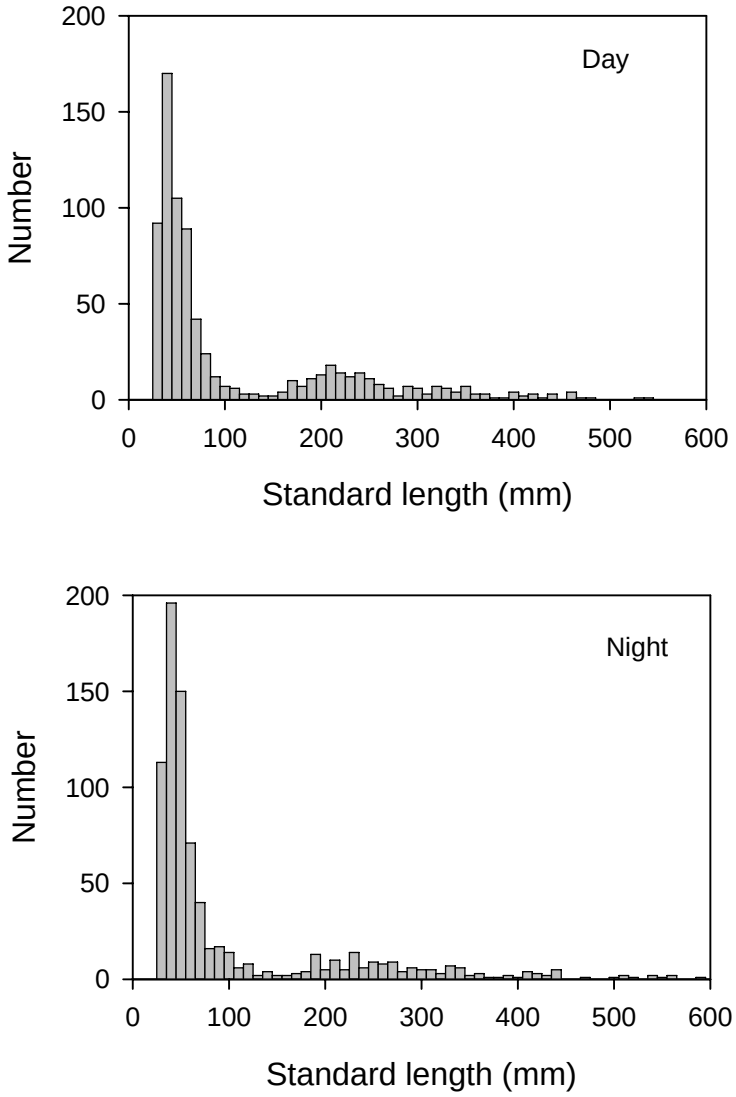


Figure 5. Length frequencies (SL-mm) converted from target strength (dB) distribution of fish tracked during the 2004 survey at Black Canyon Reservoir.

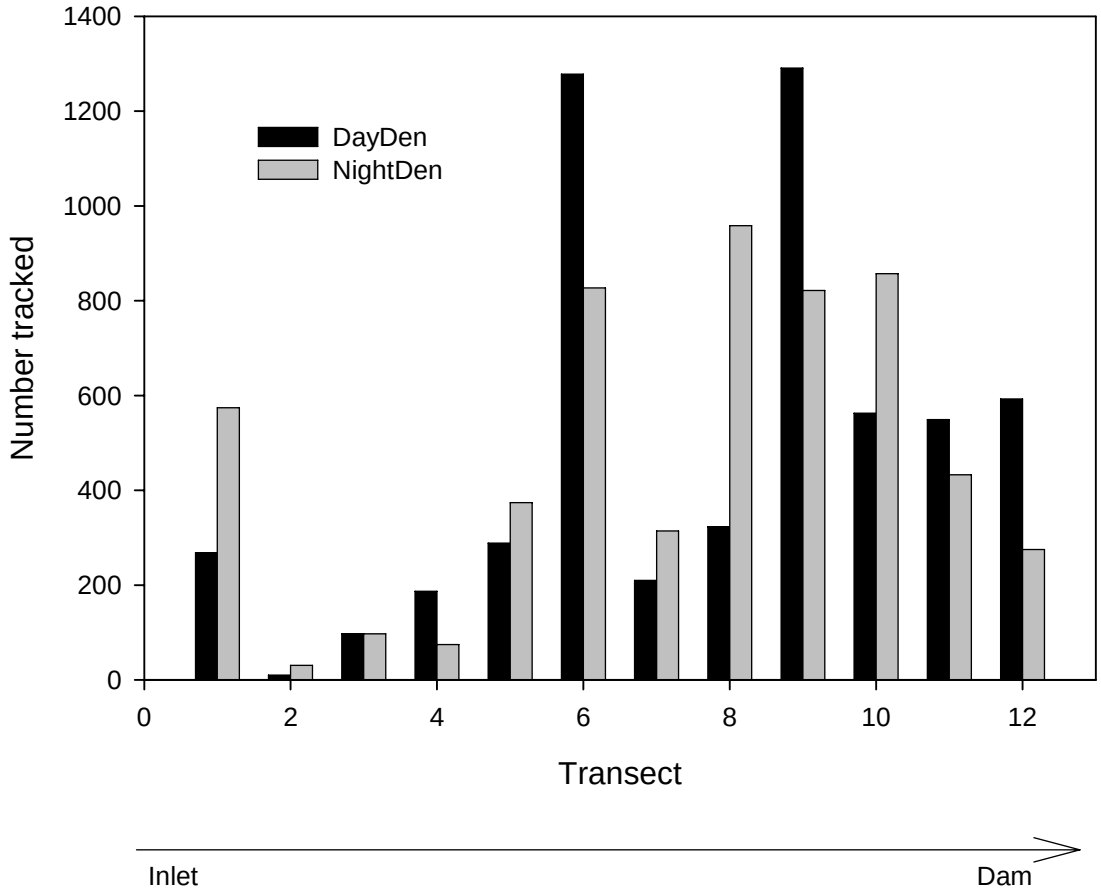


Figure 6. Number of fish tracked per transect during day and night at Black Canyon Reservoir in 2004.

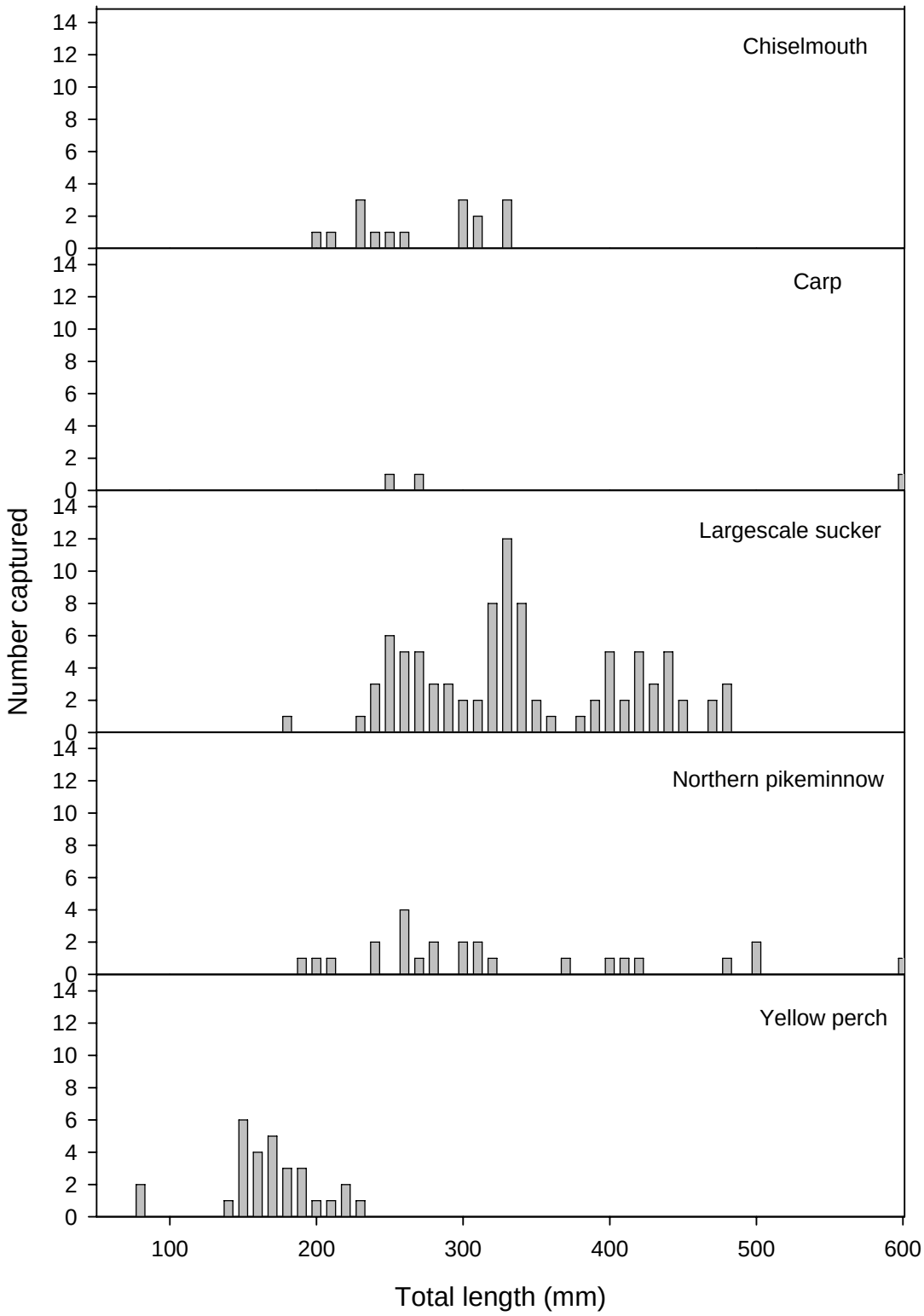


Figure 7. Length distributions of fish species caught in net curtains at Black Canyon Reservoir in 2004.

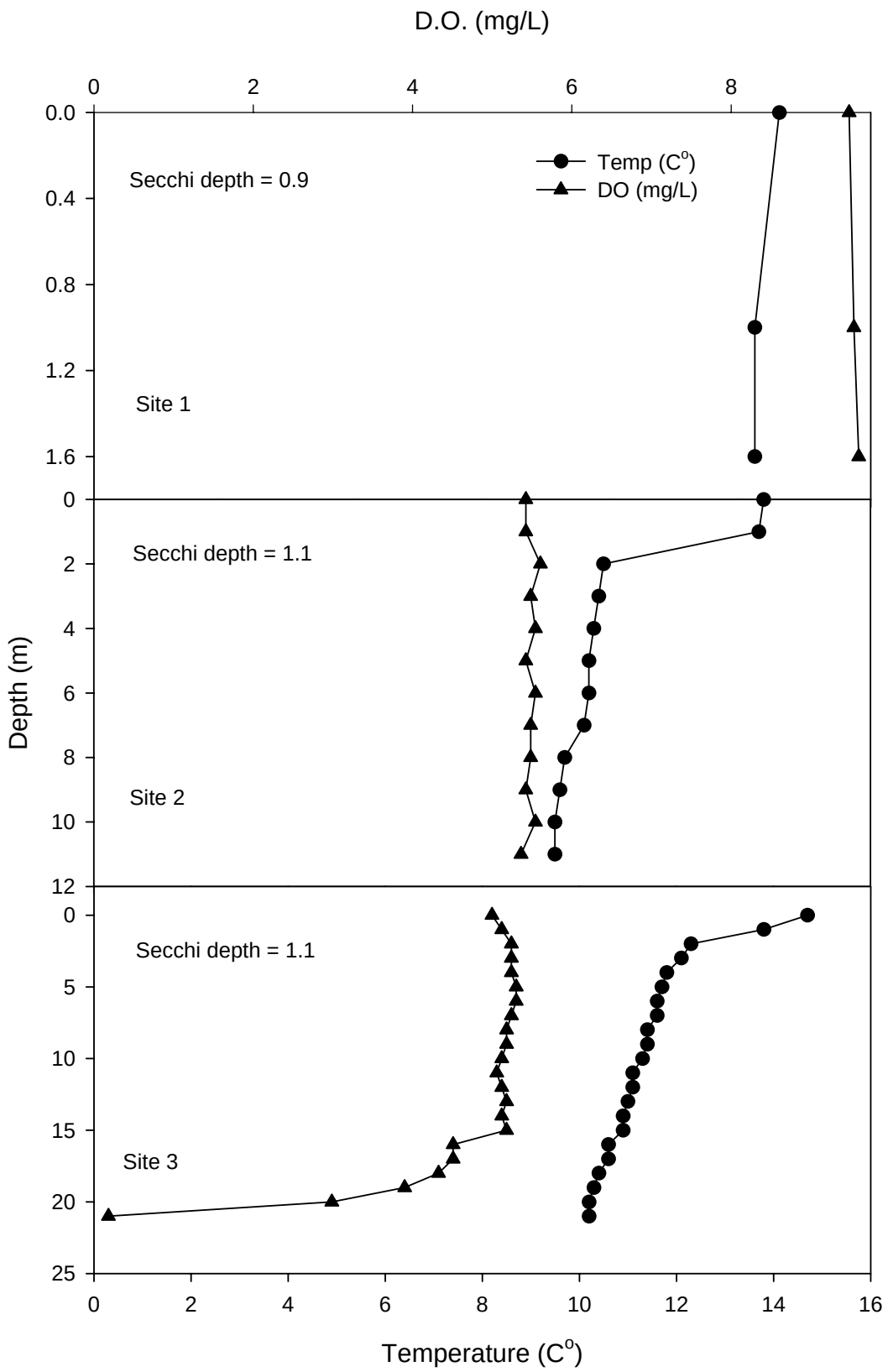


Figure 8. Vertical temperature (°C) and dissolved oxygen profiles (DO; mg/L) profiles at three sites in Black Canyon Reservoir in 2004.

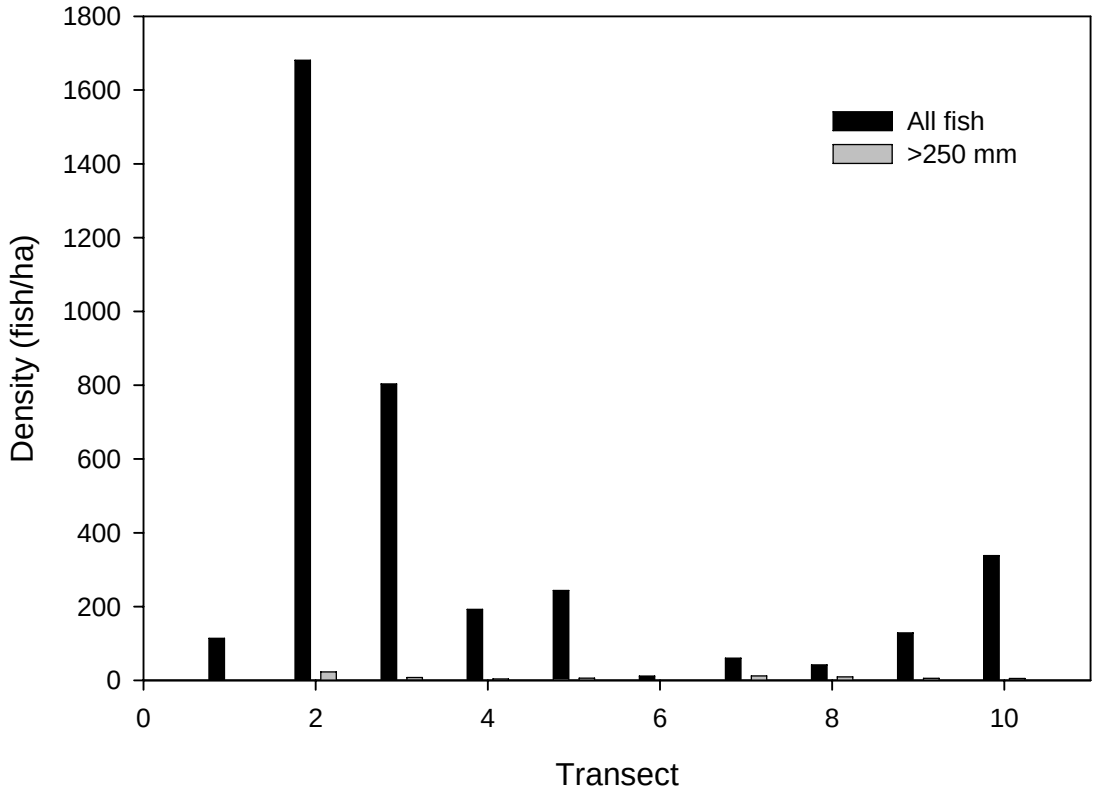


Figure 9. Density of fish (fish/ha) tracked per transect at Cascade Reservoir in 2004.

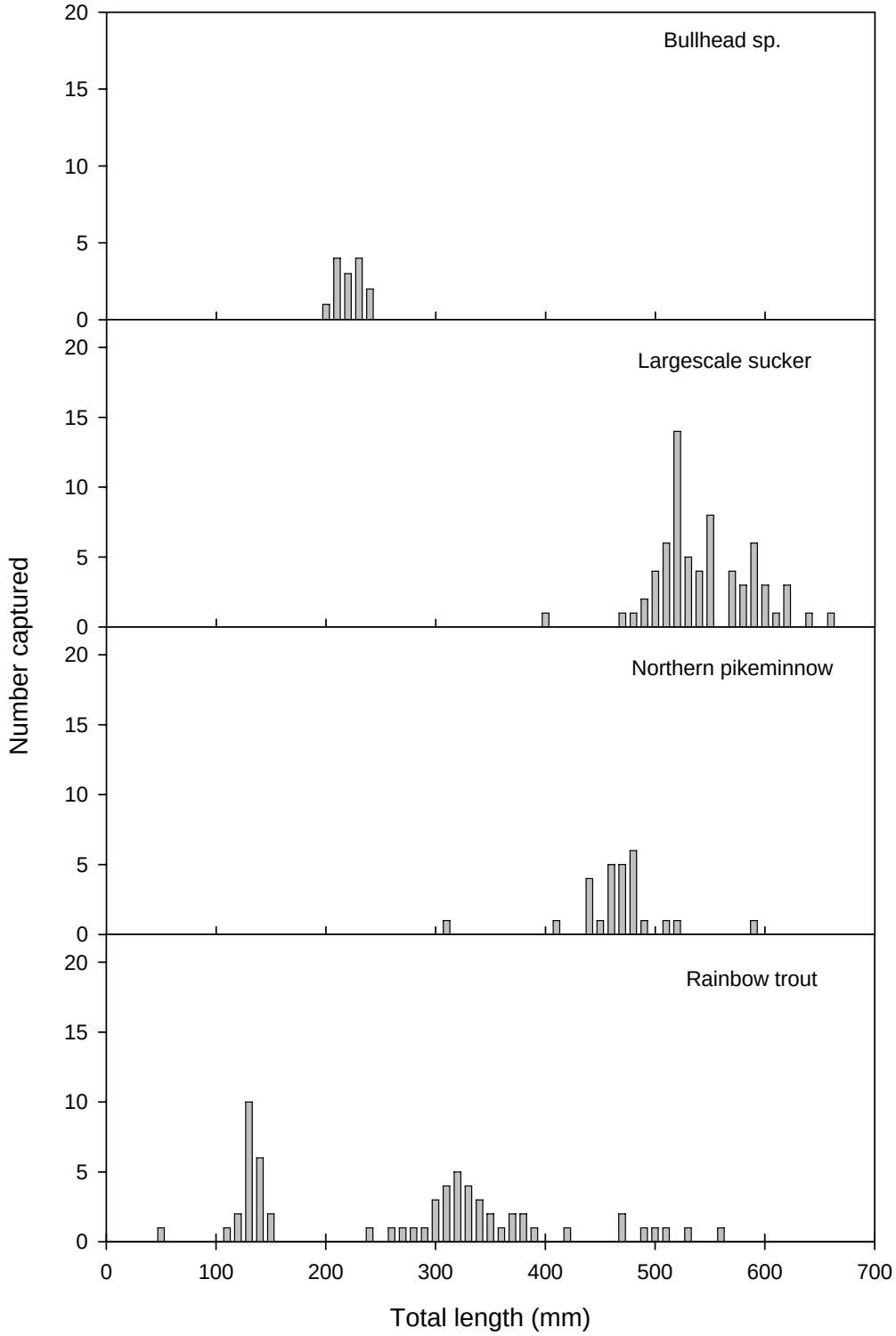


Figure 10. Length distributions of fish species caught in net curtains at Cascade Reservoir in 2004.

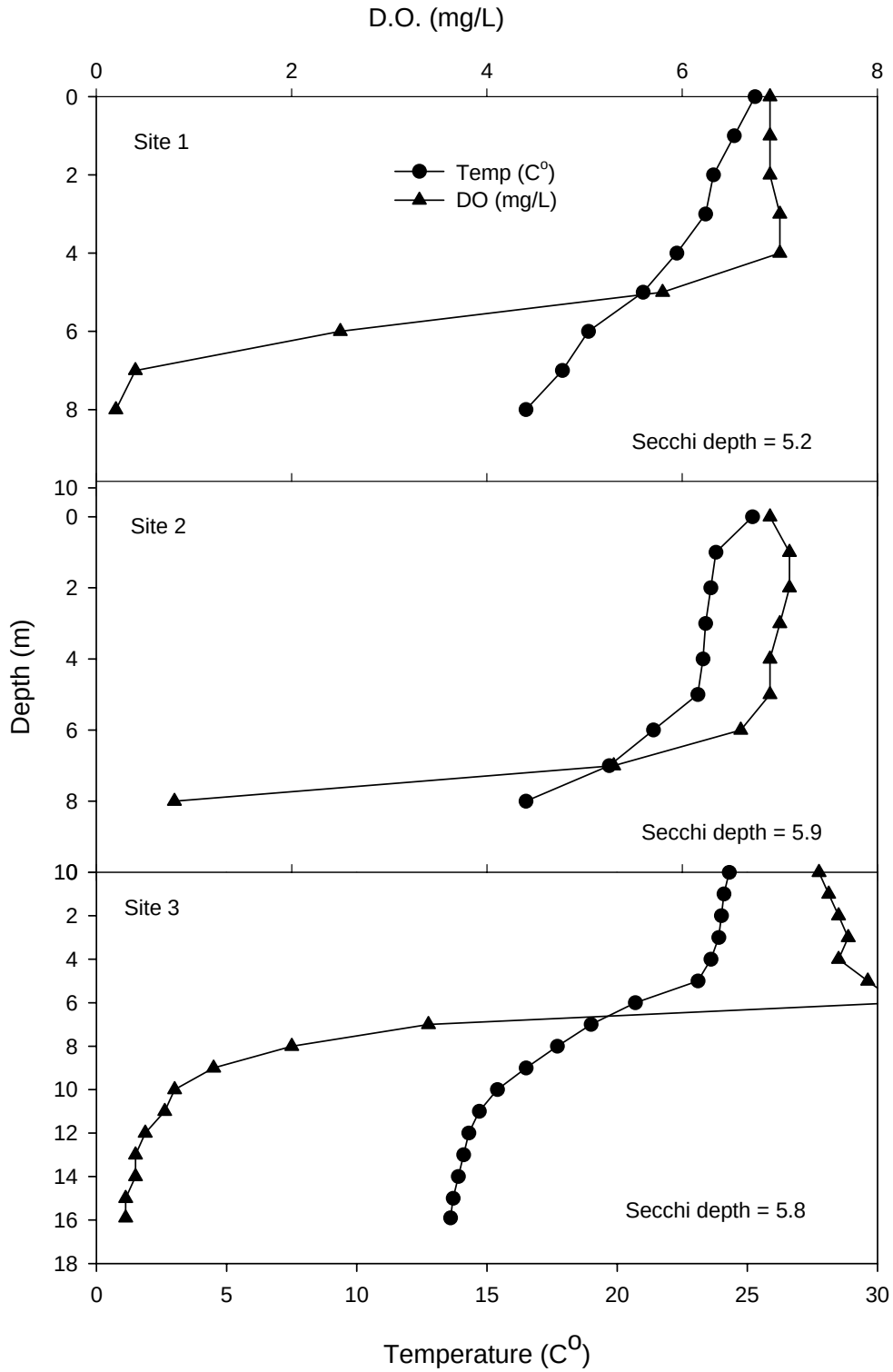


Figure 11. Vertical temperature (°C) and dissolved oxygen profiles (DO; mg/L) at three sites in Cascade Reservoir in 2004.

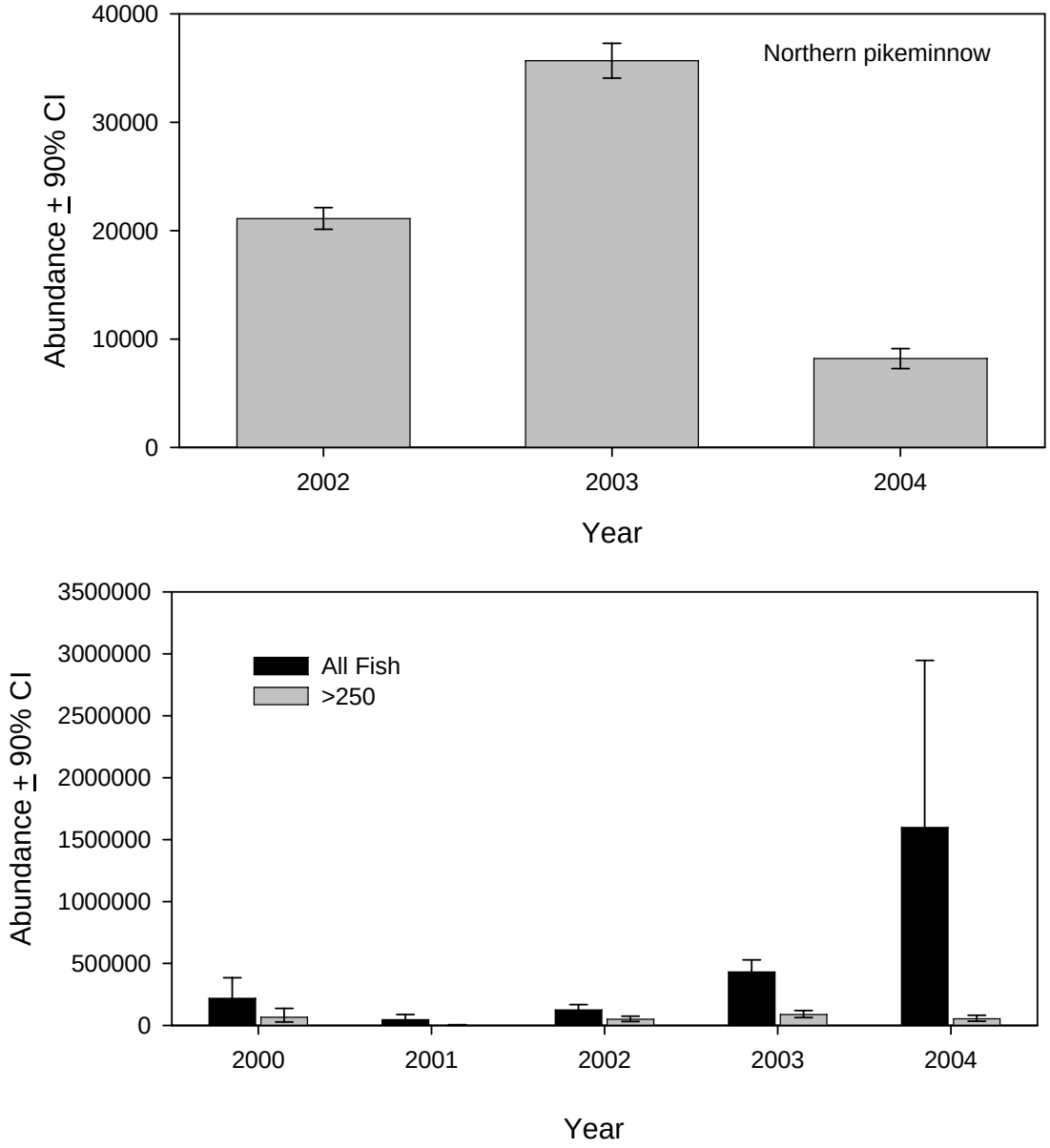


Figure 12. Abundance of northern pikeminnow (top panel), and of total fish and fish >250 mm (lower panel), based on estimates from hydroacoustics and netting.

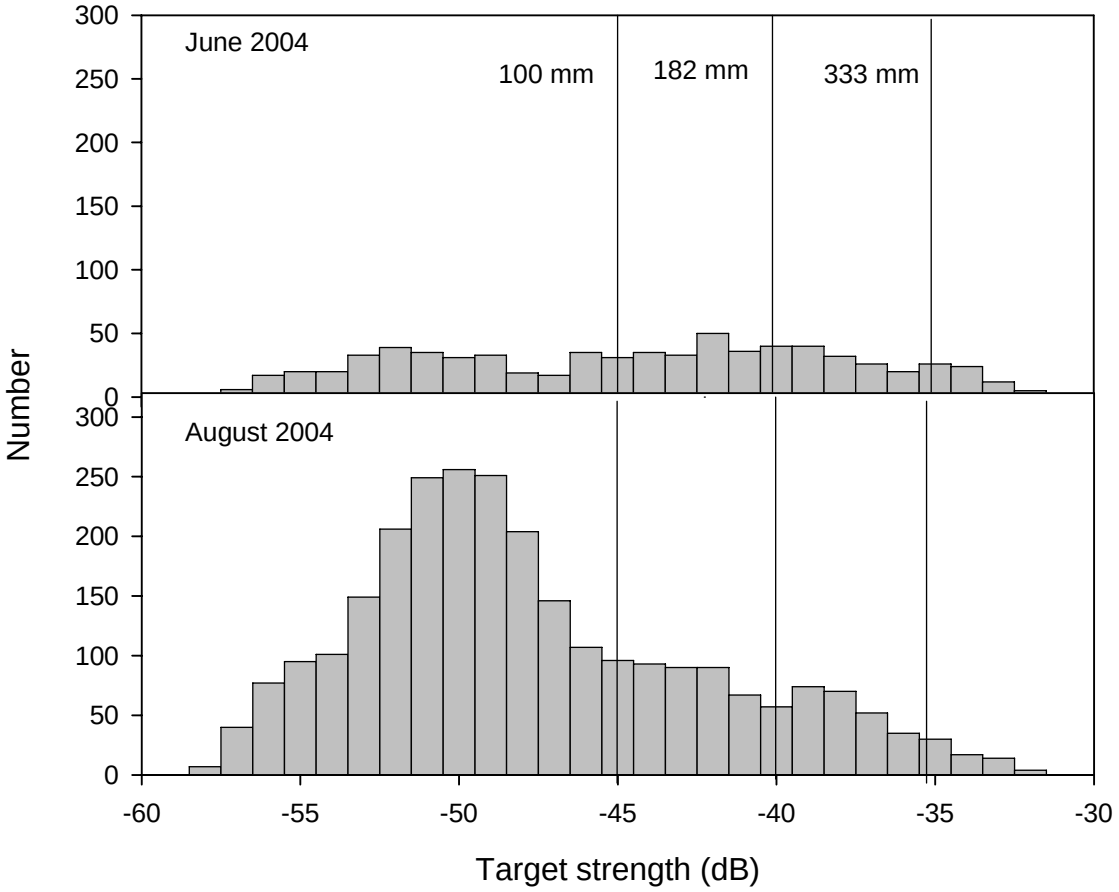


Figure 13. June and August target strength (dB) distribution of fish tracked during the 2004 survey at Deadwood Reservoir.

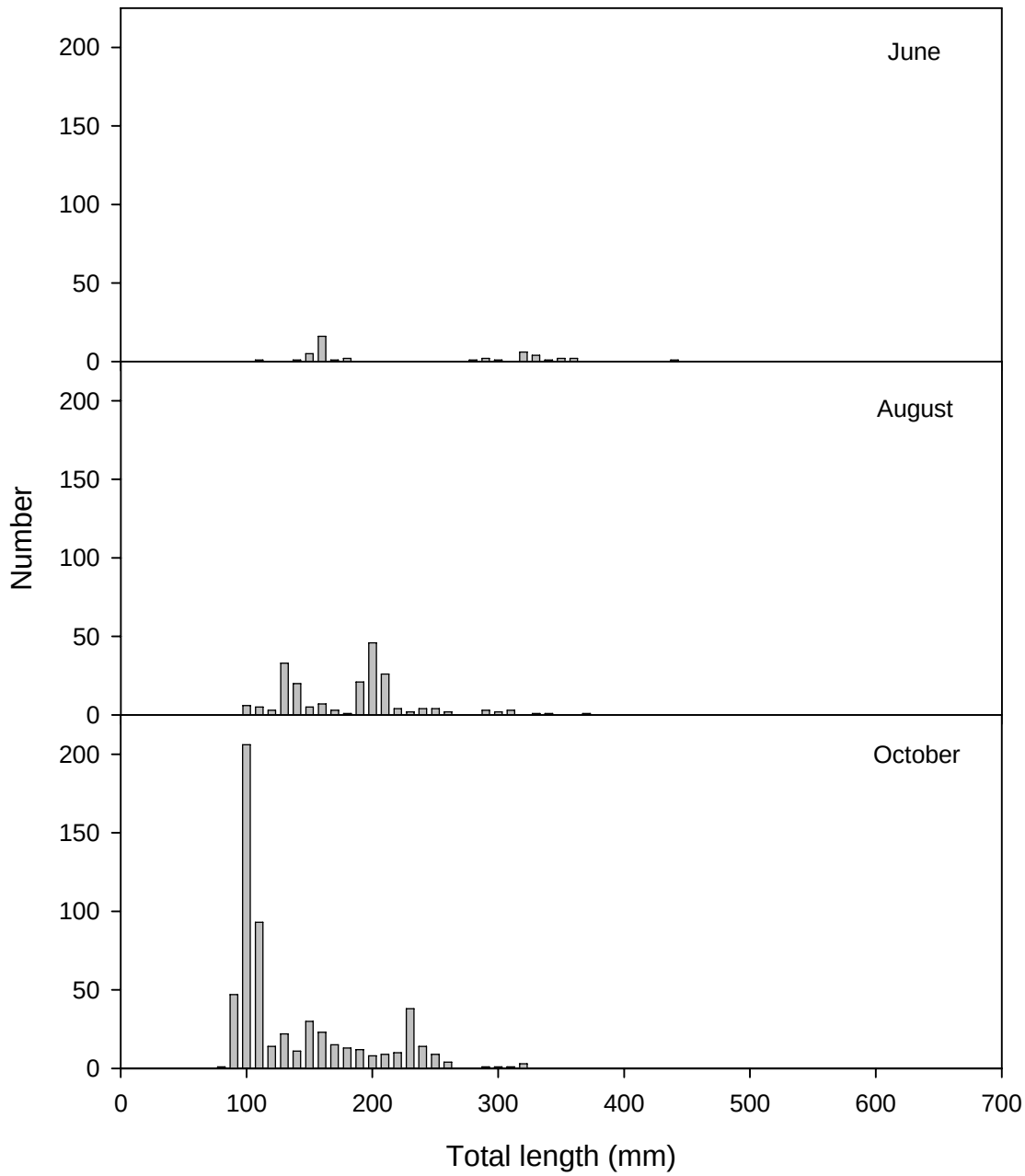


Figure 14. Length distributions of kokanee caught in net curtains during June, August, and October at Deadwood Reservoir in 2004.

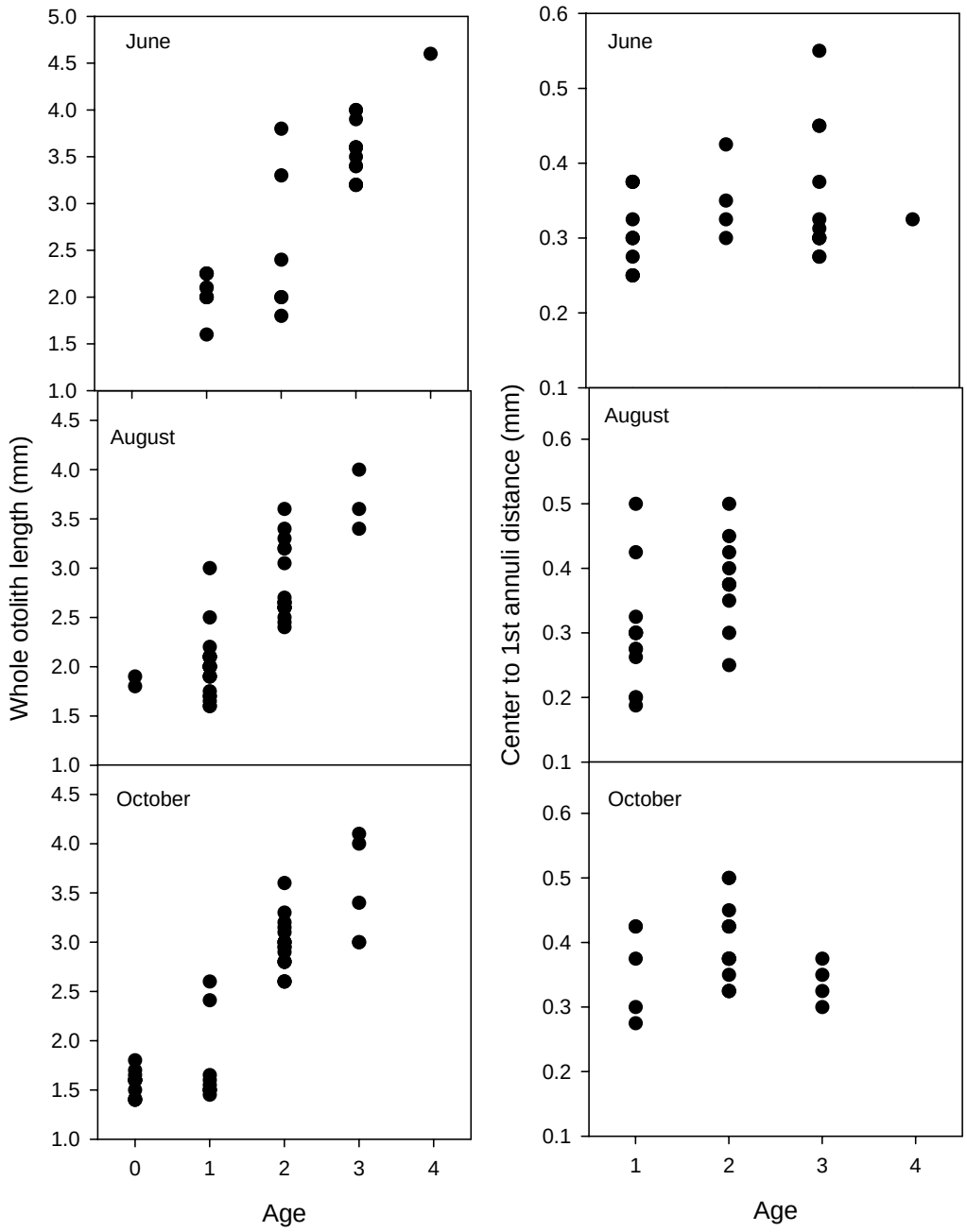


Figure 15. Comparison of whole otolith length and distance to first annulus for kokanee at Deadwood Reservoir in 2004.

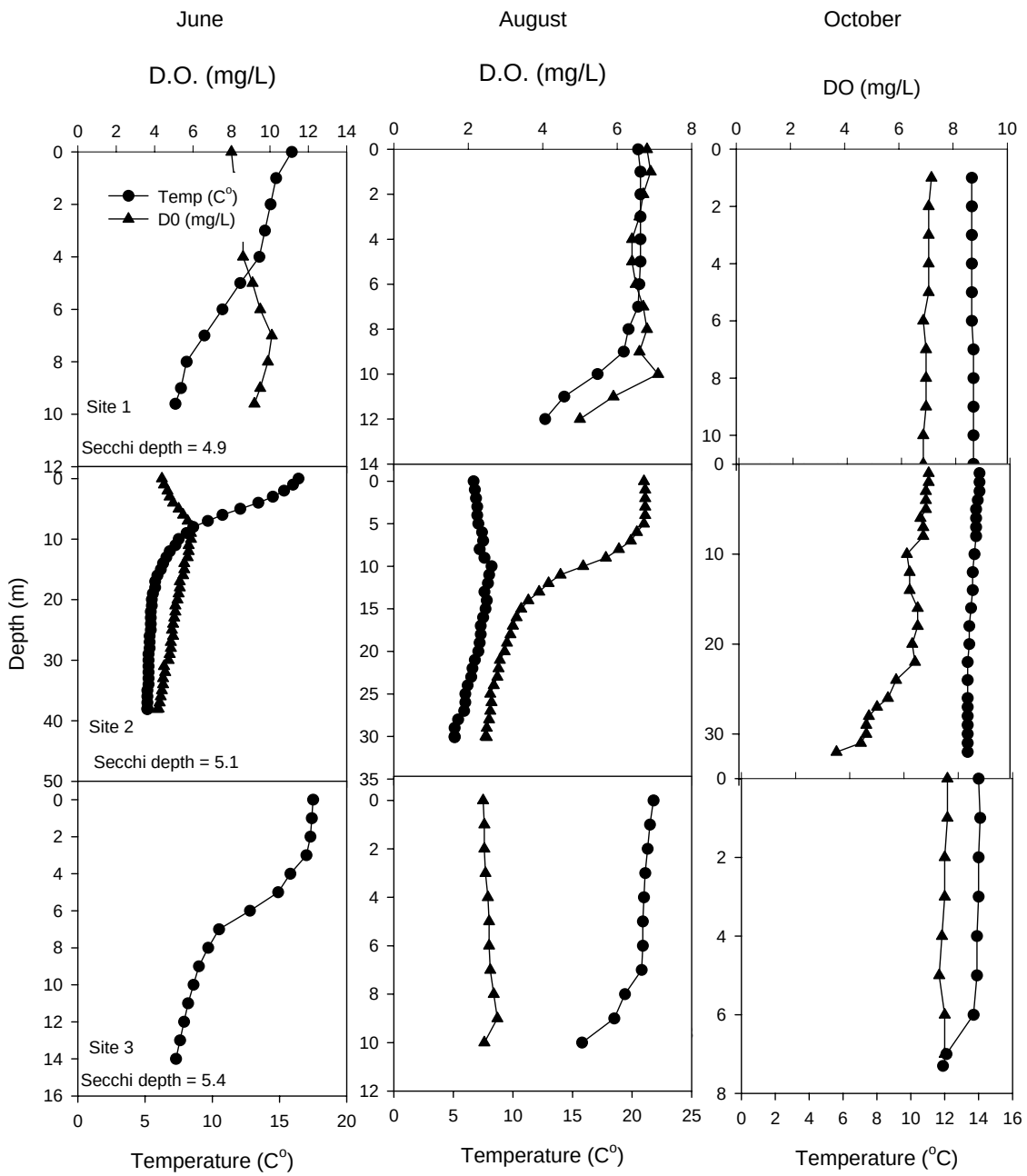


Figure 16. Vertical temperature (°C) and dissolved oxygen profiles (DO; mg/L) at three sites in Deadwood Reservoir in June, August, and October 2004.

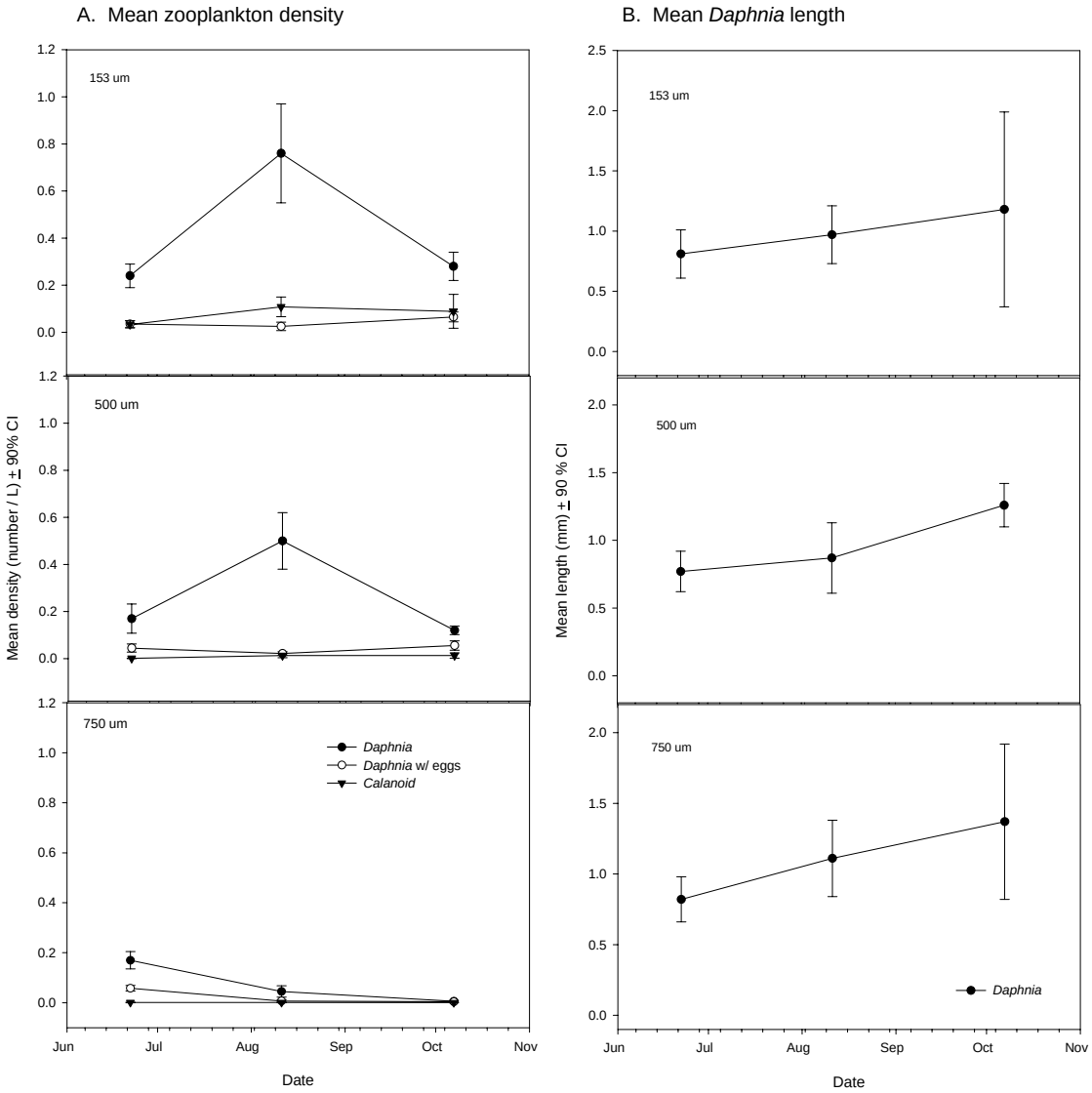


Figure 17. Mean zooplankton density (number/L; A) and mean *Daphnia* length (mm; B) at Deadwood Reservoir in 2004.

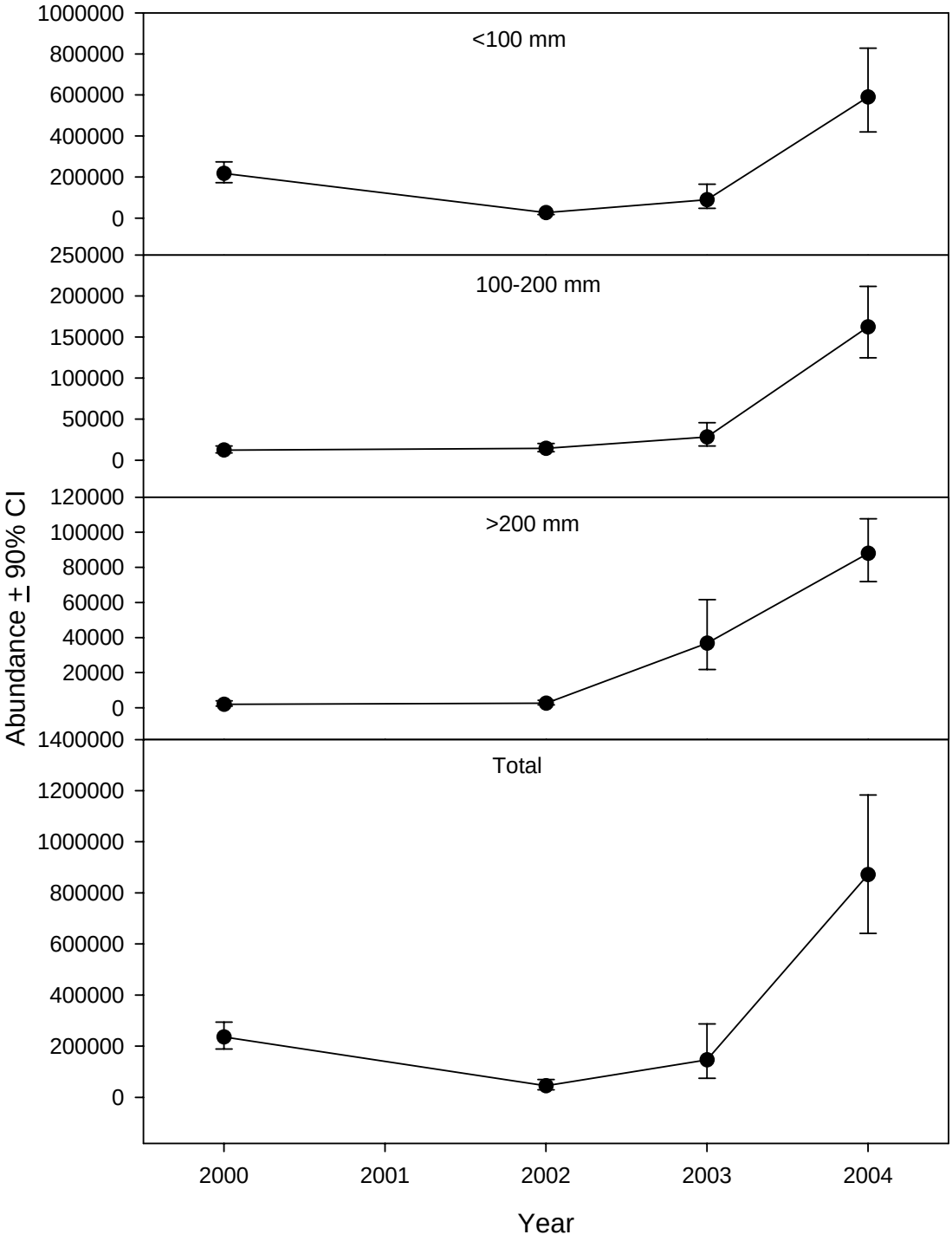


Figure 18. Trends in hydroacoustic kokanee abundance from 2000-2004 at Deadwood Reservoir.

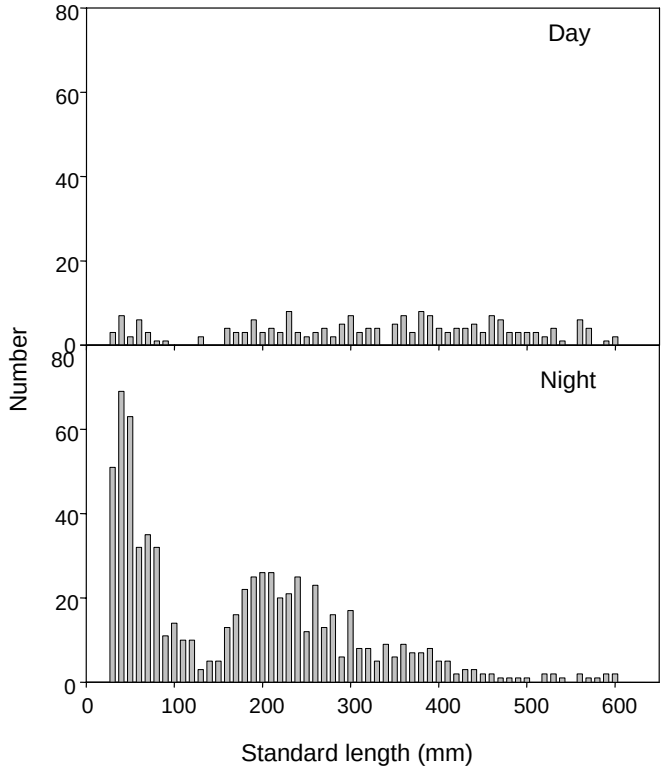


Figure 19. Length frequencies (SL-mm) converted from target strength (dB) distribution of fish tracked during the 2004 survey at Island Park Reservoir.

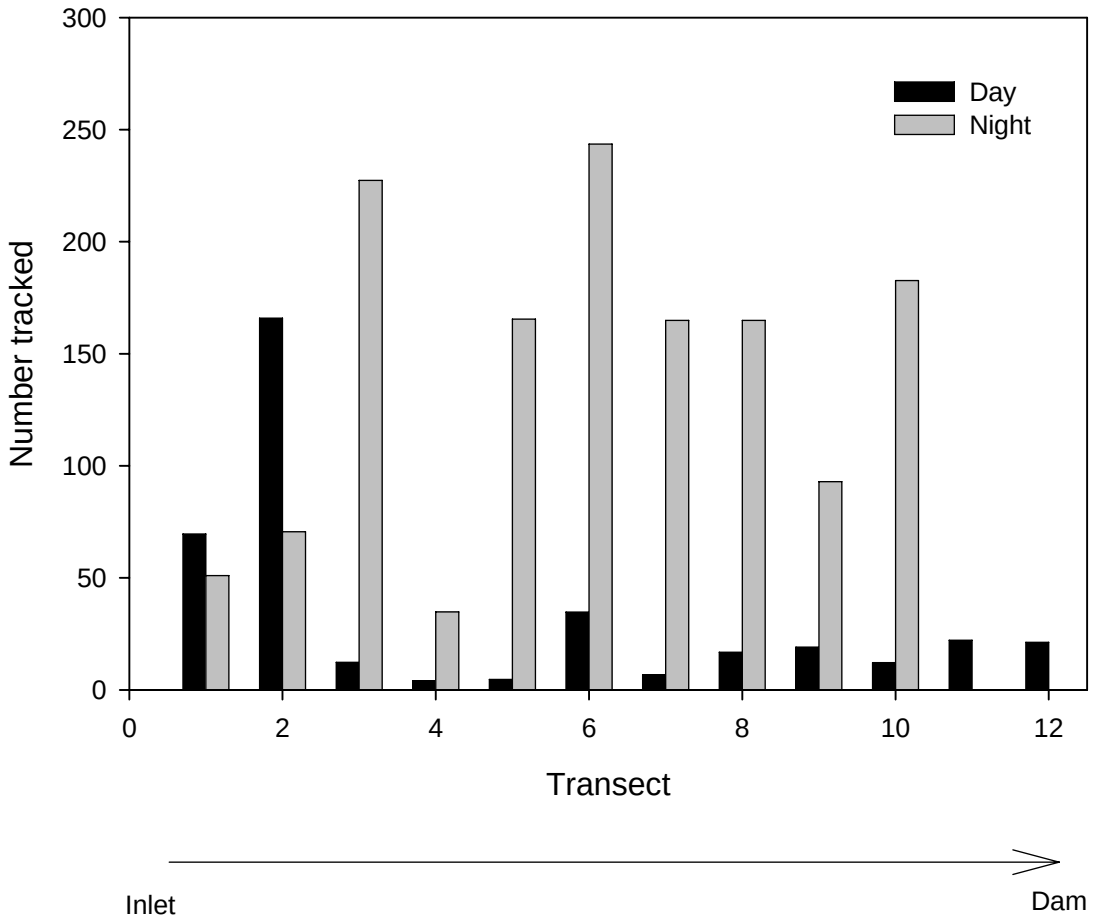


Figure 20. Number of fish tracked by transect during day and night surveys at Island Park Reservoir in 2004.

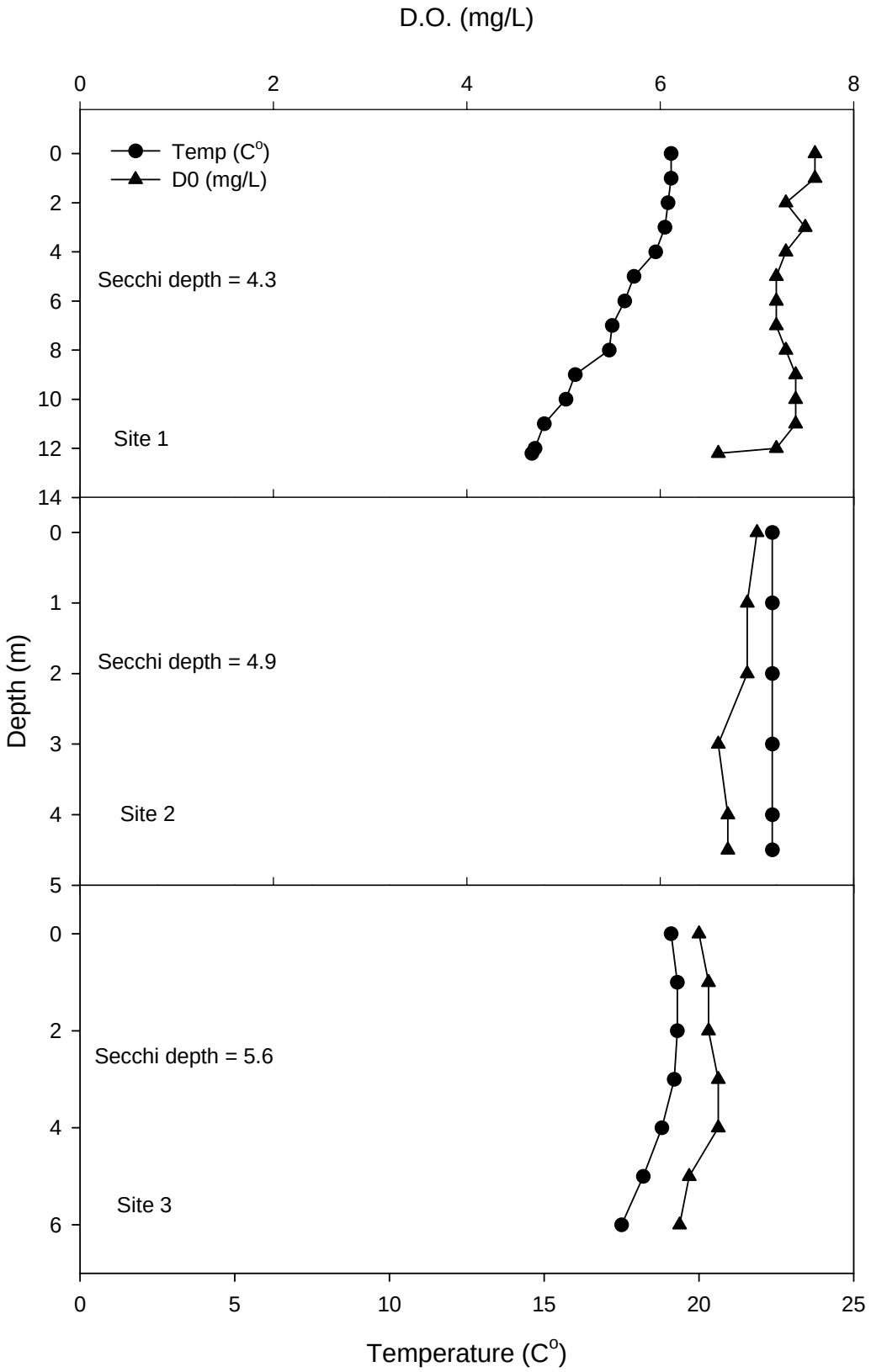


Figure 21. Vertical temperature (°C) and dissolved oxygen profiles (DO; mg/L) at three sites in Island Park Reservoir in 2004.

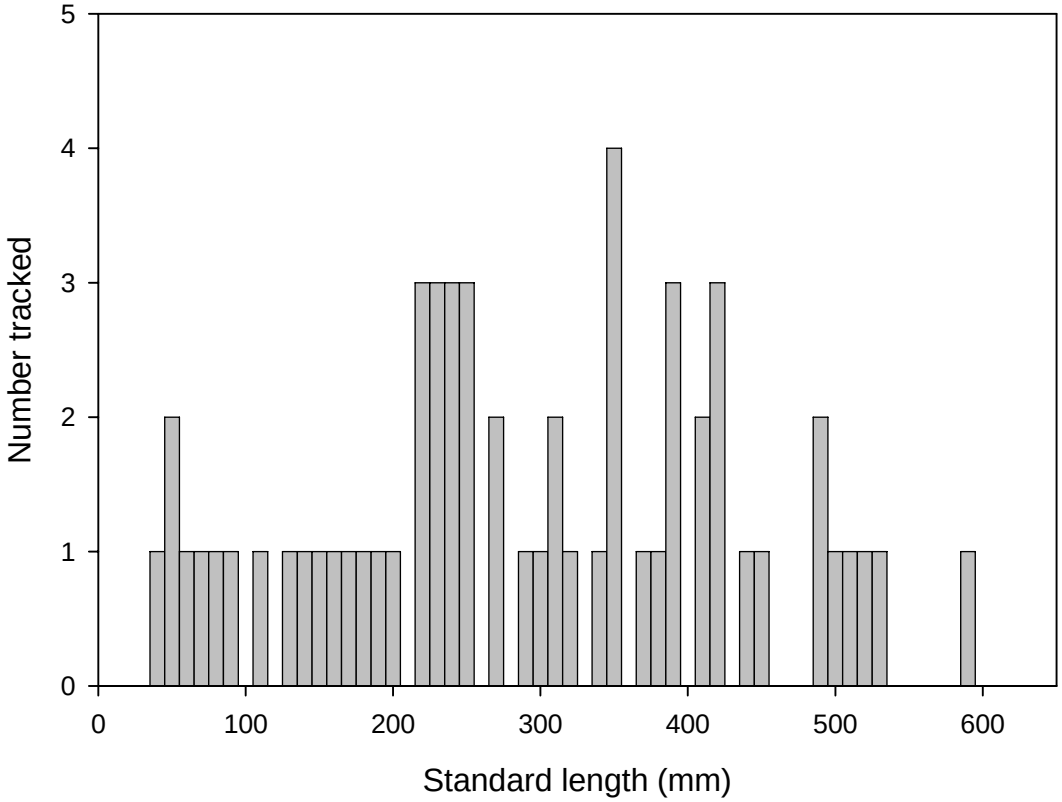


Figure 22. Length frequency (SL-mm) converted from target strength (dB) distribution of fish tracked during the 2004 survey at Little Wood Reservoir.

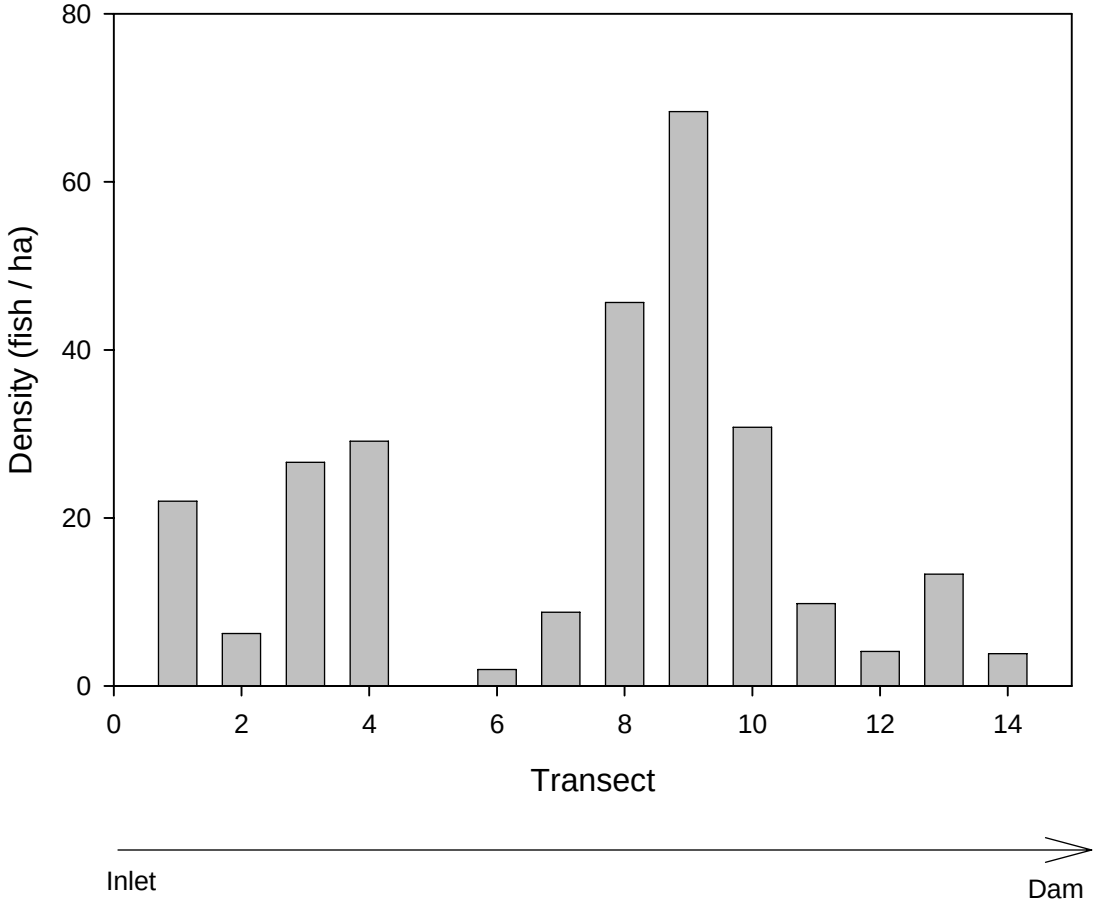


Figure 23. Fish density (fish/ha) by transect during day and night surveys at Little Wood Reservoir in 2004.

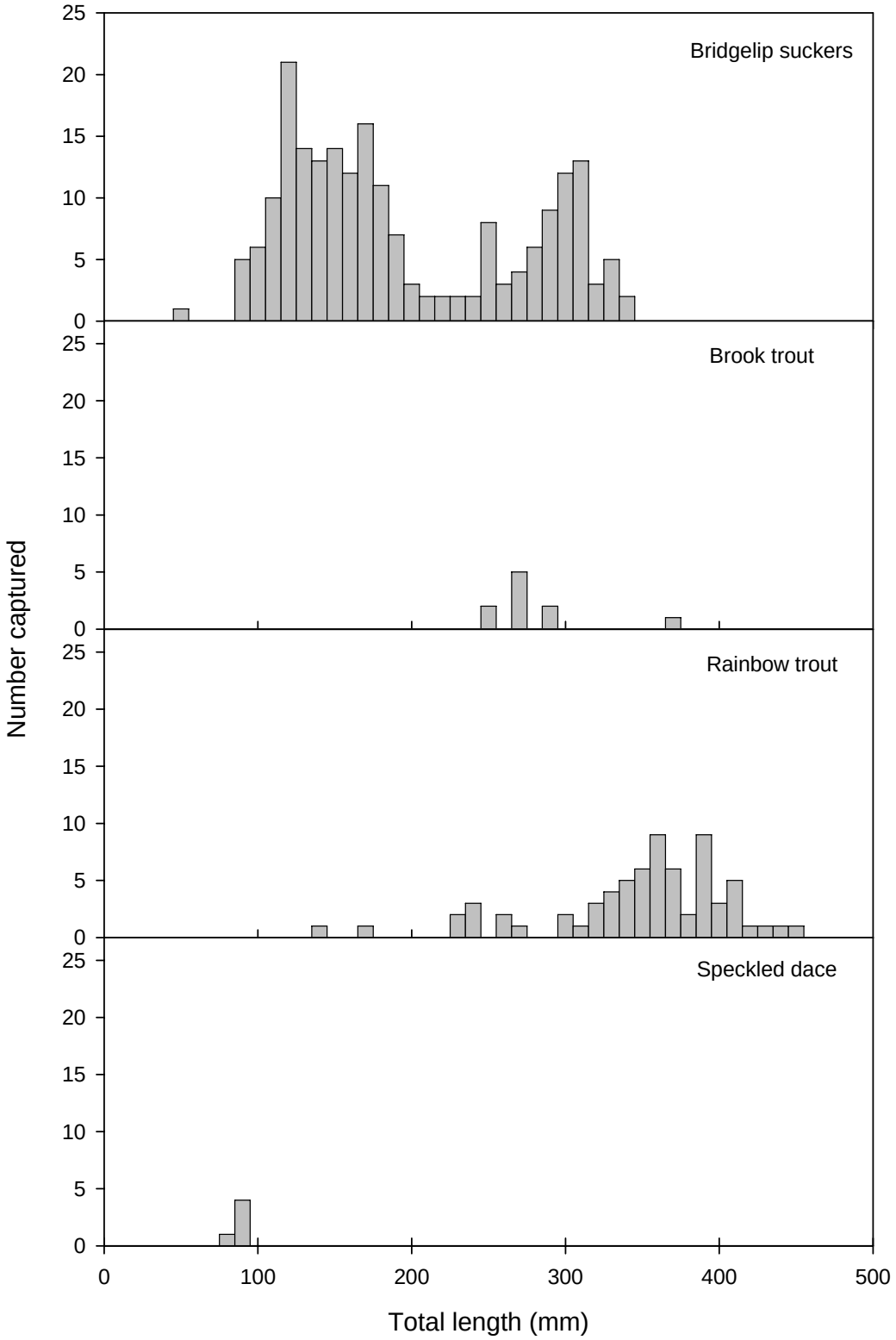


Figure 24. Length distributions of fish species caught in net curtains at Little Wood Reservoir in 2004.

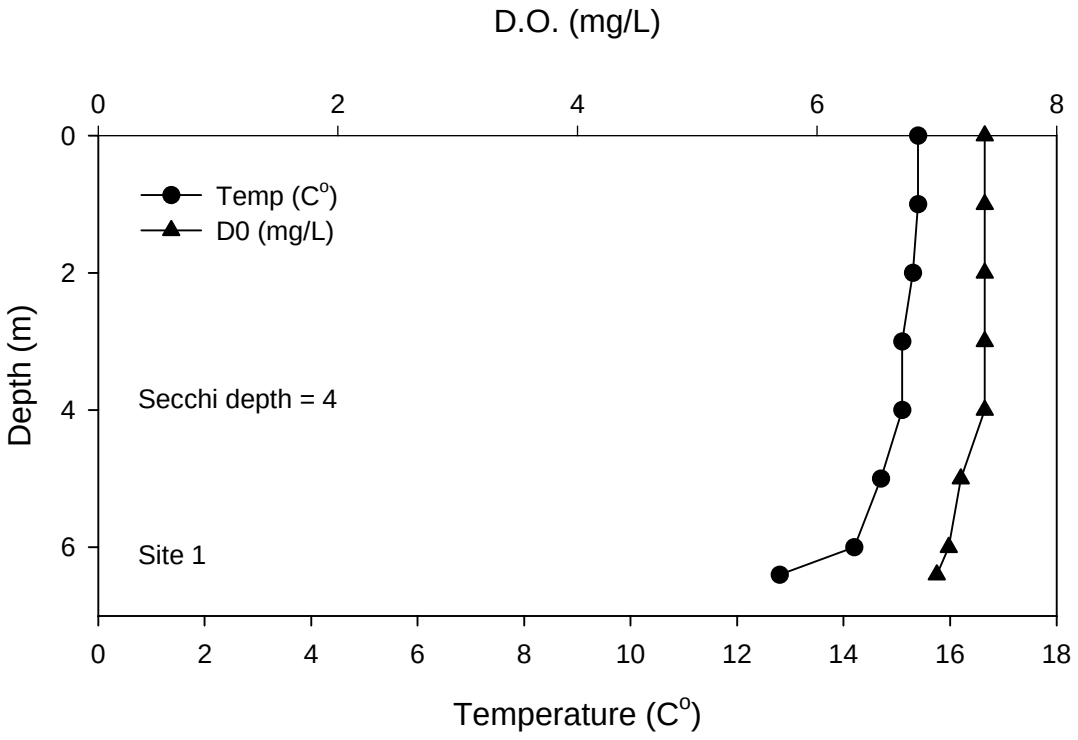


Figure 25. Vertical temperature (°C) and dissolved oxygen profile (DO; mg/L) in the Little Wood Reservoir in 2004.

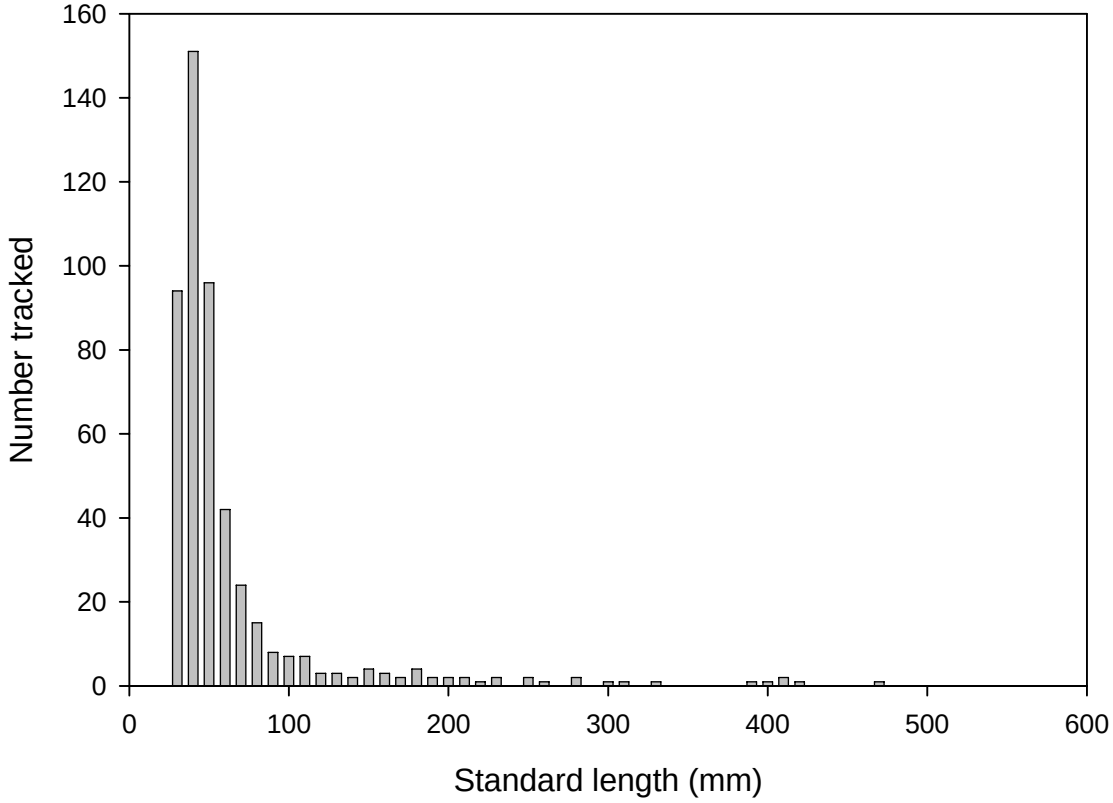


Figure 26. Length frequency (SL-mm) converted from target strength (dB) distribution of fish tracked during the 2004 survey at Mann Creek Reservoir.

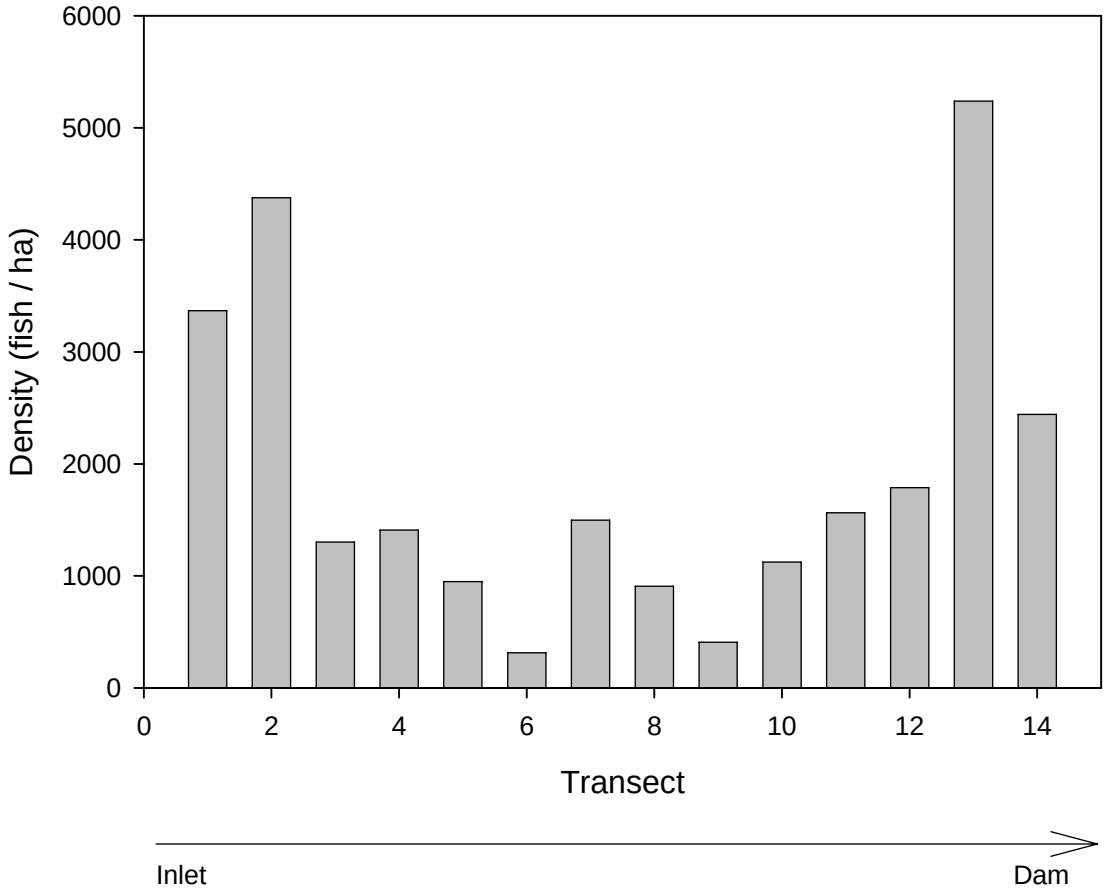


Figure 27. Fish density (fish/ha) by transect during day and night surveys at Mann Creek Reservoir in 2004.

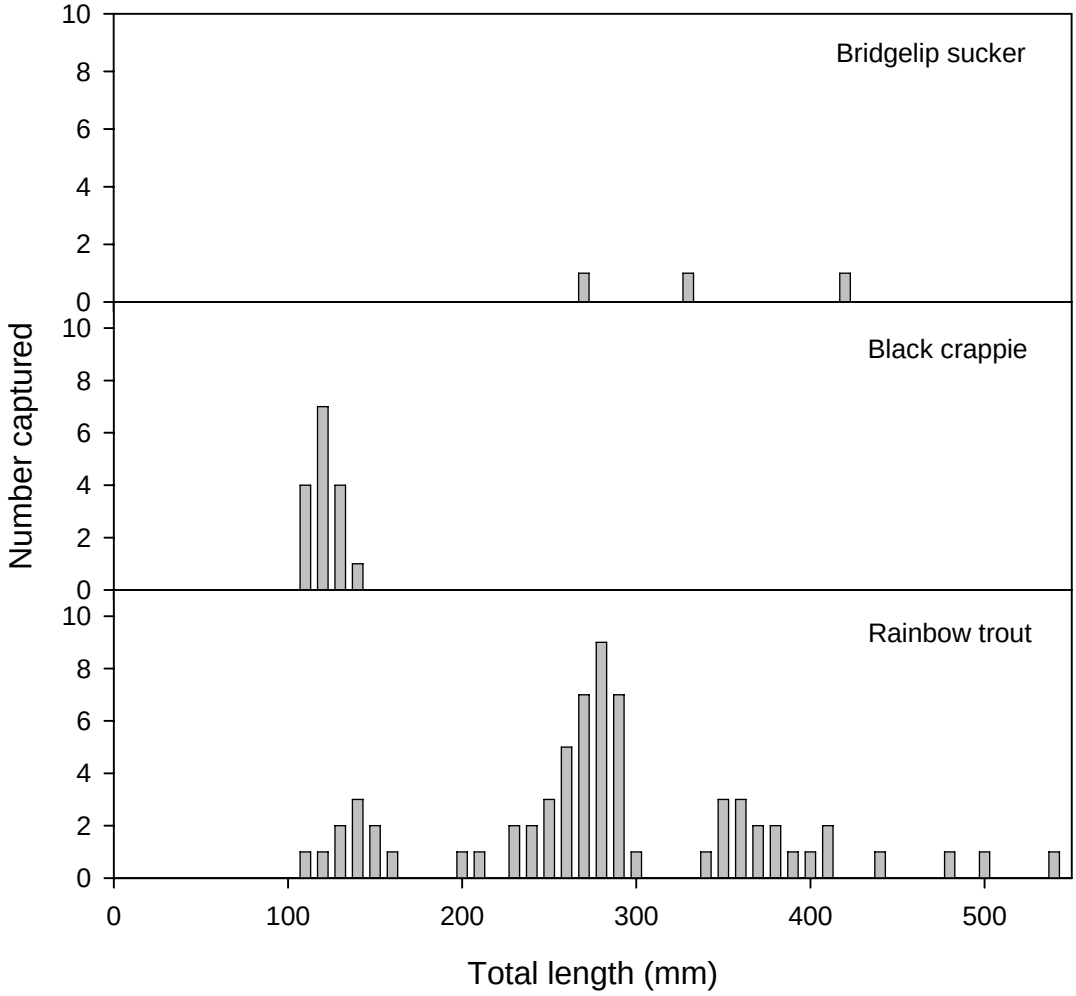


Figure 28. Length distributions of fish species caught in net curtains at Mann Creek Reservoir in 2004.

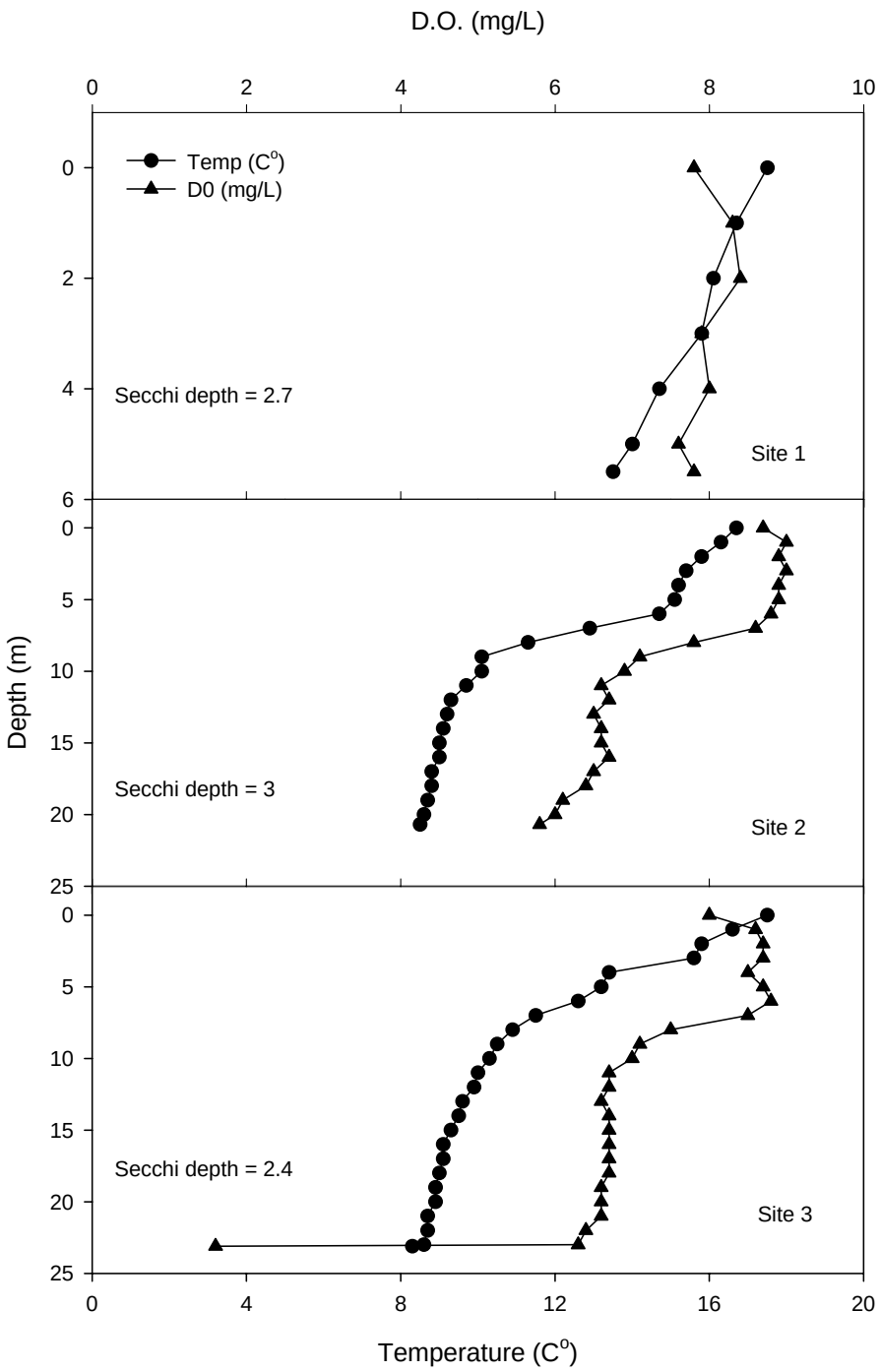


Figure 29. Vertical temperature (°C) and dissolved oxygen profiles (DO; mg/L) at three sites in Mann Creek Reservoir in 2004.

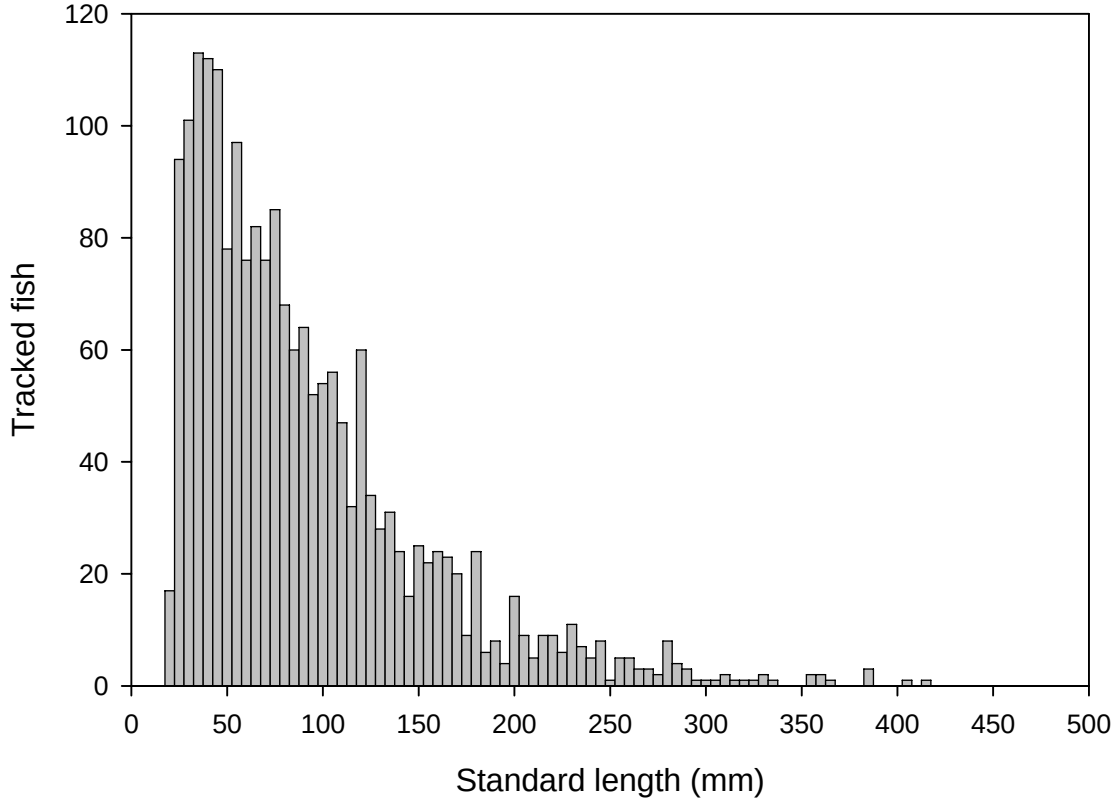


Figure 30. Length frequency (SL-mm) converted from target strength (dB) distribution of fish tracked during the 2004 survey at Payette Lake.

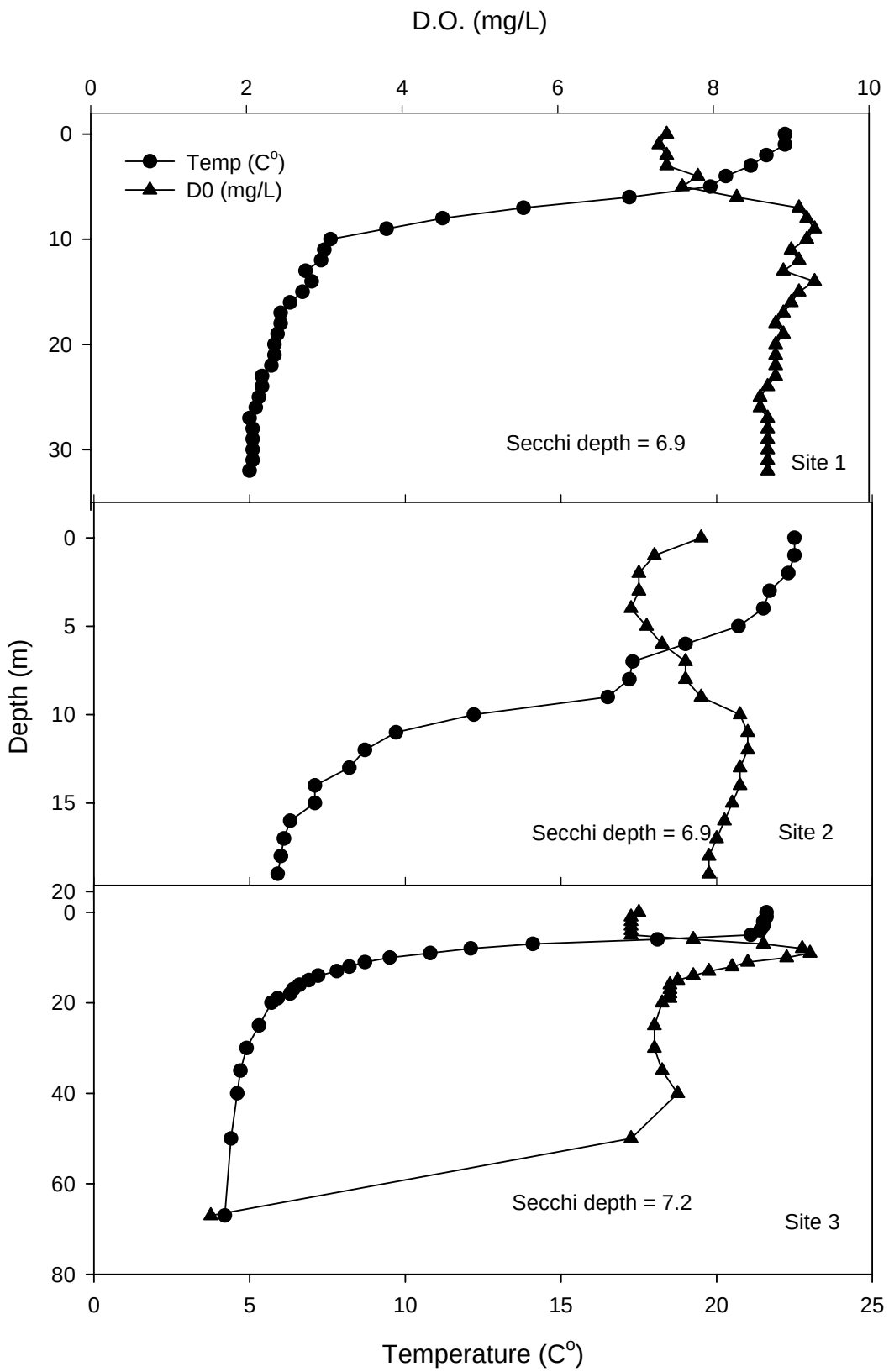


Figure 31. Vertical temperature (°C) and dissolved oxygen profiles (DO; mg/L) at three sites in Payette Lake in 2004.

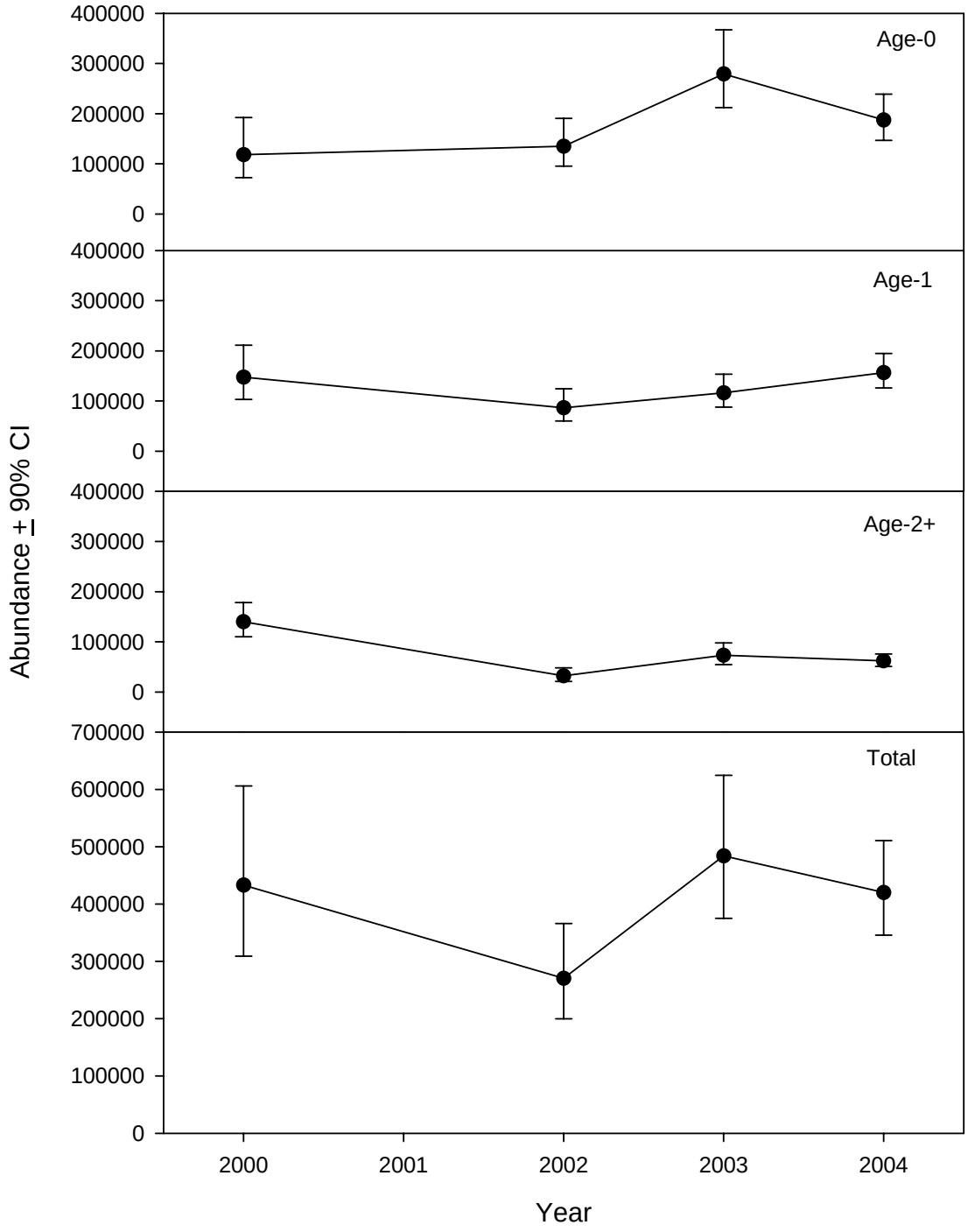


Figure 32. Trends in hydroacoustic kokanee abundance at Payette Lake from 2000-2004.

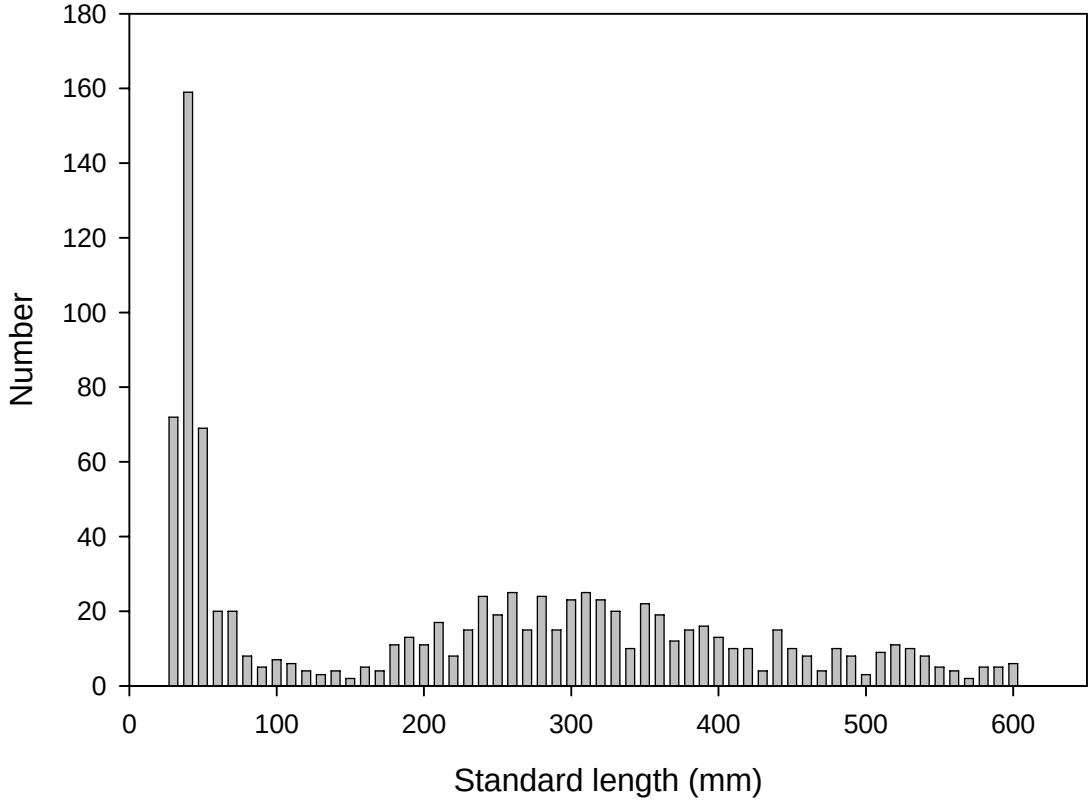


Figure 33. Length frequency (SL-mm) converted from target strength (dB) distribution of fish tracked during the 2004 survey at Lake Walcott.

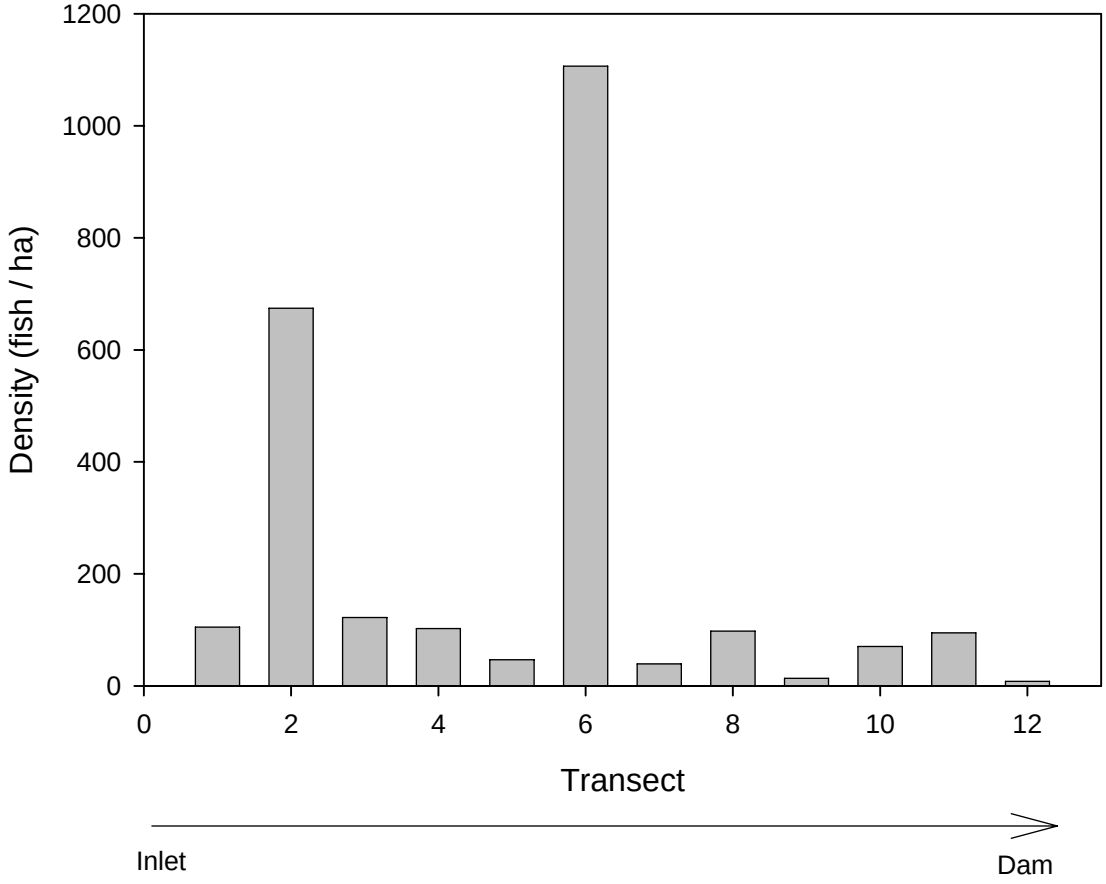


Figure 34. Fish density (fish/ha) by transect during day and night surveys at Lake Walcott in 2004.

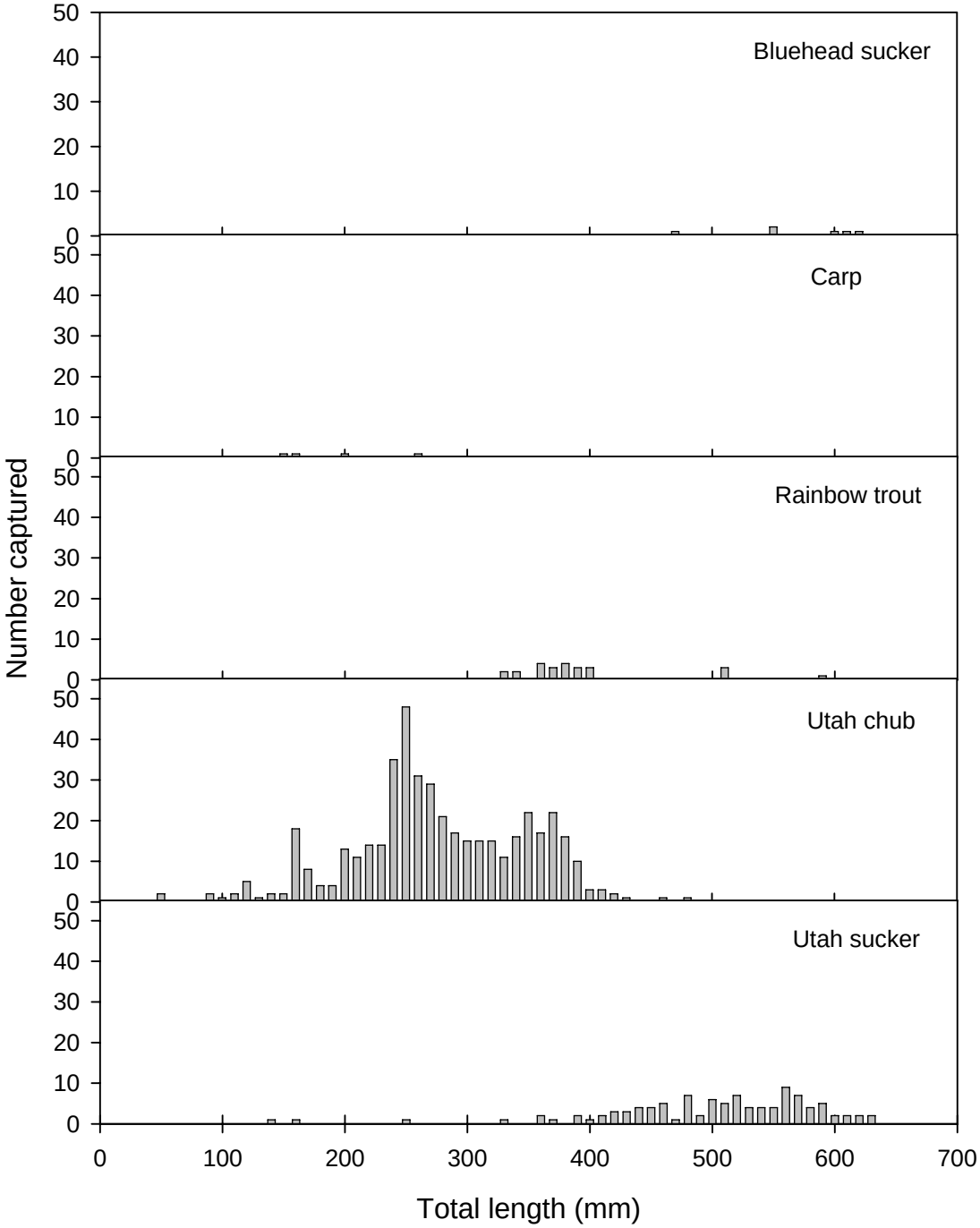


Figure 35. Length distributions of fish species caught in net curtains at Lake Walcott in 2004.

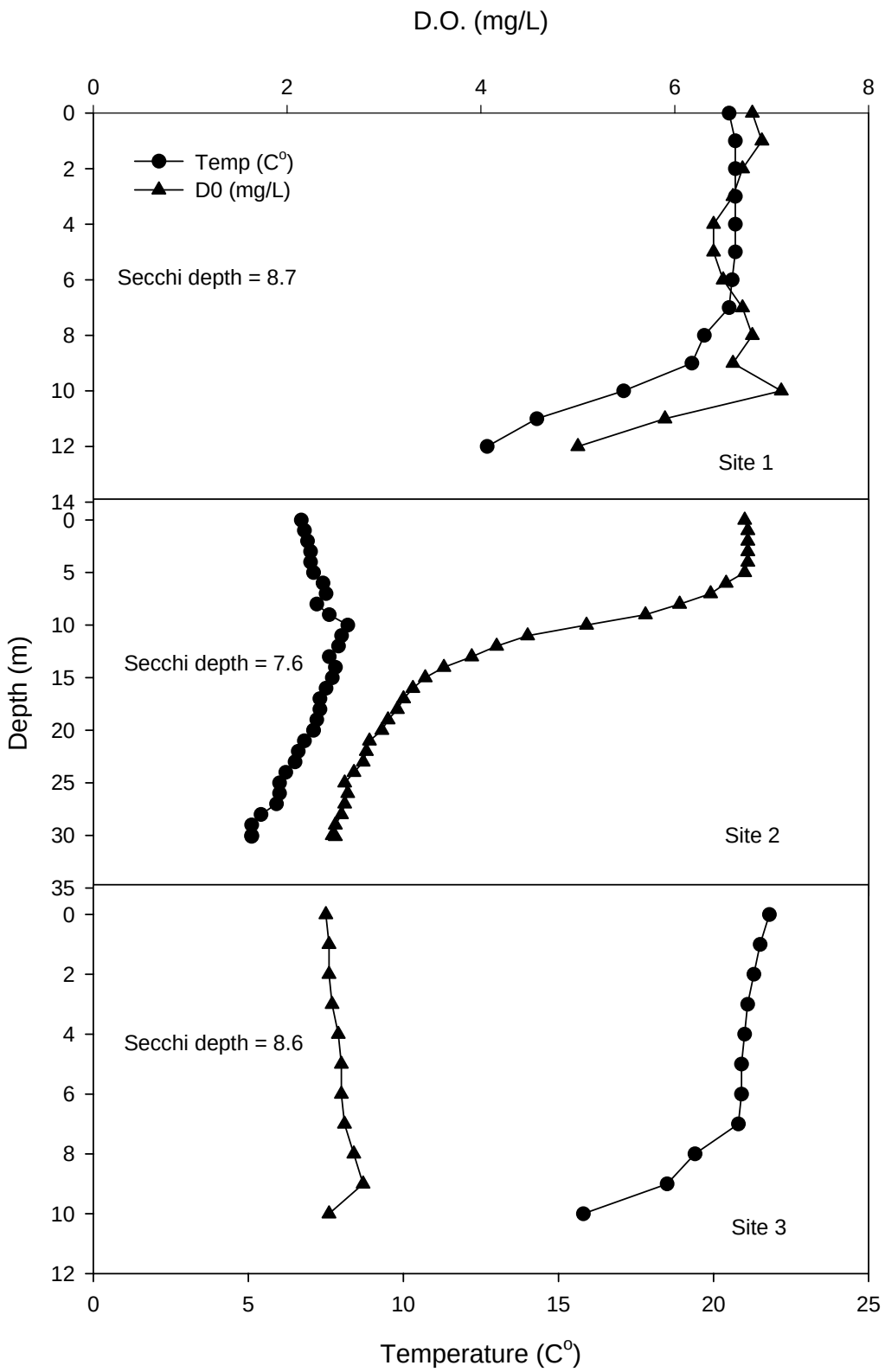


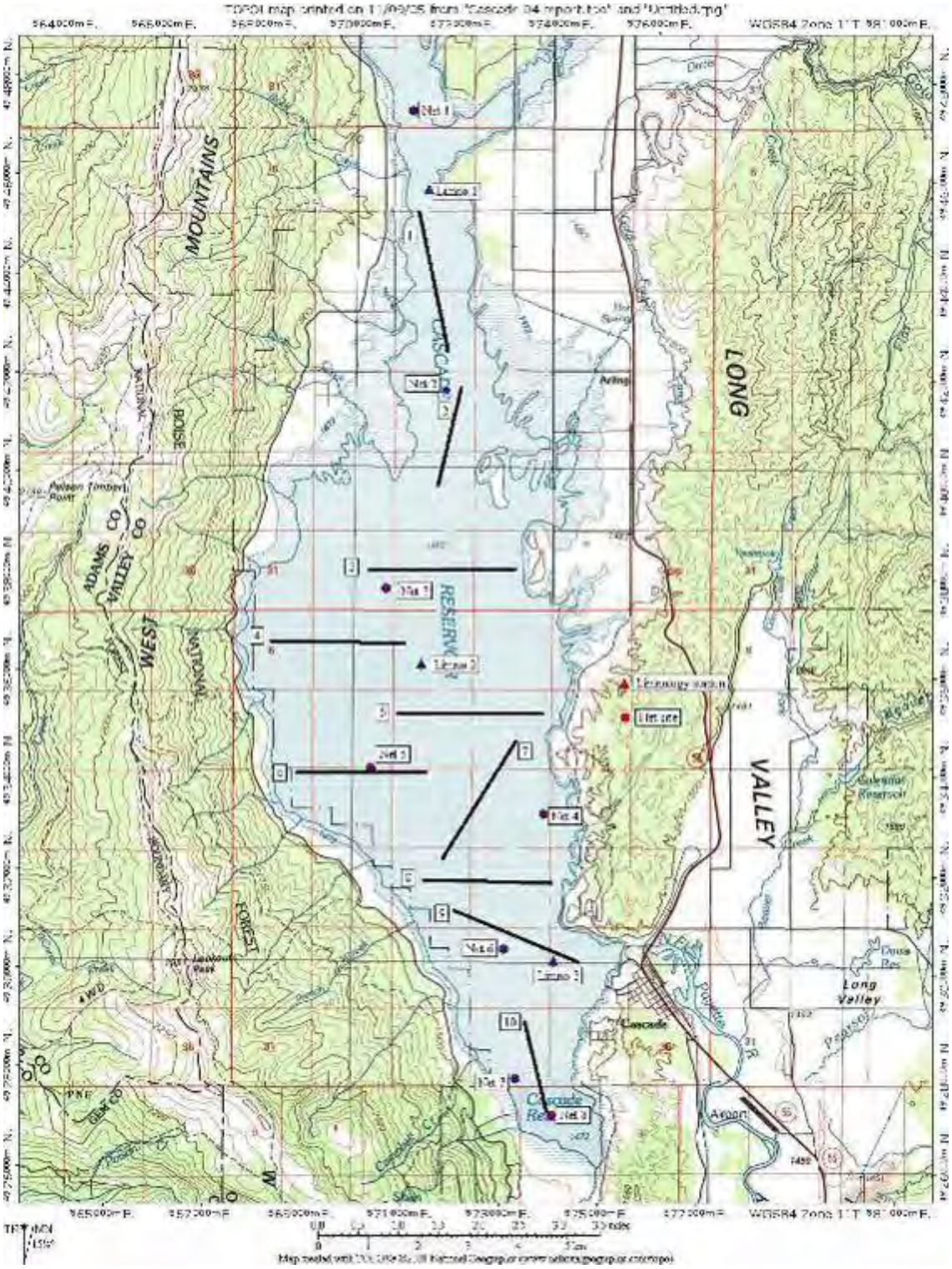
Figure 36. Vertical temperature (°C) and dissolved oxygen profiles (DO; mg/L) at three sites in Lake Walcott in 2004.

APPENDICES

Appendix A. Hydroacoustic transects, and limnology stations for the 2004 fish assessment survey at Anderson Ranch Reservoir.

Appendix B. Hydroacoustic transects, netting sites, and limnology stations for the 2004 fish assessment survey at Black Canyon Reservoir.

Appendix C. Hydroacoustic transects, netting sites, and limnology stations for the 2004 fish assessment survey at Cascade Reservoir.



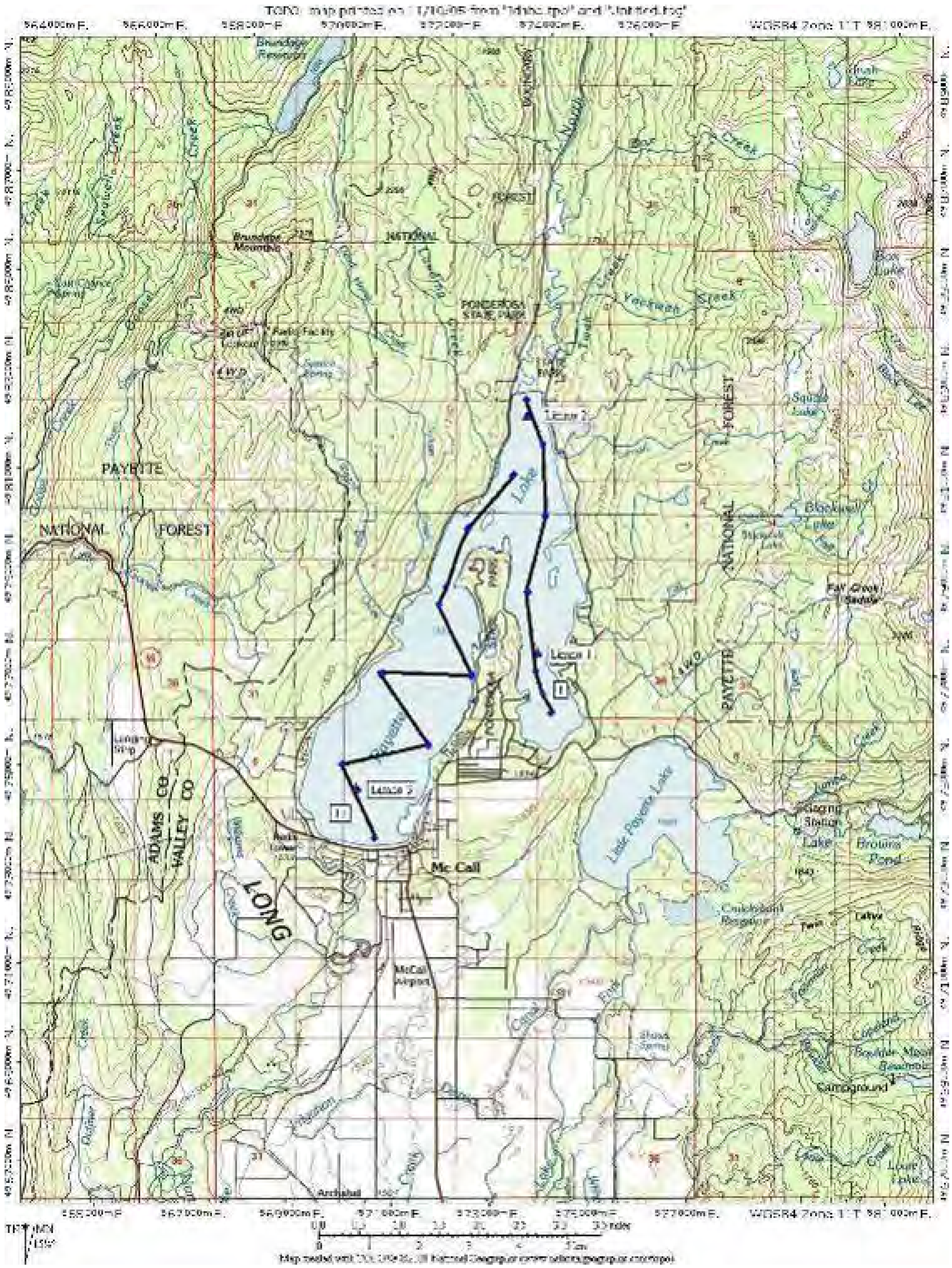
Appendix D. Hydroacoustic transects, netting sites, and limnology stations for the 2004 fish assessment survey at Deadwood Reservoir.

Appendix E. Hydroacoustic transects, and limnology stations for the 2004 fish assessment survey at Island Park Reservoir.

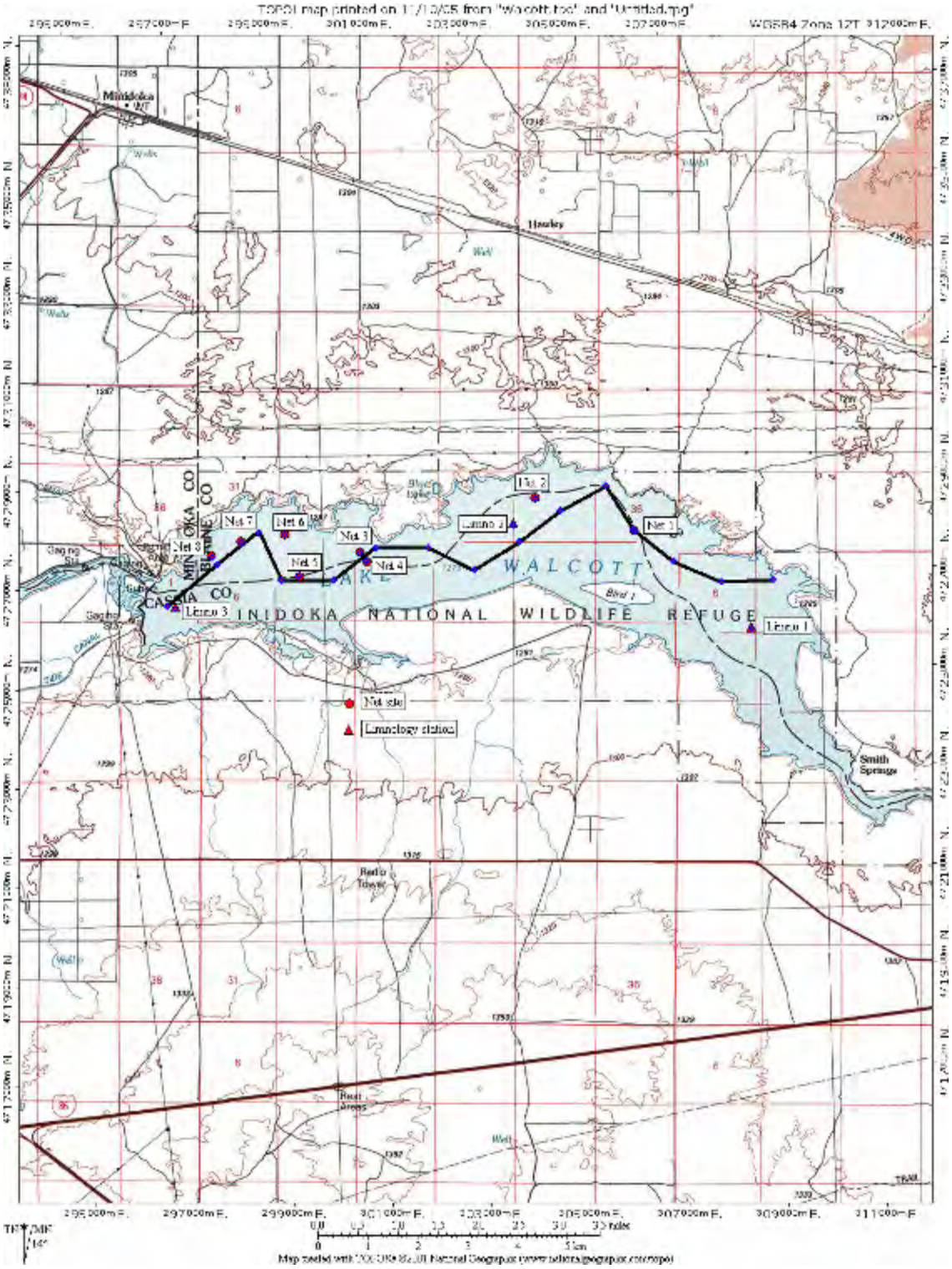
Appendix F. Hydroacoustic transects, netting sites, and limnology stations for the 2004 fish assessment survey at Little Wood Reservoir.

Appendix G. Hydroacoustic transects, netting sites, and limnology stations for the 2004 fish assessment survey at Mann Creek Reservoir.

Appendix H. Hydroacoustic transects, and limnology stations for the 2004 fish assessment survey at Payette Lake.



Appendix I. Hydroacoustic transects, netting sites, and limnology stations for the 2004 fish assessment survey at Lake Walcott.



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