FISHERY RESEARCH

PROJECT 5—LAKE AND RESERVOIR RESEARCH

Grant F-73-R-25

Report Period July 1, 2002 to June 30, 2003

Arthur E. Butts
Senior Fishery Research Biologist

IDFG Report Number 04-06
January 2004

Annual Performance Report

July 1, 2002 to June 30, 2003

Grant #F-73-R-25

Project 5—Lake and Reservoir Research

By

Arthur E. Butts

Idaho Department of Fish and Game
600 South Walnut Street
P.O. Box 25
Boise, ID 83707

IDFG Report Number 04-06
January 2004

TABLE OF CONTENTS

LIST OF TABLES

Page

List of Tables, continued.

Page

LIST OF FIGURES

List of Figures, continued.

Page

List of Figures, continued.

Page

LIST OF APPENDICES

Page

JOB PERFORMANCE REPORT

State of: Idaho Grant No.: F-73-R-25, Fishery Research

Project No.: 5 Title: Lake and Reservoir Research

Contract Period: July 1, 2002 to June 30, 2003

ABSTRACT

Hydroacoustics were used to estimate pelagic fish abundance and size structure in American Falls, Anderson Ranch, Arrowrock, Cascade, Deadwood, and Lucky Peak reservoirs and Payette Lake. Many of the reservoirs contain multiple species, overlapping in both distribution and size. Hydroacoustic surveys were conducted during day and night periods to determine the optimal period for estimating fish abundance at each reservoir. At American Falls and Cascade reservoirs, floating gillnets, net curtains, and purse seining were used to collect fish so that hydroacoustic estimates could be partitioned into individual species estimates. Sinking nets were also set at each site to assess numbers and species of fish that were not vulnerable to sonar gear. Limnological data were collected at sites along the trophic gradient at most of the reservoirs to assist in the explanation of fish distributions. Population abundance was estimated for northern pikeminnow *Ptychocheilus oregonensis*, rainbow trout *Oncorhynchus mykiss*, and largescale sucker *Catostomus macrocheilus* at Cascade Reservoir and rainbow trout, Utah chub *Gila atraria*, and Utah sucker *Catostomus ardens* at American Falls Reservoir. However, confidence intervals around many of the species estimates suggest that both netting and hydroacoustic sampling should be increased during future surveys. Size selectivity of fish caught in gillnets was also evident, and more effort should be placed on sampling with the purse seine. Fish assessments in 2002 provided valuable information on species abundance in pelagic habitats and environmental, seasonal, diel, and fish behavioral influences on survey results. It was demonstrated that hydroacoustic sampling, conducted in concert with intensive fish collection, provides managers with much more information than standard monitoring methods such as trend netting.

Author:

Arthur E. Butts
Senior Fishery Research Biologist

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).

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).

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, estimate age structure, mortality, etc.).

Like any sampling methodology, hydroacoustics do not come without limitations. Hydroacoustics require a high initial investment in equipment and training personnel to operate the equipment. Secondly, 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. Finally, direct identification of species is not possible with hydroacoustics. Partitioning species generally requires collecting fish through other sampling methodologies and coupling this information with knowledge on size, species-specific distributions, and behavior.

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 and Teuscher 2002). Many important fisheries in Idaho contain mixed and complex 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 ground-truthing 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 abiotic and biotic data. Temperature and dissolved oxygen (DO) are critical variables that structure lakes 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 OBJECTIVE

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

OBJECTIVES

1. To determine during the 2002 and 2003 field seasons whether or not hydroacoustic methods can be used to produce useable population estimates in complex fish communities.

TASKS

1. Estimate the number of pelagic fish at American Falls Reservoir, Anderson Ranch Reservoir, Arrowrock Reservoir, Cascade Reservoir, Deadwood Reservoir, Lucky Peak 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%).

STUDY SITES

American Falls Reservoir

American Falls Reservoir is a large, shallow, eutrophic impoundment located on the upper Snake River in southeastern Idaho. The reservoir has a mean depth of 9.3 m, a storage capacity of 2,097 x 10^6 m^3, and is primarily managed for irrigation and power generation. The surrounding area is composed of mainly agricultural land with the town of American Falls located to the southwest. Resident species include rainbow trout *Oncorhynchus mykiss*, cutthroat trout *O. clarki*, brown trout *Salmo trutta*, yellow perch *Perca flavescens*, black bullheads *Ameiurus melas*, smallmouth bass *Micropterus dolomieu,* and sucker species

Catastomus sp. Fishery management efforts have focused on providing a rainbow trout fishery through artificial propagation (Idaho Department of Fish and Game [IDFG] 2001).

Anderson Ranch Reservoir

Anderson Ranch Reservoir is a deep mesotrophic impoundment located on the South Fork of the Boise River and provides irrigation water, power, and flood and sediment control. The reservoir has a mean depth of 32.3 m, a total storage capacity of 5,200 x 10^5 m^3, and is located 32 km northeast of Mountain Home, Idaho. Species include kokanee *O. nerka*, resident and adfluvial bull trout *Salvelinus confluentus*, rainbow trout, smallmouth bass, yellow perch, and northern pikeminnow *Ptychocheilus oregonensis*. Fishery management efforts emphasize providing a kokanee fishery (IDFG 2001).

Arrowrock Reservoir

Arrowrock Reservoir is a mesotrophic reservoir located on the Boise River immediately above Lucky Peak Reservoir. The reservoir has a mean depth of 28.3 m, a total storage capacity of 3,355 x 10^5 m^3 272,000 acre feet, and is drafted heavily during the summer to provide irrigation water to the Boise River. Arrowrock Reservoir contains a mixed species assemblage that includes smallmouth bass, yellow perch, rainbow trout, kokanee, mountain whitefish *Prosopium williamsoni*, northern pikeminnow, and largescale sucker *Catastomus macrocheilus*. Arrowrock also contains an adfluvial bull trout population that migrates up the Middle Fork and the North Fork of the Boise River during the spawning period. Fishery management efforts focus on annual stockings of fingerling and catchable rainbow trout (IDFG 2001).

Cascade Reservoir

Cascade Reservoir is a large, shallow, upper mesotrophic impoundment located on the North Fork of the Payette River. The reservoir is utilized for power generation and irrigation storage, and has a mean depth of 7.5 m and a total storage capacity of 8,057 x 10^5 m^3. The surrounding watershed is used for agricultural and recreational purposes and is intensively grazed. Resident species include coho salmon *O. kisutch*, kokanee, rainbow trout, whitefish *Prosopium* sp., yellow perch, northern pikeminnow, smallmouth bass, channel catfish *Ictalurus punctatus*, and largescale sucker *Catastomus macrocheilus*. Cascade Reservoir provided a high quality perch fishery in the late 1980s and early 1990s but had collapsed by 1997 (Anderson et al. 2002). The recent decline in abundance of yellow perch has in part been attributed to predation from an expanding population of northern pikeminnow. Efforts to reduce the northern pikeminnow population by trapping fish as they enter spawning tributaries began in 2002. More recently, a control program using extreme drawdown has been proposed (Paul Janssen, IDFG, personal communication).

Deadwood Reservoir

Deadwood Reservoir is an oligomesotrophic impoundment located in the Payette River drainage on the Deadwood River, 40 km southeast of Cascade, Idaho. The impoundment has a mean depth of 15.4 m, a total storage capacity of 1,998 x 10^5 m^3, and is managed to provide irrigation to the Payette and Emmett areas and a regulated flow to the power plant at Black Canyon Dam. The reservoir contains a coldwater fish assemblage of kokanee, cutthroat trout, rainbow trout, fall chinook salmon *O. tshawytscha*, brook trout, mountain whitefish, and bull trout. Fishery management objectives for kokanee in Deadwood Reservoir are to yield four-year-old kokanee with a mean length that exceeds 13 inches by controlling the spawning escapement in the Deadwood River. Another long-term objective is to establish a self-sustaining population of westslope cutthroat *O. clarki lewisi* (IDFG 2001).

Lucky Peak Reservoir

Lucky Peak Reservoir is a large mesotrophic impoundment in the Boise River drainage, immediately downstream from Arrowrock Reservoir. It has a mean depth of 32.8 m, a total capacity of 3,615 x 10^5 m^3, and is managed to provide irrigation, power generation, and recreation. Because of the reservoir's close proximity to the Boise area, it is utilized intensively for boating and water skiing. The impoundment has a mixed species assemblage that includes smallmouth bass, yellow perch, rainbow trout, kokanee, mountain whitefish, bull trout, northern pikeminnow, and largescale sucker. The reservoir is managed primarily as a yield fishery for smallmouth bass, kokanee, and rainbow trout (IDFG 2001).

Payette Lake

Payette Lake is a natural, deep oligotrophic lake located in the Payette River drainage on the North Fork Payette River. The lake has a total capacity of 5,057 x 10^4 m^3 and a mean depth of 35 m, although it reaches a maximum depth of approximately 95 m. The surrounding area is primarily forested, although over 70% of the shoreline contains urban or housing development. The coldwater fishery includes kokanee, lake trout, rainbow trout, and cutthroat trout. Management efforts focus on maintaining an average kokanee size of 10 to 12 inches through population manipulation and providing a trophy catch-and-release lake trout fishery (IDFG 2001).

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 at a 1 m depth using a retractable pole mount 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 A-G).

Data were collected by fast multiplexing equally between both transducers at a sampling rate of 3.0-6.7 pings/s, which allowed for near-simultaneous data collection at 1.5-3.35 ping/s per transducer. A transmit pulse width of 0.2 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. Therefore, the sidelooking transducer (6°) collected data in the top 8 m of the water column at a range of 10-50 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).

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, I 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 (>8 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 8 m of the water column were excluded from analysis to avoid double counting.

Sidelooking fish densities (<8 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).

Total fish abundance was estimated by multiplying the 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:

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

where s^2x is the variance of x,
s^2_y is the variance of y, and
n_x and n_y is the sample size of each estimate.

The Bureau of Reclamation provided surface area and volume data for all reservoirs sampled during 2002. Ninety-five percent confidence intervals were calculated for population estimates using the methods described in Brown and Austen (1996). Regardless of transect length, each transect was considered a sample unit.

Vertical depth distributions of tracked fish were calculated for all 2002 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 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 sinking and floating experimental gillnets and net curtains were set in pelagic regions for target verification and species partitioning at American Falls Reservoir, Arrowrock Reservoir, and Cascade Reservoir during both daytime and nighttime periods. Nets were set at various sites along hydroacoustic transects using GPS; sites were spaced longitudinally from inlet to outlet. Floating gillnets 46 m long by 2 m deep were set at the surface and were comprised of 8 m long panels of randomly placed 38, 51, 64, 76, 102, and 127 mm stretch mesh. 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. Sinking nets had the same dimensions and array of randomly placed mesh sizes as the floating nets. Sinking nets were not used to partition species because of their proximity to the bottom, where fish were not vulnerable to hydroacoustic sampling. However, sinking nets did provide an indication of the numbers of fish and species that were excluded from sonar estimates. Because different sampling gear was used, one floating net and one net curtain were combined to equal one sampling unit during analysis.

Fish were identified 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) were recorded. Total depth at each netting site was also recorded.

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 *i*th cluster, $i = 1, 2, \ldots, n$.

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):

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

where $v(\overline{x}\overline{y})$ is the variance of the product $\overline{x}\overline{y}$,
$s^2(y)$ is the variance of $\overline{y}$,
$s^2(x)$ is the variance of $\overline{x}$, 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 $D = B^2\overline{M}^2/4$, and
σ_p^2 is estimated by s_p^2.

Because the total possible number of clusters *N* is unlimited, I assumed $N = \infty$ in our estimates. I 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.

In addition to using gillnets and net curtains in the parsing of hydroacoustic targets, I also attempted to collect fish using a purse seine in two study waters. Purse seining does not result in the size selectivity and fish activity biases that are often associated with gillnets, because it is an active sampling methodology. A 9.1 m deep purse seine was used at American Falls Reservoir and Cascade Reservoir. The 183 m long net consisted of 19 mm stretch mesh (knotless) with an 8 m long bunt in the center of the seine comprised of 6 mm long stretch mesh. The purse seine encircled 0.27 ha and was set and retrieved in 30 min using a 9 m long barge and a 5 m long skiff. Scuba divers employed by the Wyoming Game and Fish Department estimated the effective sampling depth of a purse seine of the same dimensions to be 7.6 m (Yule 2000).

Limnology

In four of the seven study waters, limnological data were collected concurrently with hydroacoustic sampling to help explain horizontal and vertical fish distributions. Limnological variables were measured at 2-4 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, I collected data on size structure and abundance of zooplankton communities in the lower, middle, and upper reaches of four reservoirs. Zooplankton were 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 were 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 us 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).

Data Collected

Density, distribution, and abundance estimates were obtained for American Falls Reservoir, Anderson Ranch Reservoir, Arrowrock Reservoir, Cascade Reservoir, Deadwood Reservoir, Lucky Peak Reservoir, and Payette Lake. Limnological measurements were taken at most water bodies, and data were coupled with hydroacoustic estimates to enhance the understanding of fish distribution and movement. Fish were collected at American Falls Reservoir, Arrowrock Reservoir, Cascade Reservoir, and Lucky Peak Reservoir. Species-specific abundance estimates were limited to American Falls, Anderson Ranch, Cascade, and Deadwood reservoirs and Payette Lake, because fish collections were either not attempted or sample sizes were restricted because of logistical problems.

RESULTS

American Falls Reservoir

The survey at American Falls Reservoir took place from July 15-31, 2002. The hydroacoustic survey at American Falls Reservoir was conducted during the day on July 24, 2002, and the night survey took two nights to complete because of inclement weather on July 29 and July 31, 2002. Day and night hydroacoustic transects began at the lower end of the reservoir near the dam and continued upstream (Appendix A). Wind gusts caused us to disregard planned transects, and instead, boat travel was determined by wave direction. Fish densities varied greatly between transects (Table 1). During the day, densities and population estimates were greatest in the top 8 m (sidelooking) but shifted to depths >8 m during night surveys. A modal depth of 4 m was observed during the day for all tracked fish, while a bimodal depth of 4 m and 9 m was observed during evening surveys (Figure 1). The overall vertical distribution of fish tracked by hydroacoustics suggested that most fish were located below the thermocline during both day and night. Larger fish occupied the top 8 m and were at greater densities during daylight periods (Figure 2). Diel abundance estimates were similar, as I estimated 1,027,600 ± 577,716 (± 56%) pelagic fish during the day survey and 1,123,816 ± 544,776 (± 48%) fish during the night survey.

From July 16-25, six floating gillnets, six net curtains, and eight sinking nets were set during the day, and nine floating gillnets, nine net curtains, and nine sinking nets were set during the night at five sites. Day sets averaged an 8 h 43 min soak time, while night sets averaged an 11 h 33 min soak time. Catches were comprised mainly of rainbow trout, Utah chub, Utah suckers, and kokanee, while smallmouth bass, yellow perch, and redside shiners *Richardsonius balteatus* were less frequently caught (Table 2). Day sets were much less productive than night sets, which is likely a result of visual avoidance of nets.

Rainbow trout and Utah chub captured during both diel periods overlapped in size with modes of approximately 400 mm and 385 mm, respectively. A much larger length mode of 515 mm was observed in Utah suckers (Figure 3). Rainbow trout were not captured at the uppermost site (Site 2), and numbers increased towards the dam (Figure 4). This distribution corresponds to the availability of quality forage available at the lower end of the reservoir. Lengths ranged from 185 mm to 620 mm, and fish were caught in mesh sizes ranging from 25 mm to 152 mm (stretch mesh) (Figure 5). The majority of fish were caught in 64 mm and 76 mm mesh. Catches increased during evening sets, and the majority of fish were caught in the epilimnion. Sinking nets captured 58% of total rainbow trout catches during the day and 24% during the evening, which were not used in estimating species proportions because hydroacoustic detection of targets near the bottom is limited (Table 2).

Utah chub were captured at all netting stations, with the upper sites (Sites 1-4) containing the most fish (Figure 6). Utah chub occupied all depths, and catches were greatest during evening periods as well. Captured Utah chub lengths ranged from 60 mm to 575 mm and were caught in a range of mesh sizes from 19 mm to 152 mm stretch mesh (Figure 7). Size selectivity was apparent between mesh sizes as length distributions increased with mesh size. The majority of fish were caught in mesh sizes between 76 mm and 102 mm. Seventy-one percent of the total Utah chub sampled were caught in sinking nets in the day compared to only 35% during the night (Table 2).

Utah suckers were also captured at all stations, and numbers were greatest at the upper stations during the evening sets (Figure 8). Percentages of Utah suckers captured in sinking nets were more similar between diel periods than the other species with 62% in the day and 50% in the evening (Table 2). Size selectivity was most apparent in Utah sucker catches, probably because of their more cylindrical morphology (Figure 9). Utah sucker lengths ranged from 80 mm to >800 mm, and they were caught in mesh sizes from 19 mm to 152 mm stretch mesh. The vast majority was caught in 102 mm and 127 mm stretch mesh, with much fewer fish captured in an intermediate mesh size of 114 mm. This indicates strong size selectivity for different mesh sizes in catches of Utah suckers.

Purse seine catches were variable, and seining was abandoned; the seine was continuously snagging on the bottom because of a lack of depths >8 m (Table 2). Accordingly, fish caught in the purse seine were not used to partition species.

The lake was slightly stratified at the upper end of the reservoir (station 1), and the thermocline decreased towards the dam (station 3; Figure 10). Water temperatures varied between 22 and 26°C throughout the entire water column and DO levels were also adequate (3.4-11.9 mg/L) at all sites. Mean Secchi transparency increased from the upper end of the reservoir (0.8 m) to the dam (2.8 m). Zooplankton were not sampled at station 1, because an overabundance of filamentous algae prevented water filtration through plankton nets. Both ZPR and ZQI index values were high and increased dramatically from mid to lower reservoir, which indicated very favorable foraging conditions for large cladocerans near the dam (Table 3). The increased level of *Daphnia* corresponded to the observed increase in water transparency in the lower end of the reservoir.

I estimated the population proportions for both day and night netting periods using all species captured in floating and curtain nets. Proportion estimates varied by diel period for rainbow trout, Utah chub, and Utah sucker but were not statistically different given the error around each estimate (Table 4). Total catch was comprised largely of Utah sucker during both diel periods (68% ± 12% in the day; 47% ± 21% in the night). Rainbow trout proportions increased from 12% ± 17% in the day to 28% ± 23% in the evening. The majority of variance between day and night proportions was more likely due to the poor gill net catch rates during the day for all species rather than actual fish distributions.

Because gillnetting was much more successful during the evening, population estimates were likely more reliable during the night as well. In addition, higher proportions of fish were caught in floating gillnets and net curtains at night, which increased the size of each sample. Based on population proportion estimates, I estimated the rainbow trout population to be 315,357 ± 255,040 (± 81%) fish, the Utah chub population to be 246,552 ± 214,486 (± 87%) fish, and the Utah sucker population at 531,328 ± 320,460 (± 60%) (Table 4).

Anderson Ranch Reservoir

Two hydroacoustic surveys took place on the evenings of May 15, 2002 and September 9, 2002 using only the downlooking transducer. Transects began at the upper end of the reservoir downstream from the inlet and ended along the dam (Appendix B). Based on past IDFG trawling, pelagic targets were considered kokanee and, therefore, fish collection for target verification was not conducted during either survey. Limnological data were not collected on either date because of time constraints. Based on midwater trawling conducted by regional staff on July 10, 2002, estimates were divided into age classes where <100 mm were age-0 fish, 100-200 mm were age-1 fish, and >200 mm were older fish (Figure 11).

Age classes were overlapped in depth during both surveys. In May, all age classes displayed a modal depth of approximately 12 m in transects above Falls Creek and 13 m in transects below Falls Creek (Figure 12). By September, all year classes had shifted to deeper water with a modal depth of approximately 16 m above Falls Creek and 35 m below Falls Creek (Figure 13).

In May, age-0 kokanee may have been residing in littoral regions or near the inlet area after out-migration and thus were not fully recruited to the pelagic region. As age-0 kokanee moved into the pelagic region, smaller targets (<-47 dB) increased dramatically between the May and September survey (Table 5). During both surveys, densities appeared to increase from the upper end of the reservoir towards the dam, which is likely related to the availability of deeper water and potentially greater foraging opportunities.

Estimates of age-0 kokanee abundance (<100 mm) increased over 200% from 70,083 ± 17,184 in May to 219,408 ± 34,788 in September (Table 5). Numbers of age-1 fish decreased from 87,464 ± 23,013 in May to 43,017 ± 8,610 in September. This could possibly be a result of growth in age-1 fish and smaller age-2 fish between the July trawling period and the September hydroacoustic survey. Age-2+ kokanee abundance estimates declined from 90,422 ± 33,078 in May to 22,996 ± 9,017 fish in September. The observed reduction in age-2+ numbers was expected, because the kokanee spawning escapement in the South Fork Boise River begins in mid-August.

Total abundance estimates of kokanee were much lower in 2002 than in previous surveys conducted in 2000 and 2001. An estimated 285,421 ± 44,332 kokanee were observed in September 2002, whereas Butts and Teuscher (2002) estimated 1,103,975 ± 281,155 in July 2001, and Teuscher (2001) estimated 2,887,000 ± 692,880 in July 2000.

Arrowrock Reservoir

Arrowrock Reservoir was surveyed from June 26-27 and from July 1-3, 2002. Transects began at the upper end of the reservoir, but the September survey began lower than the July survey and did not include the SF Boise arm because of the decrease in surface elevation between the two surveys (Appendix C).

Hydroacoustic surveys were conducted during both day and night periods on July 2-3 and September 18, 2002. The depth distribution of pelagic targets was similar between diel periods in July, when fish were heavily distributed between 5 and 23 m depth (Figure 14). During the day in July, a group of targets were tracked in the epilimnion where water temperatures ranged from 18°C to 25°C with targets decreasing in the evening. The majority of fish were tracked in cooler waters where temperatures ranged from 6°C to 15°C (Figure 15). During the September surveys, a pronounced increase in targets between 18 and 33 m was observed during the night survey.

Target strength distributions were similar between diel periods during July but showed a change in observed frequencies in September (Figure 16). During the September survey, larger targets decreased from day to night in the top 8 m, and a dramatic increase in smaller fish was observed during the evening. A decrease in the overall number of tracked fish between July and September was also evident.

Fish appeared to inhabit deeper waters in July, regardless of diel period. Densities were greatest below 8 m during both day and night surveys in July (Table 6). Fish density in the top 8 m changed from 7.9 fish/ha at night to 13 fish/ha during the day, while densities below 8 m increased from 114.1 fish/ha to 123.4 fish/ha. Overall, total density estimates were quite similar between day surveys (127.1 ± 67.8 fish/ha) and evening surveys (131.4 ± 49.0 fish/ha).

Diel period had a much stronger effect on density estimates in September when estimated total fish density was 52.6 ± 23.8 fish/ha during the day and increased to 163.2 ± 60.9 fish/ha in the night (Table 7). Fish in the top 8 m displayed a more pronounced decline in density (3.7 fold) during the evening than was observed in July as fish moved to deeper water.

During a period from June 26-27 and from July 9-11, 2002, seven net curtains and four sinking nets were set during the day and 11 net curtains and seven sinking nets were set during the night. Because of restrictions placed on the take of bull trout, net soak times were limited to 30 min, which severely limited the number of fish collected. Twenty fish were caught in all nets, and only seven fish were caught in net curtains (Table 8). Because of the low catches of fish, I did not try to partition hydroacoustic estimates into individual species estimates at Arrowrock Reservoir.

The reservoir was weakly stratified at the upper end of the reservoir near the inlet (Site 1) where temperatures ranged from 22 to 16°C surface to bottom (Figure 15). At the lower end of the reservoir, thermal stratification was much more pronounced with temperatures ranging from 25°C at the surface to 6°C at the bottom. Dissolved oxygen concentrations also displayed vertical stratification but never fell below 4 mg/L at any sampling station. Mean Secchi transparency was lowest at the upper end of the reservoir (2.3 m) and highest near the dam (6.0 m), suggesting that a productivity gradient existed between the inlet and dam. The ZPR values were moderate at all sites and ranged from a low of 0.56 at the inlet to a high of 0.75 at the dam (Table 3). However, ZQI values suggest that when abundance is also taken into account, zooplankton levels may actually be limiting, particularly at the lower end of the reservoir where the ZQI = 0.05.

In July, I estimated total abundance of pelagic fish to be 113,176 ± 60,344 in the day and 116,948 ± 43,656 in the evening (Table 6). In contrast, an abundance of 27,662 ± 12,545 fish was estimated during the day and 85,877 ± 32,015 was estimated during the night in September (Table 7). Although not statistically significant, the decline in mean abundance coincided with a 65% decline in reservoir volume between the two surveys.

Cascade Reservoir

The survey at Cascade Reservoir was a continuation of a series of annual hydroacoustic surveys where the main objective was to estimate the abundance of northern pikeminnow. Cascade Reservoir presents a difficult scenario for estimating the abundance of an individual species, because it contains a wide array of fishes that overlap in both habitat use and size. Limnological sampling and fish collection took place from August 5-16, 2002. Day and night hydroacoustic surveys were not completed until September 5, 2002, because eight other attempts at completing an entire sonar survey were compromised by winds and heavy wave action. Although fish collection and sonar surveys took place during different times, I assumed that estimates of species proportions would not have changed during the two weeks between sampling.

Hydroacoustic transects began at the lower end of the reservoir near Blue Heron campground and continued upstream above Sugarloaf Island (Appendix D). Density estimates varied greatly between transects with the majority of fish being tracked in the top 8 m (Table 9) because of the shallow nature of the reservoir and low oxygen levels in deeper water (Figure 17). Fish density estimates were quite similar between day and night periods when 16.0 ± 7.4 fish/ha was estimated in the day and 18.7 ± 9.6 fish/ha in the night. Estimates of total pelagic abundance increased somewhat during the night period from 138,265 ± 64,136 in the day to 161,539 ± 82,868 in the night.

Between August 6 and 15, 2002, 10 floating nets, 10 net curtains, and 10 sinking nets were set during both day and night periods at five sites in Cascade Reservoir (Appendix D). Day sets averaged a 9 h 12 min soak time, while night sets averaged a 12 h 39 min soak time. Catches predominately consisted of northern pikeminnow, largescale sucker, and rainbow trout (Table 10). Coho salmon, kokanee, mountain whitefish, smallmouth bass, brown bullhead, pumpkinseed, and yellow perch were also encountered less frequently. Nets set during the evening periods were much more productive, a likely result of visual avoidance of nets during daylight conditions.

Length distributions of northern pikeminnow, rainbow trout, and largescale sucker overlapped but did display modal differences (Figure 18). Northern pikeminnow total lengths ranged from 93 mm to 537 mm with a mean of 431 mm. Fish were captured in mesh sizes that ranged from 25 to 152 mm stretch mesh with the majority of fish captured in 76 mm mesh (Figure 19). Size selectivity was not readily apparent in catches of >400 mm pikeminnow, as the range of lengths were quite similar between 51 mm stretch mesh and 152 mm stretch mesh. Rainbow trout ranged from 86 mm to 540 mm with a mean total length of 347 mm (Figure 18). Rainbow trout were captured in mesh sizes ranging from 32 mm to 127 mm with the majority of fish captured in 51 and 64 mm stretch mesh (Figure 20). Similar to American Falls Reservoir, a wide size range of rainbow trout were caught with each mesh size, probably as a result of the higher susceptibility of being captured by their teeth compared to the other species. Total lengths of largescale suckers ranged from 399 mm to 800 mm with a mean of 529 mm (Figure 18). Fish were captured in net mesh sizes that ranged from 38 to 152 mm stretch mesh with the majority of fish captured in the 102 mm mesh (Figure 21). Our inability to capture fish <400 mm, despite a wide array of mesh sizes, suggests that size selectivity caused bias in our efforts to sample largescale suckers.

I conducted 10 purse seine hauls with limited success, as the seine routinely snagged the bottom. Thirty-two fish were captured but were not used to partition species because of questions concerning the speed with which the seine was closed and the apparent ability of northern pikeminnow to avoid capture (Table 10).

Depth distributions of northern pikeminnow captured in nets showed that pikeminnow were distributed throughout the entire water column during both day and night periods (Figure 22). Forty-seven percent of the total number of northern pikeminnow were captured in sinking nets during the day, while 36% were captured during the night, none of which were used for species partitioning (Table 10).

Rainbow trout were caught at various depths during both day and night but did appear to stay within the epilimnion (Figure 23). Sinking nets captured only 36% of the total rainbow trout catch during the day and 22% at night (Table 10). Largescale suckers were also captured at all depths except at site 4 (Figure 24), which was located near the dam where the hypolimnion was anoxic. Over half of the total number of largescale suckers captured during the survey were caught in sinking nets (56% in the day; 51% in the night) and were excluded from partitioning estimates (Table 10).

Cascade Reservoir was thermally stratified at two of the three limnological stations (Figure 17). A 6 m deep epilimnion was measured at the upper end of the reservoir with the thermocline between 6 and 8 m. Temperatures ranged from 23°C to 15°C from surface to bottom and DO concentrations ranged from 7 mg/L to 1 mg/L, indicating that fish may have avoided the benthic regions. Temperature and DO varied only slightly from surface to bottom at site 2, but again showed strong stratification near the dam. Near the dam, temperatures ranged from 24°C to 13°C, and the thermocline was located between 6 and 8 m. Dissolved oxygen was adequate from the surface to 10 m depth but quickly dropped to very low levels below the thermocline. Secchi transparencies were similar between all stations at approximately 4 m depth. The ZPR values ranged from a high of 1.22 at station 1 to a low of 0.87 at station 2, while ZQI values were greatest at station 2 (0.68) and lowest at station 3 (0.24; Table 3). Both indices suggested that zooplankton foraging conditions were adequate throughout the reservoir.

Abundance of pelagic fish was estimated for all species caught during both diel periods (Table 11). However, estimates for species other than northern pikeminnow, rainbow trout, and largescale sucker are suspect because of low capture rates. Northern pikeminnow proportions were estimated to be 58% ± 18% in the day and 43% ± 12% during the night, which resulted in population abundance estimates of 79,537 ± 35,793 in the day and 69,035 ± 29,610 in the night. Rainbow trout population estimates also remained similar between day and night periods where 31,123 ± 15,322 was estimated in the day and 39,267 ± 17,361 in the night. Largescale sucker showed the largest discrepancy between population estimates during diel periods where 13,832 ± 7,568 were estimated during the day compared to 41,801 ± 18,768 during the night.

Deadwood Reservoir

The Deadwood Reservoir hydroacoustic survey was completed on September 16, 2002. Based on past IDFG trawling, all suspended pelagic targets below 10 m depth were considered kokanee and, therefore, fish sampling was not conducted. I attempted to measure temperature and DO profiles, but the data display was not functioning properly. Transects began in the northwest arm, headed toward the dam, and continued toward the inlet (Appendix E). At the time of the survey, Deadwood Reservoir was at 33% total capacity, which restricted the areas in which the boat could safely survey.

Age classes of kokanee were approximated using the target strength distribution from data collected with the downlooking transducer (>8m; Figure 25). Age-0 and age-1 kokanee were more difficult to separate using a size frequency distribution because of the presence of two age classes of larger, hatchery-raised kokanee. In June 2001, 135,741 kokanee fingerlings were stocked into Deadwood Reservoir, and an additional 119,920 were stocked in July 2002. Before 2001, kokanee had not been stocked since 1997, when approximately 30,000 kokanee fingerlings were stocked into Deadwood Reservoir. Fingerlings ranged from 63-127 mm standard length (SL) (-49.1 to –43.5 dB), using length conversions described by Carlander (1969), and were likely much larger than wild cohorts. Therefore, I approximated age-0 fish as targets <100 mm SL, age-1 fish as targets 100-200 mm SL, and age-2+ as targets >200 mm SL.

Transducer threshold settings did not allow for the detection of targets less than 132 mm in the top 8 m. Therefore, depth distributions revealed that no targets <100 mm SL (age-0) were detected above 9 m depth, whereas targets that were 100-200 mm (age-1) and >200 mm (age-2+) in length showed bimodal depth distributions between 0-10 m depth and 10-20 m depth (Figure 26). Using both depth and size-frequency distributions, density and abundance of kokanee were estimated using all <100 mm SL targets and only targets ≥10 m depth for the two other size groups.

Density estimates were variable but were highest in deeper areas near the dam (transects 8-16; Table 12). The majority of our total abundance estimates were comprised of kokanee (90%), and only 5% of the total abundance was estimated in the top 8 m (sidelooking). I estimated a total 4,687 ± 1,695 fish in the top 8 m (sidelooking) and 83,985 ± 25,978 in depths >8 m (downlooking), for a total pelagic abundance estimate of 88,689 ± 26,045.

Density estimates of age-0 and age-1 kokanee were much lower than expected given the previous two years' stocking history (Table 13). Age-0 density was estimated at 85.1 fish/ha, and age-1 fish were estimated at 35.6 fish/ha, while age-2+ fish were lowest at an estimated 10.8 fish/ha. Using these density estimates, I estimated 51,647 ± 17,423 age-0 kokanee, 21,635 ± 6,047 age-1 kokanee, and 6,576 ± 3,197 age-2+ kokanee, for a total abundance estimate of 79,858 ± 24,350 kokanee at Deadwood Reservoir.

Lucky Peak Reservoir

Lucky Peak Reservoir was sampled with hydroacoustics on June 19, 2002 and September 25, 2002. During the September survey, the reservoir was drawn down to 17% capacity, and fish were crowded into the remaining pool and the returning echoes overlapped extensively enough that individual targets could not be resolved. The difference between surveys was likely a result of the dramatic change in reservoir volume, where Lucky Peak Reservoir was dropped from 90% of total capacity during the June survey to 17% during the September survey. Generally, when echoes overlap, echo integration can be used in place of target tracking to estimate biomass and abundance. However, it was determined that echo integration would not yield useful results, because the pelagic fish population at Lucky Peak Reservoir is potentially comprised of a number of different species, overlapping in both size and distribution. In addition, fish were not collected for target verification and, therefore, the mean weight per fish, a required parameter for echo integration, was unknown.

Hydroacoustic transects began at the upper end of the reservoir below Arrowrock Dam and continued downstream to Lucky Peak Dam (Appendix F). The depth distributions of tracked fish during day and night displayed a shallow mode of approximately 8 m and a deeper peak at >20 m depth (Figure 27). The bimodal distribution was a result of the differences in depth between the shallow upper half of the reservoir above the Lucky Peak Recreation Area and the lower half of the reservoir, which contains deep canyon areas. A shift in depth was observed during the night as the distribution of tracked fish moved from a mode >30 m deep to approximately 20 m deep. However, the thermal change was only 3°C (11-14°C), suggesting the change was not temperature related.

Target strength distributions were similar between day and night periods with larger fish residing in the top 8 m (Figure 28). No fish <173 mm were tracked in the top 8 m, despite threshold settings that allowed for the detection of fish <132 mm. Also of note was an increase in larger fish in depths >8 m during the evening, which could be a result of larger pelagic fish moving to greater depths or fish moving off shore into pelagic regions during evening.

Lucky Peak Reservoir was thermally stratified at all stations during the June survey, with temperatures ranging from 18°C to 11°C surface to bottom at station 1 and 18°C to 8°C at station 3 (Figure 29). Dissolved oxygen concentrations never fell below 6 mg/L at any depth or station. Secchi transparencies were similar between all stations but were greatest in the upper portion of the reservoir (4.1 m). Mean zooplankton biomass estimates from the different net meshes indicated that fish cropping of large cladocerans was occurring (Table 3). The ZPR and ZQI values also indicated the presence of substantial zooplanktivory to the extent that forage resources may possibly be limiting at the lower end of the reservoir (Teuscher 1998). The ZPR values declined from 0.67 at station 1 to 0.36 at station 3, while ZQI values dropped from 0.23 at the uppermost station to 0.06 and 0.07 at station 2 and 3, respectively.

Densities were variable between transects but showed a substantial increase in numbers during the evening period, particularly in the lower end of the reservoir near the dam (Table 14). Most of the changes in densities were attributed to fish >8 m depth (downlooking) as numbers in the top 8 m (sidelooking) remained stable between diel periods. Total density estimates increased from 55.2 ± 14.4 fish/ha in the day to 108.1 ± 18.9 fish/ha in the night. Hydroacoustic densities yielded total pelagic abundance estimates of 60,266 ± 15,727 fish in the day and 118,083 ± 20,606 fish in the night (Table 14). Because there was not any evidence of schooling behavior with the hydroacoustics, the increase in night estimates was likely a result of fish entering the pelagic zone from littoral or benthic regions, where they were not detectable using sonar gear.

Payette Lake

The survey at Payette Lake took place at night on August 15, 2002. The objective of the survey was to estimate kokanee abundance and provide managers with an indication of the cohort strength of age-2+ fish that would potentially spawn in 2002. However, as kokanee generally enter the North Fork (NF) of the Payette River by mid August, the survey may have been conducted later than what would have been optimal given the objective. Although kokanee were not observed in the NF Payette by the survey date, fish may have been staging near the inlet, which was not sampled by sonar gear. Kokanee age classes were separated using the same criteria as a previous survey 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, and thus sampling for target verification was not conducted.

Transects began at the lower end of the lake near the McCall city boat ramp and continued upstream into the smaller basin (Appendix G). Age-0 kokanee inhabited shallower depths during our survey than older cohorts, as they displayed a modal depth of 13 m and a mean depth of 18 m (Figure 30). In comparison, age-1 and older kokanee were nearly identical in distribution where the modal and mean depths fell approximately between 20-22 m. Teuscher (2001) observed a similarly skewed depth among <-49 dB targets and hypothesized that smaller non-salmonids targets may overlap age-0 kokanee in size and thus cause the shallower distribution.

The age class criteria suggested by Teuscher (2001) fit well with the observed target strength distributions in 2002 (Figure 31). As is common of hydroacoustic assessments of kokanee populations, age-0 and age-1 cohorts were distinguishable in frequency distributions, whereas age-2+ fish generally blend together without discernible modes. Because it is difficult to separate age-2 and older cohorts, any estimates of the potential number of spawners from hydroacoustics would be highly dependent on where the size break is drawn.

Densities of age-0 fish were highest among all cohorts (95.0 ± 74.3 fish/ha) while estimates of age-2+ fish were substantially lower (13.1 ± 6.2 fish/ha; Table 15). As previously mentioned, estimates of age-2+ may understate actual density because spawners could have been staging at the mouth of the NF Payette River given the timing of the survey. In addition, spawners in the NF Payette River primarily consist of three- to six-year-old cohorts that vary between males and females. Using length frequency histograms from 1992 and 1993 spawning escapements in the NF Payette River (Bennett and Frost 1995), I determined that targets between –39.5 dB and –33 dB (252-568 mm) might provide a reasonable estimate of the number of age-3+ fish that could participate in the 2002 spawning escapement.

I estimated 205,194 ± 160,513 age-0 kokanee, 132,490 ± 97,349 age-1 fish, and 28,281 ± 13,371 age-2 and older kokanee (Table 15). An estimated 15,937 ± 7,993 kokanee were age-3 and older and, therefore, could have spawned in 2002. Age-3+ kokanee densities increased dramatically in transects 8 and 9, which were the sampling units closest to the NF Payette mouth. This may suggest that spawners were indeed staging at or near the inlet of the NF Payette River.

DISCUSSION

Through intensive netting efforts, individual species estimates were obtained at American Falls Reservoir and Cascade Reservoir. In both cases, estimates of individual species should be limited to fishes that frequently appear in net catches. For example, northern pikeminnow, rainbow trout, and largescale suckers comprised 91% of the total species caught in day sets and 93% of night sets at Cascade Reservoir. Smallmouth bass, yellow perch, mountain whitefish, kokanee, pumpkinseeds, and brown bullheads were rarely captured. Many of these species primarily reside in littoral regions of the lake, and the irregular capture of such fish in the pelagic zone suggests that hydroacoustic abundance estimates would not be useful. Pelagic species, such as coho salmon and kokanee, were also rarely caught compared to the three main species in Cascade and American Falls reservoirs. In these cases, catches were low enough to consider any abundance estimates as suspect because of small sample size.

Netting efforts were much more successful during the night sets. For example at American Falls Reservoir, 475 fish were caught in the day compared to 1,008 at night. Similarly at Cascade Reservoir, day sets caught 102 fish versus 443 fish caught at night. The increased catches at night are likely a result of less net avoidance due to reduced visibility and peaks in activity during nocturnal and crepuscular periods (Hubert et al. 1994). However, differences in abundance estimates and their associated error bounds between diel periods were species dependent. During the day survey, rainbow trout estimates at American Falls Reservoir were 125,463 ± 150,685 or a 95% CI of 120%. However, during the night survey, our estimates were 315,357 ± 255,040, which equated to an error bound of 81%. At Cascade Reservoir, northern pikeminnow abundance estimates were very similar between diel periods as 79,537 ± 35,793 (± 45%) were estimated in the day and 69,035 ± 29,610 (± 42%) at night. Yet rainbow trout estimates at Cascade Reservoir showed an increase in abundance from 31,123 ± 15,332 in the day to 39,267 ± 17,361 in the night, but the 95% CI declined from 16% to 11%. Because overall netting catch data were less variable at night, species proportion estimates derived from nighttime netting provided more precise estimates for hydroacoustic surveys.

Another important factor in determining the optimal period for conducting a sonar abundance assessment for a particular species is the diel depth distribution of fish. The inability of echo sounding gear to detect fish near boundaries is a well-documented limitation of sonar surveys (Brandt 1996). Therefore, knowledge of diel changes in depth or habitat utilization (i.e. benthic or pelagic) will assist in determining appropriate timing of hydroacoustic surveys. I set sinking nets to determine the proportion of each species that would be undetectable during the survey. I found that despite the overall low catch rates during day periods, the proportion of rainbow trout caught near the bottom in sinking nets decreased at night from 58% (day) to 24% (night) at American Falls Reservoir and 36% (day) to 22% (night) at Cascade Reservoir. Northern pikeminnow displayed a similar but smaller decline in sinking net capture rates from 47% in the day to 36% in the night. This suggests that rainbow trout and northern pikeminnow are moving higher in the water column at night where they are more detectable to sonar gear.

At present, the requisite amount of netting appears to be a limitation for effectively partitioning hydroacoustic estimates into individual species estimates. The variance formula for the cluster sampling analysis I used to estimate species proportions is only a good estimator when sample size is large. In fact, Scheaffer et al. (1996) suggest that 20 or more sampling units (net sets) would be required for both proportion and variance estimates to be unbiased.

However, during my analysis, one floating net and one net curtain had to be combined to equal one sampling unit, because they were different sampling gear. In addition, fish caught in sinking nets could not be used for partitioning hydroacoustic estimates, because fish caught in sinking nets were not detectable by sonar gear. This resulted in a great deal of effort for a relatively small sample size. For example, 60 total net sets (sinking, floating, curtain) were conducted over a brief 5-day period at Cascade Reservoir, yet this only equated to 10 sampling units each for day and night periods. I were limited by both number of nets and the time it took to retrieve, process, and reset the nets to ensure a reasonable soak time for both diel periods.

Using 2002 variance estimates for population proportions, I generated netting sample size requirements for different species within a given error bound (Table 16). Sample size requirements increased with the variance of population proportion estimates. For example, the variance estimate s_p^2 for rainbow trout at American Falls Reservoir during night sets was 0.013, where at Cascade Reservoir s_p^2 was 0.004 and 0.003 for northern pikeminnow and rainbow trout, respectively. Higher variability around the population proportion estimate yields much higher sample size requirements for an error bound of 0.05 (95% CI). Based on our observed variability, achieving a proportion estimate of rainbow trout with a 95% bound at American Falls Reservoir, a total of 216 clusters with a 0.05 error bound would require a total of 216 units of netting. At Cascade Reservoir, 59 units of netting would be required for northern pikeminnow and 49 units for rainbow trout. Obviously, attaining the required samples for proportion estimates within a 95% CI is somewhat unrealistic. Given a limited budget where only four of each gear type can be realistically purchased and fished, it would require 15 nights of netting to sample the suggested 59 clusters to estimate the population proportion of northern pikeminnow at Cascade Reservoir.

Decreasing acceptable error bounds from 95% to 90% dramatically decreases sample size requirements. At American Falls Reservoir, the required sampling effort for rainbow trout would be reduced from 216 to 54 netting units. In Cascade Reservoir, required sampling effort for northern pikeminnow would be reduced to 15 net units, while rainbow trout is reduced to 12 units. However, the latter two estimates of n are below the $n \geq 20$ suggested by Scheaffer et al. (1996) for cluster sampling. To attain the suggested minimum number of samples, a crew with four of each gear type could sample the acceptable number of clusters with five days of netting. This would equate to setting, retrieving, and processing 12 nets/day, if sinking nets are included to assess fish missed by sonar gear.

Despite the above limitations and considerable manpower needs and statistical shortcomings, species estimates calculated for American Falls Reservoir and Cascade Reservoir appear to be reasonable indicators of abundance for species that appear frequently in collections. Because hydroacoustics can only provide an estimate of abundance for the pelagic portion of the population, in many cases an argument can be made that estimates indicate relative abundance and not total abundance. For example, northern pikeminnow and largescale suckers are caught at much higher frequencies near the shoreline in the littoral region (P. Janssen, personal communication). In addition, at both reservoirs all of the primary species such as rainbow trout, northern pikeminnow, Utah chub, and largescale and Utah suckers were frequently captured on the substrate where they would not be detectable by sonar gear. This suggests that hydroacoustic estimates of fish abundance for many species are actually relative to the total population. However, this is not necessarily a limitation that should overshadow the benefits provided by sonar surveys. In many fisheries assessments, absolute population estimation is not essential, because management activities and decisions are often based on estimates of relative abundance (Thorne 1983). In fact, a stable relative abundance estimate, whether it understates or overstates actual abundance, has many of the same advantages as an absolute estimate of abundance (Mulligan and Kieser 1986; Yule 2000).

Determining the appropriate sampling time appears to be the most important factor in attaining a stable relative abundance estimate. Seasonal and diel changes in environmental characteristics such as temperature, DO, light, and forage availability can affect fish distribution and abundance estimates. Hydroacoustic estimates of fish abundance at Cascade Reservoir were compared on a diel, seasonal, and annual basis. I found that although abundance estimates were not statistically distinct between years, the magnitude of error and mean fish abundance varied considerably (Figure 32). Abundance estimates increased dramatically on a seasonal basis from spring/early summer estimates to summer estimates in 2000 and 2001. In August 2002, abundance estimates were quite similar between day and night, but mean fish abundance was much lower than summer 2000 and fall 2001 estimates.

The effects of seasonal differences in environmental characteristics, i.e. thermal stratification, DO, etc., on lentic fish distribution have been documented by many researchers. For example, Unger and Brandt (1989) noted tremendous differences in acoustic estimates of fish abundance between periods of thermal stratification and post-mixing periods. During summer stratification, brook trout *Salvelinus fontinalis* were primarily located in the metalimnion offshore but then migrated inshore into littoral habitats after fall turnover, where they were not effectively sampled by acoustic gear. Seasonal distribution of Bear Lake cutthroat trout *O. clarki utah* in Strawberry Reservoir, Utah was tracked by ultrasonic telemetry (Baldwin et al. 2002). Tagged cutthroat generally occupied pelagic habitats during summer months, when they were most often observed in the metalimnion and epilimnion of the stratified reservoir. After fall turnover, tagged cutthroat utilized a much broader range of depths and most often occupied shallower, nearshore habitats.

In the case of Cascade Reservoir, the observed differences in abundance estimates between spring and summer could plausibly be a result of thermal differences between the two periods. The unexpectedly low estimate of mean fish abundance in 2002 could also be related to environmental characteristics. Prior to the completion of the day and night surveys, numerous attempts were averted as a series of fronts moved through the area causing high waves, cooler air temperatures, and precipitation. These changes may have temporarily altered normal summer fish distribution and movement, particularly in a shallow reservoir such as Cascade. These examples illustrate the importance of survey timing on the success with which stable abundance estimates can be attained and compared between years. Once a reservoir-specific standardized sampling approach has been developed and methodologies have been established to reduce extrinsic sources of error estimates, the ability to detect changes in fish populations, either natural or as a response to management efforts, should be greatly enhanced. Such a standardized sampling approach may be water and/or species specific and may require a good deal of up-front effort.

Although I was ineffective in my attempts to incorporate purse seining into our sampling regime, purse seining remains a potentially useful method to collect fish for partitioning abundance estimates from the sidelooking transducer (Yule 2000). Efforts are currently underway to increase the speed with which the seine closes by modifying the hydraulic system on the purse seine barge. In addition, a motorized roller bar to assist crews in bringing the seine onboard is also being constructed. This would reduce the physical exertion spent on manually hauling in the seine and thereby increase the number of hauls that a crew could accomplish in one day.

The ZPR and ZQI indices were developed to assess zooplankton forage resources within an entire reservoir to help managers determine appropriate trout stocking densities. I slightly altered the methodologies described by Teuscher (1998) so that zooplankton availability could be assessed along potential trophic gradients within a water body. For example, at American Falls Reservoir, rainbow trout were not distributed throughout the entire reservoir. Rainbow trout gillnet catches increased in the lower sections of the reservoir, which coincided with an increased biomass of large cladocerans. The preference of large-bodied *Daphnia* sp. by rainbow trout has been well documented in lakes and reservoirs (Wurtsbaugh et al. 1975; Hubert et al. 1994; Tabor et al. 1996). It is also well documented that *Daphnia* densities tend to be much higher in the pelagic epilimnion than in littoral nearshore habitats or deeper waters (Wurtsbaugh et al. 1975; Tabor and Wurtsbaugh 1991). The availability of greater depths and cooler waters near the dam, in combination with higher levels of forage, are reasonable explanations for rainbow trout to be distributed more toward the lower section of the reservoir.

Anderson Ranch Reservoir has been annually sampled since 2000, and a substantial decline in kokanee abundance has been observed. A 74% decline was calculated from 2001 to 2002 estimates, and an overall 90% decline in total abundance was observed from the initial survey in July 2000. Such a drastic decline in numbers could be related to a number of factors, including predation, entrainment, or unfavorable conditions that were not conducive to survival and recruitment. For example, a fish kill was observed shortly after the July 2001 survey where dead kokanee were observed above and below the dam (D. Megargle, IDFG, personal communication). However, recent drought-like conditions may be a more important factor in the observed decline of kokanee abundance at Anderson Ranch Reservoir. The reservoir has experienced successive low water years since 2000. For example, Anderson Ranch Reservoir was only drawn down to a low of 43% total capacity in 1999 and 59% in 2000. Since then, the reservoir has been drawn down to a low of 13% total capacity in 2001 and 8% in 2002. The extreme drawdowns could impact kokanee populations by increasing entrainment through the dam, reducing productivity of the reservoir, and restricting spawning escapement.

The 2002 kokanee estimates at Deadwood Reservoir were much lower than estimates from a previous survey conducted on September 13, 2000 (Teuscher 2001), despite stocking over 250,000 kokanee fingerlings between 2001 and 2002. Although similar target strength values were used to separate kokanee age classes, Teuscher (2001) estimated 247,232 ± 94,686 age-0 kokanee, 9,698 ± 5,188 age-1 kokanee, and 7,200 ± 4,143 age-2+ kokanee. These numbers suggest a 69% decline in total kokanee estimated between 2000 and 2002. The kokanee decline was corroborated by estimates of total fish trapped at the Deadwood River weir, which is operated by the Idaho Department of Fish and Game Nampa Fish Hatchery. Approximately 12,296 and 8,408 kokanee were trapped in 1998 and 1999, respectively, while only 2,955 fish were trapped in 2001 and 3,881 in 2002. The 68% decline is identical to the one observed by hydroacoustic surveys after correcting for escapement numbers that left the reservoir prior to the survey. There are a number of potential causes for the considerable reduction in kokanee abundance between 2000 and 2002. Aside from predation, the kokanee population at Deadwood Reservoir has experienced two successive poor water years in which the total volume was dropped to 32% and 31% of total capacity in 2001 and 2002, respectively. In comparison, Deadwood Reservoir was only dropped to 72% in 1998, 49% in 1999, and 56% of total capacity in 2000. The drawdowns of 2001 and 2002 could have impacted the kokanee population through both fish and zooplankton entrainment. This may also be the cause of the observed poor survival of stocked kokanee as well.

The survey at Payette Lake was requested by regional managers to assist in decisions concerning the possibility of taking eggs from kokanee spawners to stock in other systems.

Although it is extremely difficult to separate kokanee age classes from target strength distributions beyond age-1 fish, it was decided that a proximate estimate of age-3+ fish might provide an index for predicting the magnitude of the spawning escapement. This decision was based on a previous research study that characterized the kokanee spawning escapement in the NF Payette River. For example, Bennett and Frost (1995) estimated that females in the 1992 spawning escapement were comprised of age-3 (31%), age-4 (61%), age-5 (8%), and age-6 (0.5%) fish, while the 1993 escapement consisted of age-3 (18%), age-4 (80%), and age-5 (2%) fish. The age composition of spawning males was similar in proportions with a few notable exceptions, such as the presence of age-2 males or jacks (2%) and a large proportion of age-3 males (58%) in 1992, whereas age-4 males were the dominant group in 1993 (65%). Because of the variability between age groups and sex of fish that participate in the spawning escapement, an estimate of total escapement based on hydroacoustic size frequency and abundance estimates was problematic. However, it may be possible to provide an indication of escapement size based on hydroacoustic estimates of fish within size thresholds determined by length at age data. Using a one-day spawner count conducted on September 9, 2002 and multiplied by an expansion factor of 1.73, regional personnel estimated that 16,300 kokanee took part in the spawning escapement in 2002. This is surprisingly similar to the 15,937 ± 7,993 estimate of age-3+ kokanee abundance obtained from hydroacoustics. However, the usefulness of sonar estimates to predict spawner numbers at Payette Lake can only be assessed after multiple years have been recorded.

In some instances, surveys at Anderson Ranch Reservoir, Deadwood Reservoir, and Payette Lake provided managers with reasonable kokanee abundance estimates that were comparable to estimates obtained in previous years. I recommend that monitoring of the above fisheries be continued with the existing hydroacoustic setup to address specific management issues.

At both Arrowrock Reservoir and Lucky Peak Reservoir, attempts to collect fish for target verification was hindered by soak time restrictions to prevent lethal take of bull trout. It was quickly determined that obtaining enough fish for estimating species proportions was not realistic, given the 30 minute restriction on net soak time. These restrictions were based primarily on gillnetting information along shoreline habitats. In pelagic habitats, gillnet catches are generally much lower, and therefore it may be plausible to increase soak times in pelagic waters inhabited by bull trout. It is important to note that bull trout were never captured in our nets at Arrowrock Reservoir or in the minimal netting efforts that occurred at Lucky Peak Reservoir, which were not reported here.

The fish population surveys conducted in 2002 provided valuable information on a number of flatwater fisheries in Idaho in terms of both fish population trends and techniques for partitioning hydroacoustic estimates into estimates of individual species abundance. In addition, progress was made in understanding the level of effort required to estimate individual species abundance in water bodies with mixed species assemblages. Species estimates were only obtained at American Falls and Cascade reservoirs because of logistical problems created by learning how to operate the purse seine and soak time restrictions in bull trout waters. However, these reservoirs are representative of the type of systems where estimating species proportions is important because of shallow depths and the presence of numerous overlapping species. Finally, abundance and distribution estimates were enhanced by abiotic and biotic data, which are important in structuring fish distributions and movement.

A number of improvements can be made to future fish assessment surveys. First, more efforts should be made to identify and partition hydroacoustic targets into individual abundance estimates of dominant pelagic species. Many logistical problems associated with purse seine operation and netting at various depths were overcome during the latter 2002 surveys. Increasing the number of clusters that can be sampled to four per night will allow us to reach the suggested 20 sampling units after five nights of netting. This should also result in a greater number of water bodies that can be sampled during a field season.

Limnological sampling should take place at all surveys, including during one-day kokanee estimates. Knowledge of thermal stratification and the depths of stratification zones, in addition to estimates of zooplankton biomass along potential horizontal gradients, enhanced our understanding of fish distributions in 2002. Additionally, collecting this type of information could possibly provide important baseline information for future research studies.

Better understanding of differences in movement and distribution between species on a seasonal and diel basis would greatly enhance our ability to partition species estimates. For example, adult rainbow trout have been observed to inhabit offshore pelagic habitats during the day while moving to nearshore habitats during the evening (Yule 2000; Teuscher 2001). However, these observations were obtained by hydroacoustic surveys in simple trophic systems where rainbow trout were the dominant pelagic species. In more complex systems, where a number of species inhabit pelagic habitats, species-specific knowledge of seasonal or diel changes in movement and distribution would help determine an appropriate sampling period for a species of interest. Radio or ultrasonic telemetry, where movement and distribution data can be collected on an individual basis, would compliment population-level data from hydroacoustics (Baldwin et al. 2002).

RECOMMENDATIONS

1. Continue to develop standardized gillnetting and purse seining methods to accompany hydroacoustic surveys that are based on the size of the water body and horizontal and vertical gradients in fish distributions and where $n \geq 20$ in accordance to cluster sampling assumptions for variance estimates.

2. Incorporate horizontal and vertical environmental gradient measurements (i.e., temperature, dissolved oxygen, and secondary production) to assist in the interpretation of fish distributions.

3. Continue monitoring of kokanee populations at Anderson Ranch and Deadwood reservoirs and Payette Lake to assist in ongoing management efforts.

Table 1. Total fish abundance estimates and associated densities (fish/ha) per transect and at American Falls Reservoir in July 2002.

			Density (fish/ha)		
Diel Period	**Transect**	**Transect length (m)**	**Downlooking**	**Sidelooking**	**Total**
Day	1	55.8	227.1	7.0	234.2
	2	42.3	0.0	8.5	8.5
	3	1502.0	92.4	3.9	96.3
	4	1274.1	59.4	12.3	71.7
	5	1234.6	74.8	4.8	79.6
	6	1076.5	32.8	9.0	41.8
	7	1176.4	65.5	16.9	82.4
	8	891.5	0.0	3.8	3.8
	9	548.2	0.0	4.1	4.1
	10	1528.2	15.7	3.6	19.3
	11	1314.6	0.0	7.3	7.3
	12	1299.6	0.0	28.6	28.6
	13	1185.8	0.0	75.6	75.6
	14	530.3	0.0	154.0	154.0
	15	1537.4	0.0	96.0	96.0
	16	1390.0	0.0	191.0	191.0
	17	1465.1	0.0	84.0	84.0
	18	1336.5	0.0	91.4	91.4
	19	1263.6	0.0	54.3	54.3
	20	1088.8	0.0	20.9	20.9
	21	1615.6	0.0	53.1	53.1
	22	1617.5	0.0	183.5	183.5
	23	1586.7	0.0	109.4	109.4
	24	596.0	0.0	30.6	30.6
	25	888.9	0.0	8.6	8.6
	26	544.3	86.2	3.1	89.2
	27	467.8	0.0	4.1	4.1
	28	342.2	132.1	4.4	136.5
		Mean	**28.1**	**45.5**	**73.6**
		95% CI	**20.8**	**22.0**	**41.4**
		Abundance	**391,948 ± 290,414**	**635,135 ± 307,500**	**1,027,600 ± 577,716**
Night	1	1,114.9	34.0	8.6	42.6
	2	1,676.4	181.5	5.8	187.2
	3	1,149.1	80.6	9.4	90.0
	4	1,287.7	213.6	15.0	228.7
	5	515.9	156.3	8.0	164.3
	6	446.6	22.9	1.5	24.5
	7	1,165.2	99.1	11.9	111.0
	8	551.3	125.3	4.4	129.7
	9	1,236.7	102.8	17.7	120.5
	10	1,364.5	51.5	9.8	61.3
	11	1,093.3	0.0	1.0	1.0
	12	1,340.3	191.8	10.7	202.5
	13	1,386.3	27.0	9.7	36.7
	14	1,540.0	0.0	12.5	12.5
	15	1,182.2	0.0	175.9	175.9
	16	174.3	0.0	242.9	242.9
	17	333.9	74.8	83.1	157.9
	18	985.0	0.0	55.3	55.3
	19	1,053.6	5.1	20.7	25.8
		Mean	**71.9**	**37.0**	**108.9**
		95% CI	**± 35.0**	**± 31.3**	**± 52.8**
		Abundance	**742,122 ± 360,953**	**382,306 ± 322,499**	**1,123,816 ± 544,776**

Table 2. Total catches by species and gear type for night and day collections at American Falls Reservoir from July 16-25, 2003.

Species	Gear				
Day	**Sinking (n = 8)**	**Floating (n = 6)**	**Net curtain (n = 6)**	**Purse seine (n = 5)**	**Total**
Rainbow Trout	29 (9.6%)	5 (19.2%)	16 (11%)	1	51 (10.5%)
Rainbow X Cutthroat Trout	1				1
Utah Chub	77 (25.4%)	1	30 (20.5%)		108 (22.3%)
Utah Sucker	195 (64.4%)	20 (76.9%)	97 (66.4%)	5	317 (65.5%)
Kokanee	1				1
Redside Shiner				1	1
Smallmouth Bass					
Yellow Perch			3	2	5
Total	303 (62.6%)	26 (5.4%)	146 (30.2%)	9	484
Night	**Sinking (n = 9)**	**Floating (n = 9)**	**Net curtain (n = 9)**		**Total**
Rainbow Trout	52 (12.4%)	27 (37.5%)	138 (26.7%)		217 (21.5%)
Rainbow X Cutthroat Trout			3		3
Utah Chub	70 (16.7%)	14 (19.4%)	115 (22.3%)		199 (19.7%)
Utah Sucker	282 (67.1%)	31 (43.1%)	247 (47.9%)		560 (55.6%)
Kokanee	7		5		12
Redside Shiner			4		4
Smallmouth Bass	2				2
Yellow Perch	7		4		11
Total	420 (41.7%)	72 (7.1%)	516 (51.2%)		1008

Table 3. Mean biomass (g/m), zooplankton ratio index (ZPR), and zooplankton quality index (ZQI) values for American Falls, Arrowrock, Cascade, and Lucky Peak reservoirs in 2002.

		Mean biomass (g/m)			ZPR	ZQI
Water	**Station**	**153 mm**	**500 mm**	**750 mm**	**750 mm / 500 mm**	**(500 mm + 750 mm) ZPR**
American Falls Res.	2	1.88	1.4	1.37	0.98	2.71
7/24/2002	3	3.53	4.07	5.04	1.24	11.28
Arrowrock Res.	1	0.17	0.16	0.09	0.56	0.14
6/26/2002	2	0.18	0.26	0.15	0.58	0.24
	3	0.25	0.23	0.13	0.57	0.20
	4	0.20	0.04	0.03	0.75	0.05
Cascade Res.	1	0.38	0.18	0.22	1.22	0.49
8/1/2002	2	0.57	0.31	0.33	1.06	0.68
	3	0.34	0.15	0.13	0.87	0.24
Lucky Peak Res.	1	0.61	0.21	0.14	0.67	0.23
6/13/2002	2	0.22	0.08	0.04	0.50	0.06
	3	0.25	0.14	0.05	0.36	0.07

Table 4. Abundance estimates for individual species from data collected during day and night July 2002 hydroacoustic surveys at American Falls Reservoir. Abundance was estimated as the product of a species proportion from gillnetting data and the total abundance estimate from hydroacoustics.

Species	Proportion ± 95% CI	Abundance	95% CI
Day			
Rainbow Trout	0.12 ± 0.17	125,463	150,685
Utah Chub	0.18 ± 0.07	185,207	173,004
Utah Sucker	0.68 ± 0.12	699,007	335,205
Yellow Perch	0.02 ± 0.02	17,923	53,778
Night			
Rainbow Trout	0.28 ± 0.23	315,357	255,040
Rainbow X Cutthroat Trout	0.01 ± 0.01	5,734	32,362
Utah Chub	0.22 ± 0.09	246,552	214,486
Utah Sucker	0.47 ± 0.21	531,328	320,460
Kokanee (Early Spawner)	0.01 ± 0.01	9,556	41,895
Redside Shiner	0.01 ± 0.01	7,645	37,476
Yellow Perch	0.01 ± 0.01	7,645	37,319

Table 5. Fish densities (fish/ha) per transect and total fish abundance estimates at Anderson Ranch Reservoir on May 15 and September 9, 2002.

		Fish densities (number/ha)			
Transects	**Transect length (m)**	**<100 mm**	**100-200 mm**	**>200 mm**	**Total**
May					
1	869	13.3	30.8	18.1	62.2
2	506	37.8	40.0	8.7	86.5
3	738	51.2	58.1	38.1	147.4
4	196	91.6	36.8	0.0	128.4
5	565	58.8	25.1	34.6	118.5
6	2008	36.4	43.7	26.7	106.8
7	1365	49.9	55.2	55.9	161.0
8	1074	85.1	88.3	121.0	294.4
9	519	78.9	100.2	131.1	310.3
10	820	65.1	126.4	89.5	281.0
11	1294	98.9	119.7	102.8	321.5
12	716	120.2	159.1	198.9	478.2
13	1003	131.8	104.0	198.4	434.1
14	592	47.4	124.9	148.2	320.4
15	987	101.2	134.8	148.9	385.0
16	762	60.7	143.4	120.7	324.8
17	992	48.5	63.5	67.4	179.4
18	640	22.2	42.6	38.1	103.0
	Mean	66.6	83.1	86.0	235.7
	95% CI	16.3	21.9	31.4	64.1
	Abundance	70,083 ± 17,184	87,464 ± 23,013	90,422 ± 33,078	247,970 ± 67,435
September					
1	777.7	161.8	35.4	6.6	203.8
2	822.2	383.0	34.8	4.2	422.0
3	541.3	304.3	50.0	9.2	363.4
4	492.7	316.6	62.7	0.0	379.3
5	381.3	149.2	58.8	10.1	218.1
6	595.3	268.6	83.7	0.0	352.3
7	473.5	170.0	29.1	15.2	214.2
8	558.6	177.3	31.5	5.1	214.0
9	845.8	180.9	28.7	5.1	214.7
10	1453.0	213.5	35.2	13.8	262.5
11	810.8	146.1	15.8	8.0	169.8
12	1155.0	127.3	18.5	26.6	172.4
13	826.1	213.0	51.3	51.6	315.9
14	1317.1	172.6	24.2	22.8	219.7
15	739.5	250.6	36.2	30.9	317.8
16	1081.7	191.6	41.8	29.7	263.1
17	531.5	207.6	73.1	53.0	333.6
18	1026.5	274.7	45.1	31.4	351.1
19	567.1	325.8	90.0	81.1	496.8
20	938.3	466.2	78.8	50.8	595.8
21	604.4	262.3	52.5	50.4	365.2
22	641.6	223.0	39.5	38.1	300.6
	Mean	235.7	46.2	24.7	306.6
	95% CI	37.4	9.3	9.7	47.6
	Abundance	219,408 ± 34,788	43,017 ± 8,610	22,996 ± 9,017	285,421 ± 44,332

Table 6. Fish densities (fish/ha) per transect and total fish abundance estimates during day and night surveys at Arrowrock Reservoir on July 2, 2002.

		Density (number/hectare)		
Day Transect	**Transect length (m)**	**Downlooking**	**Sidelooking**	**Total**
1	586.1	7.7	0.0	7.7
2	399.1	12.2	0.0	12.2
3	453.3	7.2	4.2	11.4
4	1130.6	6.2	3.0	9.2
5	467.4	0.0	4.4	4.4
6	900.0	5.9	3.5	9.4
7	519.0	10.9	1.5	12.4
8	771.6	0.0	1.0	1.0
9	263.9	19.2	0.0	19.2
10	351.9	22.9	0.0	22.9
11	1474.9	9.1	0.5	9.6
12	881.5	5.2	0.0	5.2
13	726.0	40.9	32.3	73.3
14	900.7	81.7	4.3	86.0
15	578.8	18.4	6.5	24.9
16	480.7	26.0	43.6	69.6
17	729.1	374.1	27.3	401.4
18	595.9	764.5	5.4	770.0
19	665.2	341.6	15.3	356.9
20	821.9	287.4	21.5	308.9
21	1604.4	19.9	0.5	20.4
22	424.2	31.9	0.0	31.9
23	779.6	2.0	0.0	2.0
24	1201.8	3.1	1.8	4.9
25	922.6	250.8	3.0	253.8
26	1436.8	370.0	26.1	396.2
27	440.9	161.7	33.6	195.3
28	916.0	186.5	50.2	236.8
29	881.5	241.5	88.0	329.5
	Mean	**114.1**	**13.0**	**127.1**
	95% CI	**67.3**	**7.8**	**67.8**
	Abundance	**101,581 + 59,945**	**11,594 + 6,928**	**113,176 + 60,344**
Night Transect				
1	626.8	6.9	3.6	10.5
2	475.0	2.8	0.0	2.8
3	100.6	66.4	0.0	66.4
4	759.8	21.0	1.8	22.8
5	518.0	28.1	6.2	34.3
6	800.7	9.3	2.6	12.0
7	648.9	9.0	2.6	11.6
8	886.0	27.9	3.2	31.0
9	212.0	22.2	0.0	22.2
10	1637.2	11.5	0.0	11.5
11	1037.3	14.2	0.0	14.2
12	563.5	248.7	16.6	265.3
13	976.1	250.2	15.8	266.0
14	550.2	211.1	6.0	217.1
15	915.8	236.6	7.8	244.4
16	651.0	210.2	1.0	211.2
17	1531.9	69.7	5.1	74.7
18	392.2	58.2	2.5	60.7
19	928.8	28.7	4.9	33.5
20	1209.9	17.1	0.0	17.1
21	1004.5	178.0	1.4	179.4
22	1428.3	312.3	19.4	331.7
23	494.6	232.2	27.8	260.0
24	429.9	329.2	23.8	353.0
25	517.4	301.1	28.7	329.7
26	915.5	306.3	25.8	332.1
	Mean	**123.4**	**7.9**	**131.4**
	95% CI	**48.9**	**3.9**	**49.0**
	Abundance	**109,876 + 43,519**	**7,072 + 3,467**	**116,948 + 43,656**

Table 7. Fish densities (fish/ha) per transect and total fish abundance estimates during day and night surveys at Arrowrock Reservoir on September 18, 2002.

		Density (number/hectare)		
Day Transect	**Transect length (m)**	**Downlooking**	**Sidelooking**	**Total**
1	286.5	81.6	38.7	120.2
2	446.2	56.9	15.5	72.4
3	238.5	58.8	18.9	77.7
4	357.8	63.7	5.6	69.3
5	304.2	165.1	12.7	177.8
6	624.2	26.8	8.0	34.8
7	318.7	93.2	0.0	93.2
8	798.0	101.0	0.0	101.0
9	569.3	54.6	4.1	58.7
10	652.5	14.5	2.6	17.1
11	159.8	11.0	10.9	21.9
12	862.8	10.2	0.7	10.9
13	925.9	6.2	7.5	13.7
14	751.5	0.0	8.8	8.8
15	659.3	19.5	7.9	27.4
16	1183.8	11.1	22.4	33.5
17	678.5	0.0	18.7	18.7
	Mean	**45.5**	**10.8**	**52.6**
	95% CI	**23.3**	**5.1**	**23.8**
	Abundance	**23,958 + 12,279**	**5,665 + 2,681**	**27,662 + 12,545**
Night Transect				
1	745.6	11.9	4.4	16.2
2	890.2	7.5	3.3	10.8
3	688.4	24.2	0.9	25.1
4	1065.8	31.0	2.2	33.3
5	710.0	100.4	1.7	102.1
6	860.4	135.1	1.4	136.6
7	720.5	105.5	0.0	105.5
8	564.1	179.3	7.8	187.1
9	450.4	211.4	8.7	220.1
10	666.2	225.3	1.7	227.0
11	1018.1	251.2	1.8	253.1
12	510.1	247.2	1.2	248.3
13	235.4	356.6	2.4	359.0
14	268.5	257.9	2.3	260.2
15	474.4	260.5	3.7	264.2
	Mean	**160.3**	**2.9**	**163.2**
	95% CI	**60.8**	**1.4**	**60.9**
	Abundance	**84,353 + 32,007**	**1,524 + 712**	**85,877 + 32,015**

Table 8. Total catches by species and gear type for night and day collections at Arrowrock Reservoir from June 26-27 and July 9-11, 2002.

Species	**Gear**		
Day	**Sinking (n = 4)**	**Net curtain (n = 7)**	**Total**
Rainbow Trout		1	1
Kokanee		1	1
Northern Pikeminnow	2	2	4
Largescale Sucker	8	1	9
Total	10	5	15
Night	**Sinking (n = 7)**	**Net curtain (n = 11)**	**Total**
Rainbow Trout		1	1
Kokanee			
Northern Pikeminnow	2	1	3
Largescale Sucker	1		1
Total	3	2	5

Table 9. Fish densities (fish/ha) per transect and total fish abundance estimates during day and night surveys at Cascade Reservoir on September 5, 2002.

		Density (fish/ha)		
Day Transect	**Transect length (m)**	**Downlooking**	**Sidelooking**	**Total**
1	1,449.1	0.0	8.3	8.3
2	761.3	0.0	3.0	3.0
3	2,177.1	4.1	36.7	40.8
4	558.2	7.6	37.6	45.2
5	1,540.5	8.9	6.0	14.9
6	2,012.8	4.0	22.3	26.2
7	2,232.4	0.0	3.4	3.4
8	830.9	7.5	2.3	9.8
9	1,368.7	7.9	17.8	25.7
10	2,545.9	5.0	5.6	10.6
11	1,557.4	8.7	4.1	12.8
12	2,181.0	5.6	2.7	8.3
13	2,321.1	6.7	5.3	12.0
14	2,227.6	0.0	3.6	3.6
	Mean	**4.7**	**11.3**	**16.0**
	95% CI	**2.0**	**7.2**	**7.4**
	Abundance	**40,603 ± 17,136**	**97,722 ± 61,819**	**138,265 ± 64,136**
Night Transect				
1	988.5	0.0	17.1	17.1
2	1,185.0	0.0	16.4	16.4
3	2,031.5	6.9	1.9	8.8
4	2,307.9	11.7	7.3	19.0
5	2,268.2	4.4	45.1	49.5
6	2,225.6	3.4	10.4	13.8
7	2,471.6	4.0	12.2	16.2
8	2,071.5	1.8	3.9	5.7
9	747.8	20.2	9.3	29.6
10	2,226.8	7.6	2.5	10.1
11	419.2	0.0	4.6	4.6
12	1,705.7	0.0	45.8	45.8
13	2,110.9	2.3	4.7	7.0
	Mean	**4.8**	**13.9**	**18.7**
	95% CI	**3.5**	**9.0**	**9.6**
	Abundance	**41,329 ± 30,393**	**120,174 ± 77,186**	**161,539 ± 82,868**

Table 10. Total catches by species and gear type for night and day collections at Cascade Reservoir from August 6-15, 2002.

Species			**Gear**		
Day	**Bottom (n = 10)**	**Floating (n = 10)**	**Net curtain (n = 10)**	**Purse seine (n = 10)**	**Total**
Northern Pikeminnow	20 (60.6%)		23 (34.7%)	9	52 (38.8%)
Largescale Sucker	5 (15.2%)		4		9 (6.7%)
Rainbow Trout	5 (15.2%)	2	7 (10.4%)	6	20 (14.9%)
Coho Salmon				3	3
Kokanee			1	1	2
Mountain Whitefish			1		1
Smallmouth Bass			2		2
Brown Bullhead	1				1
Pumpkinseed					
Yellow Perch	2		29 (43.3%)	13	44 (32.8%)
Total	33 (24.6%)	2	67 (50%)	32 (23.9%)	134

Night	**Bottom (n = 10)**	**Floating (n = 10)**	**Net curtain (n = 10)**		**Total**
Northern Pikeminnow	61 (39.1%)	11 (22%)	98 (41.4%)		170 (38.4%)
Largescale Sucker	68 (43.6%)	4	62 (26.2%)		134 (30.2%)
Rainbow Trout	17 (10.9%)	31 (62%)	31 (13.1%)		79 (17.8%)
Coho Salmon		2	4		6
Kokanee		1	6		7
Mountain Whitefish	2				2
Smallmouth Bass		1	1		2
Brown Bullhead	5		2		7
Pumpkinseed			1		1
Yellow Perch	3		32 (13.5%)		35 (7.9%)
Total	156 (35.2%)	50 (11.3%)	237 (53.5%)		443

Table 11. Abundance estimates for individual species from data collected during day and night August 2002 fish assessment surveys at Cascade Reservoir. Abundance was estimated as the product of a species proportion from gillnetting data and the total abundance estimate from hydroacoustics.

Species	**Proportion ± 95% CI**	**Abundance**	**95% CI**
Day			
Northern Pikeminnow	0.58 ± 0.18	79,537	35,793
Rainbow Trout	0.23 ± 0.16	31,123	15,332
Kokanee	0.03 ± 0.05	3,458	2,663
Largescale Sucker	0.01 ± 0.11	13,832	7,568
Mountain Whitefish	0.03 ± 0.05	3,458	2,617
Smallmouth Bass	0.05 ± 0.1	6,916	5,235
Night			
Northern Pikeminnow	0.43 ± 0.12	69,035	29,610
Coho Salmon	0.02 ± 0.03	3,800	2,043
Rainbow Trout	0.24 ± 0.11	39,267	17,361
Kokanee	0.03 ± 0.04	4,433	2,532
Largescale Sucker	0.26 ± 0.14	41,801	18,768
Pumpkinseed	0.004 ± 0.01	633	479
Smallmouth Bass	0.01 ± 0.01	633	479
Brown Bullhead	0.01 ± 0.01	1,267	711

Table 12. Fish densities (fish/ha) per transect and total pelagic fish abundance estimates at Deadwood Reservoir on September 16, 2002.

		Density (number/hectare)		
Transect	**Transect length (m)**	**Sidelooking**	**Downlooking**	**Total**
1	344.2	9.8	0.0	9.8
2	184.1	9.3	0.0	9.3
3	289.0	0.0	43.2	43.2
4	394.1	4.3	28.5	32.8
5	361.6	0.0	121.0	121.0
6	305.1	10.6	117.9	128.5
7	286.5	11.6	115.5	127.1
8	389.7	25.6	305.9	331.4
9	618.4	10.2	253.7	263.9
10	584.4	17.5	197.1	214.6
11	456.6	18.4	307.1	325.5
12	280.7	5.0	237.1	242.0
13	703.8	6.9	307.8	314.7
14	490.4	4.5	148.2	152.7
15	400.2	10.8	190.1	200.9
16	416.9	9.9	211.8	221.7
17	534.5	4.0	125.5	129.4
18	512.8	9.4	152.0	161.4
19	904.9	1.8	99.9	101.8
20	552.4	4.2	115.1	119.3
21	629.3	0.0	45.9	45.9
22	363.3	1.9	39.5	41.4
23	412.7	1.9	19.4	21.3
	Mean	**7.7**	**138.4**	**146.1**
	Abundance	**4,687**	**83,985**	**88,689**
	95% CI	**± 1,695**	**± 25,978**	**± 26,045**

Table 13. Kokanee densities (fish/ha) total abundance estimates by transect and age class in Deadwood Reservoir on September 16, 2002.

		Density (number/hectare)			
Transect	**Transect length (m)**	**<100 mm**	**100-200 mm**	**>200 mm**	**Total**
1	344.2	0.0	0.0	0.0	0.0
2	184.1	0.0	0.0	0.0	0.0
3	289.0	27.8	15.4	0.0	43.2
4	394.1	18.0	10.5	0.0	28.5
5	361.6	74.9	27.2	19.0	121.0
6	305.1	63.2	54.7	0.0	117.9
7	286.5	48.0	34.0	10.4	92.4
8	389.7	186.6	54.8	35.1	276.5
9	618.4	128.3	69.5	31.5	229.3
10	584.4	98.2	51.8	39.4	189.4
11	456.6	206.6	66.8	19.8	293.1
12	280.7	174.2	54.8	0.0	229.0
13	703.8	222.6	45.1	14.9	282.5
14	490.4	75.6	58.9	13.7	148.2
15	400.2	106.5	72.9	10.7	190.1
16	416.9	131.6	58.0	22.3	211.8
17	534.5	98.3	13.1	8.9	120.3
18	512.8	107.6	33.0	4.4	145.0
19	904.9	57.9	33.1	6.2	97.2
20	552.4	82.0	20.2	12.9	115.1
21	629.3	29.4	16.5	0.0	45.9
22	363.3	19.6	10.4	0.0	30.0
23	412.7	0.0	19.4	0.0	19.4
	Mean	**85.1**	**35.6**	**10.8**	**131.6**
	Abundance	**51,647**	**21,635**	**6,576**	**79,858**
	95% CI	**± 17,423**	**± 6,047**	**± 3,197**	**± 24,350**

Table 14. Fish densities (fish/ha) per transect and total fish abundance estimates during day and night surveys at Lucky Peak Reservoir on June 19, 2002.

		Density (number/hectare)		
Day Transect	**Transect length (m)**	**Downlooking**	**Sidelooking**	**Total**
1	1346.0	12.4	0.5	13.0
2	1023.9	6.4	2.0	8.4
3	1001.8	8.1	6.1	14.2
4	224.6	11.1	27.0	38.2
5	577.7	15.5	11.1	26.6
6	848.8	39.9	49.5	89.5
7	734.6	29.7	54.4	84.1
8	644.5	140.0	28.8	168.8
9	791.3	55.4	10.9	66.3
10	884.1	46.1	13.7	59.8
11	600.9	31.5	8.2	39.7
12	721.7	19.9	2.8	22.7
13	689.9	47.2	3.0	50.2
14	720.6	51.6	8.5	60.1
15	948.3	56.1	5.9	62.0
16	674.9	32.2	21.0	53.2
17	520.2	67.5	19.9	87.5
18	992.5	34.7	19.5	54.2
19	580.4	33.1	0.0	33.1
20	870.3	55.6	4.7	60.3
21	852.5	61.0	3.3	64.3
22	975.9	55.2	2.2	57.4
	Mean	**41.4**	**13.8**	**55.2**
	95% CI	**12.8**	**6.6**	**14.4**
	Abundance	**45,215 ± 13,949**	**15,051 ± 7,265**	**60,266 ± 15,727**
Night Transect				
1	1247.0	40.2	2.2	42.3
2	989.0	44.2	3.1	47.3
3	911.0	96.2	7.1	103.3
4	925.8	106.9	25.3	132.1
5	818.9	80.3	140.9	221.3
6	742.0	73.8	41.7	115.5
7	648.2	86.7	7.0	93.7
8	775.6	77.3	14.8	92.1
9	878.8	100.7	2.5	103.2
10	543.8	104.2	7.4	111.6
11	698.6	97.3	1.0	98.3
12	734.4	70.7	3.8	74.5
13	717.9	108.1	6.1	114.3
14	952.2	92.3	1.6	94.0
15	700.6	24.0	2.7	26.7
16	622.0	94.3	7.9	102.2
17	866.6	64.3	12.9	77.2
18	594.8	78.9	0.0	78.9
19	827.2	96.4	1.9	98.3
20	823.4	138.7	64.8	203.5
21	1023.6	162.8	0.7	163.5
22	882.3	120.9	1.5	122.5
23	937.2	157.5	3.4	160.9
24	379.4	145.3	0.0	145.3
25	468.9	64.7	14.5	79.2
	Mean	**93.1**	**15.0**	**108.1**
	95% CI	**14.2**	**12.4**	**18.9**
	Abundance	**101,690 ± 15,505**	**16,393 ± 13,572**	**118,083 ± 20,606**

Table 15. Kokanee densities (fish/ha) total abundance estimates by transect and age class in Payette Lake on August 15, 2002. An attempt to estimate spawners in the upcoming kokanee escapement was made by determining the number of age-3+ fish from target strength (dB) data.

		Kokanee (number / ha)				
Transect	**Length (m)**	**YOY**	**Age-1**	**Age-2+**	**Total**	**Spawners**
1	2539.9	90.4	56.8	12.1	159.3	5.4
2	2022.8	94.7	50.9	22.5	168.0	7.9
3	1843.9	61.2	66.7	16.2	144.0	6.9
4	1391.1	24.5	22.7	6.7	53.9	4.5
5	1785.7	20.8	17.4	7.3	45.5	3.2
6	1922.9	24.3	31.4	9.5	65.2	5.1
7	968.1	24.0	36.9	8.0	68.9	5.0
8	1303.8	146.7	128.3	20.7	295.8	15.3
9	2023.6	446.9	262.4	36.8	746.1	22.0
10	1438.4	80.2	16.9	7.8	104.9	5.7
11	1168.3	60.8	37.6	9.4	107.8	7.6
12	456.8	65.4	8.2	0.0	73.6	0.0
	Mean	**95.0**	**61.3**	**13.1**	**169.4**	**7.4**
	Abundance	**205,194**	**132,490**	**28,281**	**365,965**	**15,937**
	95% CI	**± 160,513**	**± 97,349**	**± 13,371**	**± 266,917**	**± 7,993**

Table 16. Estimated number of clusters that should be sampled to estimate population proportion of rainbow trout at American Falls and Cascade reservoirs and northern pikeminnow at Cascade Reservoir for a given error bound.

	American Falls	Cascade Reservoir	
Error bound *B*	**Rainbow trout**	**Northern pikeminnow**	**Rainbow trout**
0.01	5388	1482	1222
0.02	1347	370	305
0.03	599	165	136
0.04	337	93	76
0.05	216	59	49
0.06	150	41	34
0.07	110	30	25
0.08	84	23	19
0.09	67	18	15
0.1	54	15	12
0.12	37	10	8
0.13	32	9	7
0.14	27	8	6
0.15	24	7	5
0.2	13	4	3
0.25	9	2	2
0.3	6	2	1
0.35	4	1	1
0.4	3	1	1
0.45	3	1	1
0.5	2	1	0

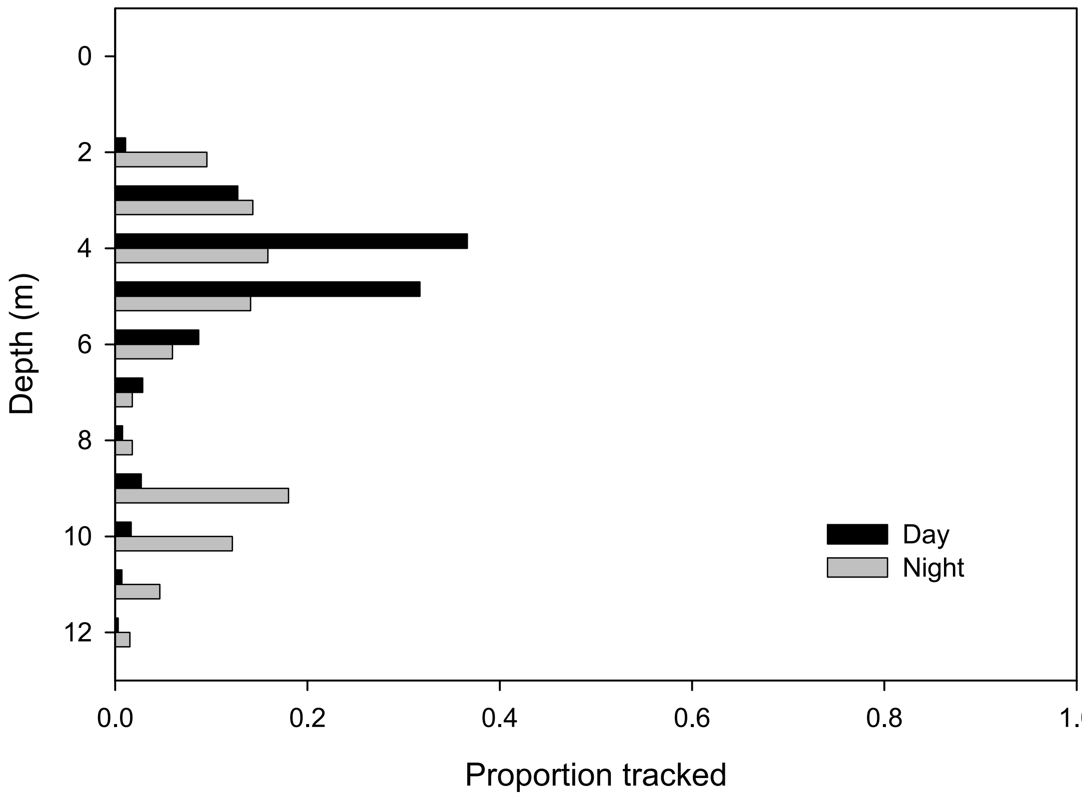


Figure 1. Depth distributions of tracked fish during day and night at American Falls Reservoir during July 2002 hydroacoustic surveys.

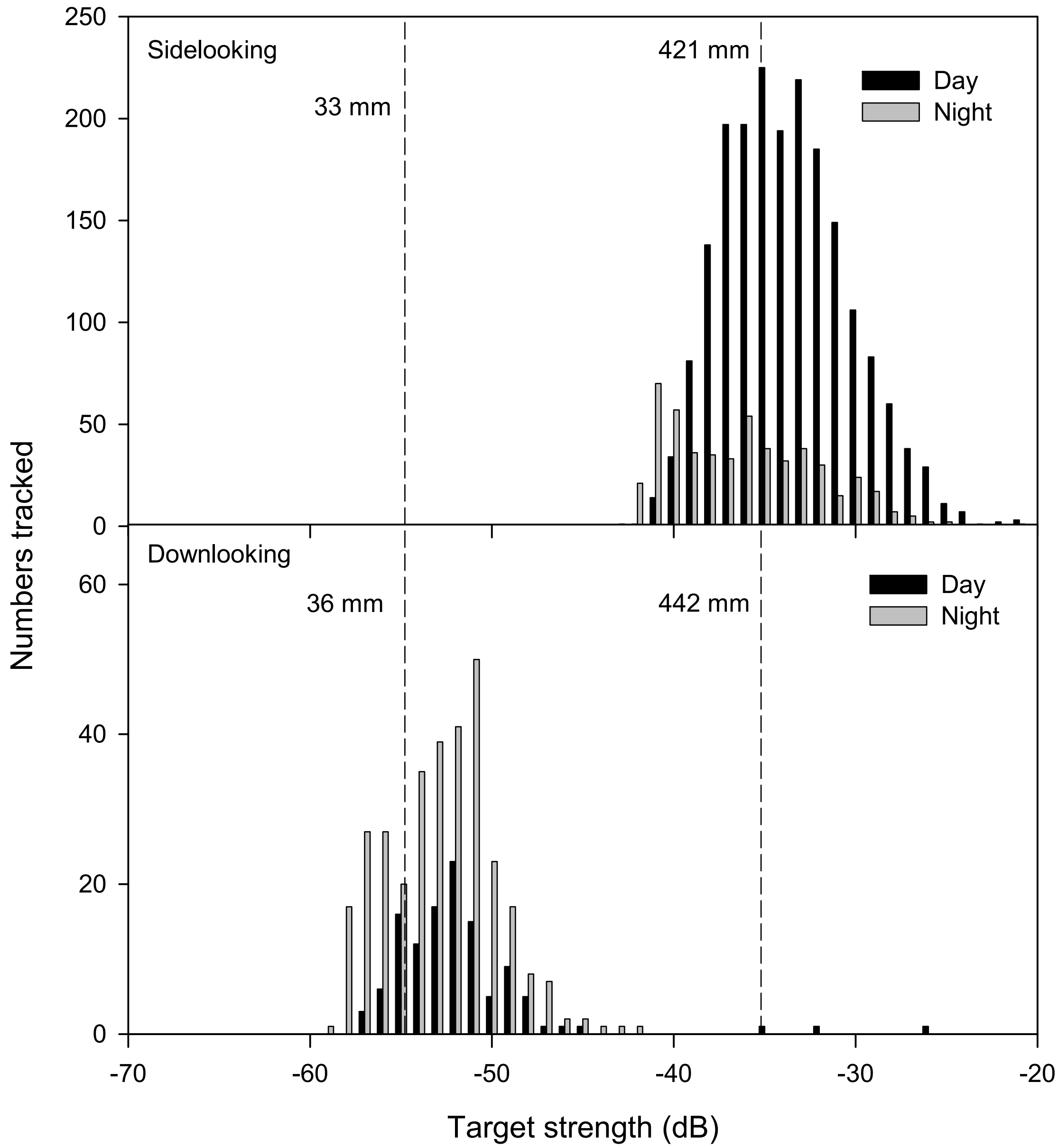


Figure 2. Target strength (dB) distribution of fish tracked during day and night hydroacoustic surveys at American Falls Reservoir in July 2002.

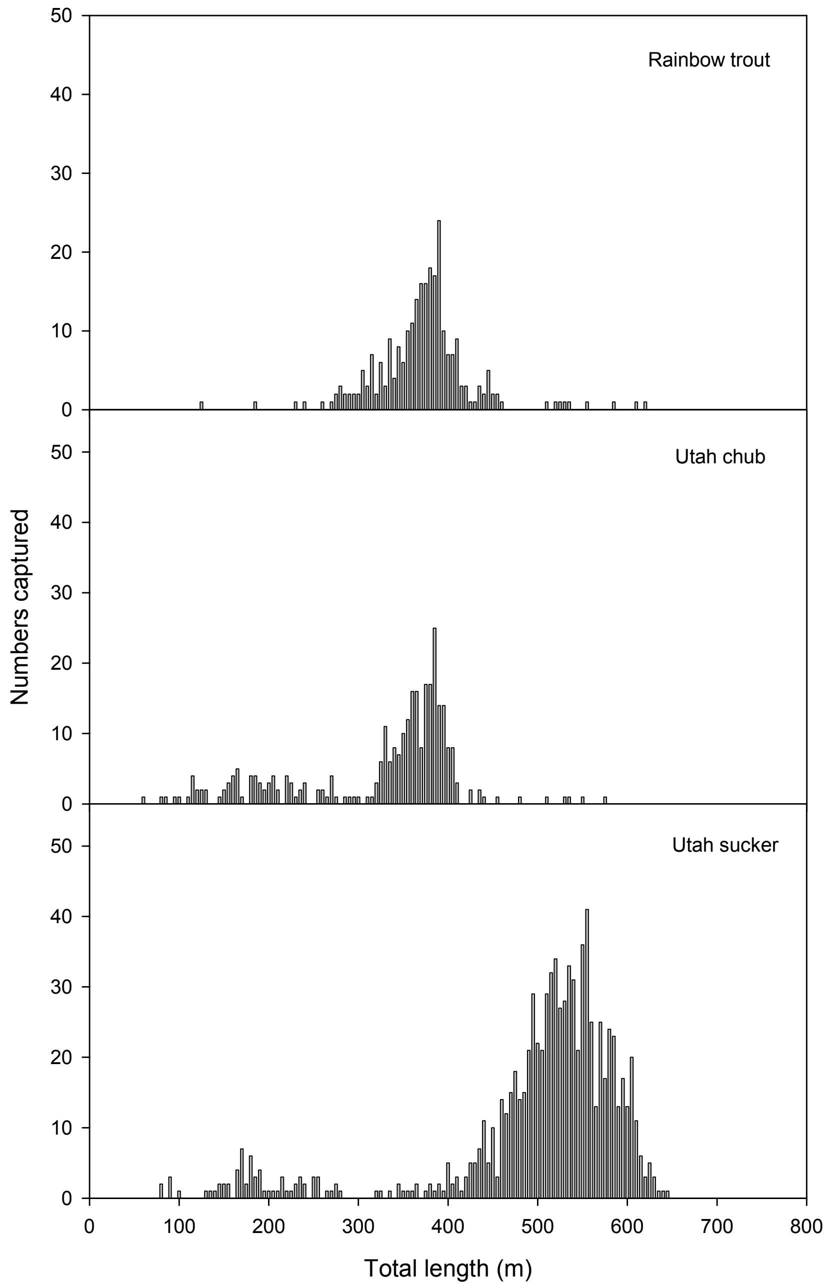


Figure 3. Length distributions of dominant fish species caught in floating, sinking, and curtain nets at American Falls Reservoir from July 16-25, 2002.

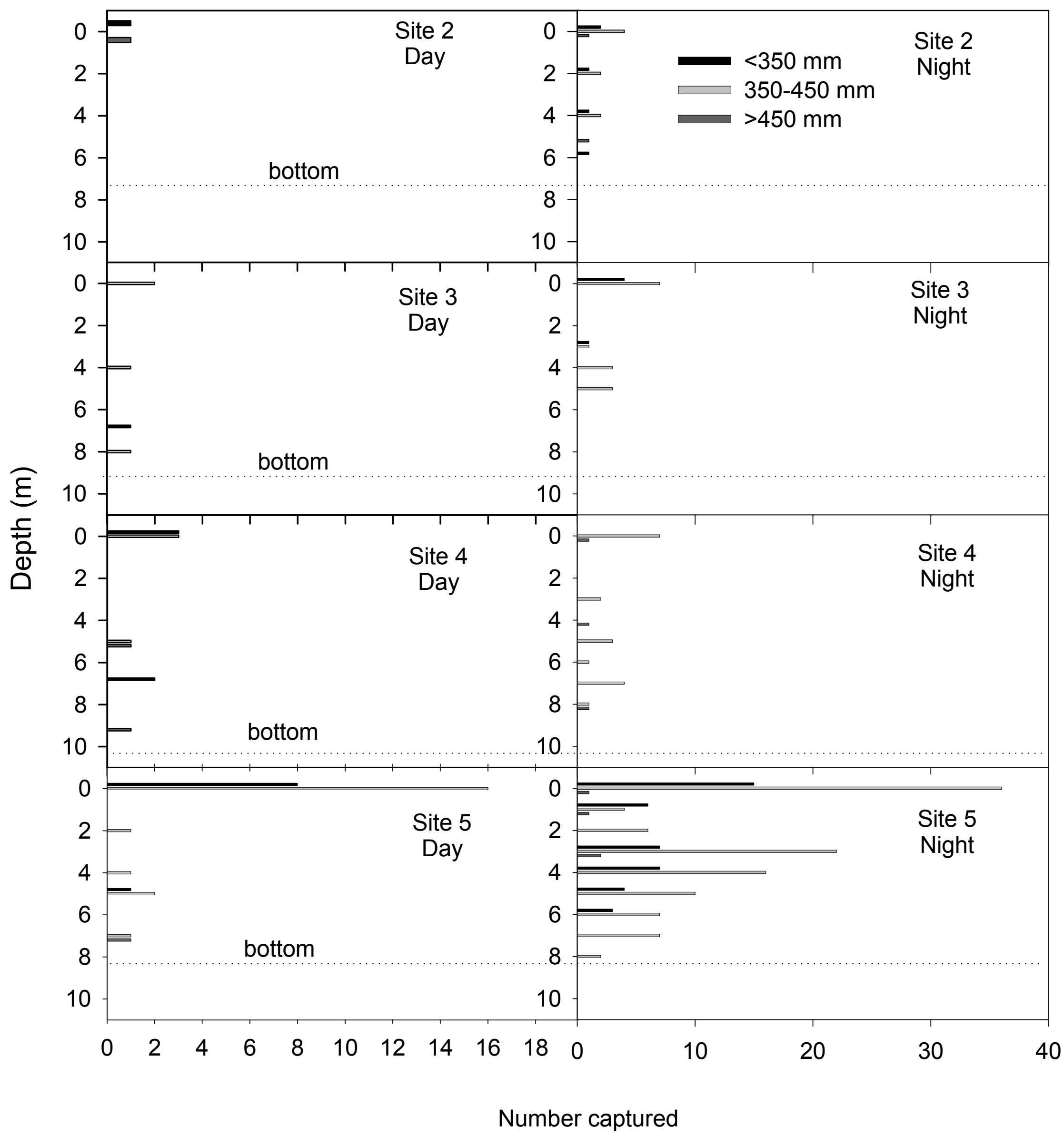


Figure 4. Day and night depth distributions of three size classes of rainbow trout captured in nets at different sites in American Falls Reservoir from July 16-25, 2002.

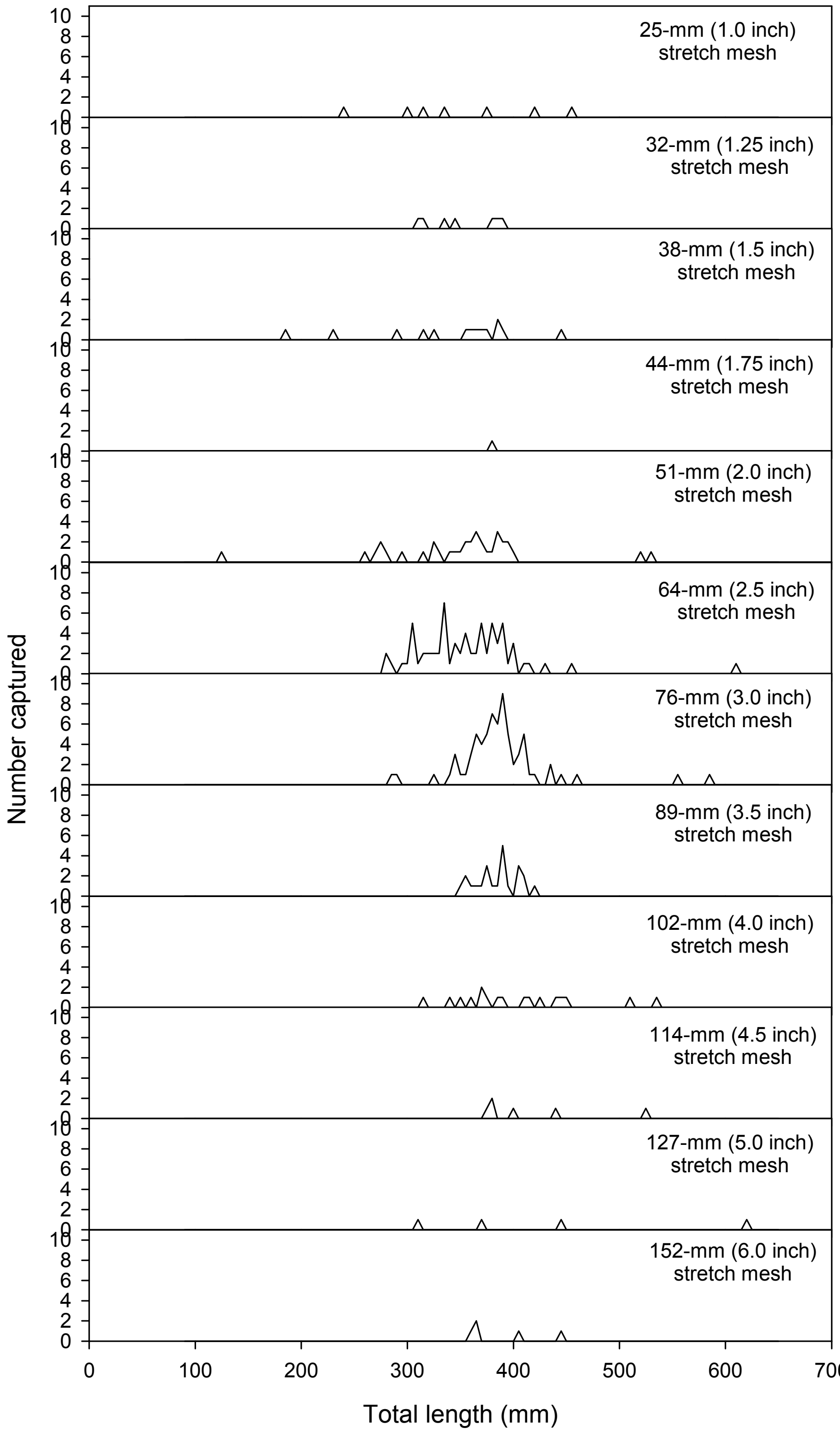


Figure 5. Catches of rainbow trout by total fish length (mm) and gillnet mesh size (mm) at American Falls Reservoir from July 16-25, 2002.

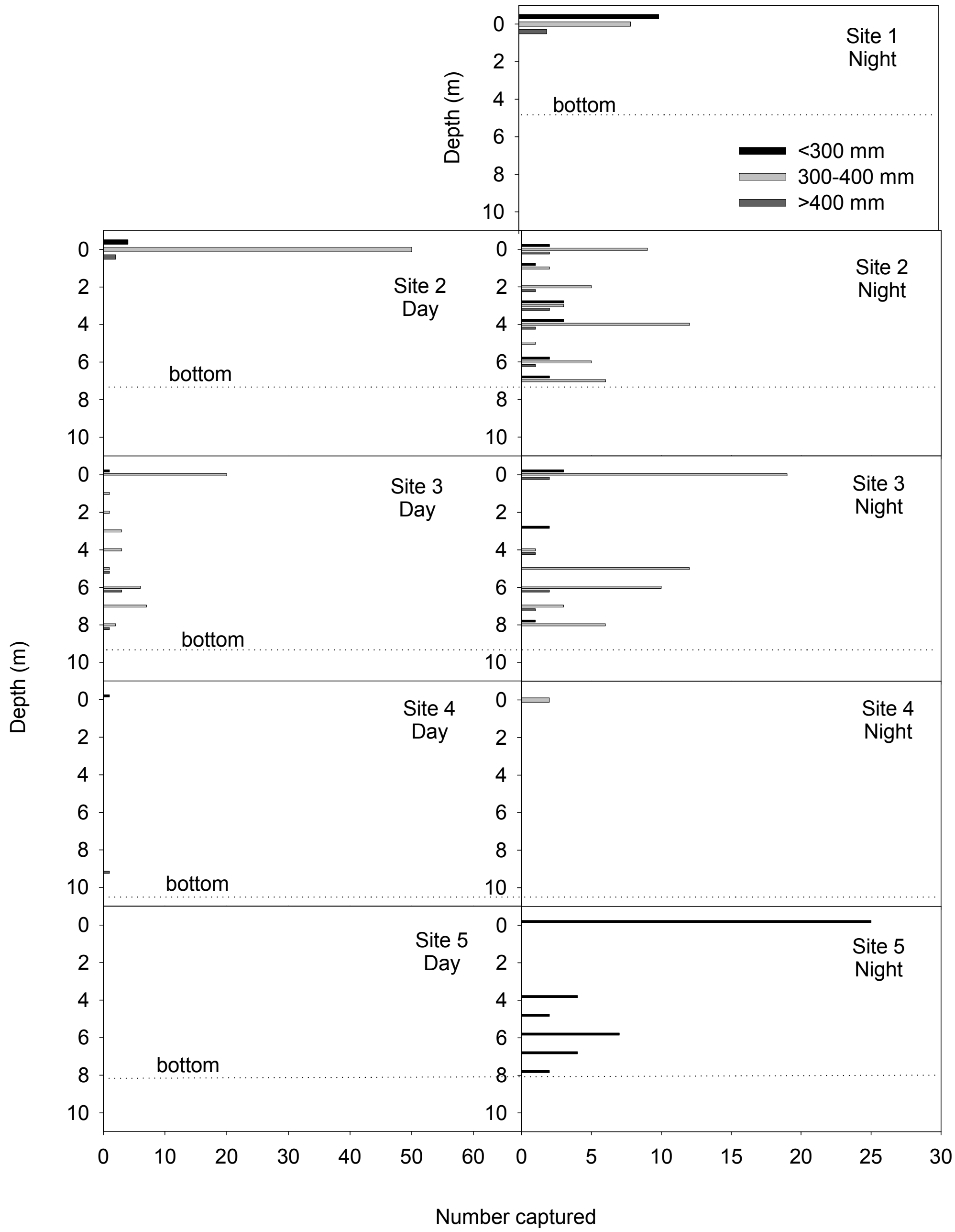


Figure 6. Day and night depth distribution of three size classes of Utah chub captured in nets at different sites in American Falls Reservoir from July 16-25, 2002.

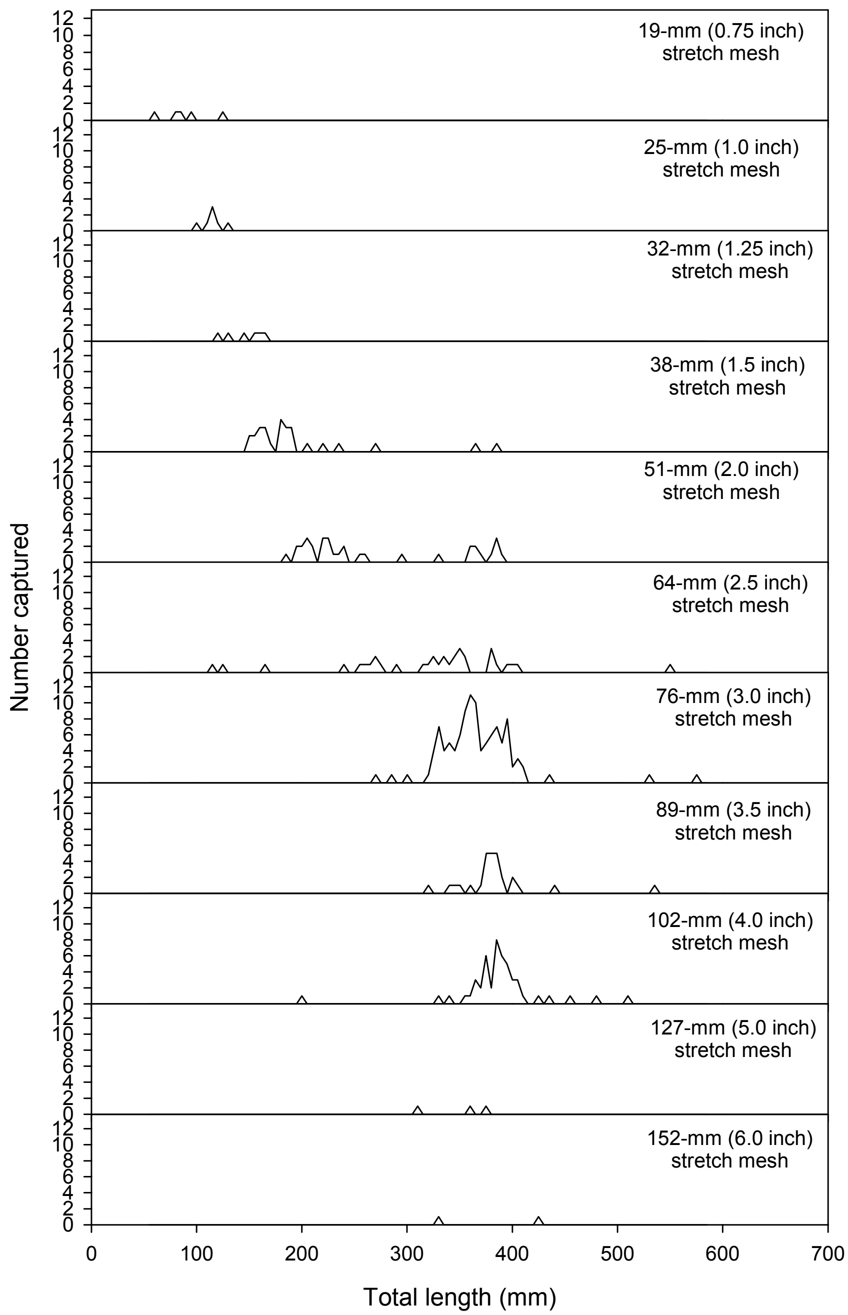


Figure 7. Catches of Utah chub by total fish length (mm) and gillnet mesh size (mm) at American Falls Reservoir from July 16-25, 2002.

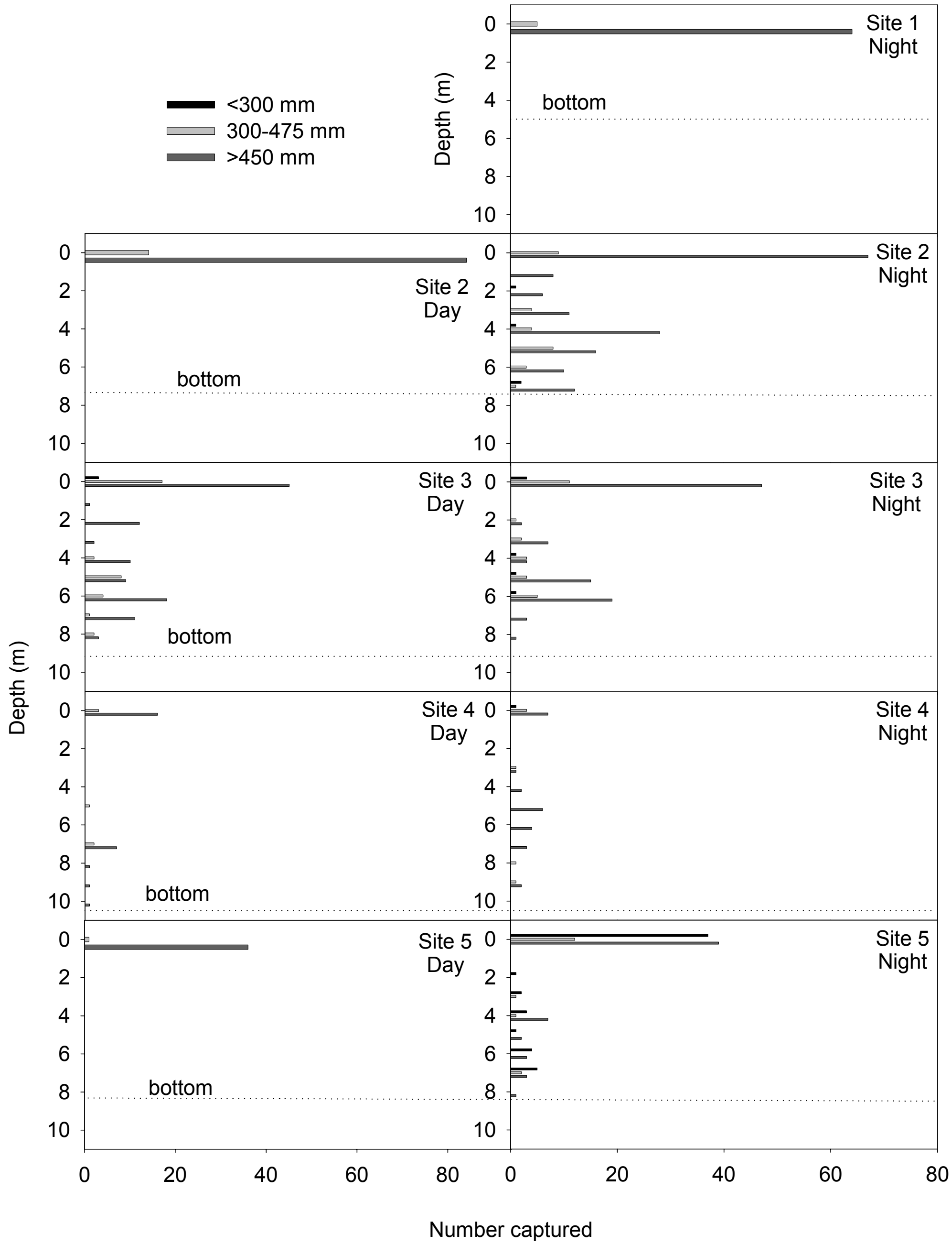


Figure 8. Day and night depth distribution of three size classes of Utah suckers captured in nets at different sites in American Falls Reservoir from July 16-25, 2002.

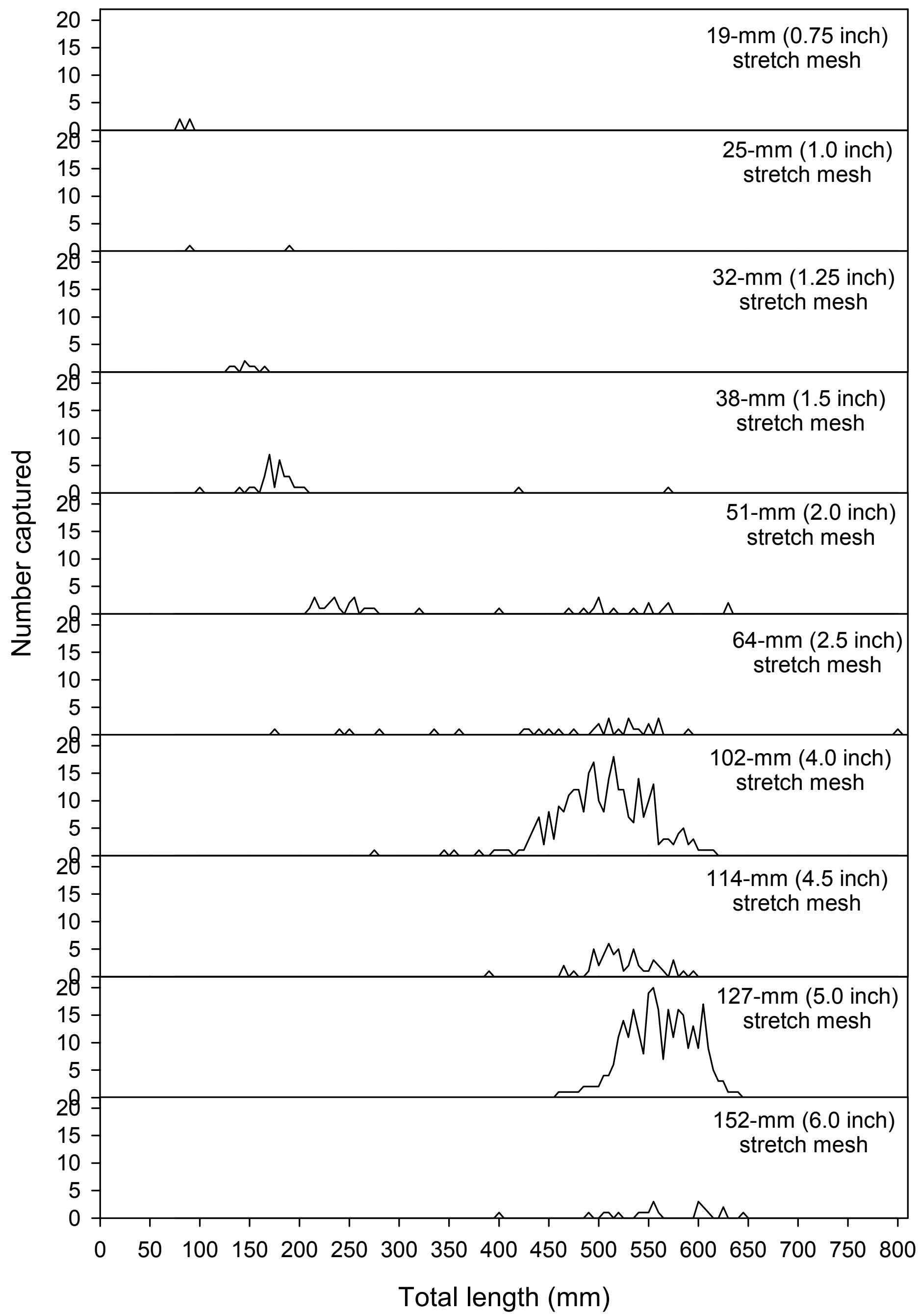


Figure 9. Catches of Utah suckers by total fish length (mm) and gillnet mesh size (mm) at American Falls Reservoir from July 16-25, 2002.

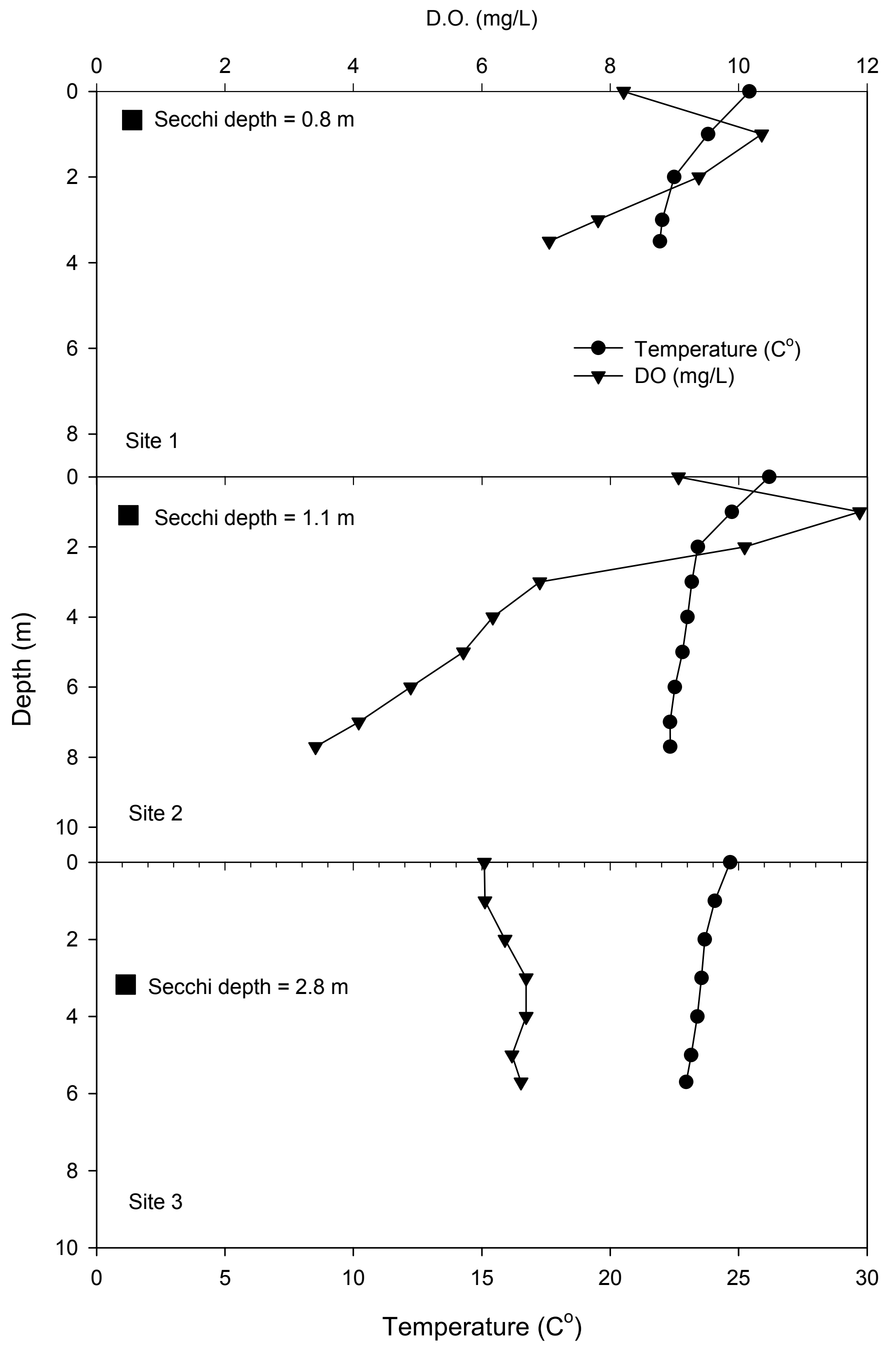


Figure 10. Vertical temperature (°C) and dissolved oxygen (DO; mg/L) profiles at three sites in American Falls Reservoir during the fish assessment survey in July 2002.

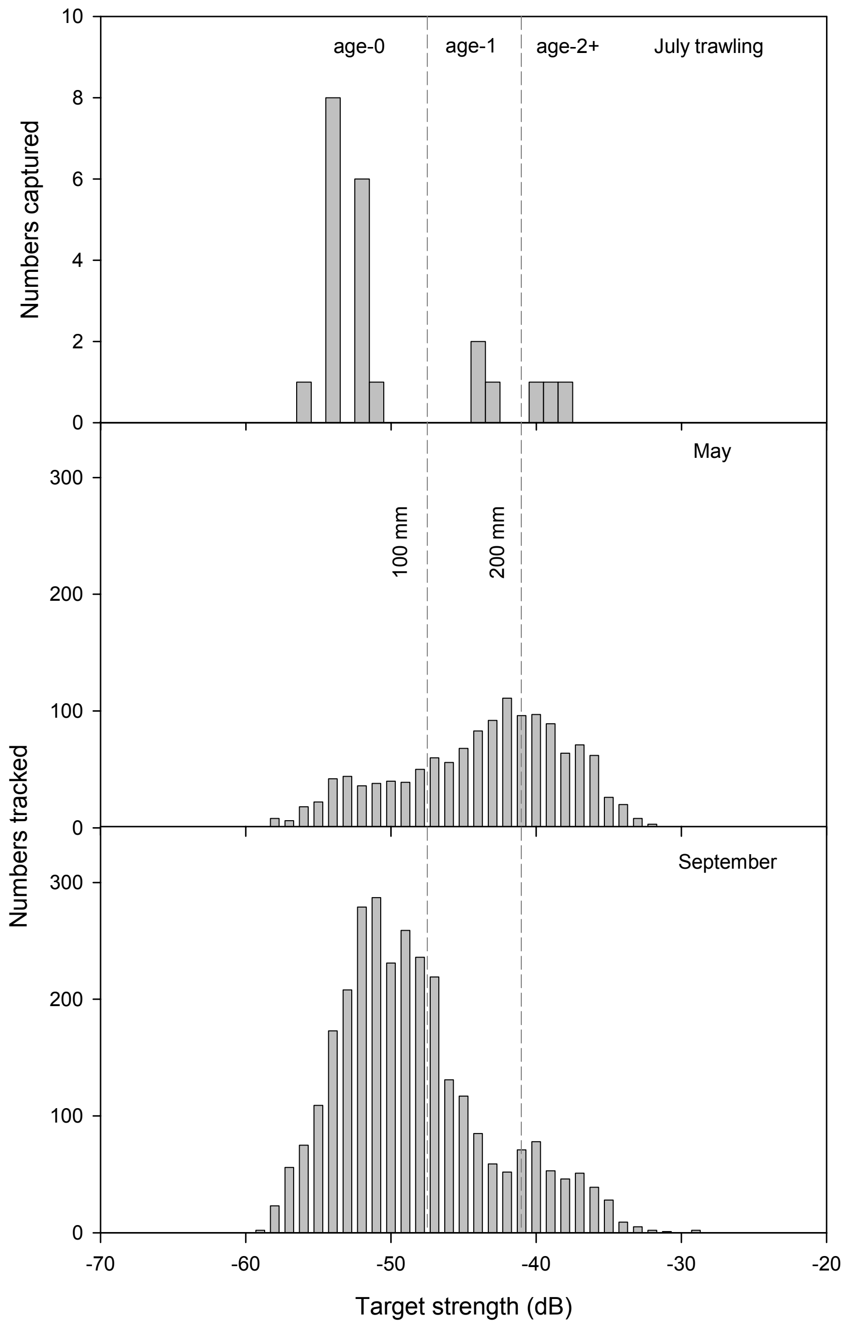


Figure 11. Fish length and target strength distribution of kokanee sampled by July trawling and May and September hydroacoustics at Anderson Ranch Reservoir in 2002. Trawl caught fish were converted to target strength by Love's (1977) equation.

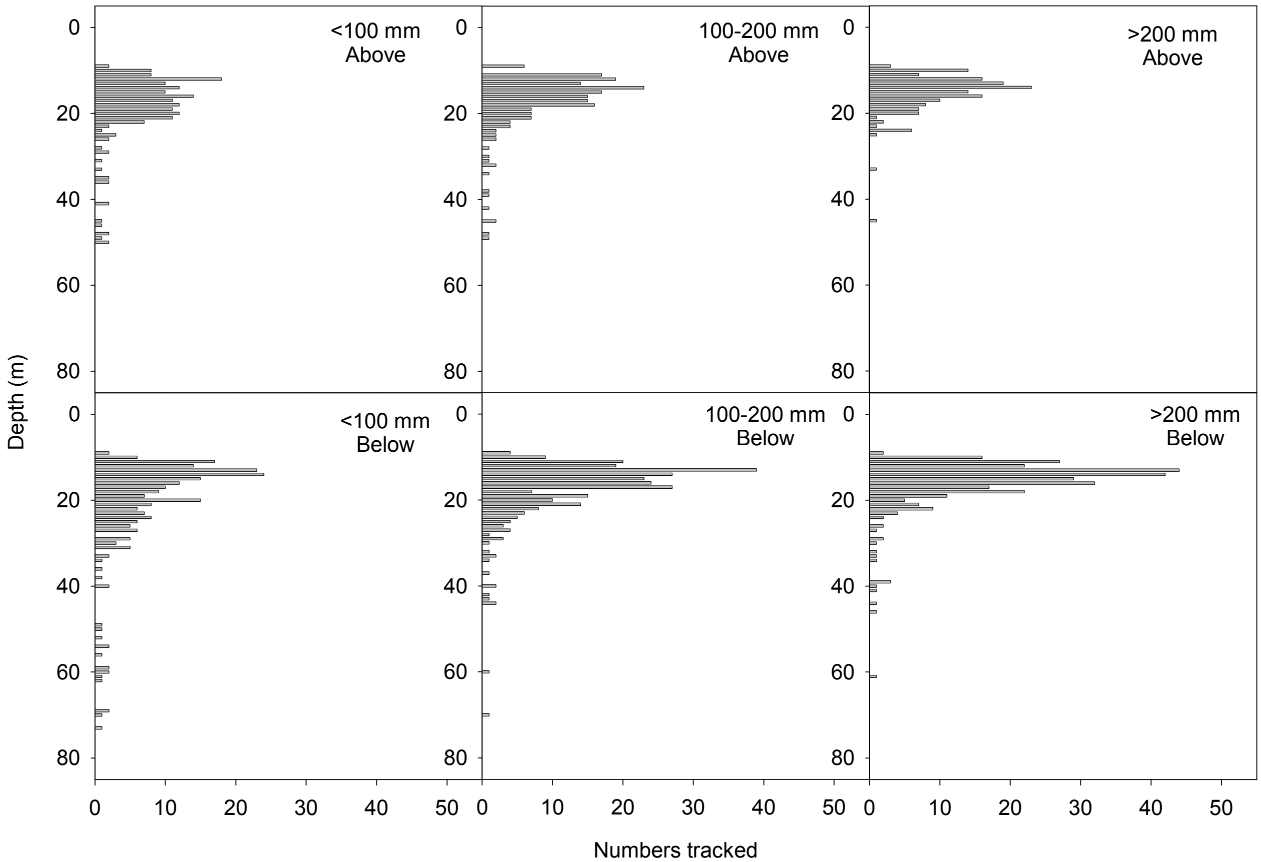


Figure 12. Depth distributions of three size classes of kokanee above and below the Falls Creek tributary to Anderson Ranch Reservoir on May 15, 2002.

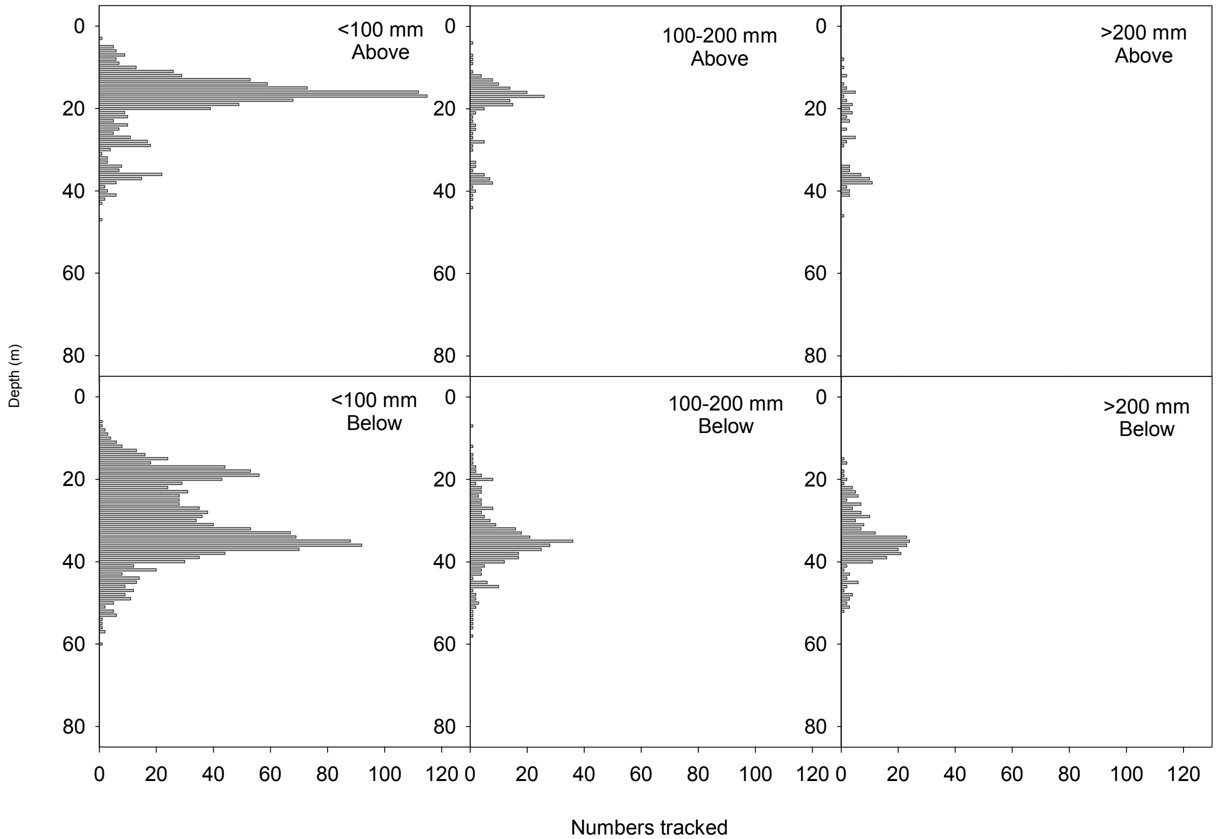


Figure 13. Depth distributions of three size classes of kokanee above and below the Falls Creek tributary to Anderson Ranch Reservoir on September 9, 2002.

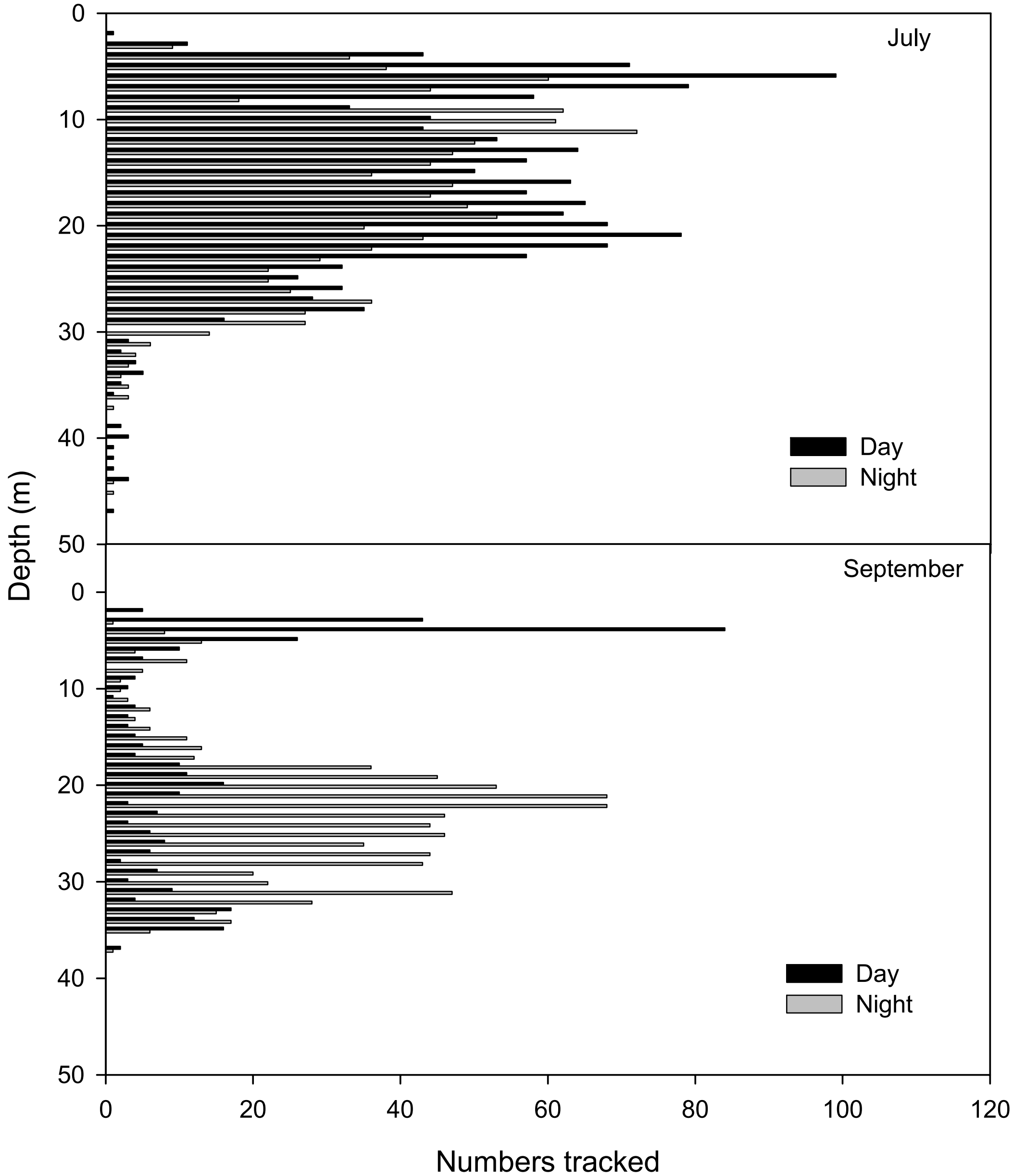


Figure 14. Depth distributions of tracked fish during day and night at Arrowrock Reservoir during July and September 2002 hydroacoustic surveys.

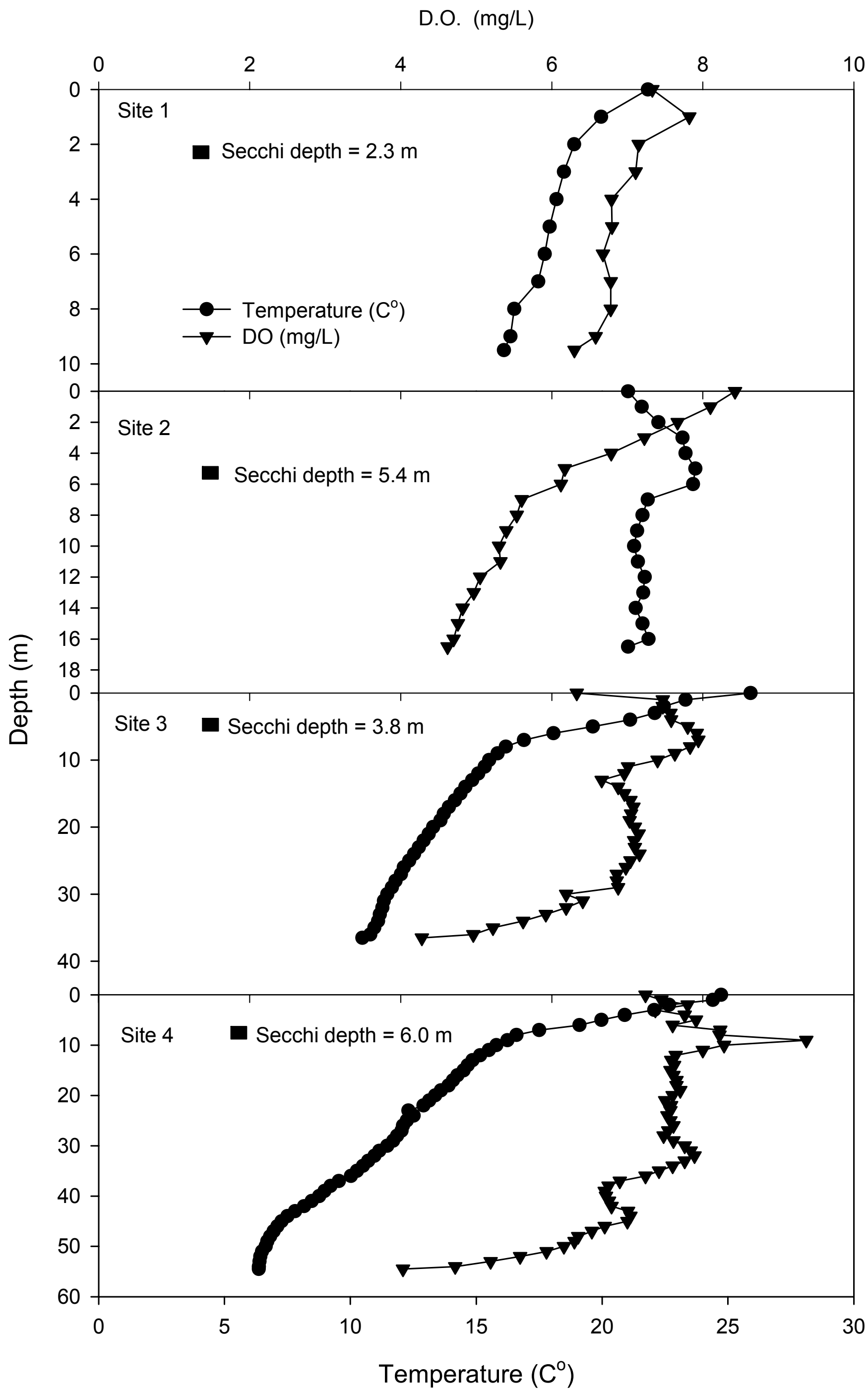


Figure 15. Vertical temperature (°C) and dissolved oxygen (DO; mg/L) profiles at three sites in Arrowrock Reservoir during the fish assessment survey in July 2002.

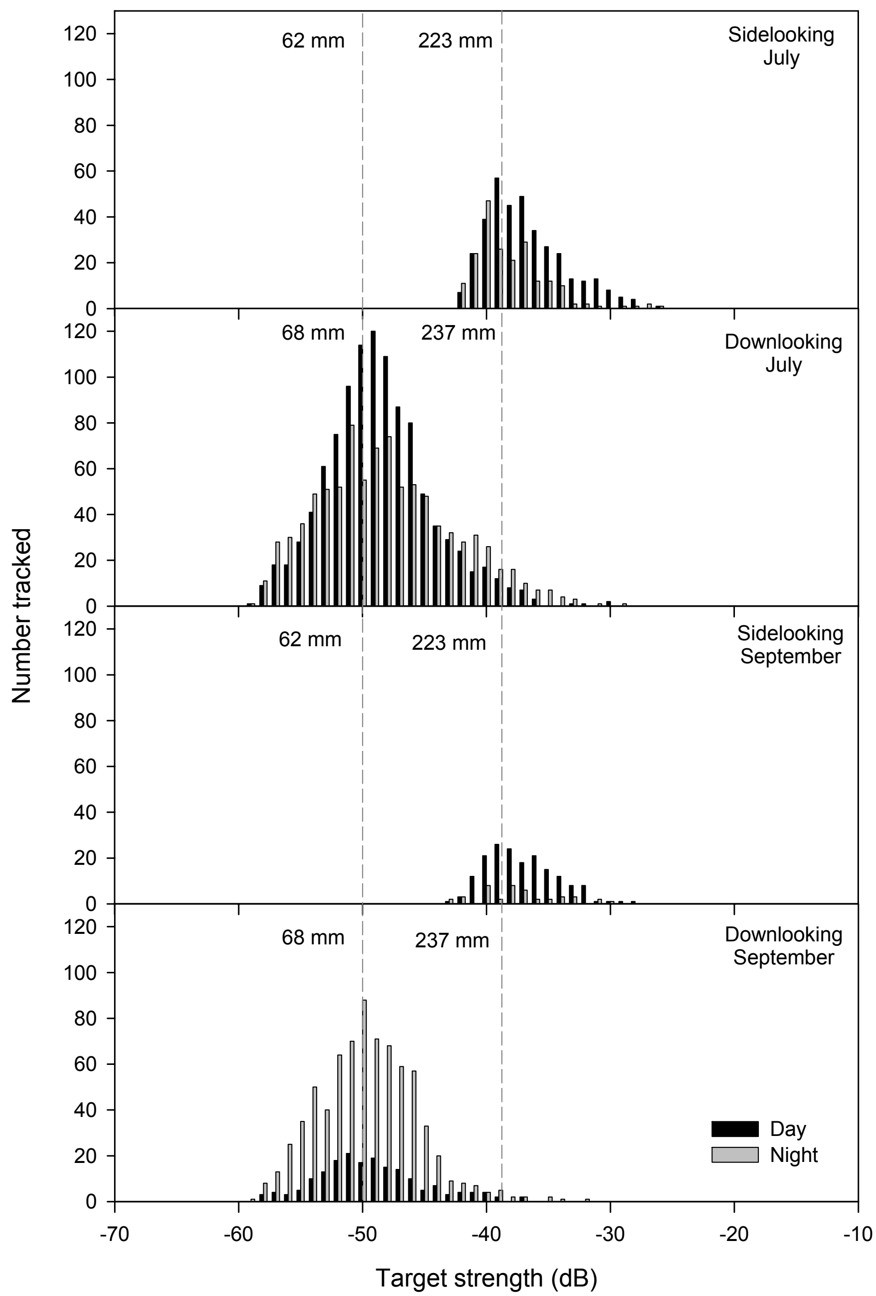


Figure 16. Target strength (dB) distribution of fish tracked during day and night hydroacoustic surveys at Arrowrock Reservoir in July and September 2002.

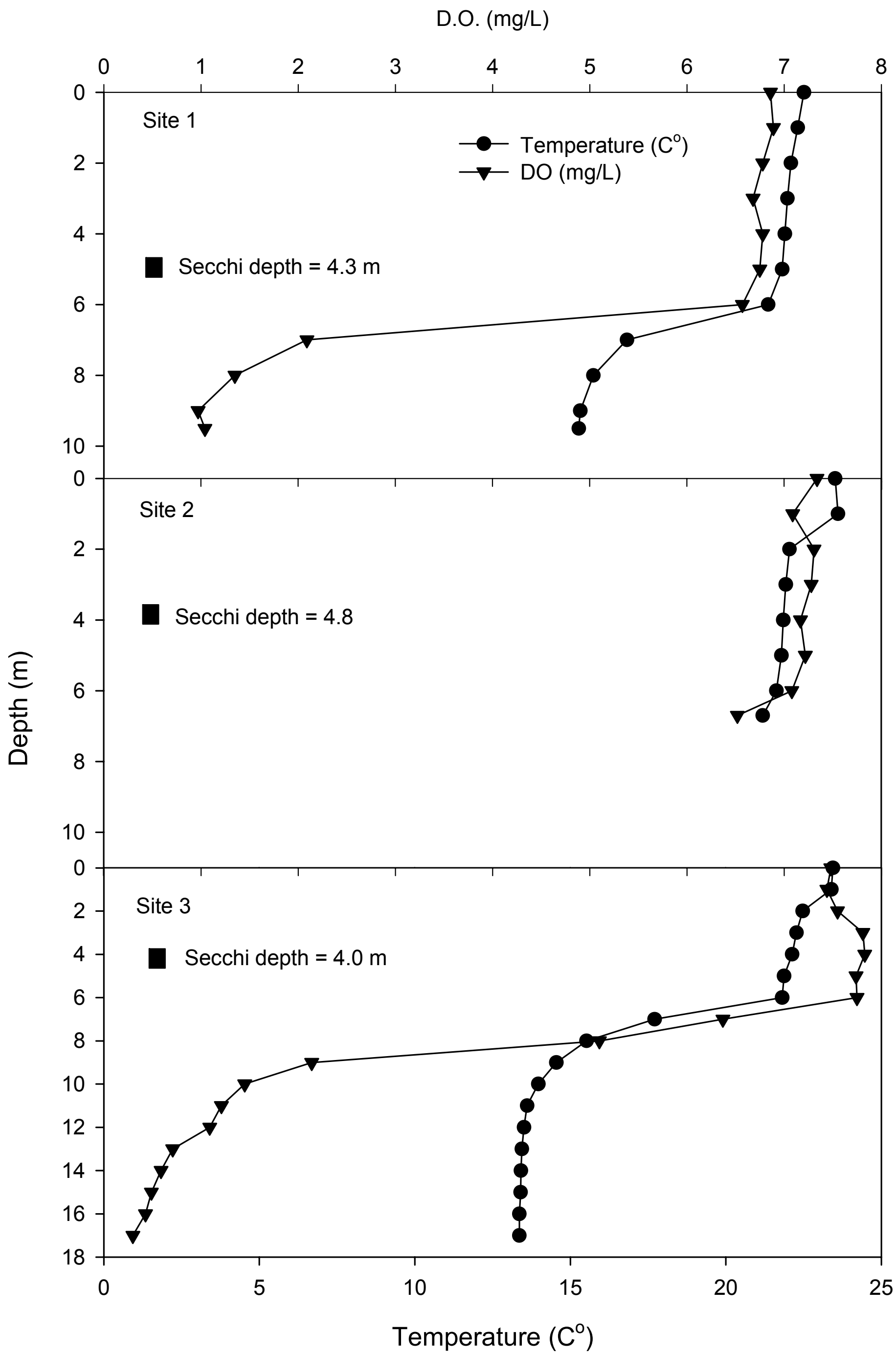


Figure 17. Vertical temperature (°C) and dissolved oxygen (DO; mg/L) profiles at three sites in Cascade Reservoir during the fish assessment survey in August 2002.

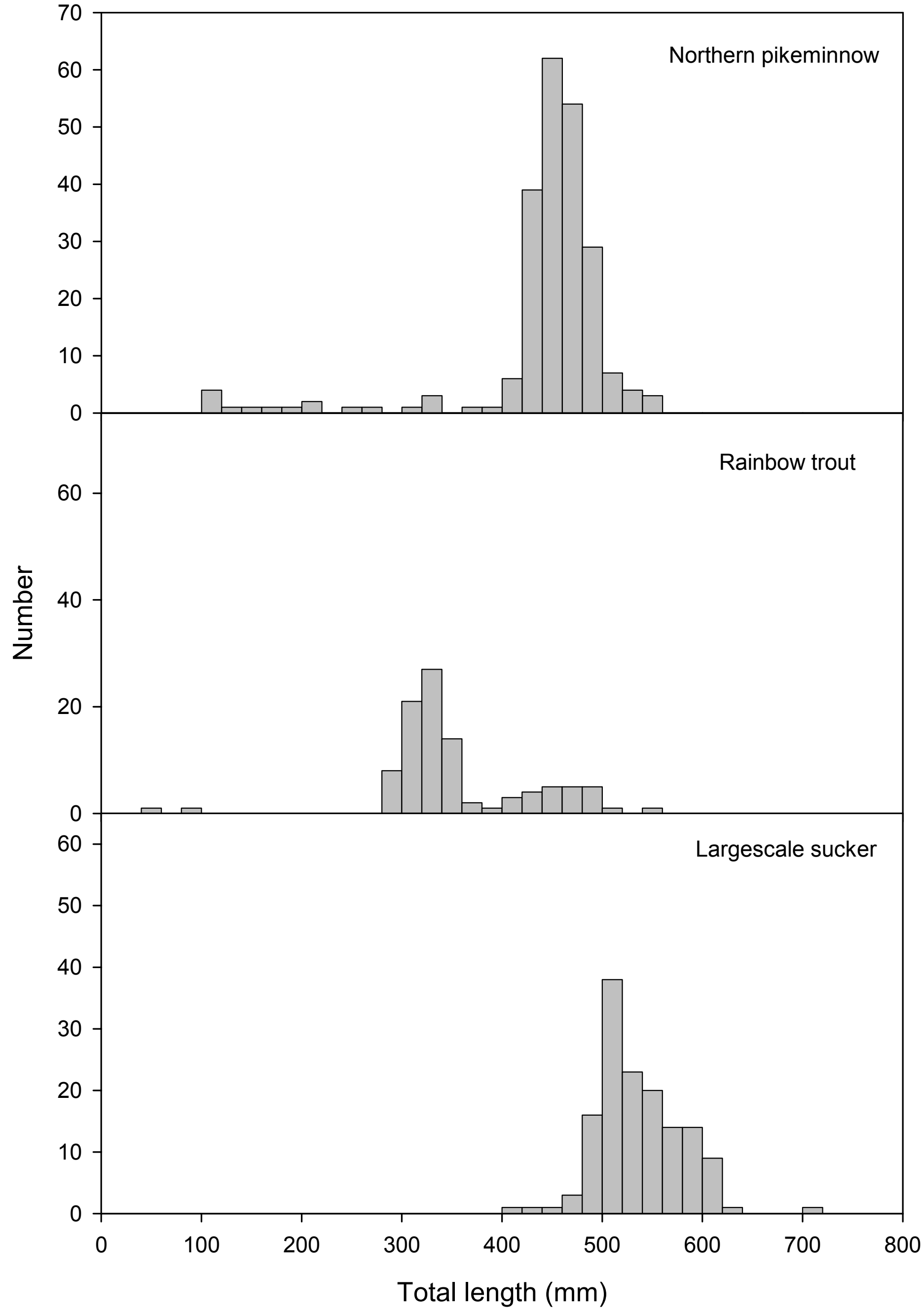


Figure 18. Length distributions of dominant fish species caught in floating, sinking, and curtain nets at Cascade Reservoir from August 6-15, 2002.

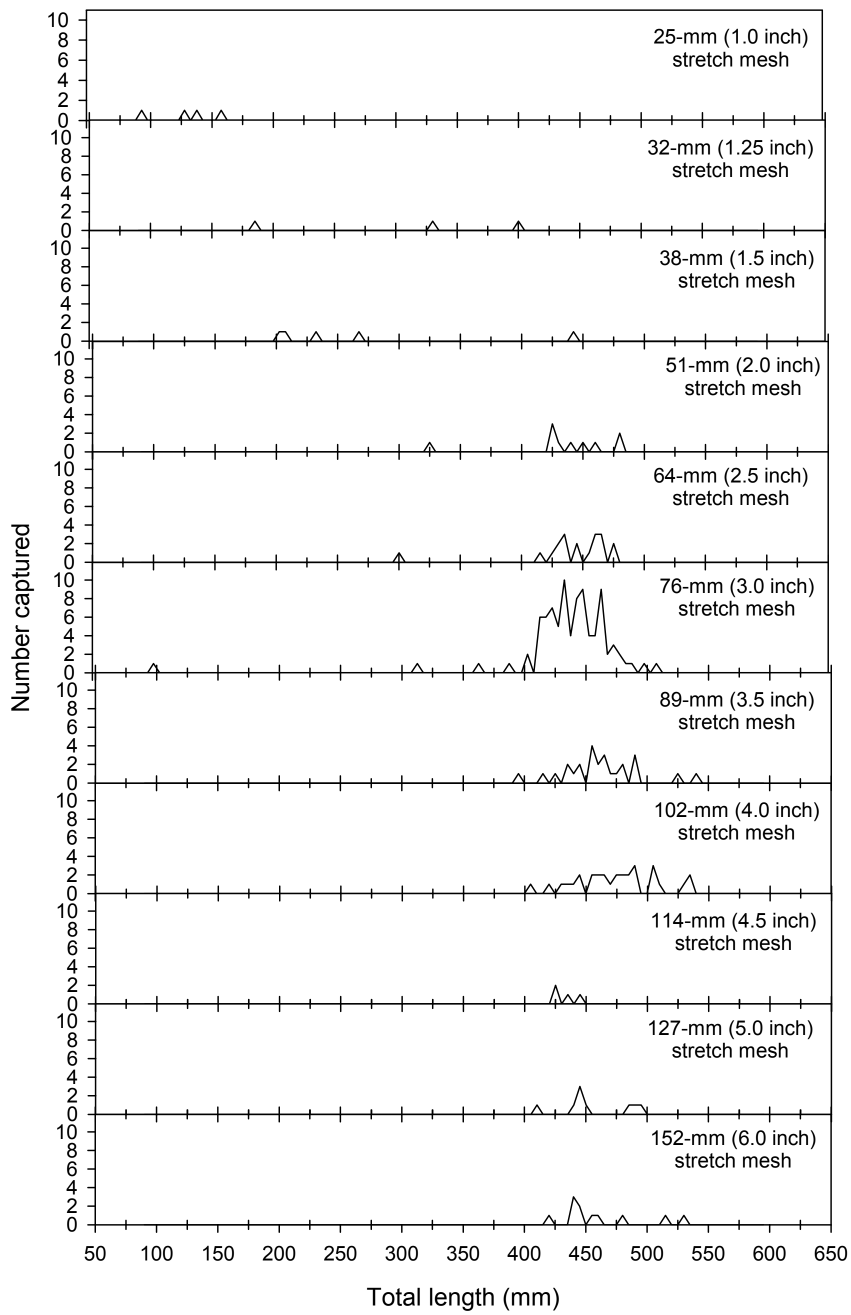


Figure 19. Catches of northern pikeminnow by total fish length (mm) and gillnet mesh size (mm) at Cascade Reservoir from August 6-15, 2002.

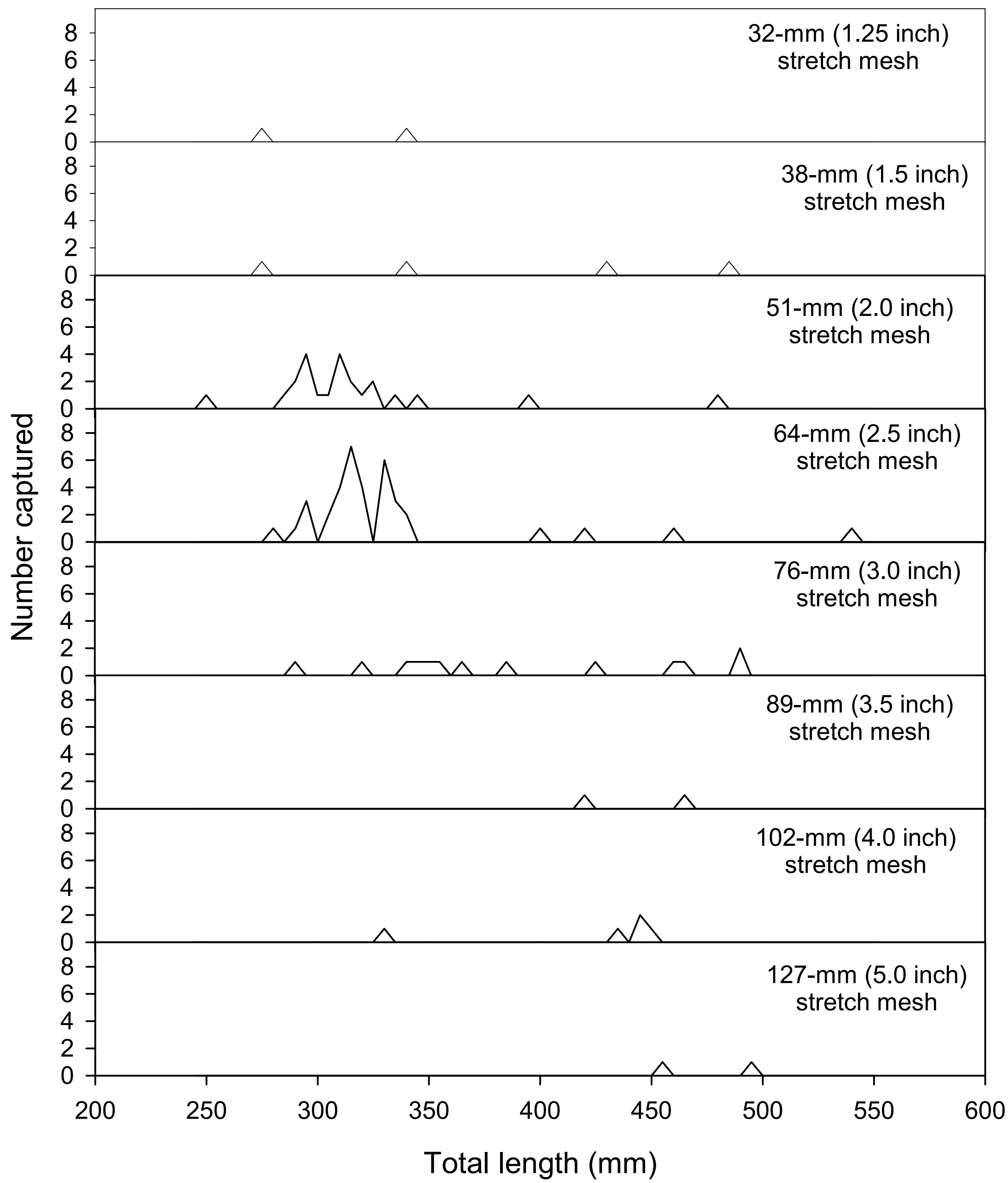


Figure 20. Catches of rainbow trout by total fish length (mm) and gillnet mesh size (mm) at Cascade Reservoir from August 6-15, 2002.

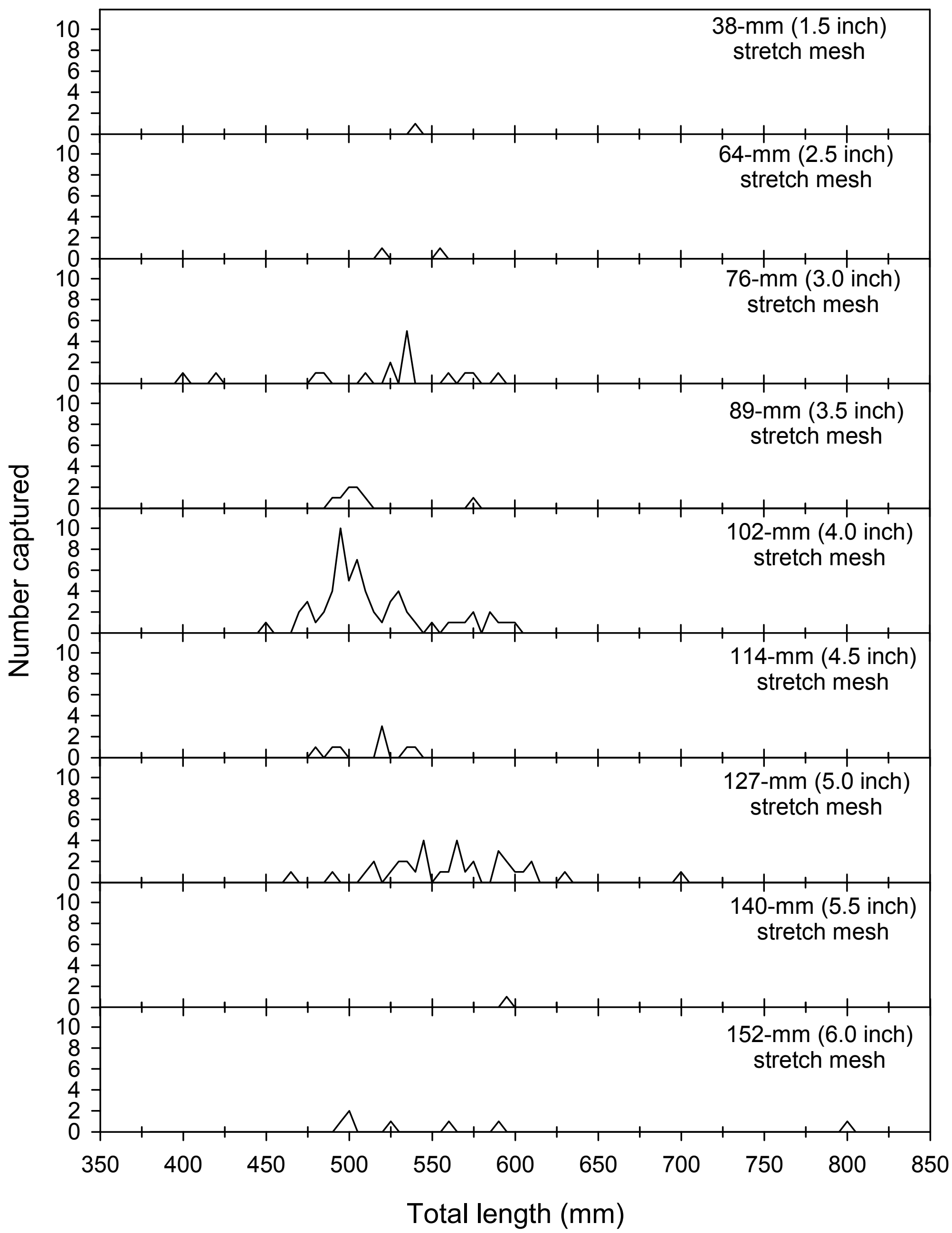


Figure 21. Catches of largescale suckers by total fish length (mm) and gillnet mesh size (mm) at Cascade Reservoir from August 6-15, 2002.

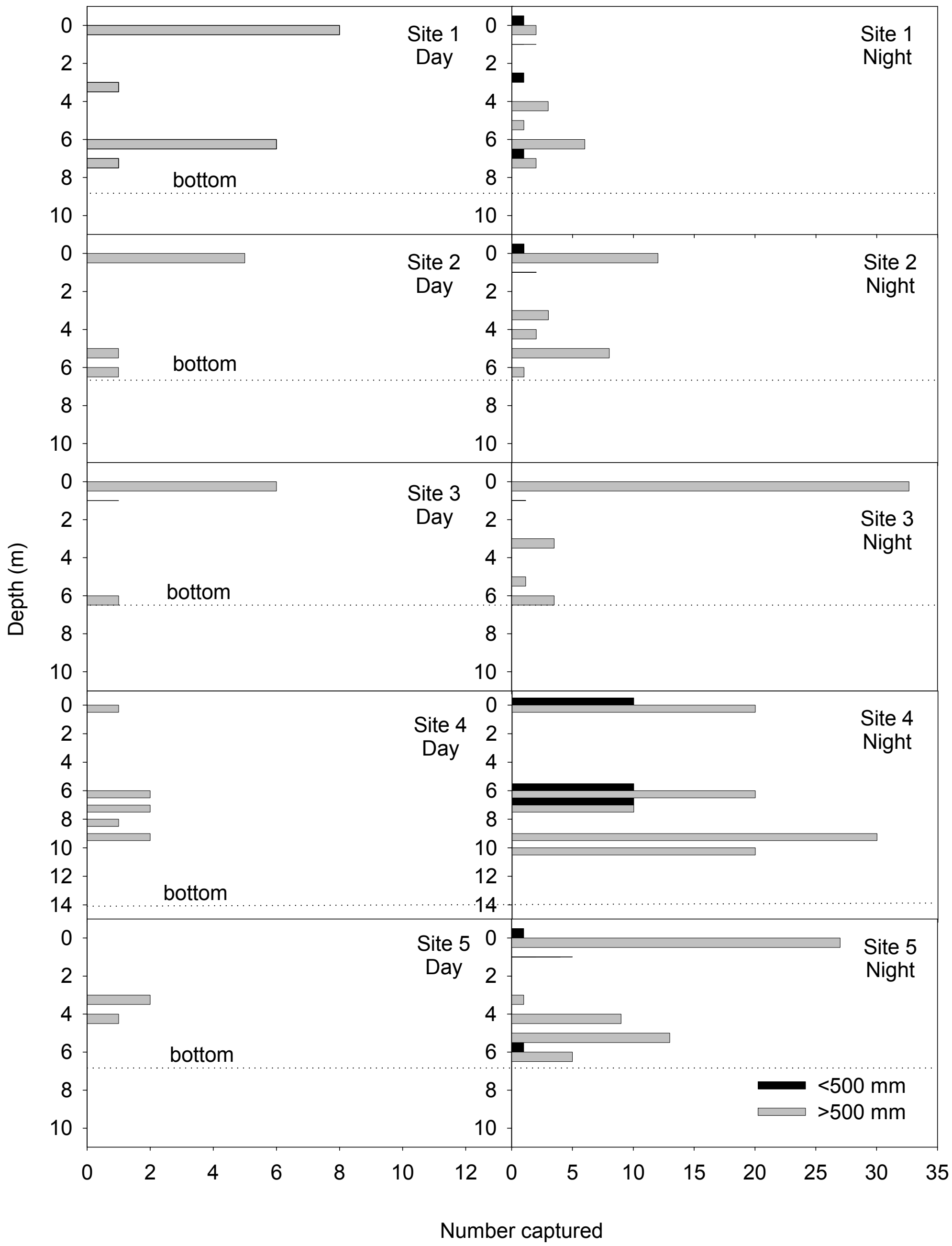


Figure 22. Day and night depth distributions of two size classes of northern pikeminnow captured in nets at different sites in Cascade Reservoir from August 6-15, 2002.

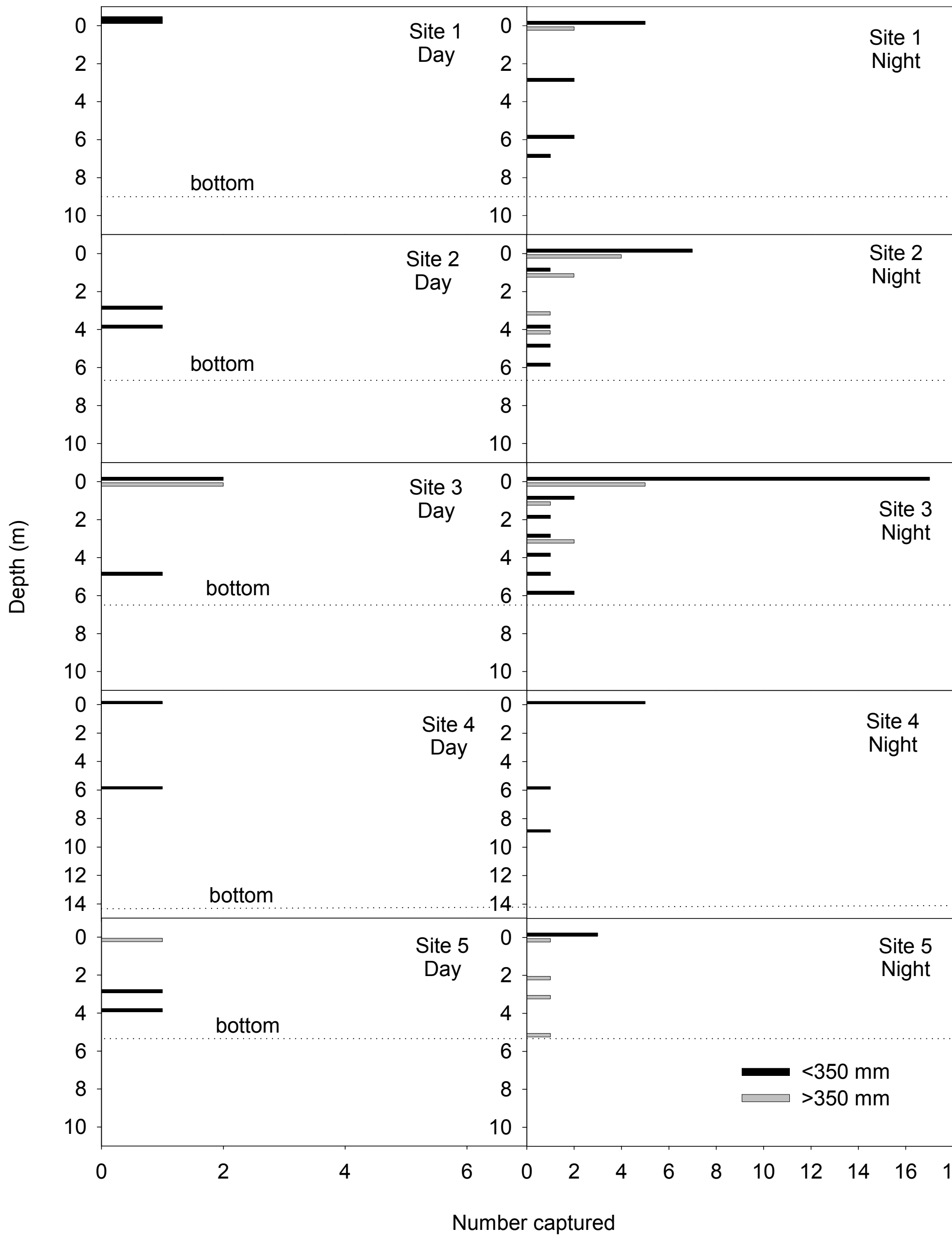


Figure 23. Day and night depth distributions of two size classes of rainbow trout captured in nets at different sites in Cascade Reservoir from August 6-15, 2002.

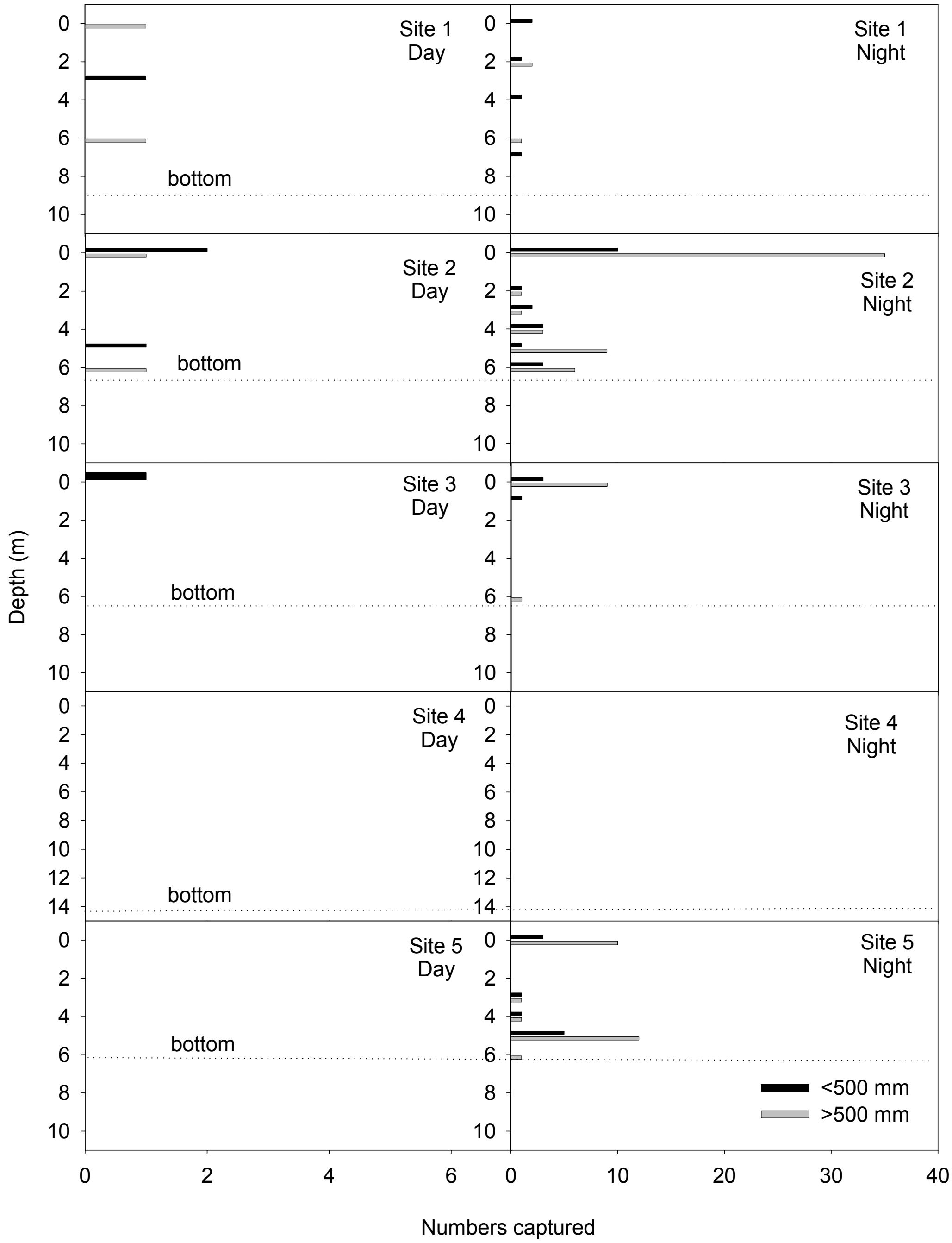


Figure 24. Day and night depth distributions of two size classes of largescale suckers captured in nets at different sites in Cascade Reservoir from August 6-15, 2002.

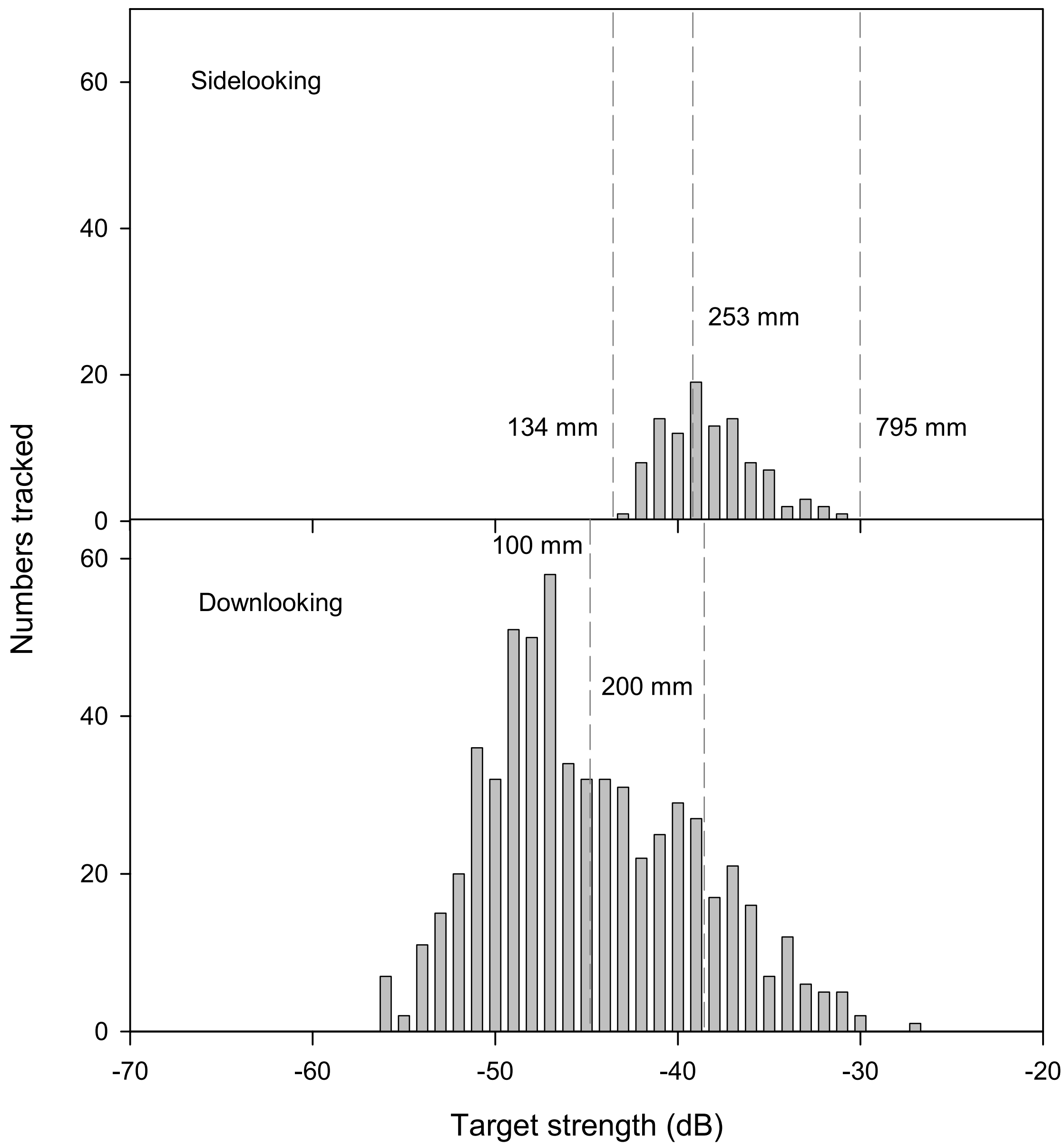


Figure 25. Target strength (dB) distribution of fish tracked during day and night hydroacoustic surveys at Deadwood Reservoir on September 16, 2002. Fish lengths are standard lengths and were converted to target strength using Love's (1977) equation.

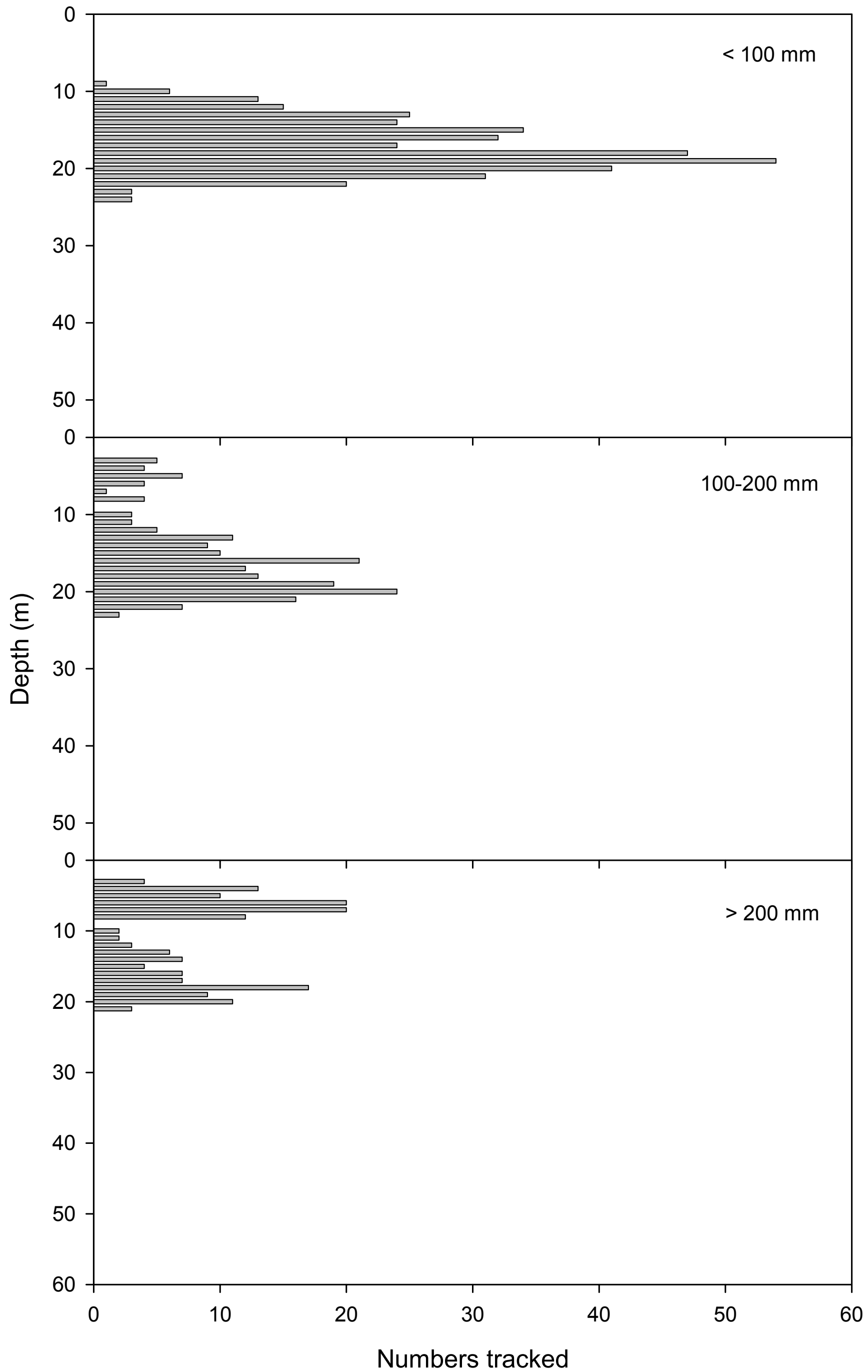


Figure 26. Depth distributions of three size classes of pelagic fish at Deadwood Reservoir on September 16, 2002.

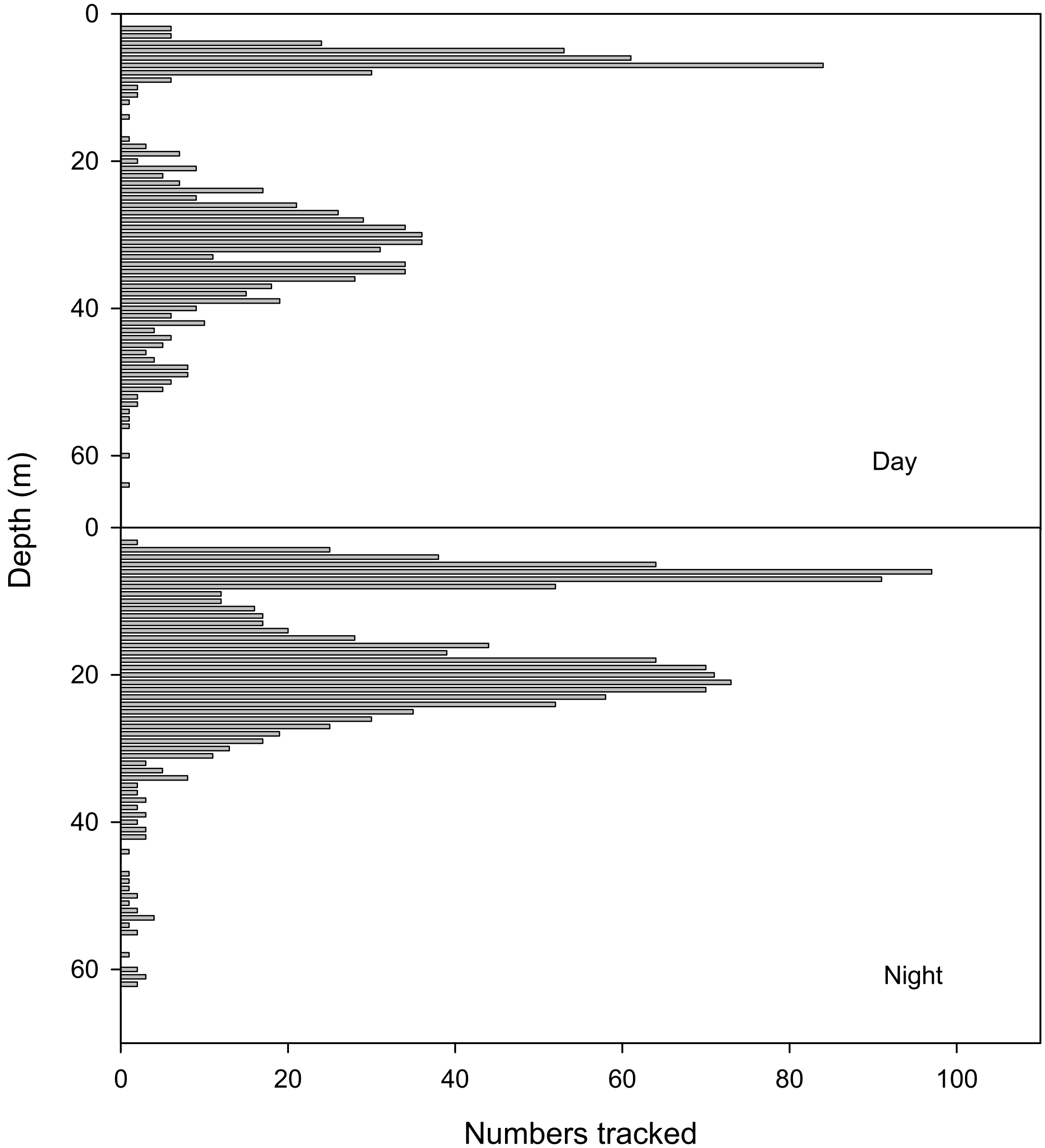


Figure 27. Depth distributions of tracked fish during day and night at Lucky Peak Reservoir during June 2002 hydroacoustic surveys.

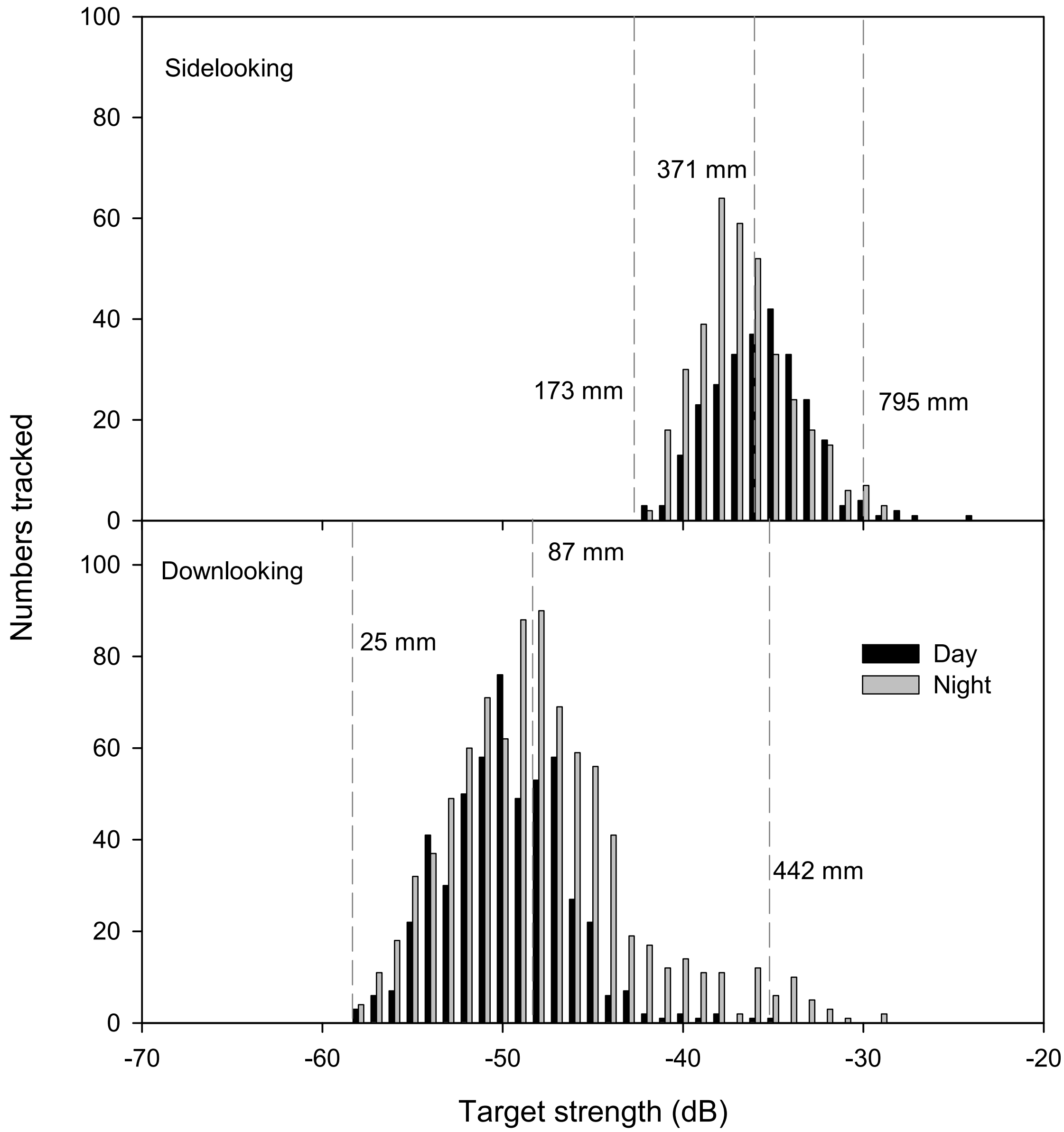


Figure 28. Target strength (dB) distribution of fish tracked during day and night hydroacoustic surveys at Lucky Peak Reservoir on June 19, 2002. Fish lengths are standard lengths and were converted to target strength using Love's (1977) equation.

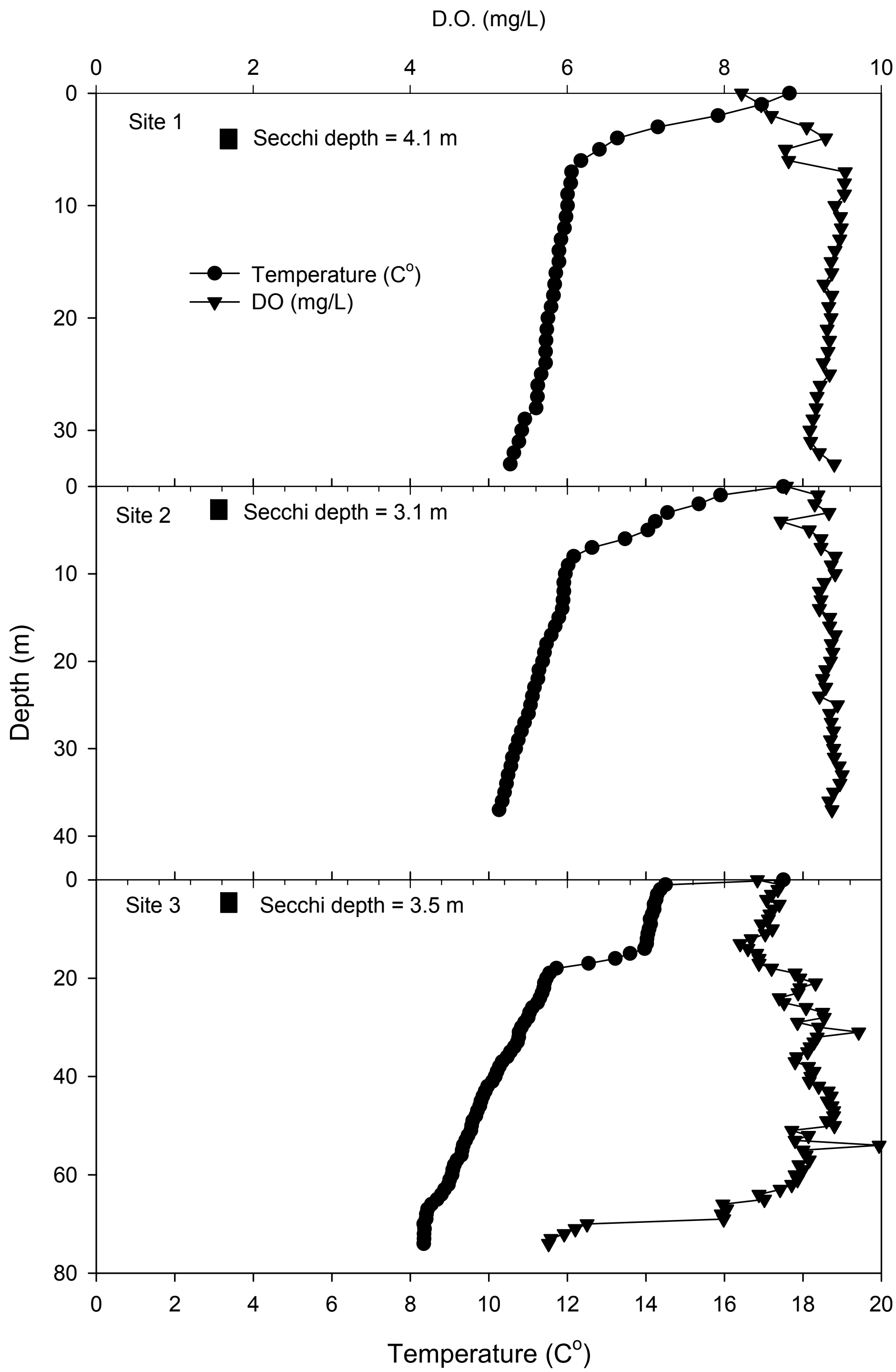


Figure 29. Vertical temperature (°C) and dissolved oxygen (DO; mg/L) profiles at three sites in Lucky Peak Reservoir during the fish assessment survey in June 2002.

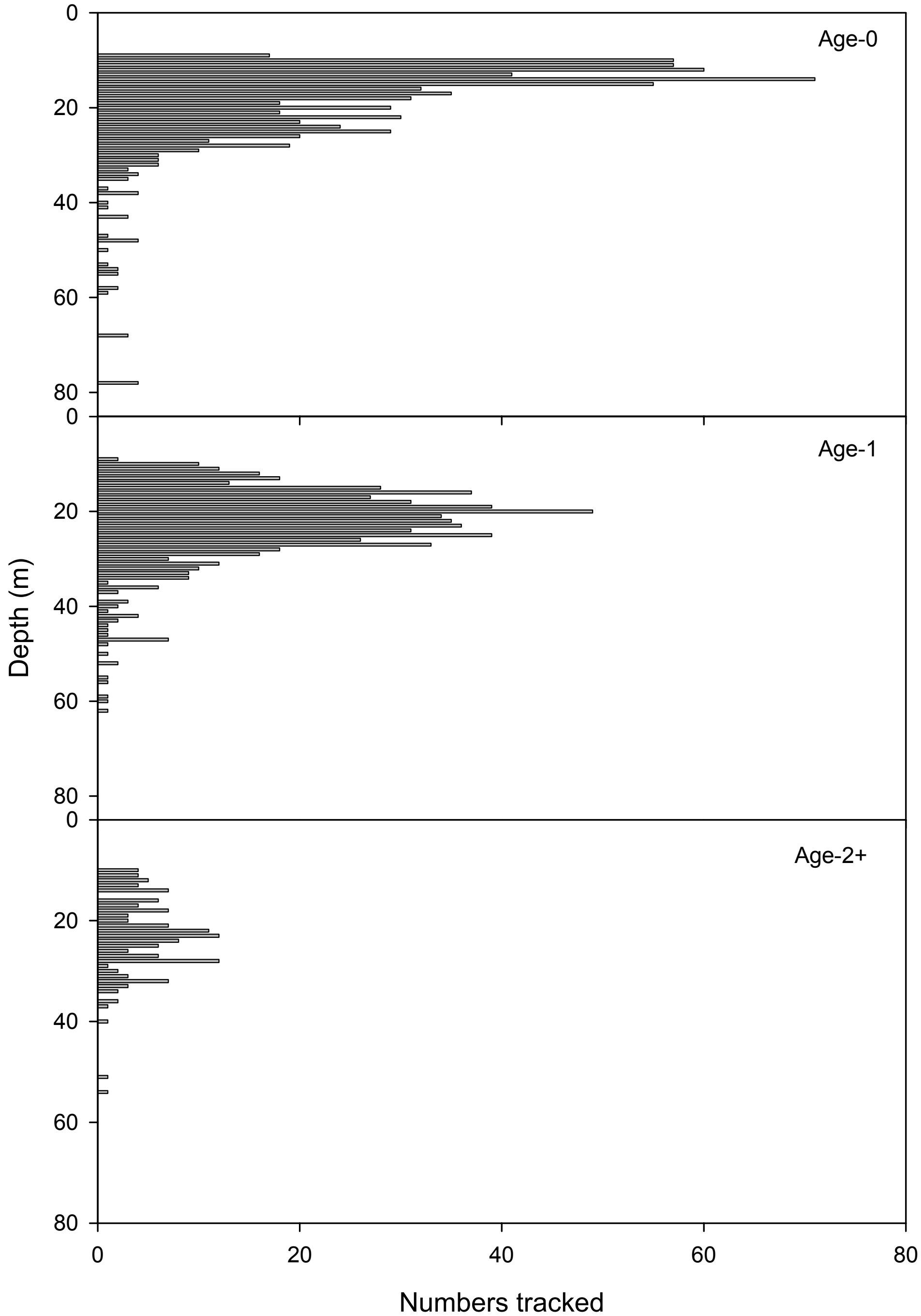


Figure 30. Depth distributions of three age classes of kokanee at Payette Lake on August 15, 2002.

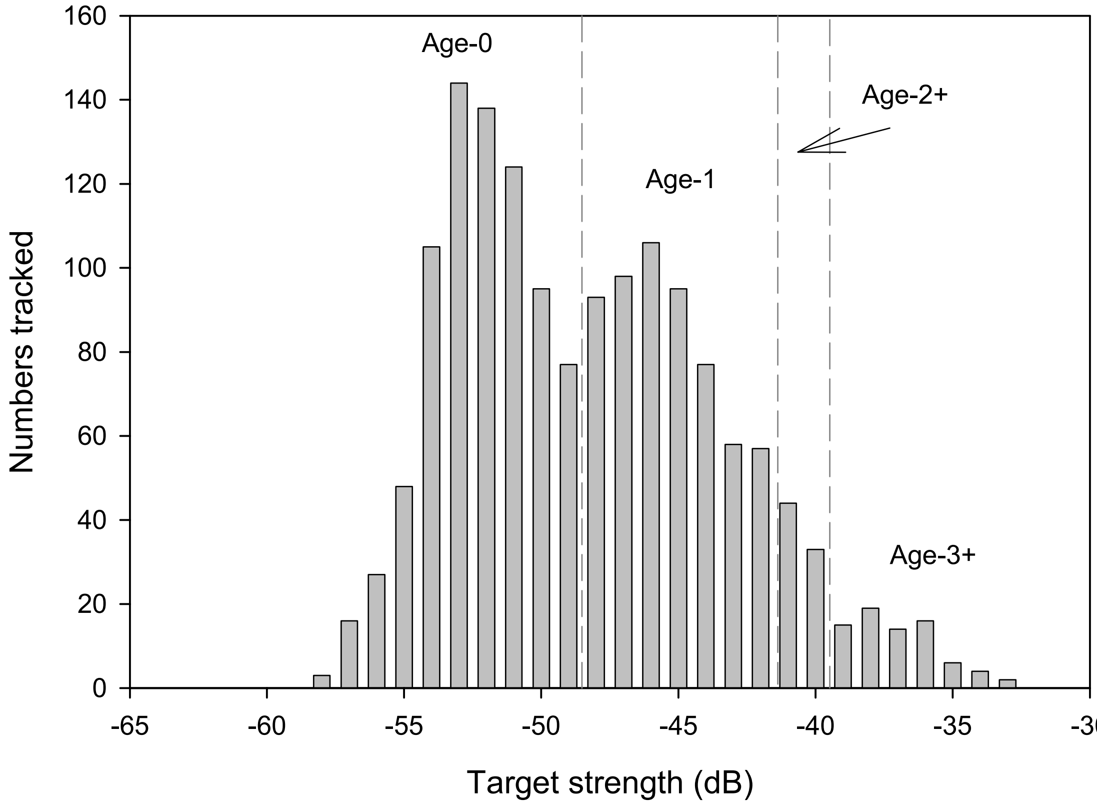


Figure 31. Target strength distributions and proposed age classes of kokanee at Payette Lake on August 15, 2002. Fish lengths are standard lengths and were converted to target strength using Love's (1977) equation.

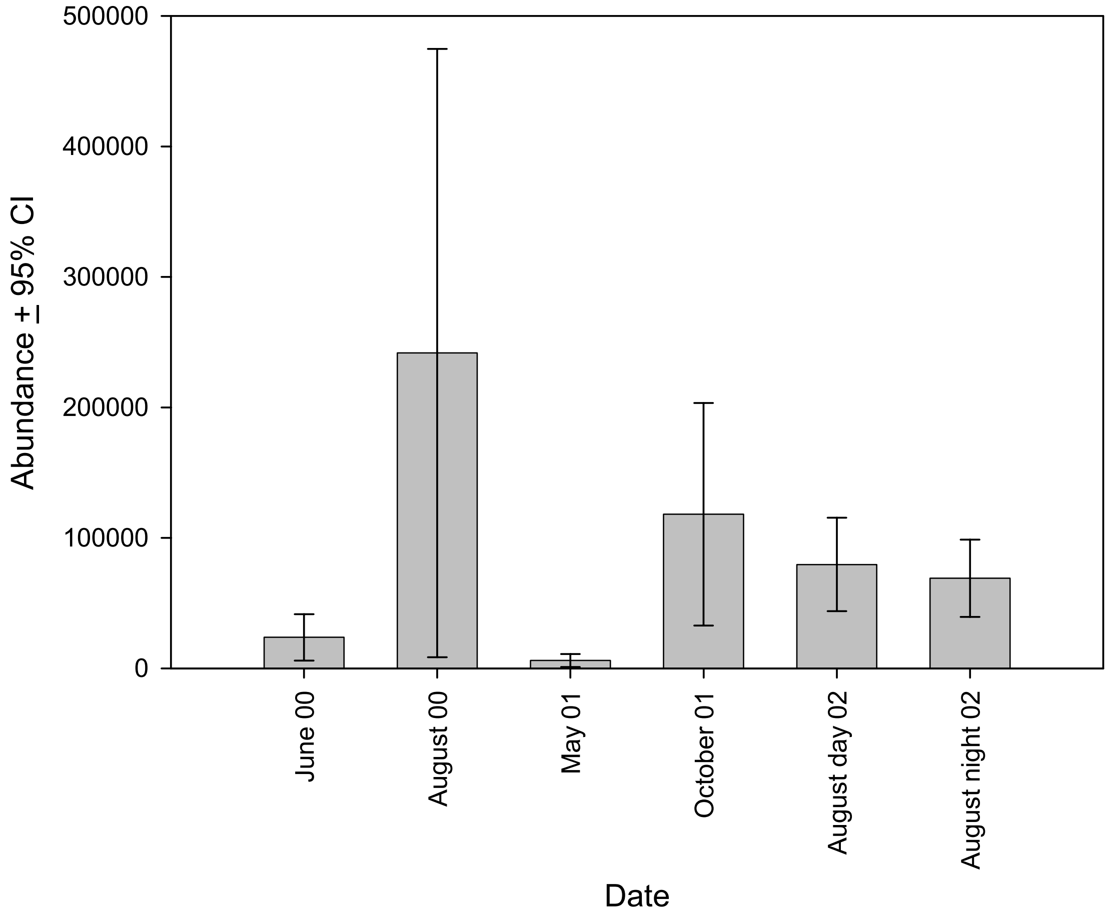


Figure 32. Abundance estimates of pelagic fish estimated by annual and seasonal hydroacoustic surveys at Cascade Reservoirs from 2000-2002.

ACKNOWLEDGEMENTS

I would like to thank IDFG regional personnel, particularly Paul Janssen and David Teuscher, for providing assistance during hydroacoustic surveys and gillnetting. Jeff Dillon provided invaluable assistance and many hours resurrecting the purse seine barge and teaching my crew how to run it. Dan Schill, Jeff Dillon, and Melo Maiolie provided valuable comments during the editing of earlier versions of this report. Ryan Hedrick, a hydrologist for U.S. Bureau of Reclamation, provided surface area and lake volume estimates for all of the waters surveyed. Kirk Steinhorst provided valuable statistical advice for the analysis of hydroacoustic data. The U.S. Bureau of Reclamation provided funding for the sonar system. Last and certainly not least, I thank Ryan Hillyard, Levi Frasier, and Adrian Hart, the 2002 lake and reservoir crew, for their dedication throughout the summer. I cannot thank Ryan Hillyard enough for his expertise, dedication, hard work, and friendship throughout the season.

REFERENCES

Aku, P. M. K., L. G. Rudstam, and W. M. Tonn. 1997. Impact of hypolimnetic oxygenation on the vertical distribution of cisco *Coregonus artedi* in Amisk Lake, Alberta. Canadian Journal of Fish and Aquatic Science 54:2182-2195.

Baldwin, C. M., D. A. Beauchamp, and C. P. Gubala. 2002. Seasonal and diel distribution and movement of cutthroat trout from ultrasonic telemetry. Transactions of the American Fisheries Society 131(1):143-158.

Beauchamp, D. A., C. Luecke, W. A. Wurtsbaugh, H. G. Gross, P. E. Budy, S. Spaulding, R. Dillenger, and C. P. Gubala. 1997. Hydroacoustic assessment of abundance and diel distribution of sockeye salmon and kokanee in the Sawtooth Valley Lakes, Idaho. North American Journal of Fisheries Management 17:253-267.

Bjerkeng, B., R. Borgstrøm, A. Brabrand, and B. Faafeng. 1991. Fish size distribution and total fish biomass estimated by hydroacoustical methods: a statistical approach. Fisheries Research 11:41-73.

Brandt, S. B. 1996. Acoustic assessment of fish abundance and distribution. Pages 385-432 *in* B. R. Murphy and D. W. Willis, editors. Fisheries Techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Brown, M. J., and D. J. Austen. 1996. Data management and statistical techniques. Pages 17-61 *in* B. R. Murphy and D. W. Willis, editors. Fisheries Techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Burczynski, J. J., and R. L. Johnson. 1986. Application of dual-beam acoustic survey techniques to limnetic populations of juvenile sockeye salmon *Oncorhynchus nerka*. Canadian Journal of Fish and Aquatic Science 43:1776-1788.

Butts, A. E. 2002. Effects of *Myxobolus cerebralis* on the population dynamics of kokanee in Porcupine Reservoir, Utah. Master's Thesis. Utah State University, Logan, Utah.

Butts, A. E., and D. Teuscher. 2002. Lake and reservoir research. Job performance report. Grant F-73-R-24 Project 5. Idaho Department of Fish and Game, Boise, Idaho.

Carlander, K. D. 1969. Handbook of freshwater fishery biology, volume one. Iowa State University Press, Ames, Iowa.

Engel, S., and J. J. Magnuson. 1976. Vertical and horizontal distributions of coho salmon *Oncorhynchus kisutch*, yellow perch *Perca flavescens*, and cisco *Coregonus artedii* in Pallette Lake, Wisconsin. Journal of the Fisheries Research Board of Canada 33(12):2710-2715.

Goodman, L. A. 1960. On the exact variance of products. Journal of the American Statistical Association 55(292):708-713.

Hubert, W. A., R. D. Gipson, R. A. McDowell, and A. C. Stewart. 1994. Diet of Eagle Lake rainbow trout in Lake DeSmet, Wyoming. North American Journal of Fisheries Management 14:457-459.

Idaho Department of Fish and Game. 2001. Fisheries Management Plan, 2001-2006. Idaho Department of Fish and Game, Boise, Idaho.

Jackson, D. A., P. R. Peres-Neto, and J. D. Olden. 2001. What controls who is where in freshwater fish communities—the role of biotic, abiotic, and spatial factors. Canadian Journal of Fisheries and Aquatic Sciences 58:157-170.

Kubecka, J. 1996. Use of horizontal dual-beam sonar for fish surveys in shallow waters. Pages 165-178 *in* I. G. Cowx, editor. Stock assessment in inland fisheries. Fishing News Books, Oxford, United Kingdom.

Kubecka, J., and A. Duncan. 1998. Acoustic size vs. real size relationships for common species of riverine fish. Fisheries Research 35:115-125.

Levy, D. A. 1991. Acoustic analysis of diel vertical migration behavior of *Mysis relicta* and kokanee *Oncorhynchus nerka* within Okanagan Lake, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 122(1):112-120.

Love, R. H. 1971. Dorsal-aspect target strength of an individual fish. Journal of the Acoustical Society of America 49:816-823.

Love, R. H. 1977. Target strength of an individual fish at any aspect. Journal of Acoustical Society of America 62:1397-1403.

Luecke, C., and W. A. Wurtsbaugh. 1993. Effects of moonlight and daylight on hydroacoustic estimates of pelagic fish abundance. Transactions of the American Fisheries Society 122:112-120.

MacLennan, D. N., 1990. Acoustical measurement of fish abundance. Journal of Acoustical Society of America 87(1):1-15.

Maiolie, M., and S. Elam. 1996. Dworshak Dam impact assessment and fisheries investigation: kokanee depth distribution in Dworshak Reservoir and implications toward minimizing entrainment. Annual Progress Report. Idaho Department of Fish and Game, Boise, Idaho.

Maiolie, M. A., B. Harryman, B. Ament. 2001. Response of free-ranging kokanee to strobe lights. Pages 27-35 *in* C. C. Coutant, editor. Behavioral technologies for fish guidance. American Fisheries Society, Symposium 26, Bethesda, Maryland.

Mulligan, T. J., and R. Kieser. 1986. Comparison of acoustic population estimates of salmon in a lake with a weir count. Canadian Journal of Fisheries Sciences 43:1373-1385.

Ransom, B. H., and T. W. Steig. 1994. Using hydroacoustics to monitor fish at hydropower dams. Lake and Reservoir Management 9(1):163-169.

Ransom, B. H., T. W. Steig, and P. A. Nealson. 1996. Comparison of hydroacoustics and net catch estimates of Pacific salmon smolt passage at hydropower dams in the Columbia River basin, USA. ICES Journal of Marine Science 53:477-481.

Scheaffer, R. L., W. Mendenhall III, R. L. Ott. 1996. Elementary survey sampling, 5th edition. Duxbury Press, Belmont, California.

Tabor, R., C. Luecke, and W. Wurtsbaugh. 1996. Effects of *Daphnia* availability on growth and food consumption of rainbow trout in two Utah reservoirs. North American Journal of Fisheries Management 16:591-599.

Tabor, R. A., and W. A. Wurtsbaugh. 1991. Predation risk and the importance of cover for juvenile rainbow trout in lentic systems. Transactions of the American Fisheries Society 120:728-738.

Teuscher, D. 1998. Hatchery trout evaluations. Job performance report. Grant F-73-R-21, Project 8, Subproject 2. Idaho Department of Fish and Game, Boise, Idaho.

Teuscher, D. 2001. Lake and reservoir research. Job performance report. Grant F-73-R-23 Project 5. Idaho Department of Fish and Game, Boise, Idaho.

Thiesfeld, S. L., J. C. Kern, A. R. Dale, M. W. Chilcote, and M. A. Buckman. 1999. Lake Billy Chinook sockeye salmon and kokanee research study 1996-1998. Oregon Department of Fish and Wildlife, Fish Division, Portland, Oregon.

Thorne, R. E. 1979. Hydroacoustic estimates of adult sockeye salmon *Oncorhynchus nerka* in Lake Washington, 1972-75. Journal of the Fisheries Research Board of Canada 36:1145-1149.

Thorne, R. E. 1983. Hydroacoustics. Pages 239-260 *in* L. A. Nielsen and D. L. Johnson, editors. Fisheries Techniques, 1st edition. American Fisheries Society, Bethesda, Maryland.

Unger, P. A., and S. B. Brandt. 1989. Seasonal and diel changes in sampling conditions for acoustic surveys of fish abundance in small lakes. Fisheries Research 7:353-366.

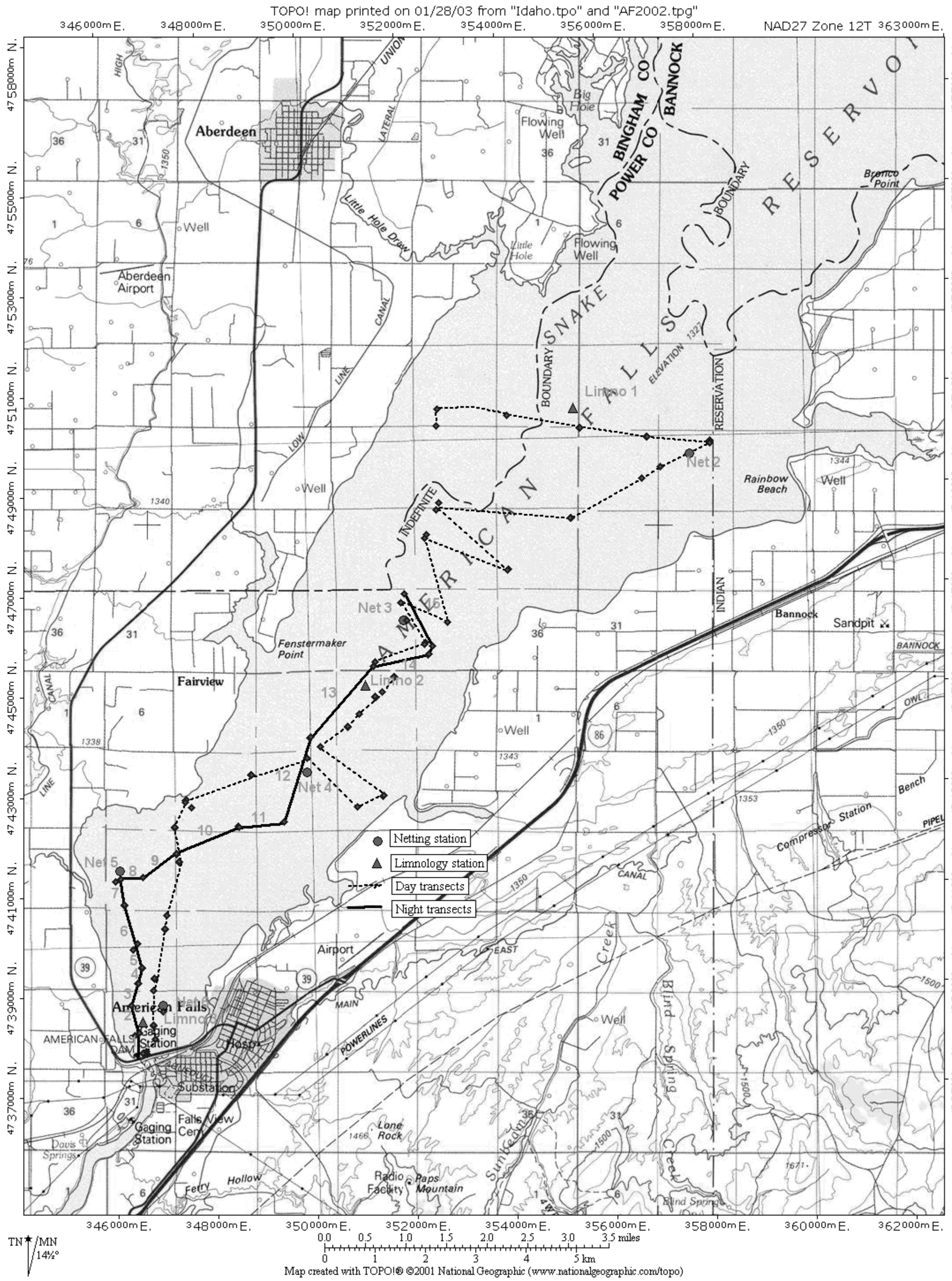
Wurtsbaugh, W. A., R. W. Brocksen, and C. R. Goldman. 1975. Food and distribution of underyearling brook and rainbow trout in Castle Lake, California. Transactions of the American Fisheries Society 104:88-95.

Yule D. L. 2000. Comparison of purse seine and horizontal acoustic estimates of trout densities and sizes in eleven Wyoming waters. North American Journal of Fisheries Management 20:759-775.

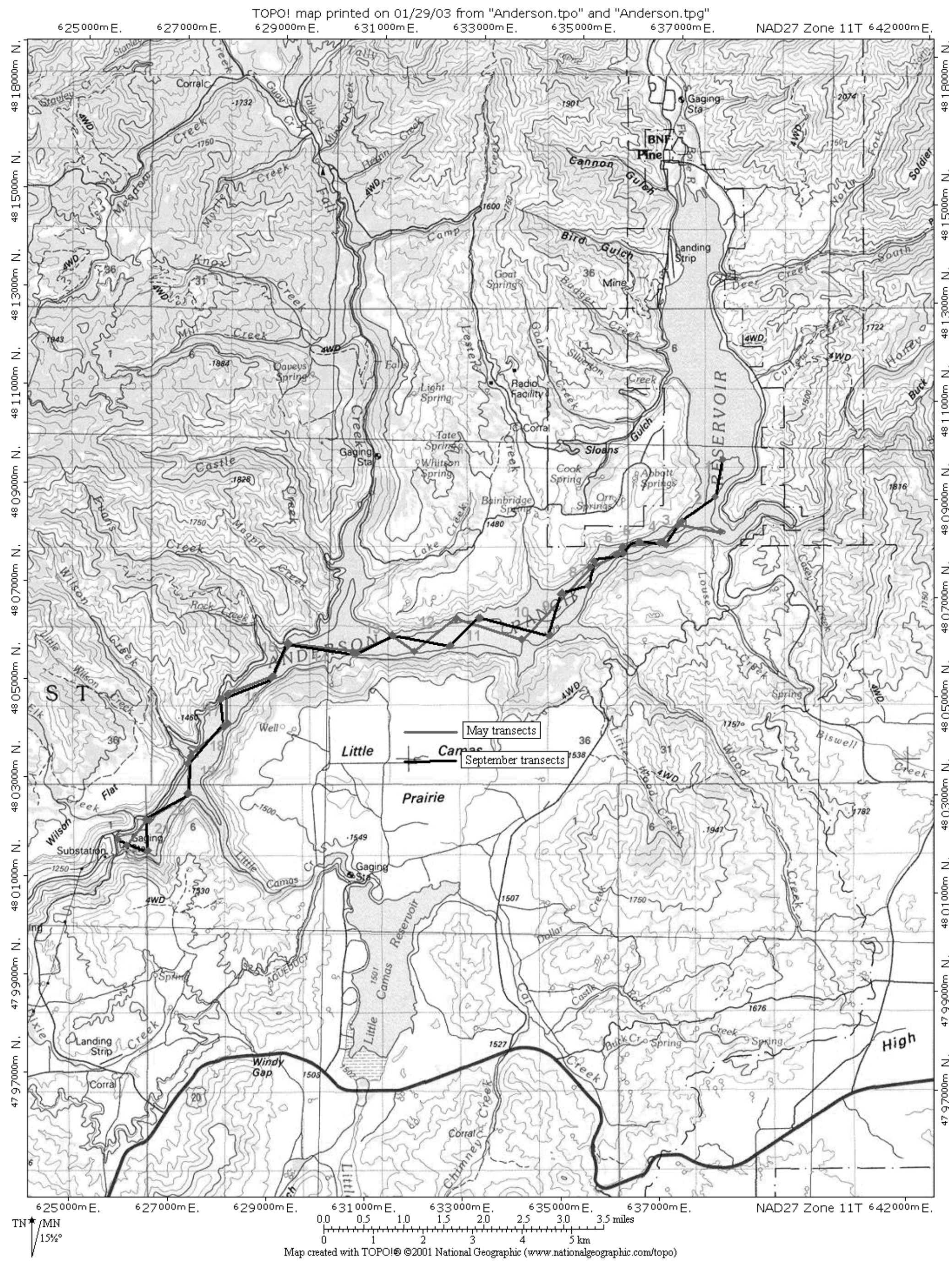
Yule, D., and R. Whaley. 2000. A simple nomograph to predict gill net catches of quality-size trout from stocking densities and zooplankton size-structure. Wyoming Game and Fish Department, Administrative report. Cheyenne, Wyoming.

APPENDICES

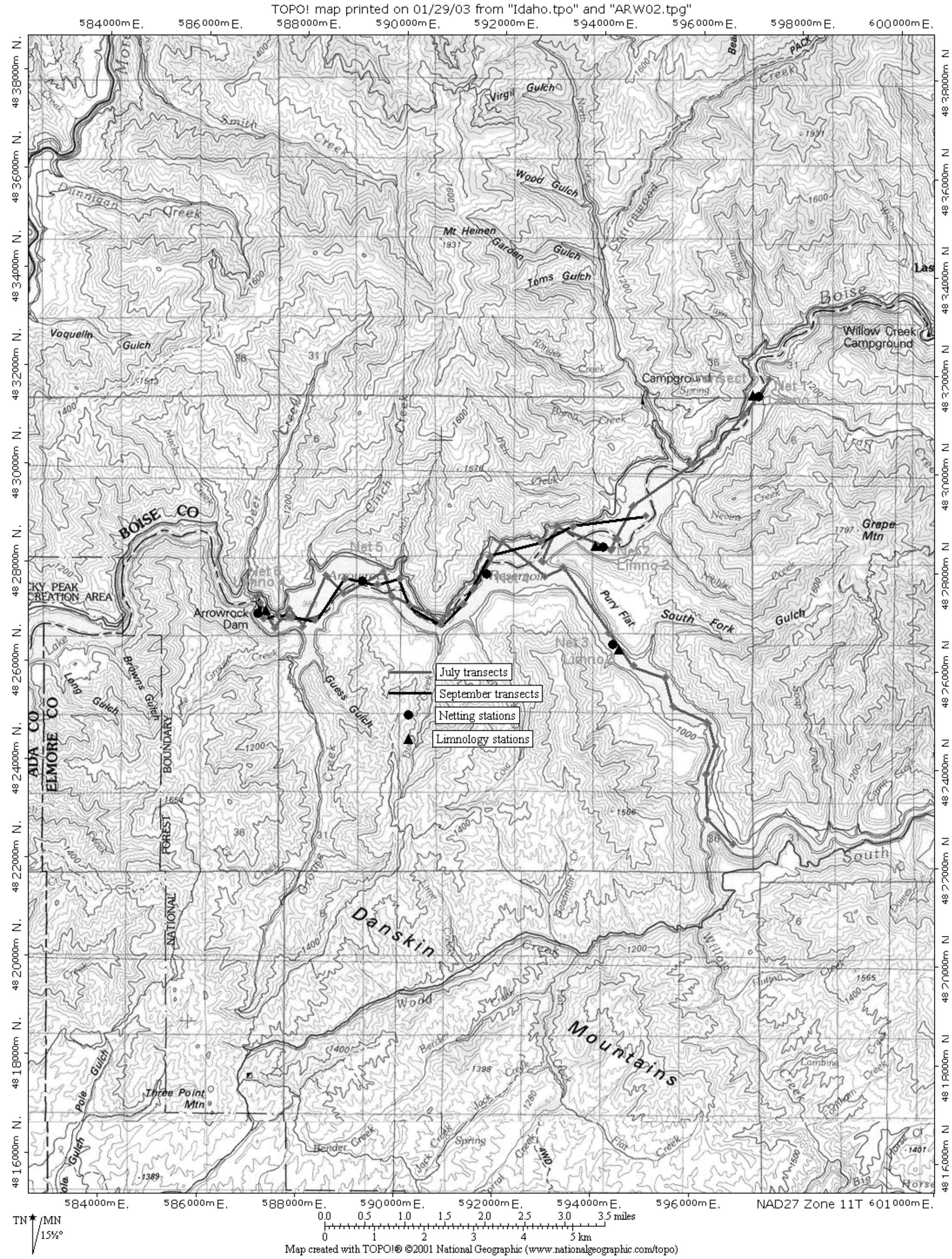
Appendix A. Hydroacoustic transects, netting sites, and limnology stations for the 2002 fish assessment survey at American Falls Reservoir.



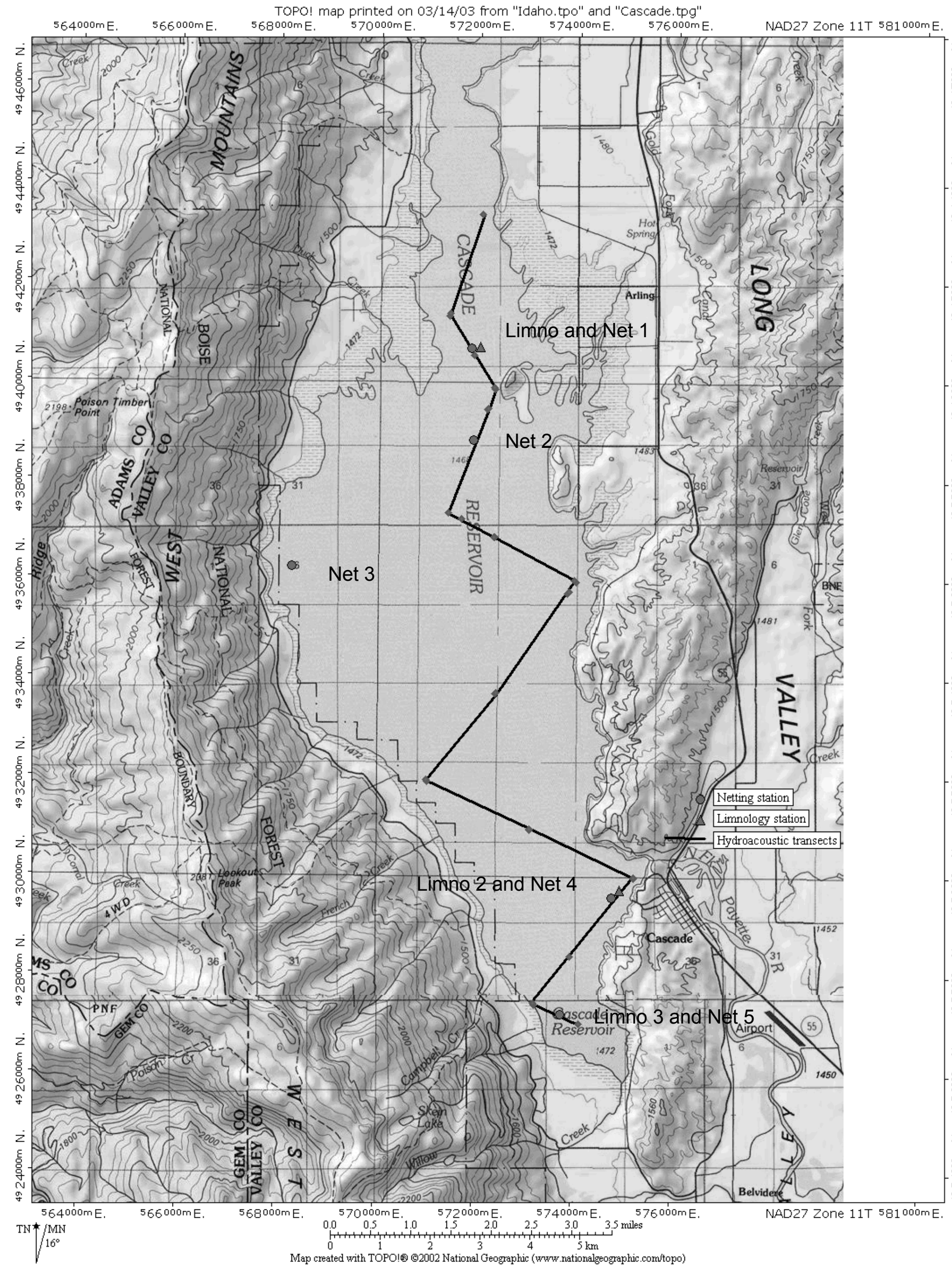
Appendix B. Hydroacoustic transects sampled in May and September 2002.



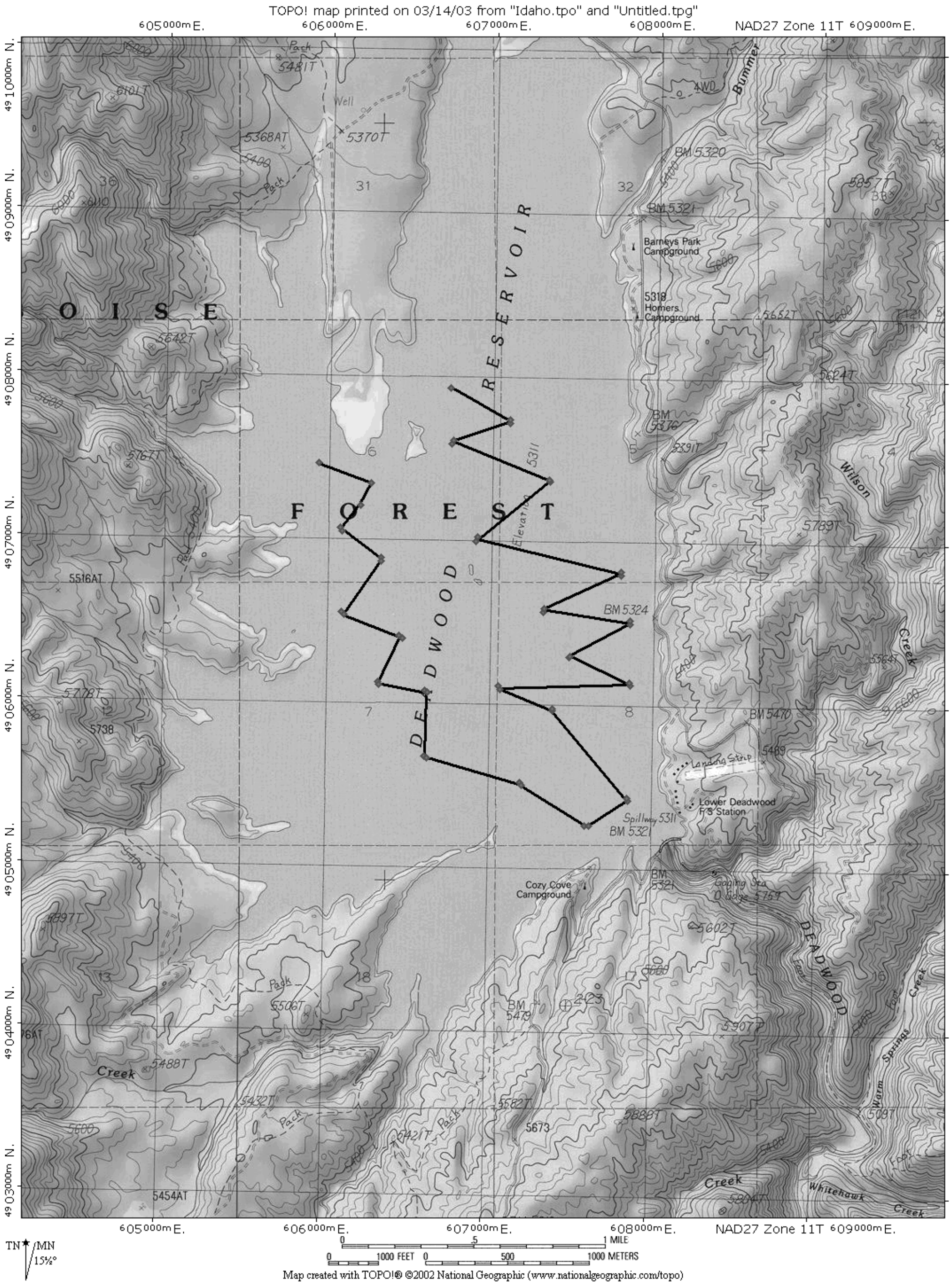
Appendix C. Hydroacoustic transects, netting sites, and limnology stations for the 2002 fish assessment surveys at Arrowrock Reservoir.



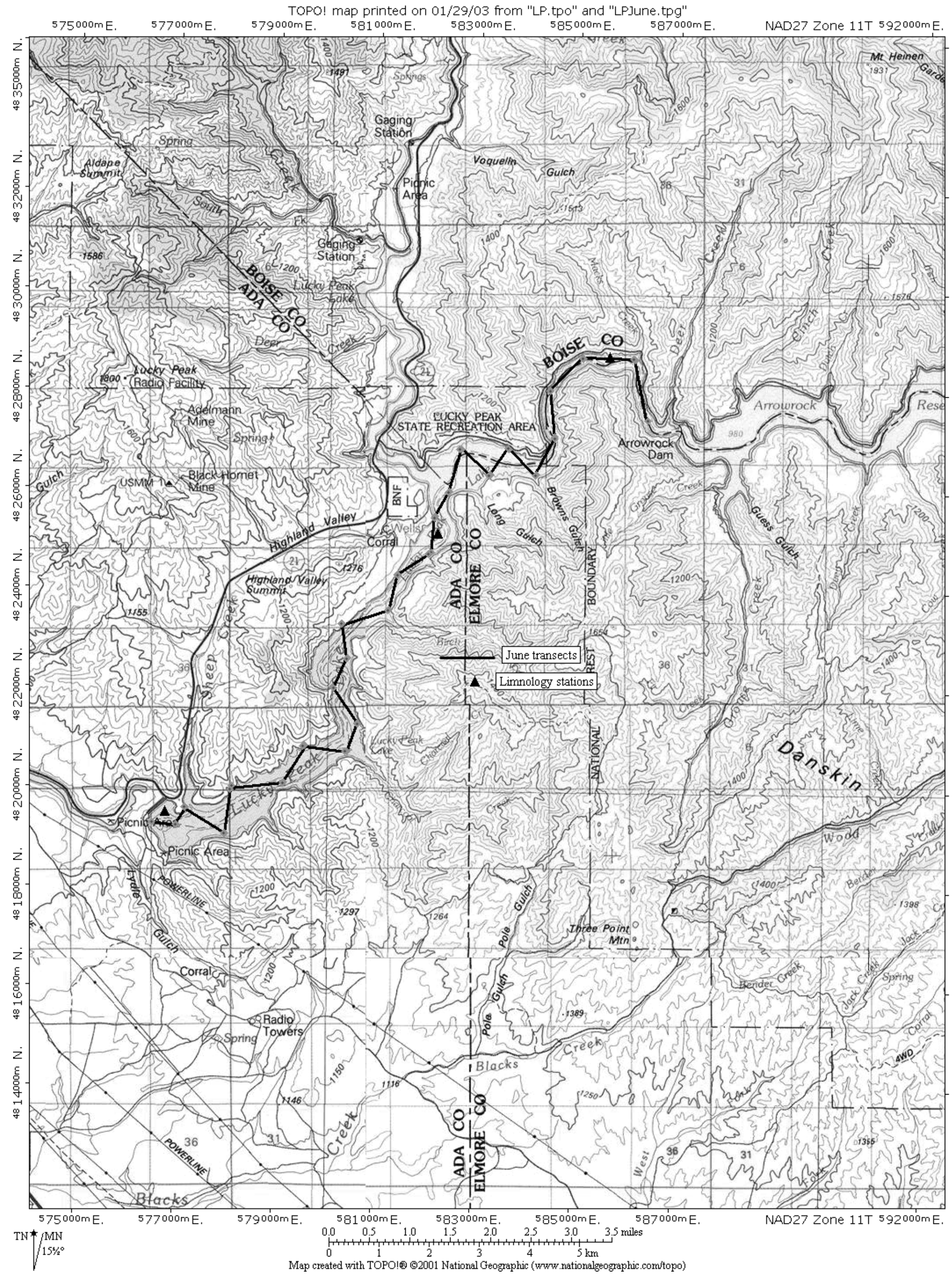
Appendix D. Hydroacoustic transects, netting sites, and limnology stations for the 2002 fish assessment survey at Cascade Reservoir.



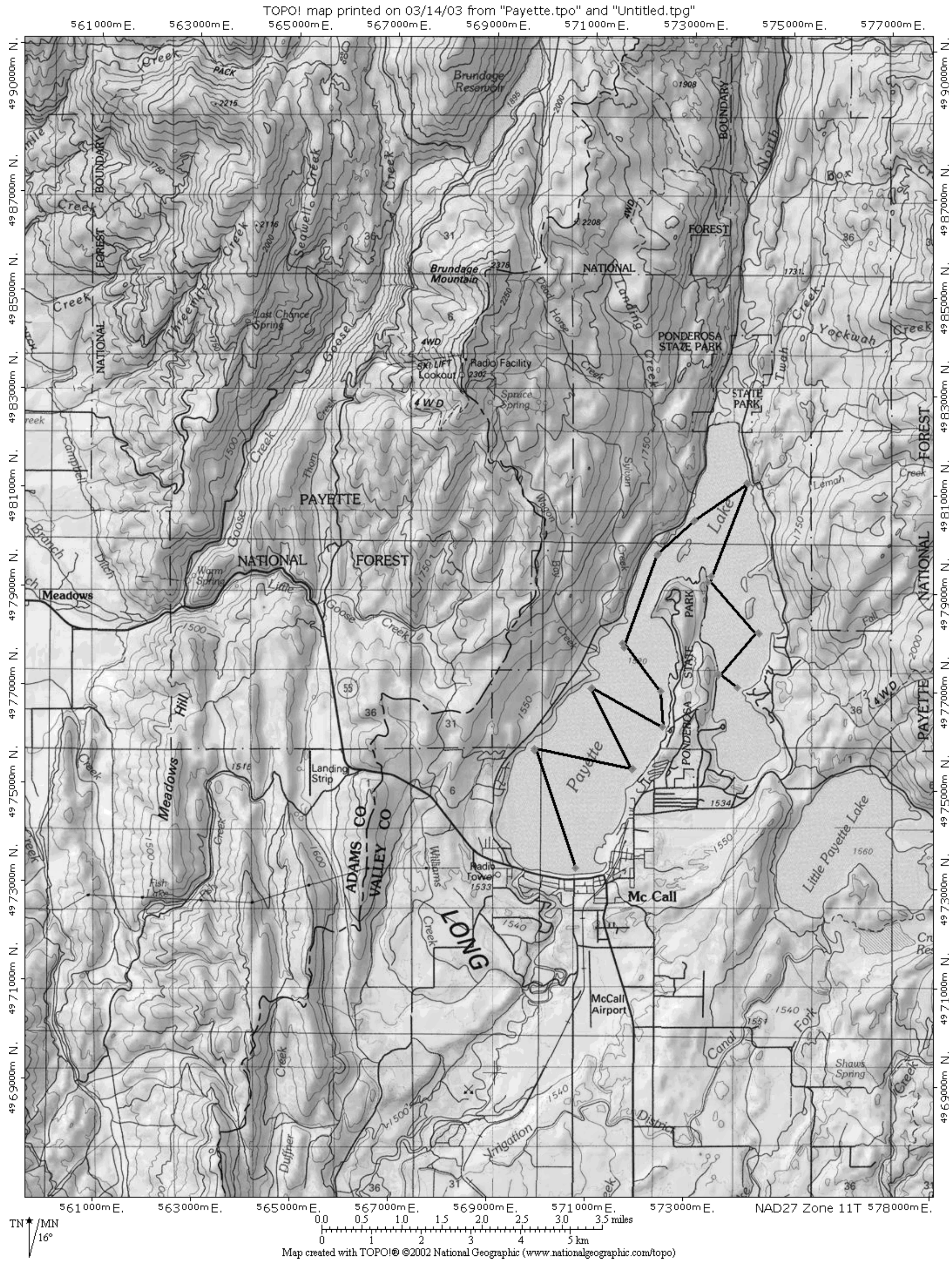
Appendix E. Hydroacoustic transects sampled at Deadwood Reservoir in September 2002.



Appendix F. Hydroacoustic transects and limnology stations sampled at Lucky Peak Reservoir in 2002.



Appendix G. Hydroacoustic transects sampled at Payette Lake 2002.



Prepared by:

Arthur E. Butts
Senior Fishery Research Biologist

Approved by:

IDAHO DEPARTMENT OF FISH AND GAME

Virgil K. Moore, Chief
Bureau of Fisheries

Daniel J. Schill
Fishery Research Manager