FISHERY RESEARCH

PROJECT 5—LAKE AND RESERVOIR RESEARCH

Grant F-73-R-27

Report Period July 1, 2005 to June 30, 2006

Arthur E. Butts
Senior Fishery Research Biologist

Patrick Kennedy
Fishery Technician

Kevin A. Meyer
Principal Fisheries Research Biologist

IDFG Report Number 07-13
March 2007

Annual Performance Report

July 1, 2005 to June 30, 2006

Grant #F-73-R-27

Project 5—Lake and Reservoir Research

Subproject 1: Hydroacoustic Evaluations
Subproject 2: Warmwater Fisheries Investigations
Subproject 3: Angler Exploitation Investigations

By

Arthur E. Butts
Senior Fishery Research Biologist

Patrick Kennedy
Fishery Technician

Kevin A. Meyer
Principal Fisheries Research Biologist

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

IDFG Report Number 07-13
March 2007

TABLE OF CONTENTS

Page

SUBPROJECT 1: HYDROACOUSTIC EVALUATIONS 1
ABSTRACT 1
INTRODUCTION 2
MANAGEMENT GOAL 3
OBJECTIVES 3
METHODS 3
Hydroacoustics 3
Target Verification 6
Limnology 7
RESULTS 8
Anderson Ranch Reservoir 8
Cascade Reservoir 9
Deadwood Reservoir 10
Payette Lake 11
DISCUSSION 11
ACKNOWLEDGEMENTS 13
LITERATURE CITED 14
APPENDICES 34
SUBPROJECT 2: WARMWATER FISHERIES INVESTIGATIONS 39
ABSTRACT 39
INTRODUCTION 40
MANAGEMENT GOAL 41
OBJECTIVES 42
METHODS 42
Larval Trawling 42
Fall Index Sampling 42
RESULTS 43
Larval Trawling 43
Fall Index Sampling 44
DISCUSSION 45
Larval Trawling 45
Fall Index Sampling 45
ACKNOWLEDGEMENTS 46
LITERATURE CITED 47
APPENDICES 59
SUBPROJECT 3: ANGLER EXPLOITATION EVALUATIONS 66
ABSTRACT 66
INTRODUCTION 67
MANAGEMENT GOAL 67
OBJECTIVES 67

Table of Contents, continued.

Page

METHODS 68
RESULTS 70
DISCUSSION 70
ACKNOWLEDGEMENTS 72
LITERATURE CITED 73

LIST OF TABLES

Table 1. Kokanee densities (fish/ha) per transect and total fish abundance estimates calculated using both the arithmetic and geometric mean densities at Anderson Ranch Reservoir in 2005. 17

Table 2. Mean biomass (g/m), zooplankton ration index (ZPR), and zooplankton quality index (ZQI) values for water bodies sampled during the 2005 field season. 17

Table 3. Fish densities (fish/ha) per transect and total fish abundance estimates calculated using both the arithmetic and geometric mean densities at Cascade Reservoir in 2005. 18

Table 4. Abundance estimates for individual species from data collected during the 2005 fish assessment survey at Cascade Reservoir. Abundance was estimated as the product of a species proportion from gillnetting data and the total abundance estimate from hydroacoustics. 19

Table 5. Fish densities (fish/ha) per transect and total fish abundance estimates calculated using both the geometric mean densities at Deadwood Reservoir in 2005. 20

Table 6. Fish densities (fish/ha) per transect and total fish abundance estimates calculated using both the arithmetic and geometric mean densities at Payette Lake in 2005. 21

Table 7. Surface water temperatures during larval and fall sampling at 2005 study waters. 49

Table 8. Mean biomass (g/m), zooplankton ration index (ZPR), and zooplankton quality index (ZQI) values for water bodies sampled during the 2005 field season. 50

Table 9. Electrofishing catch-per-unit-effort (CPUE) for various warmwater species at 2005 study sites. 51

Table 10. Trap net catch-per-unit-effort (CPUE) for various warmwater species at 2005 study sites. 51

List of Tables, continued.

Page

Table 11. Summary of tagging data for bass at four water bodies in 2005. 74

Table 12. Summary of tag loss and tag mortality data collected from smallmouth bass at CJ Strike Reservoir and largemouth bass at Bell Rapids Reservoir during 2005. 74

Table 13. Number of legally harvestable versus all smallmouth bass collected at CJ Strike Reservoir with three types of collection methods. 74

LIST OF FIGURES

Figure 1. Target strength (dB) distribution of fish tracked during the 2005 survey at Anderson Ranch Reservoir. 22

Figure 2. Vertical temperature (°C) and dissolved oxygen profiles (DO; mg/L) at three sites in Anderson Ranch Reservoir in 2005. 23

Figure 3. Trends in kokanee hydroacoustic abundance estimates at Anderson Ranch Reservoir during 2000-2005. 24

Figure 4. Target strength (dB) distribution of fish at Cascade Reservoir in 2005. 25

Figure 5. Length distributions of fish species caught in net curtains at Cascade Reservoir in 2005. 26

Figure 6. Vertical temperature (°C) and dissolved oxygen profiles (DO; mg/L) at three sites in Cascade Reservoir in 2005. 27

Figure 7. Abundance of northern pikeminnow as estimated by hydroacoustics and netting from 2002-2005 (upper panel), and of total fish and fish >250 mm from 2000-2005 (lower panel). 28

Figure 8. June and August target strength (dB) distribution of fish tracked during the 2005 survey at Deadwood Reservoir. 29

Figure 9. Vertical temperature (°C) and dissolved oxygen profiles (DO; mg/L) at three sites in Deadwood Reservoir in 2005. 30

Figure 10. Trends in hydroacoustic kokanee abundance from 2000-2005 at Deadwood Reservoir. 31

Figure 11. Length frequency (SL-mm) converted from target strength (dB) distribution of fish tracked during the 2005 survey at Payette Lake. 32

Figure 12. Trends in hydroacoustic kokanee abundance at Payette Lake from 2000-2005. 33

List of Figures, continued.

Page

Figure 13. Catch-per-unit-effort for larval fish at Brownlee Reservoir in 2005. 52

Figure 14. Catch-per-unit-effort for larval fish at CJ Strike Reservoir in 2005. 53

Figure 15. Catch-per-unit-effort for larval fish at Hauser Lake in 2005. 54

Figure 16. Catch-per-unit-effort for larval fish at Hayden Lake in 2005. 55

Figure 17. Catch-per-unit-effort for larval fish at Mann Lake in 2005. 56

Figure 18. Length frequency distribution for crappie species at 2005 sample sites. 57

Figure 19. Length frequency distribution for smallmouth bass at 2005 sample sites. 58

LIST OF APPENDICES

Appendix A. Hydroacoustic transects, and limnology stations for the 2005 fish assessment survey at Anderson Ranch Reservoir. 35

Appendix B. Hydroacoustic transects, netting sites, and limnology stations for the 2005 fish assessment survey at Cascade Reservoir. 36

Appendix C. Hydroacoustic transects, netting sites, and limnology stations for the 2005 fish assessment survey at Deadwood Reservoir. 37

Appendix D. Hydroacoustic transects, and limnology stations for the 2005 fish assessment survey at Payette Lake. 38

Appendix E1. Map of fixed larval netting sites on the upper portion of Brownlee Reservoir. 60

Appendix E2. Map of fixed larval netting sites on the lower portion of Brownlee Reservoir. 61

Appendix F. Map of fixed larval netting sites at CJ Strike Reservoir. 62

Appendix G. Map of fixed larval netting sites at Hauser Lake. 63

Appendix H. Map of fixed larval netting sites at Hayden Lake. 64

Appendix I. Map of fixed larval netting sites at Mann Lake. 65

ANNUAL PERFORMANCE REPORT
SUBPROJECT 1: HYDROACOUSTIC EVALUATIONS

State of: Idaho

Grant No.: F-73-R-27 Fishery Research

Project No.: 5

Title: Lake and Reservoir Research

Subproject #1: Hydroacoustic Evaluations

Contract Period: July 1, 2005 to June 30, 2006

ABSTRACT

Hydroacoustic technology was used to estimate pelagic fish abundance and size structure in Anderson Ranch Reservoir, Cascade Reservoir, Deadwood Reservoir, and Payette Lake. Intensive netting was conducted in concert with hydroacoustic surveys at Cascade Reservoir for species validation, which allowed for the estimation of abundance of individual species. Kokanee *Oncorhynchus nerka* abundance and cohort strength were estimated at Deadwood and Anderson Ranch reservoirs and Payette Lake. Limnological data were collected at sites along the trophic gradient at most water bodies to assist in the understanding of fish distributions. Results from work conducted this year revealed that in water bodies with diverse species assemblages, useful population assessments should be limited to the most abundant pelagic species because confidence intervals are too large for species that occur infrequently during netting efforts.

Author:

Arthur E. Butts
Senior Fishery Research Biologist

Patrick Kennedy
Fishery Technician

Kevin A. Meyer
Principal Fisheries 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).

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

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

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

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

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

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

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

MANAGEMENT GOAL

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

OBJECTIVES

1. Determine during the 2005 field season whether hydroacoustic methods can be used to produce useable population estimates in complex fish communities.

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

METHODS

Hydroacoustics

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

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

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

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

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

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

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

where F_w is weighted fish,
R is range, and
7.5° equals half the nominal transducer beam width.

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

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

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

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

where $s^2{}_x$ and $s^2{}_y$ are the variances of *x* and *y*, and

n_x and n_y is the sample size of each estimate.

The Bureau of Reclamation (BOR) provided surface area and volume data for most of the reservoirs sampled during 2005. When data was not available, surface area estimates were obtained using ARCVIEW software. Ninety percent confidence intervals were calculated for population estimates using the methods described in Scheaffer et al. (1996). Regardless of transect length, each transect was considered a sample unit.

Vertical depth distributions of tracked fish were calculated for most 2005 surveys after accounting for transducer depths. Downlooking depth distributions were calculated by simply summing the number of targets at each depth interval. Sidelooking vertical depths for each tracked fish were calculated using the following equation:

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

where F_d is fish depth (m),

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

R is range,

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

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

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

Target Verification

An array of net curtains was set at various depths in pelagic regions for target verification and species partitioning at Cascade Reservoir during the evening. Nets were set at various sites along hydroacoustic transects using GPS; sites were spaced longitudinally from inlet to outlet. During most net nights, two 49 m x 6 m net curtains were suspended at various intervals between depths covered by sinking and floating gillnets to ensure that the entire water column was sampled. Each net curtain consisted of 3 m long panels of different mesh arrays that were randomly placed. One net curtain was comprised of 19, 25, 32, 38, 51, 76, and 102 mm stretch mesh, while the other net was comprised of 51, 57, 64, 76, 89, 102, 127, and 152 mm stretch mesh. Each net curtain was considered an individual sampling unit during our analyses.

Because of netting restrictions that were in place in waters containing bull trout, the following procedure was implemented to minimize potential mortality at Arrowrock and Deadwood reservoirs: Two net curtains were set at dusk for one hour each at the beginning of each survey. When no bull trout were observed in catches, the full array of nets was set overnight.

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) was recorded. Total depth at each netting site was also recorded. In cases where fish lengths were converted to hydroacoustic target strengths or vice versa, total lengths were converted to standard lengths using species-specific conversion factors (Carlander 1969).

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

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

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

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

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

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

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

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

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

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

s_p^2 is calculated as follows:

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

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

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

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

$s^2(y)$ and $s^2(x)$ are the variances of $\overline{x}$ and $\overline{y}$, 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, it was assumed that $N = \infty$ in our estimates. We used the above formula to calculate the appropriate number of clusters that should be sampled for rainbow trout at American Falls Reservoir and rainbow trout and northern pikeminnow at Cascade Reservoir.

Limnology

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

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

RESULTS

Anderson Ranch Reservoir

Anderson Ranch Reservoir was surveyed during the evening of August 8, 2005. Twenty transects were sampled beginning near the inlet area and ending at the Anderson Ranch dam (Appendix A). Limnological data were also collected at three stations (Appendix A). Based on prior netting experience, all targets were considered kokanee *Oncorhynchus nerka*.

The majority of tracked fish were less than 100 mm long and older age classes were non-discernable from the length-frequency histogram (Figure 1). The modal size of tracked fish was -50 dB, which is approximately 55 mm using the Love (1971) equation and most fish occupied a layer between 35 and 45 meters.

The highest fish densities of all size classes were observed at the lower end of the reservoir, near the dam, in areas that contained deeper water. Densities of fish <100 mm, presumably age-0 kokanee, were much higher than densities of older fish. The geometric mean density of fish <100 mm was 983.3 (90% CIs 701.7 to 1,377.7) fish/ha, while fish between 100 mm and 200 mm was 262.0 (211.0 to 325.8) fish/ha, and fish >200 mm was 60.8 (47.6 to 77.4) fish/ha (Table 1). The overall mean fish density estimate for kokanee at Anderson Ranch Reservoir was 1,403.2 (1,047.6 to 1,879.3) fish/ha.

The overall population of kokanee at Anderson Ranch Reservoir was estimated to be 1,703,581 (1,271,890 to 2,281,652) in 2005 (Table 1). The population was comprised largely of age-0 fish, as 1,193,785 (851,925 to 1,672,632) fish were estimated, which is approximately ¾ of the total population. Meanwhile, we estimated 318,364 (256,214 to 395,520) fish that were 100-200 mm (age-1), and 73,770 (57,841 to 93,997) fish that were >200 mm.

Anderson Ranch Reservoir was thermally stratified during the August 2005 survey, with the thermocline occurring between 4 and 15 m (Figure 2). Water temperatures below 12°C were only available in the lower half of the reservoir where depths exceeded 30 m. Secchi depth increased by 1 meter, from 2 m at site 1, near the inlet, to 3.2 m at site 3, near the dam. Conversely, ZQI decreased 4 fold from the inlet area (2.4) to the dam area (0.6; Table 2). These results support the observed high densities of kokanee near the lower section of the reservoir.

We examined the annual late summer/early fall hydroacoustic estimates from Anderson Ranch Reservoir for the years 2000-2005 (Figure 3). The overall population estimate was highest in 2001, when numbers were close to 1.8 million fish and were at their lowest in 2002, when less than 500,000 fish were estimated. The numbers have increased since 2002 to over 1.7 million in 2005. The 2005 estimate of age-0 kokanee was the highest observed during the 6-year period, despite the lower number of adults as compared to previous years. This suggests that density-dependent factors may be influencing growth and survival of age-0 kokanee at Anderson Ranch Reservoir.

Cascade Reservoir

Cascade Reservoir was surveyed during the week of July 26, 2005. Ten standardized transects, beginning at the northern portion of the reservoir, were sampled with hydroacoustics and 12 net curtains were set at random sites throughout the reservoir (Appendix B). Limnological sampling was also conducted at three sites.

The majority of tracked fish were less than 100 mm long and older age classes were nondiscernable from the length-frequency histogram (Figure 4). The modal size of tracked fish was -54 dB, which is approximately 34 mm using the Love (1971) equation.

Fish density and population estimates were calculated for fish ≥250 mm as well as fish of all sizes. Fish densities of all size classes were highest in transects 1-5 and densities of fish >250 mm were low throughout the survey (Table 3). Fish density estimates for all sizes was highest below 6 m (downlooking), where 514.0 (311.5 to 847.7) fish/ha were estimated (Table 3). The total density estimate for all size classes of fish was 517.7 (313.8 to 853.7) fish/ha. For fish >250 mm, 5.1 (4.5 to 5.9) fish/ha were estimated in depths ≥6 m, while 1.7 (1.0 to 2.8) fish/ha were estimated in depths above 6m, resulting in a total density estimate of 7.5 (6.5 to 8.7) fish/ha. Expanding density estimates to abundance estimates, we estimated 75,510 (65,020 to 87,466) fish >250 mm and 5,217,098 (3,162,166 to 8,603,185) total fish abundance (Table 3).

Gillnet catches of fish >250 mm consisted primarily of rainbow trout *Oncorhynchus mykiss* (47% ± 11%), kokanee (21% ± 14%), largescale sucker *Catostomus macrocheilus* (18% ± 13%), and northern pikeminnow *Ptychocheilus oregonensis* (12% ± 9%; Figure 5). For catches of total fish, kokanee were most abundant (35% ± 21%), followed by yellow perch *Perca flavescens* (34% ± 25%), and rainbow trout (17% ± 11%). Rainbow trout ranged from 110-590 mm, with a mean total length of 388.8. Meanwhile, largescale suckers ranged from 358-600 mm ($\bar{x}$ = 523) and northern pikeminnow ranged from 180-560 mm ($\bar{x}$ =353.9).

In 2005, we estimated 890,219 (± 172,166) rainbow trout, where 35,409 (± 2,476) were >250 mm (Table 4). For northern pikeminnow, 258,785 (± 65,853) fish were estimated, of which 8,959 (± 2,113) were above 250 mm. Finally, 258,785 (± 103,623) largescale sucker were estimated, with 13,652 (± 2,979) fish >250 mm. The estimate for yellow perch <250 mm was 1,790,790 ± 382,027. Estimates for the less abundant fish species are located in Table 4.

Cascade Reservoir was thermally stratified throughout the reservoir during the survey. Water temperatures ranged from 25-12.7°C at the northern end of the reservoir and 24-8.2°C near the dam (Figure 6). In addition, zones of poorly oxygenated water existed near the bottom at all three sites where observed DO levels fell below 2 mg/L at depths >6m. ZQI increase from 3.8 at Station 1 to 6.5 at Station 3 (Table 2). These levels were among the highest measured at any reservoir in 2005 suggesting excellent forage for planktivores.

Hydroacoustic surveys have been conducted at Cascade Reservoir on an annual basis since 2000 (Figure 7). During this period, extensive removal efforts of northern pikeminnow and largescale sucker have also occurred. Hydroacoustic estimates were divided into two groups: fish >250 mm and all fish. While physical removal efforts were most productive at removing adult fish that were >250 mm, hydroacoustic estimates did not show significant reduction in estimates of this size group. Estimates of fish >250 mm were relatively low, ranging from a low of 4,258 in 2001 to 88,289 in 2003. However, between 2001 and 2005, a dramatic increase in the estimate of fish <250 mm was observed. In 2001, we estimated 46,572 fish, which increased 5,217,098 fish by 2004. Since the estimates of fish >250 mm were relatively stable during this period, this dramatic increase was comprised of primarily smaller fish.

Deadwood Reservoir

Deadwood Reservoir was sampled twice with hydroacoustics on July 5, 2005 and on August 3, 2005. Seventeen transects were sampled with hydroacoustics during both months (Appendix C). Limnological data were collected during both sampling events to assess forage availability and environmental conditions.

Differences in target strength distributions between the two surveys were observed (Figure 8). Fish ≤100 mm displayed a pronounced increase in August as a result of kokanee stocking, natural recruitment of age-0 kokanee, and thermal stratification causing kokanee to reside in deeper waters where they were more detectable to sonar gear.

Density of age-0 kokanee (fish <100 mm) increased from 338.8 (293.6 to 391.1) fish/ha in July to 747.6 (635.9 to 878.8) fish/ha in August (Table 5). Other size classes increased in density between the two time periods, albeit less substantially. The total density estimate for all size classes was estimated to be 1,365.1 (1,176.5 to 1,583.8) in August.

We estimated the total abundance of kokanee to be 1,822,344 (1,570,655 to 2,114,331), of which 55% or 997,995 (848,937 to 1,173,183) were age-0 kokanee (Table 5). Fish that were between 100 and 200 mm were estimated at 454,832 (375,973 to 550,174) and kokanee >200 mm were at 313,157 (266,673 to 367,703).

Limnological data were collected at two sites in July and three sites in August. The reservoir had thermally stratified by July and the epilimnion had warmed and deepened by August (Figure 9). ZQI levels were high at both sites in July and dramatically decreased to levels where resource competition was evident by the August sampling period (Table 2). ZQI varied between sites and was highest at sites 1 and 3 during the August sampling period. Secchi transparencies increased by at least a meter from July to August at sites 1 and 2.

The kokanee population at Deadwood Reservoir has been monitored with hydroacoustics since 2000, with the exception of 2001 (Figure 10). Total abundance estimates were lower in 2000 and 2002 where the estimates were below 225,000 but have since surpassed 1.8 million in 2005. The increase has been noticeable in all size groups of fish and has likely been a result, in part, of stocking efforts from 2001-2005.

Payette Lake

Payette Lake was surveyed with hydroacoustics on August 3, 2005 to continue annual efforts to monitor kokanee abundance. Twelve transects were surveyed beginning in the east arm, traveling north and around Cougar Island, and south towards the boat ramp (Appendix D). Limnological data were not collected at Payette Lake in 2005. Fish were not collected for target verification or age information.

Age-0 kokanee were discernible from the target strength distribution and additional size classes were separated using the same criteria as previous surveys conducted in 2000 (Teuscher 2001). Age-0 kokanee were identified as fish <-49 dB (77 mm), age-1 kokanee were fish between –49 dB and –42 dB (78 mm to 184 mm), and age-2+ fish were identified as fish between –41 dB and –33 dB (185 mm to 568 mm). All pelagic targets that fell within –49 dB and –33 dB were assumed to be kokanee (Figure 11).

Numbers of kokanee tracked varied across transects (Table 6). The highest overall density of kokanee was observed in transect 15 (634.9 fish/ha), which also had the highest densities of age-0 (479.6 fish/ha) and age-1 (88.4 fish/ha) fish. Age-0 kokanee had the highest observed densities with a mean of 160.3 (127.0 to 202.2) fish/ha. The total density for all age classes of kokanee was 248.3 (200.9 to 306.8) fish/ha.

Population estimates were calculated for three size groups of kokanee along with total overall kokanee abundance (Table 6). We estimated 346,202 (262,523 to 436,640) age-0 kokanee, 63,644 (47,288 to 85,409) age-1 kokanee, and 93,444 (78,154 to 111,644) age-2+ kokanee. The estimate of total abundance for all age classes was 536,226 (433,857 to 662,629) fish.

Since 2000, the kokanee population has stayed relatively stable aside from a large year class of age-0 kokanee in 2003 (Figure 12). Age-1 and age-2 year classes, in particular, have shown little variation between years. Estimates of total kokanee abundance were not significantly different from one another but mean abundance reached it lowest value of 270,468 in 2002 and its highest value of 536,226 in 2005.

DISCUSSION

Five hydroacoustic surveys in four water bodies were conducted in 2005. This reduction in surveys in comparison to previous years was a result of both the 2004 completion of the BOR contract and the project emphasis shifting to warmwater research. However, the surveys that took place in 2005 play an extremely important role in the management of each fishery. The surveys at Anderson Ranch Reservoir, Deadwood Reservoir, and Payette Lake provide important trend information on the kokanee fishery in each water. In all cases as the trend information continues to build, we will have better predictive ability in terms of estimating spawning run sizes or determining when supplementing year classes may be necessary. At Deadwood Reservoir, weirs are placed in the major spawning tributaries for both taking eggs and eliminating spawners to reduce the number of fry migrating into the reservoir in spring. The goal is to achieve a balance between fish size and number in the creel and adequate numbers of eggs to supply the state hatchery system with kokanee fingerlings each year. The hydroacoustic estimates should hopefully provide a tool for regional managers to assess whether efforts such as spawner removal tributaries are needed prior to each spawning run.

Cascade Reservoir illustrates another example of where hydroacoustics will continue to provide a valuable tool for managers as an index for relative abundance of yellow perch, northern pikeminnow and rainbow trout. Despite the diverse species assemblage, IDFG has developed a survey that includes hydroacoustics and intensive netting efforts to reliably estimate relative abundance for these various species (Butts and Nelson 2004; Butts 2003). Regional mangers in McCall plan to use this annual survey to determine when efforts to remove northern pikeminnow by merwin traps and rotenone are necessary. The use of hydroacoustics to track these populations has proved to provide managers with a reliable and more economically feasible alternative than traditional methods such as mark-recapture methods or gill netting alone.

Overall, the success of hydroacoustics to obtain fishery population estimates has been good during 2005. A great deal has been learned over the past four years in regards to our ability to partition hydroacoustic estimates into estimates of individual species using gillnets for species verification and reduce the inherent variation. As illustrated by the Cascade Reservoir surveys from 2000 to 2005, hydroacoustics can provide a reasonable and stable population estimate for an individual species in water bodies with complex species assemblages with a few caveats: 1) the target specie(s) must utilize pelagic habitats and not be limited to the benthic region, 2) biologists should have some understanding of the biology and behavior of the target specie(s), 3) intensive fish collection efforts are crucial to obtaining reliable estimates of species proportions and the number of nets that are deployed should be based on the desired error bound for a proportion, 4) surveys that are repeated during different seasons are extremely helpful in determining the appropriate timing for the optimal population estimate, and finally 5) as with trend netting, every effort should be made to conduct future surveys during the same seasonal or environmental period as previous surveys so that behavioral biases are minimized. The costs in terms of time and labor can be high because of the required fish collection efforts. Therefore, the benefits and value of a survey should be carefully evaluated before deciding to proceed. However, in comparison to other methods such as creel censuses or mark-recapture methods, hydroacoustics is a cost efficient alternative. The question as to whether these proposed methods under- or overestimate actual species abundance is likely irrelevant as long as they continue to provide a stable relative population estimate, which offers many of the same advantages as an absolute estimate (Thorne 1983; Yule 2000).

ACKNOWLEDGEMENTS

We would like to thank Nick Sawyer for his role in collecting all data. We also thank Chris Sullivan, Liz Mamer, Andy Knight, Sarah Nelson, Steve Elle, and other IDFG personnel for their assistance in the field and laboratory. Ryan Hedrick, a hydrologist for U.S. Bureau of Reclamation, provided surface area and lake volume estimates for all of the waters surveyed. Cheryl Leben did an outstanding job of formatting the report. The U.S. Bureau of Reclamation provided funding for the sonar system.

LITERATURE CITED

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 Fisheries 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.

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.

Butts, A. E. 2004. Lake and reservoir research. Job performance report. Grant F-73-R-25 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.

Elliott, J. M. 1983. Some methods for the statistical analysis of samples of benthic invertebrates. Freshwater Biological Association Scientific Publication 25.

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.

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, and 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.

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, and R. L. Ott. 1996. Elementary survey sampling, 5^{th} edition. Duxbury Press. Belmont, California.

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.

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.

Table 1. Kokanee densities (fish/ha) per transect and total fish abundance estimates calculated using both the arithmetic and geometric mean densities at Anderson Ranch Reservoir in 2005.

		Fish densities (number / ha)			
Transect	**Transect length (m)**	**<100 mm**	**100 mm-200 mm**	**>200 mm**	**Total**
1	1,097	308.5	253.4	107.7	669.7
2	1,042	386.4	295.2	106.2	787.8
3	538	370.0	322.2	76.7	768.9
4	1,022	450.8	266.1	56.5	773.4
5	767	394.7	148.4	43.0	586.0
6	1,226	135.5	68.1	21.6	225.2
7	1,263	206.8	64.0	19.2	289.9
8	1,447	763.1	281.0	60.4	1,104.5
9	1,003	568.8	275.3	37.3	881.3
10	732	562.3	204.6	16.9	783.8
11	762	781.2	485.9	39.2	1,306.4
12	430	5,677.0	2,305.1	719.6	8,701.6
13	987	901.5	243.7	32.8	1,178.0
14	659	2,797.9	291.3	60.4	3,149.6
15	1,087	4,096.3	323.3	59.8	4,479.4
16	636	4,992.3	396.0	79.0	5,467.3
17	1,068	2,095.2	176.4	60.1	2,331.7
18	766	3,193.6	170.9	50.9	3,415.4
19	1,250	2,257.7	229.8	115.6	2,603.0
20	416	3,793.1	500.3	135.9	4,429.3
	Arithmetic Mean (AM)	**1,736.6**	**365.0**	**94.9**	**2,196.6**
	90% CI (AM)	**518.0**	**138.3**	**44.3**	**643.6**
	Abundance (AM)	**2,108,413**	**443,201**	**115,266**	**2,666,881**
		± 628,838	**± 167,967**	**± 53,803**	**± 781,355**
	Geometric Mean (GM)	**983.3**	**262.2**	**60.8**	**1,403.2**
	90% CI (GM)	**701.7 to 1,377.7**	**211.0 to 325.8**	**47.6 to 77.4**	**1,047.6 to 1,879.3**
	Abundance (GM)	**1,193,785**	**318,364**	**73,770**	**1,703,581**
		851,925 to 1,672,632	**256,214 to 395,520**	**57,841 to 93,997**	**1,271,890 to 2,281,652**

Table 2. Mean biomass (g/m), zooplankton ration index (ZPR), and zooplankton quality index (ZQI) values for water bodies sampled during the 2005 field season.

			Mean biomass (g/m)			ZPR	ZQI
Water	**Date**	**Station**	**153 um**	**500 um**	**750 um**	**750 um / 500 um**	**(750 um + 500 um) ZPR**
Anderson Ranch Reservoir	8/8/2005	ARLIM1	3.03	2.43	1.48	0.61	2.38
Anderson Ranch Reservoir		ARLIM3	2.34	1.47	0.43	0.29	0.56
Cascade Reservoir	7/26/2005	CALIM1	5.16	3.08	2.21	0.72	3.80
Cascade Reservoir		CALIM2	1.91	0.17	0.4	2.35	1.34
Cascade Reservoir	7/27/2005	CALIM3	5.21	3.58	3.34	0.93	6.46
Deadwood Reservoir	7/6/2005	DWLIM1	3.41	3.78	1.7	0.45	2.46
Deadwood Reservoir		DWLIM2	1.45	2.79	3.26	1.17	7.07
Deadwood Reservoir	8/3/2005	DWLIM1	1.15	0.4	0.09	0.23	0.11
Deadwood Reservoir		DWLIM2	1.95	1.01	0.09	0.09	0.10
Deadwood Reservoir	8/4/2005	DWLIM3	1.24	0.29	0.04	0.14	0.05

Table 3. Fish densities (fish/ha) per transect and total fish abundance estimates calculated using both the arithmetic and geometric mean densities at Cascade Reservoir in 2005.

A. Fish>250

		Fish densities (number / ha)		
Transect	Transect length (m)	Sidelooking (0-6 m)	Downlooking (>6 m)	Total
1	2,452	9.2	3.1	12.4
2	2,567	3.8	5.0	8.7
3	3,031	4.2	5.6	9.8
4	3,090	2.1	6.3	8.5
5	3,068	0.7	7.9	8.6
6	2,760	2.1	6.2	8.4
7	2,728	0.0	5.1	5.1
8	3,016	0.2	7.1	7.3
9	2,797	2.4	3.5	6.0
10	3,089	0.2	3.4	3.6
	Geometric Mean (GM)	**1.7**	**5.1**	**7.5**
	90% CI (GM)	**1.0 to 2.8**	**4.5 to 5.9**	**6.5 to 8.7**
	Abundance (GM)	**17,326**	**51,768**	**75,510**
		9,816 to 27,671	**45,102 to 59,238**	**65,020 to 87,466**

B. All fish.

		Fish densities (number / hectare)		
Transect	Transect length (m)	Sidelooking (0-6m)	Downlooking (>6m)	Total
1	2,452	17.3	1,260.9	1278.2
2	2,567	10.7	944.1	954.8
3	3,031	11.7	1,038.1	1049.8
4	3,090	2.5	1,415.3	1417.7
5	3,068	1.2	1,864.8	1866.0
6	2,760	2.1	189.9	192.0
7	2,728	0.0	61.5	61.5
8	3,016	0.5	217.0	217.5
9	2,797	3.2	159.9	163.1
10	3,089	1.3	956.5	957.9
	Geometric Mean (GM)	**3.0**	**514.0**	**517.7**
	90 % CI (GM)	**1.6 to 5.0**	**311.5 to 847.7**	**313.8 to 853.7**
	Abundance (GM)	**29,820**	**5,179,258**	**5,217,098**
		16,284 to 50,307	**3,138,571 to 8,542,546**	**3,162,166 to 8,603,185**

Table 4. Abundance estimates for individual species from data collected during the 2005 fish assessment survey at Cascade Reservoir. Abundance was estimated as the product of a species proportion from gillnetting data and the total abundance estimate from hydroacoustics.

A. Fish > 250 mm.

Species	Proportion ± 90% CI	Abundance	90% CI
Northern pikeminnow	0.12 ± 0.09	8,959	2,113
Largescale sucker	0.18 ± 0.13	13,652	2,979
Rainbow trout	0.47 ± 0.11	35,409	2,476
Kokanee	0.21 ± 0.14	15,785	3,051
Mountain whitefish	0.01 ± 0.02	427	231
Yellow Perch	0.01 ± 0.01	427	239

B. All fish.

Species	Proportion ± 90% CI	Abundance	90% CI
Northern pikeminnow	0.05 ± 0.04	258,785	65,853
Largescale sucker	0.06 ± 0.07	331,244	103,623
Rainbow trout	0.17 ± 0.11	890,219	172,166
Kokanee	0.35 ± 0.21	1,821,844	321,117
Coho Salmon	0.01 ± 0.02	62,108	27,683
Yellow Perch	0.34 ± 0.25	1,790,790	382,027

Table 5. Fish densities (fish/ha) per transect and total fish abundance estimates calculated using both the geometric mean densities at Deadwood Reservoir in 2005.

July 2005 Estimates

		Fish densities (number / ha)			
Transect	**Transect length (m)**	**<100 mm**	**100 mm-200 mm**	**>200 mm**	**Total**
1	547	200.6	149.9	180.1	530.6
2	531	900.9	739.5	476.0	2116.4
3	535	360.2	127.5	46.5	534.2
4	508	280.7	156.1	47.0	483.8
5	502	244.8	111.3	56.3	412.4
6	532	267.0	134.3	92.8	494.2
7	352	342.9	177.2	102.7	622.9
8	550	264.8	181.1	50.3	496.2
9	506	273.0	67.5	69.0	409.5
10	508	495.9	57.7	18.0	571.6
11	495	822.4	218.2	59.6	1100.1
12	476	499.6	194.4	61.3	755.2
13	518	291.2	162.5	47.6	501.3
14	493	367.1	199.2	100.4	666.7
15	491	260.3	186.7	83.7	530.7
16	532	357.4	144.3	56.6	558.3
17	463	169.6	56.3	101.0	326.9
	Geometric Mean (GM)	**338.8**	**150.0**	**73.6**	**586.6**
	90% CI (GM)	**293.6 to 391.1**	**123.2 to 180.0**	**59.0 to 91.8**	**512.1 to 671.9**
	Abundance (GM)	**479,778**	**210,923**	**104,267**	**830,634**
		415,664 to 553,747	**174,514 to 254,865**	**83,555 to 130,027**	**725,125 to 951,466**

August 2005 Estimates

		Fish densities (number / ha)			
Transect	**Transect length (m)**	**<100 mm**	**100 mm-200 mm**	**>200 mm**	**Total**
1	530	1337.7	228.5	185.0	1751.2
2	536	1048.3	657.9	330.9	2037.1
3	551	525.6	464.8	304.1	1294.5
4	492	304.7	95.7	105.4	505.7
5	355	631.4	303.2	202.4	1137.0
6	556	1109.3	640.5	535.4	2285.3
7	511	448.1	302.7	207.3	958.1
8	523	965.4	514.8	300.3	1780.5
9	441	1614.6	217.7	150.0	1982.3
10	433	1204.4	649.8	203.7	2057.9
11	522	477.6	295.8	198.0	971.4
12	552	298.9	149.4	129.5	577.8
13	466	664.6	396.5	370.1	1431.2
14	276	1133.9	743.1	344.2	2221.1
15	120	1038.5	458.2	464.3	1961.0
16	501	755.2	432.0	334.8	1522.0
17	507	635.0	150.8	95.2	881.0
	Geometric Mean (GM)	**747.6**	**340.7**	**234.6**	**1365.1**
	90% CI (GM)	**635.9 to 878.8**	**281.6 to 412.1**	**199.8 to 275.4**	**1,176.5 to 1,583.8**
	Abundance (GM)	**997,995**	**454,832**	**313,157**	**1,822,344**
		848,937 to 1,173,183	**375,973 to 550,174**	**266,673 to 367,703**	**1,570,655 to 2,114,331**

Table 6. Fish densities (fish/ha) per transect and total fish abundance estimates calculated using both the arithmetic and geometric mean densities at Payette Lake in 2005.

		Fish densities (number / ha)			
Transect	**Transect length (m)**	**Age-0**	**Age-1**	**Age-2+**	**Total**
1	1,558	213.0	9.8	21.0	243.8
2	781	78.4	27.8	32.9	139.2
3	664	258.9	86.7	23.8	369.4
4	1,434	269.4	43.7	51.5	364.7
5	922	163.4	42.0	40.2	245.7
6	1,483	441.0	49.4	52.2	542.6
7	1,418	112.5	7.4	24.8	144.8
8	1,602	95.5	19.1	45.7	160.3
9	527	39.7	14.8	48.6	103.2
10	1,727	146.9	26.3	61.8	235.0
11	1,752	111.5	35.9	102.7	250.0
12	1,595	479.6	88.4	67.0	634.9
	Arithmetic Mean (AM)	**200.8**	**37.6**	**47.7**	**286.1**
	90% CI (AM)	**53.4**	**10.3**	**8.7**	**62.9**
	Abundance (AM)	**433,785**	**81,246**	**103,002**	**618,034**
		± 115,378	**± 22,157**	**± 18,769**	**± 135,791**
	Geometric Mean (GM)	**160.3**	**29.5**	**43.3**	**248.3**
	90% CI (GM)	**127.0 to 202.2**	**23.0 to 37.7**	**37.2 to 50.2**	**200.9 to 306.8**
	Abundance (GM)	**346,202**	**63,644**	**93,444**	**536,226**
		262,523 to 436,640	**47,288 to 85,409**	**78,154 to 111,644**	**433,857 to 662,629**

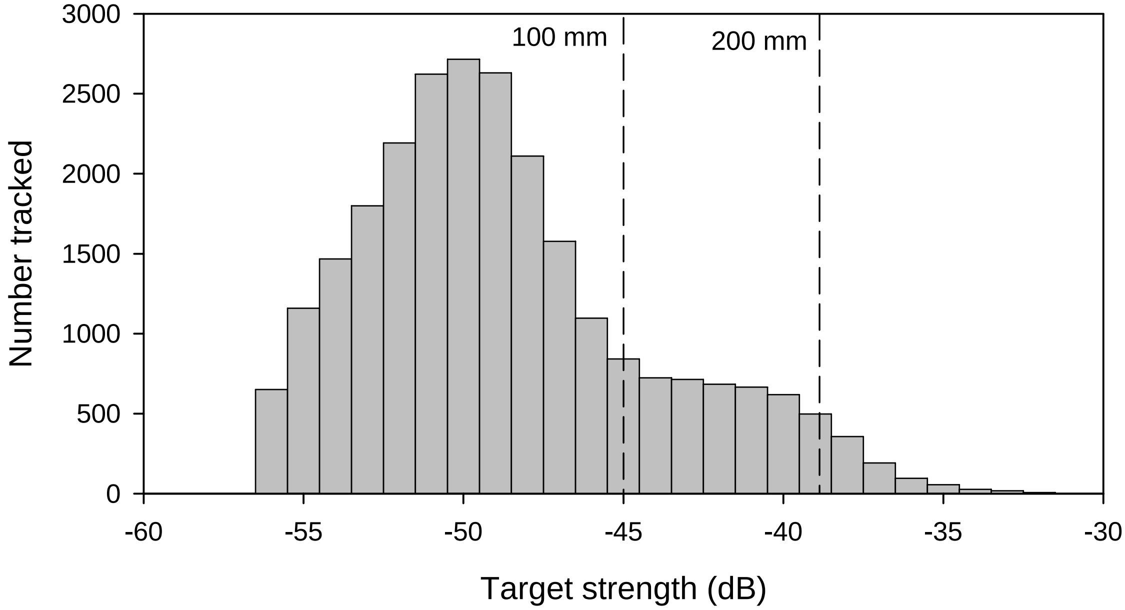


Figure 1. Target strength (dB) distribution of fish tracked during the 2005 survey at Anderson Ranch Reservoir.

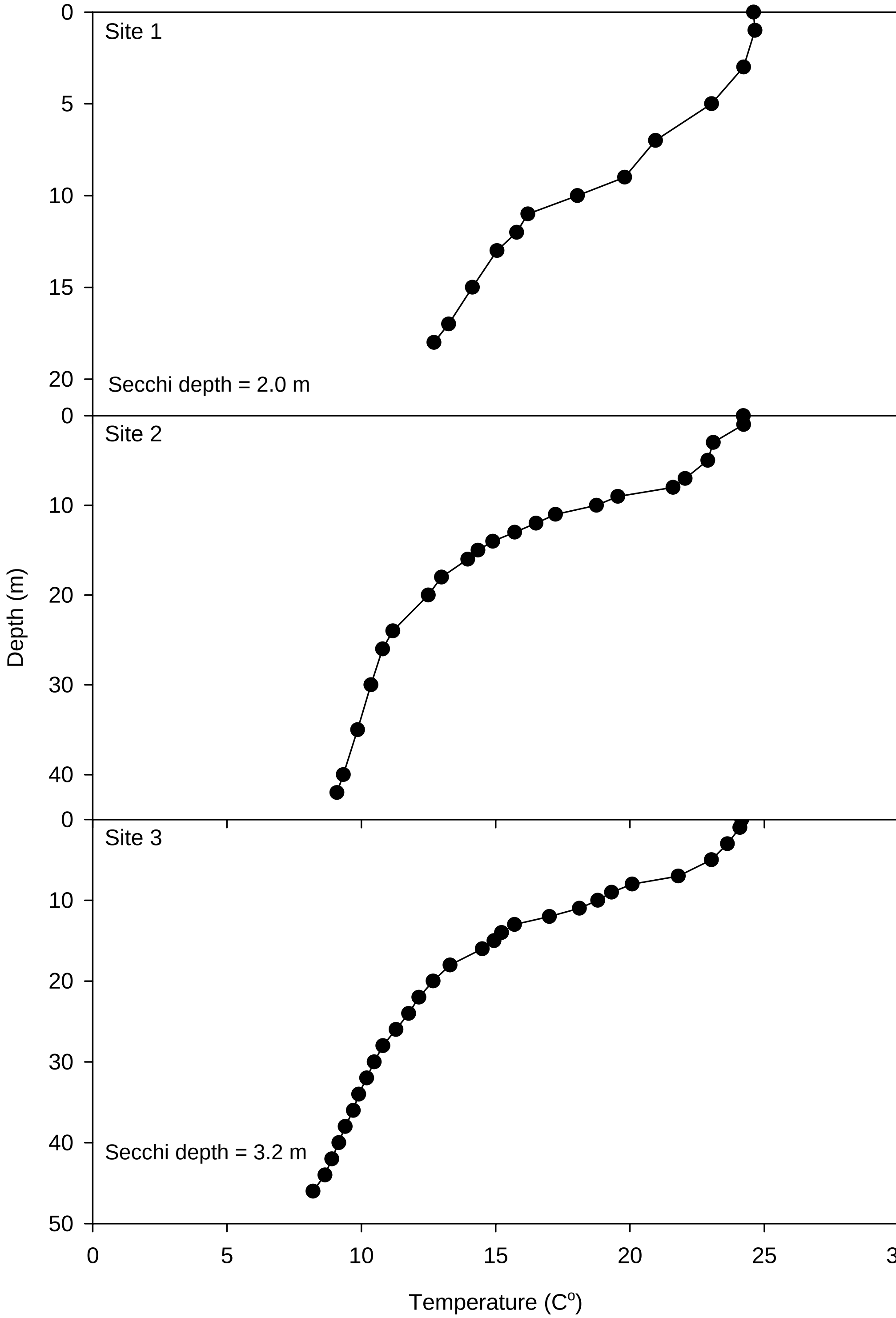


Figure 2. Vertical temperature (°C) and dissolved oxygen profiles (DO; mg/L) at three sites in Anderson Ranch Reservoir in 2005.

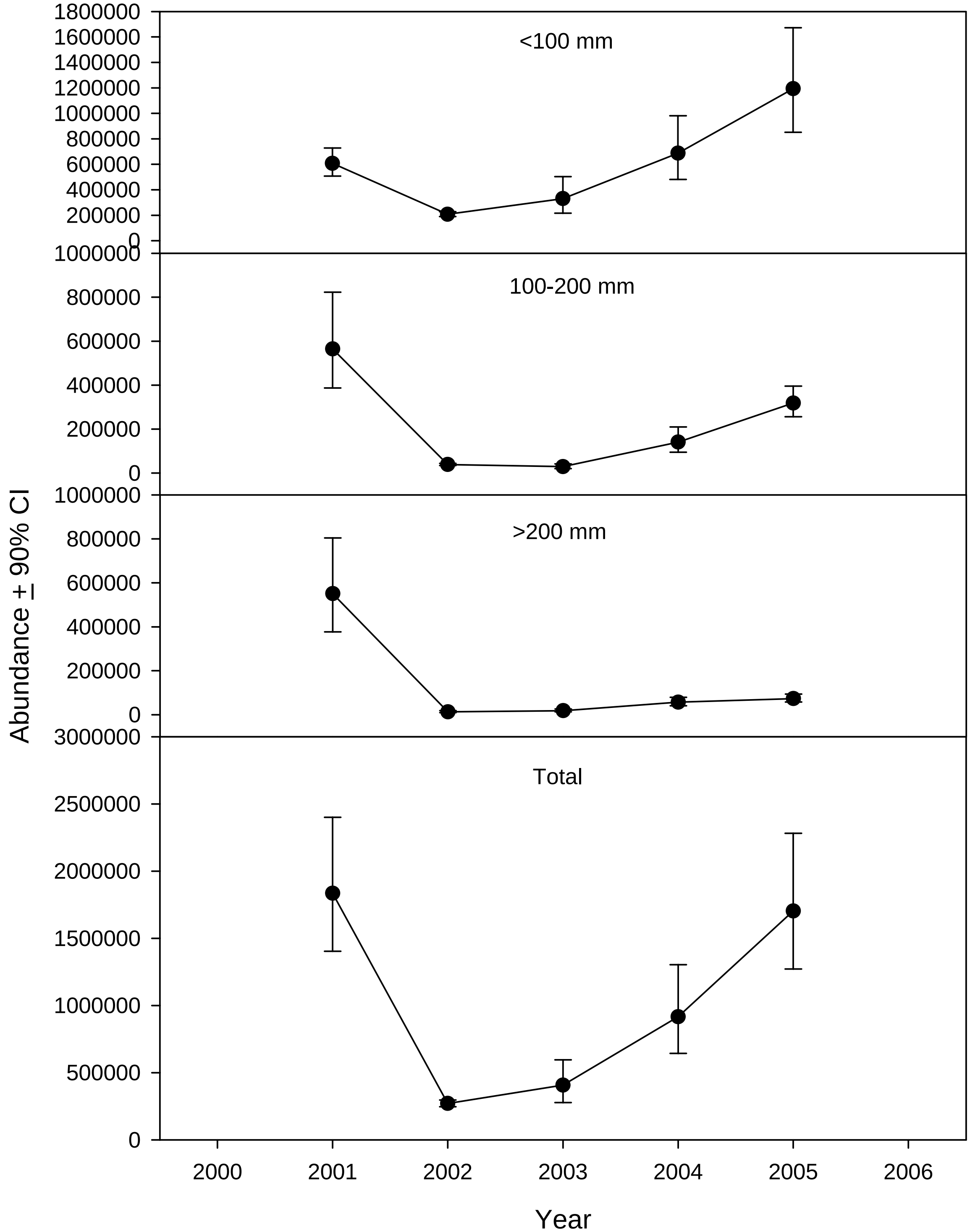


Figure 3. Trends in kokanee hydroacoustic abundance estimates at Anderson Ranch Reservoir during 2000-2005.

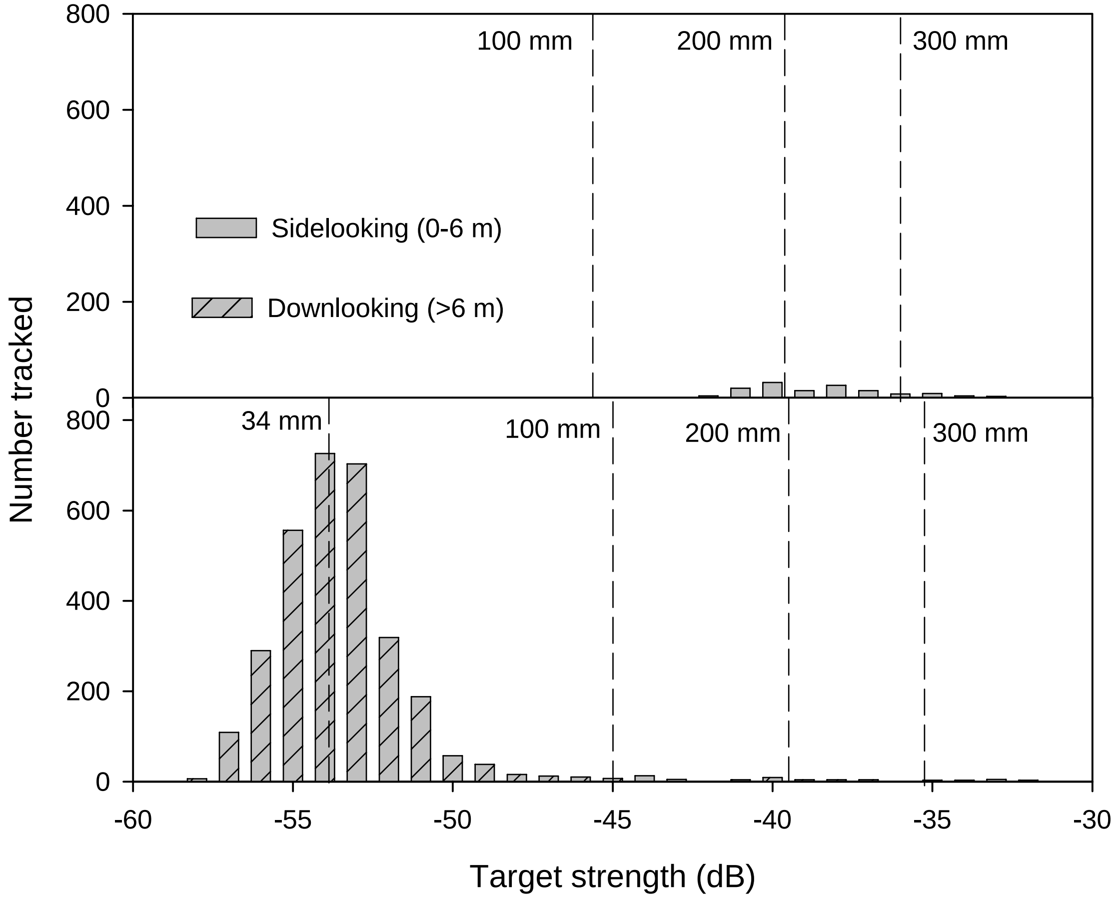


Figure 4. Target strength (dB) distribution of fish at Cascade Reservoir in 2005.

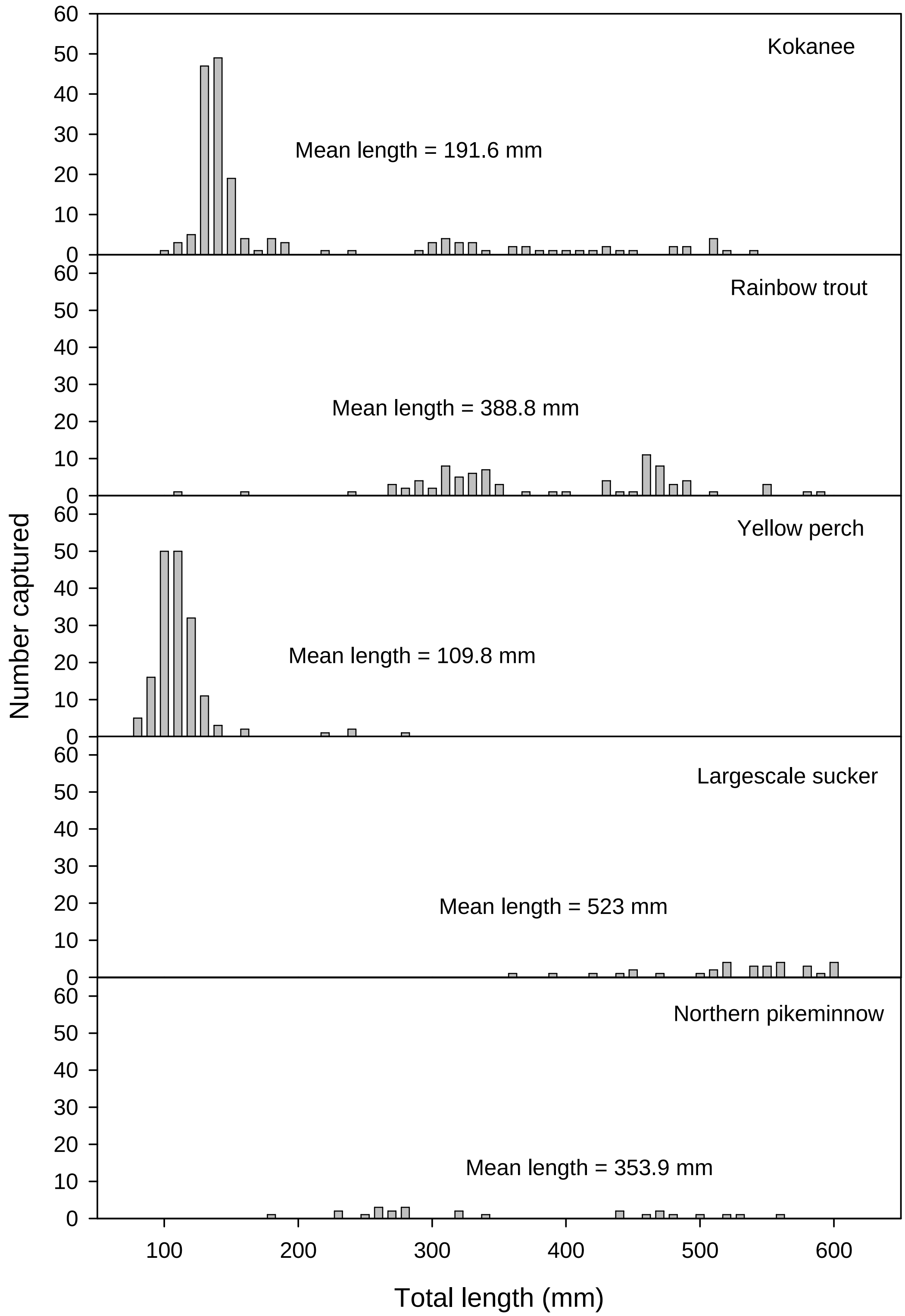


Figure 5. Length distributions of fish species caught in net curtains at Cascade Reservoir in 2005.

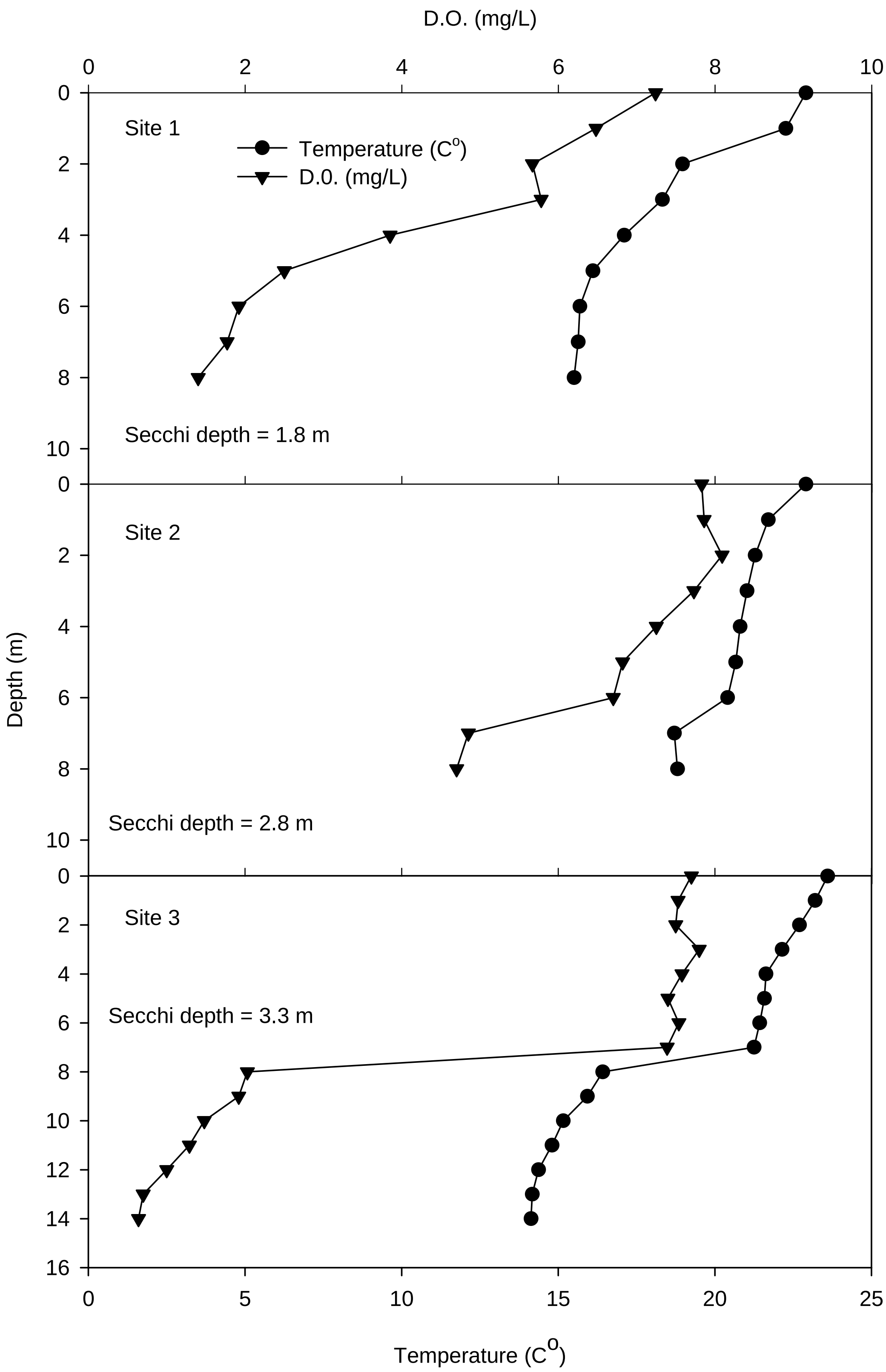


Figure 6. Vertical temperature (°C) and dissolved oxygen profiles (DO; mg/L) at three sites in Cascade Reservoir in 2005.

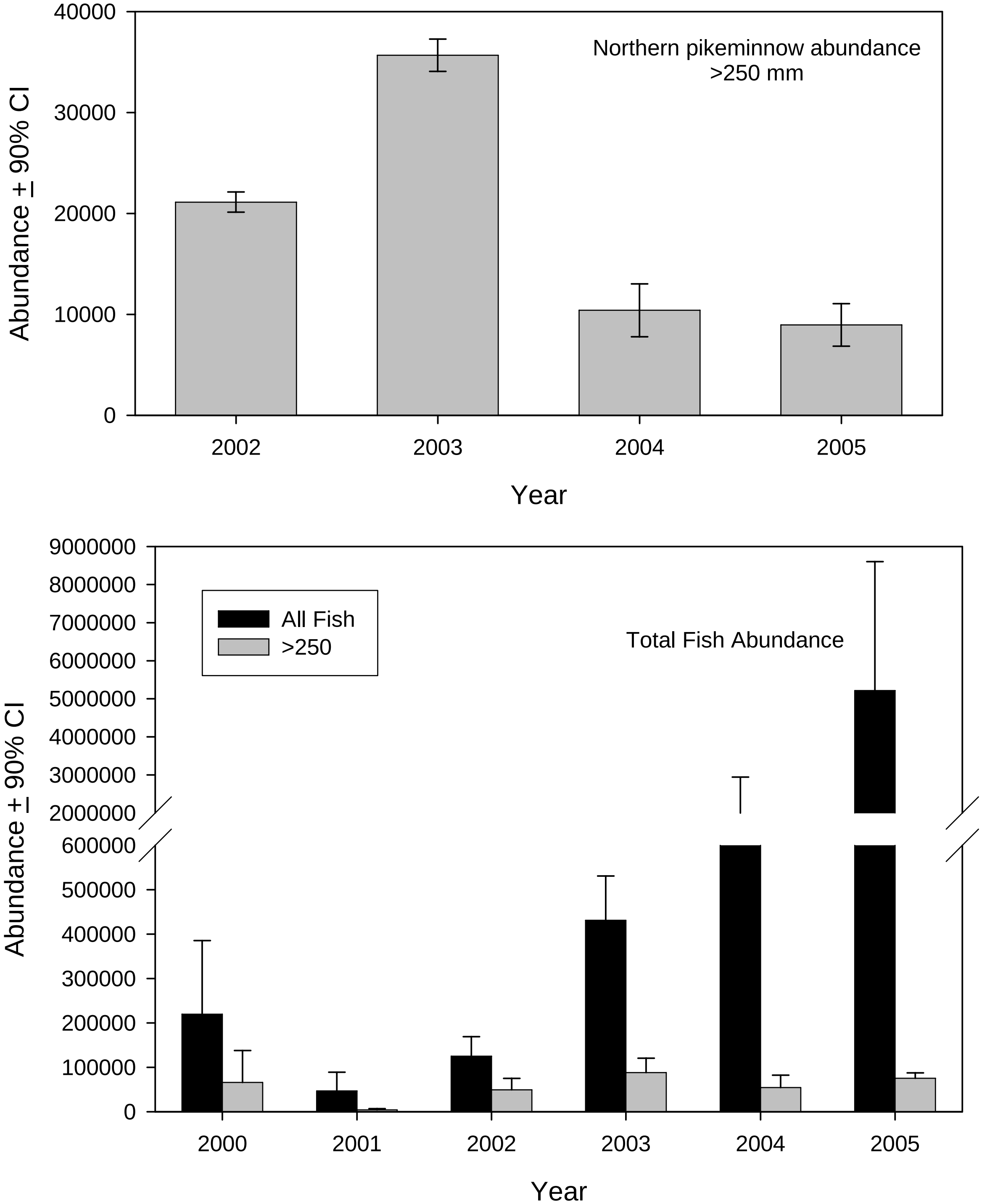


Figure 7. Abundance of northern pikeminnow as estimated by hydroacoustics and netting from 2002-2005 (upper panel), and of total fish and fish >250 mm from 2000-2005 (lower panel).

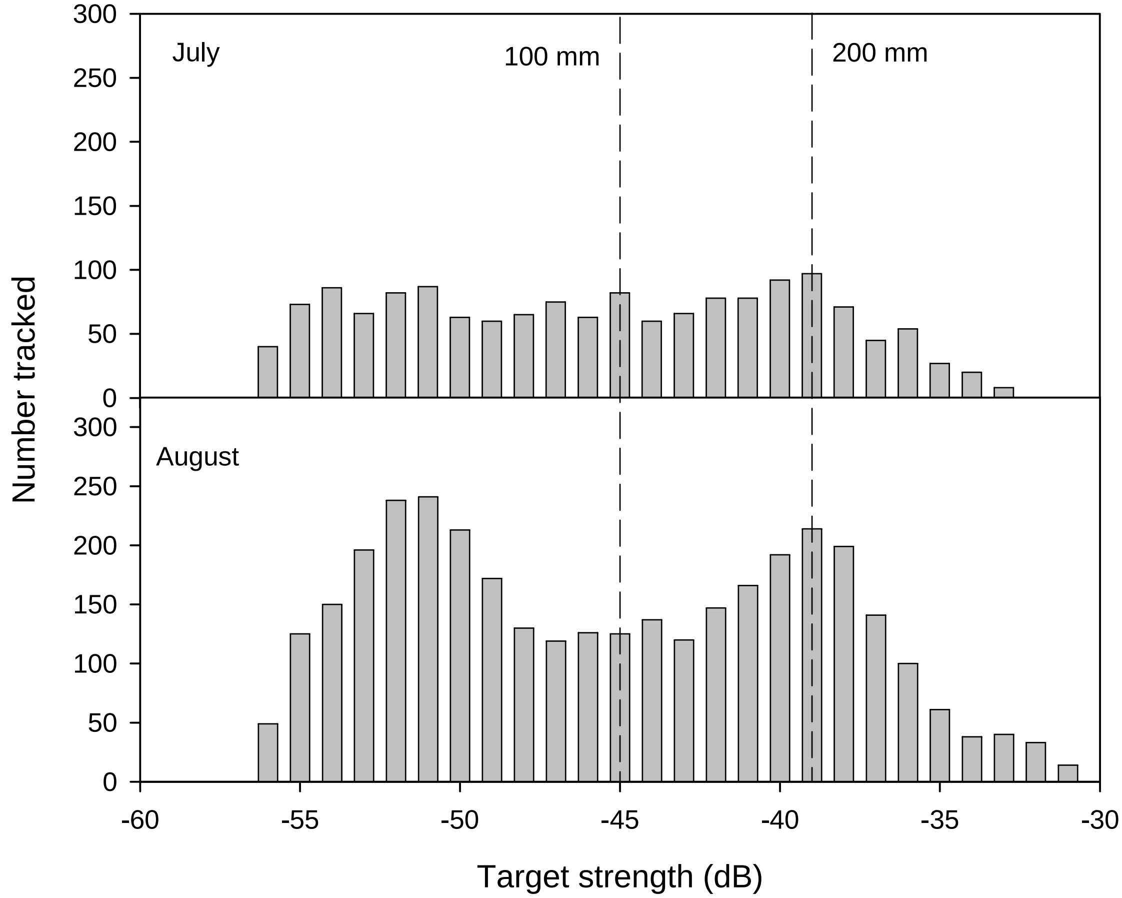


Figure 8. June and August target strength (dB) distribution of fish tracked during the 2005 survey at Deadwood Reservoir.

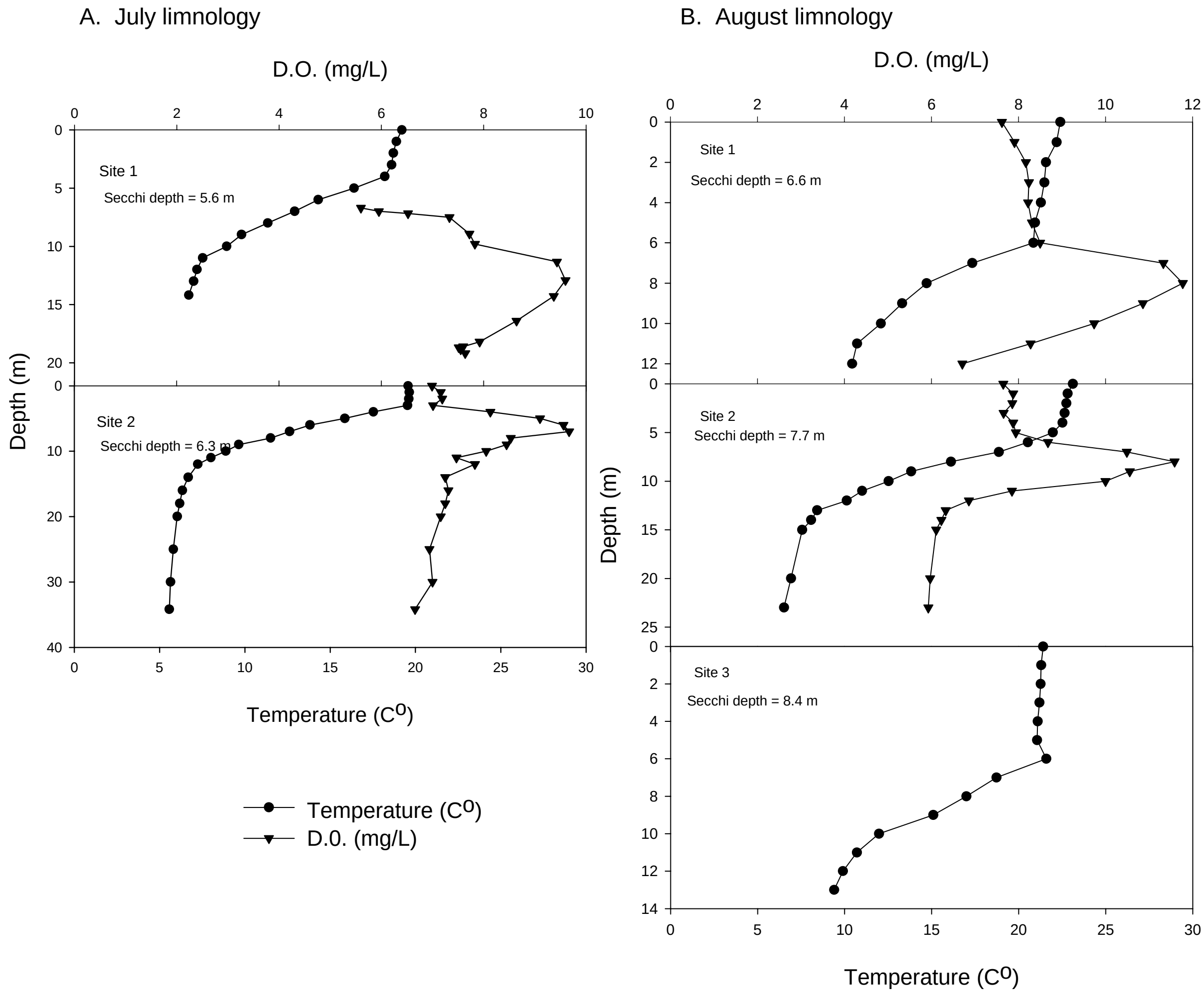


Figure 9. Vertical temperature (°C) and dissolved oxygen profiles (DO; mg/L) at three sites in Deadwood Reservoir in 2005.

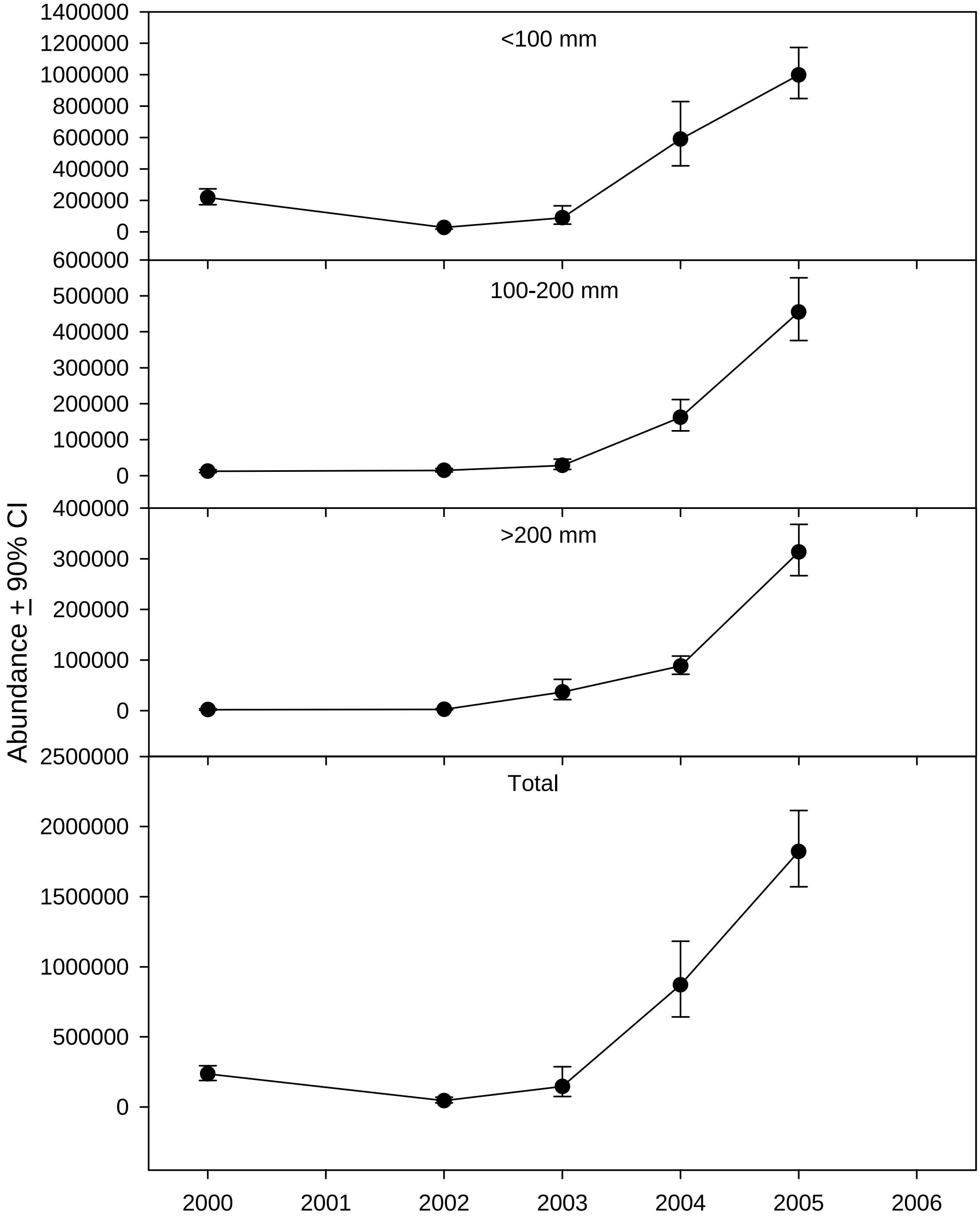


Figure 10. Trends in hydroacoustic kokanee abundance from 2000-2005 at Deadwood Reservoir.

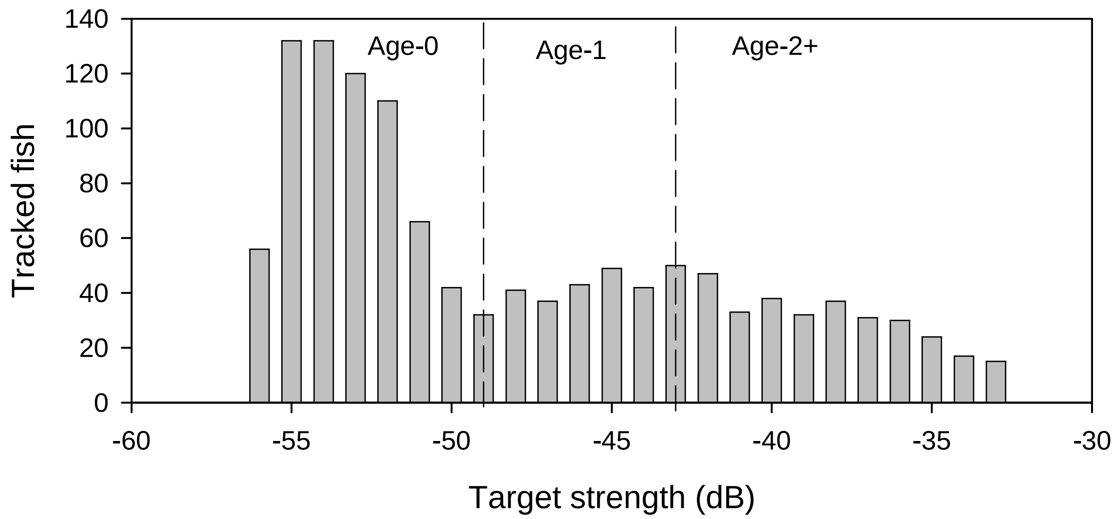


Figure 11. Length frequency (SL-mm) converted from target strength (dB) distribution of fish tracked during the 2005 survey at Payette Lake.

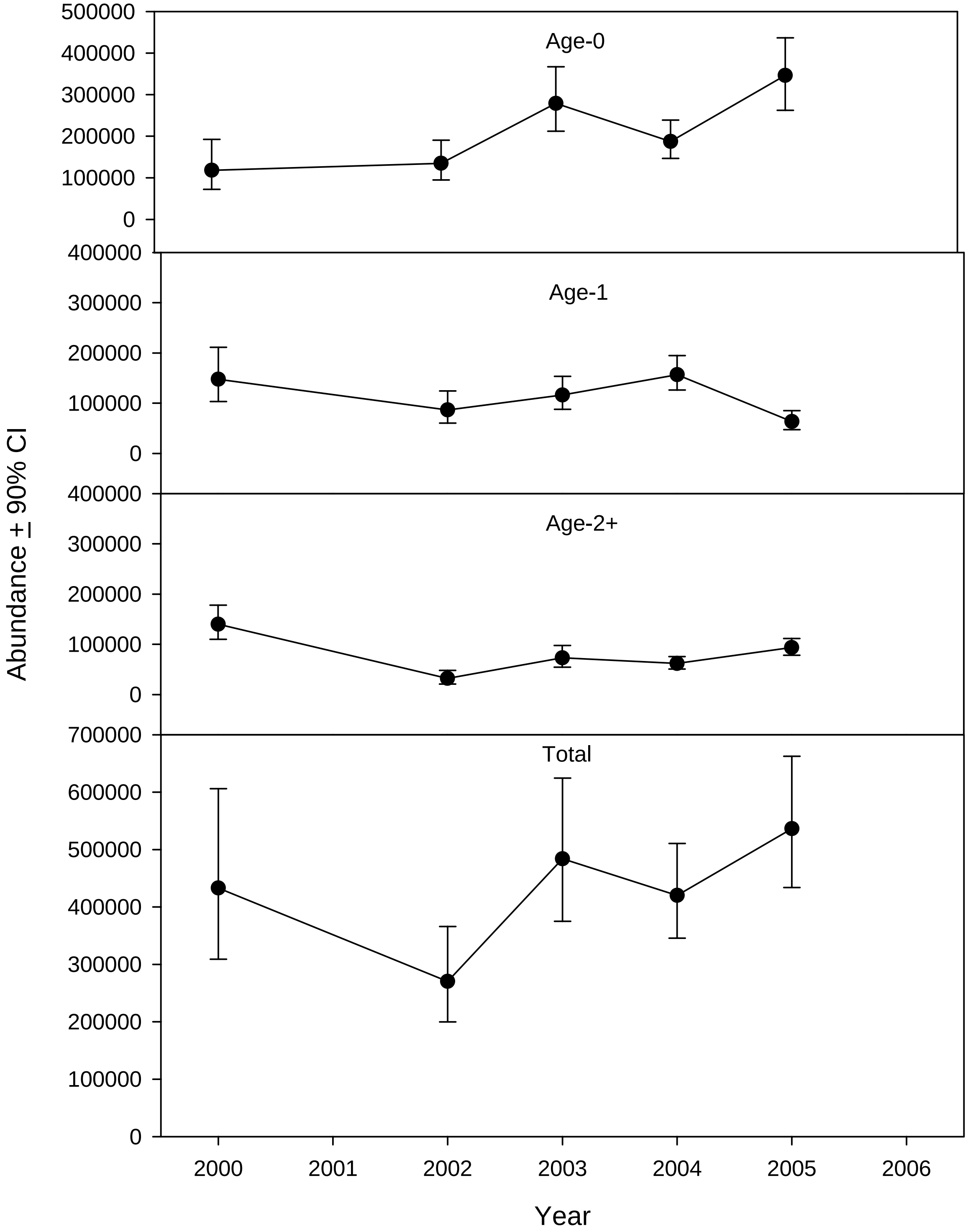
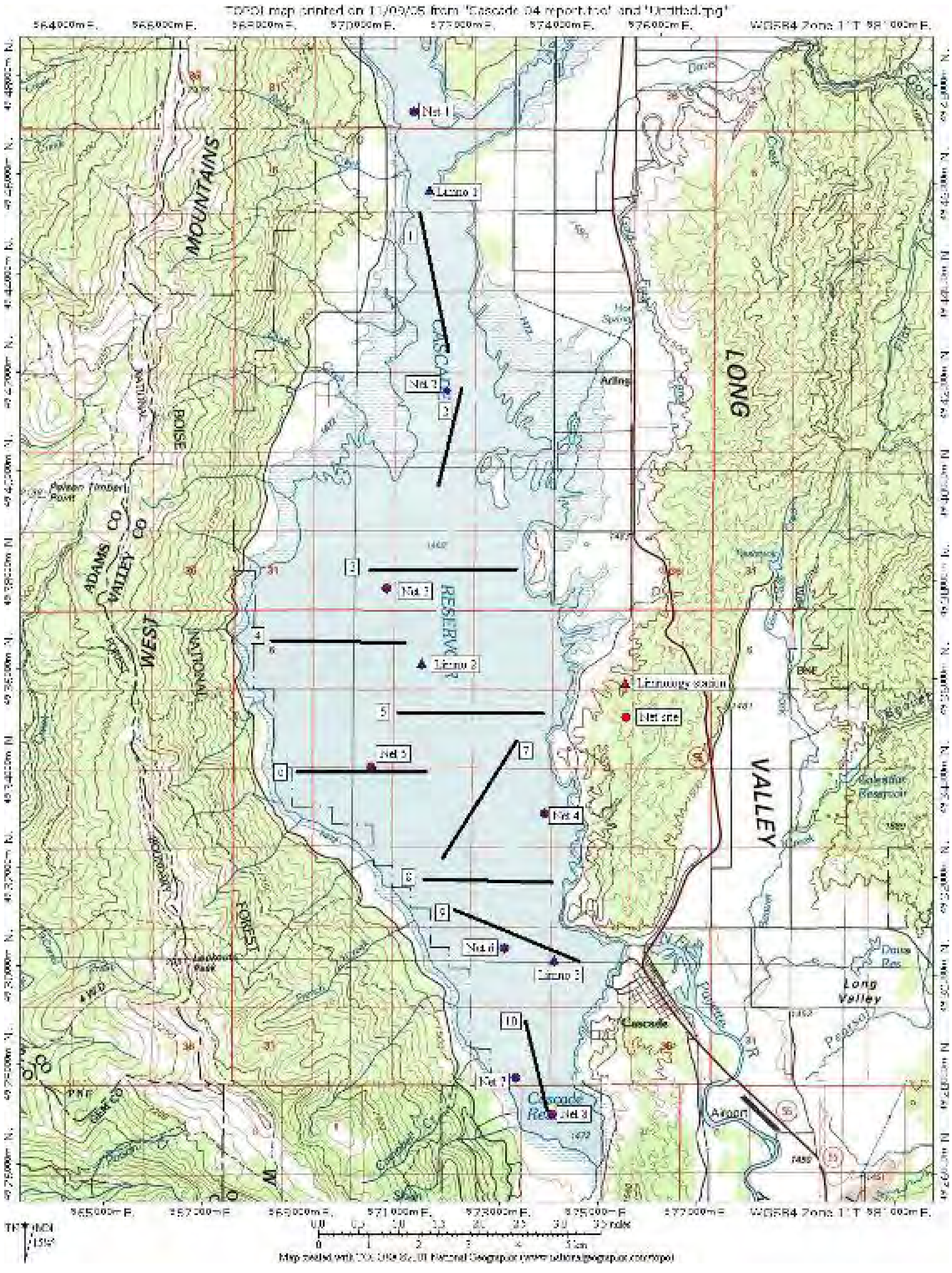


Figure 12. Trends in hydroacoustic kokanee abundance at Payette Lake from 2000-2005.

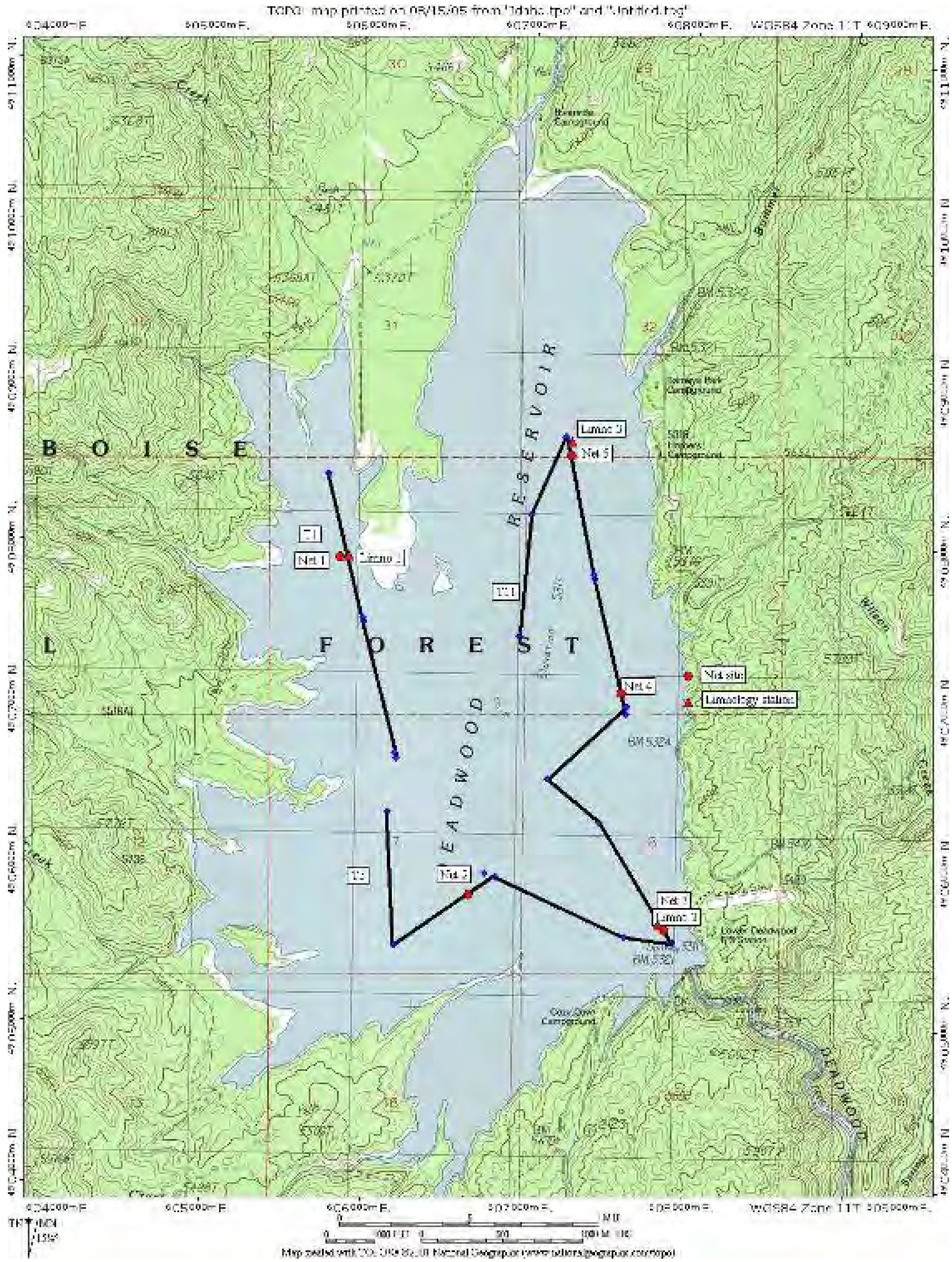
APPENDICES

Appendix A. Hydroacoustic transects, and limnology stations for the 2005 fish assessment survey at Anderson Ranch Reservoir.

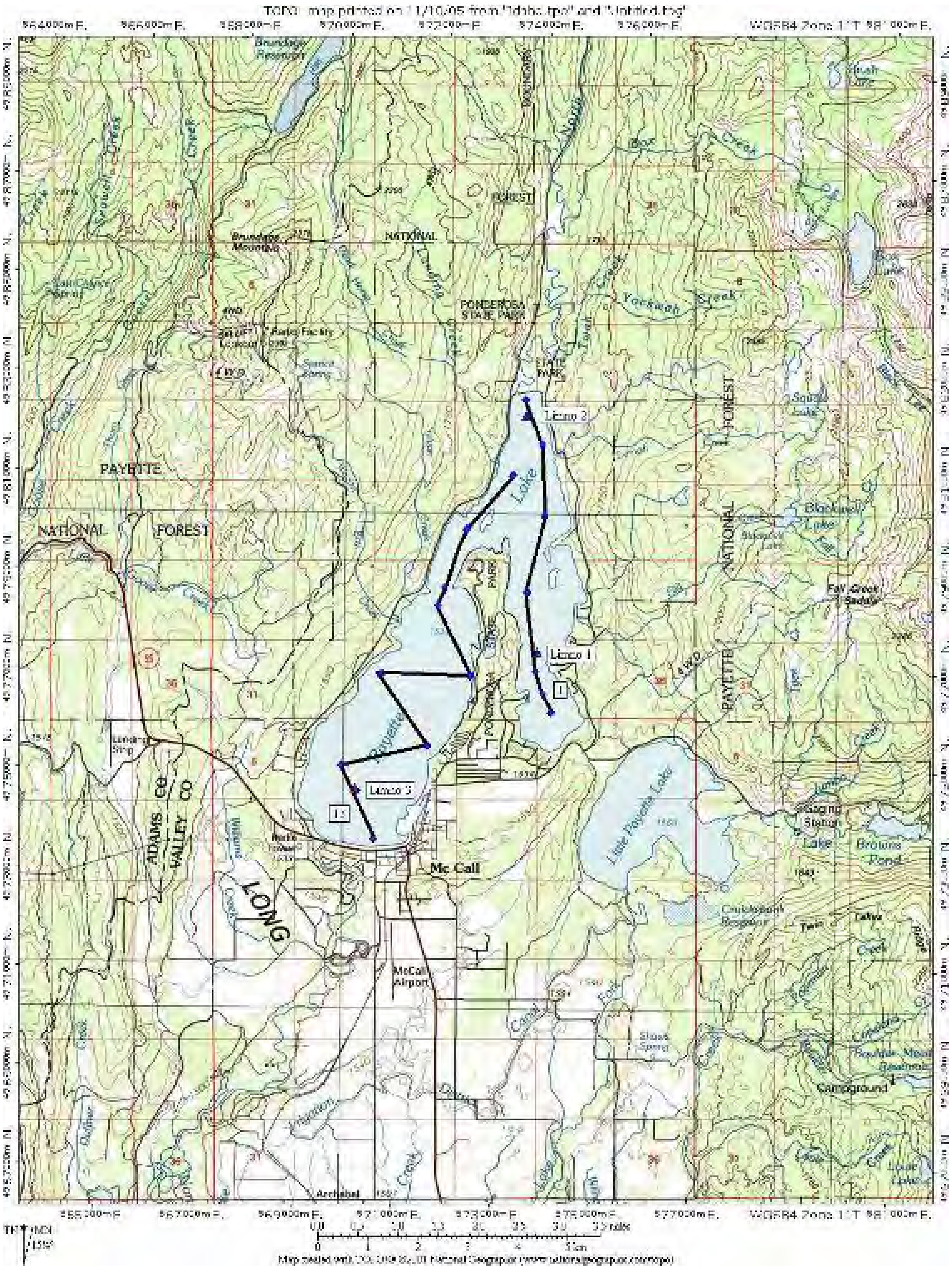
Appendix B. Hydroacoustic transects, netting sites, and limnology stations for the 2005 fish assessment survey at Cascade Reservoir.



Appendix C. Hydroacoustic transects, netting sites, and limnology stations for the 2005 fish assessment survey at Deadwood Reservoir.



Appendix D. Hydroacoustic transects, and limnology stations for the 2005 fish assessment survey at Payette Lake.



ANNUAL PERFORMANCE REPORT
SUBPROJECT 2: WARMWATER FISHERIES INVESTIGATIONS

State of: Idaho

Grant No.: F-73-R-27 Fishery Research

Project No.: 5

Title: Lake and Reservoir Research

Subproject #2: Warmwater Fisheries Investigations

Contract Period: July 1, 2005 to June 30, 2006

ABSTRACT

In 2005, we began to monitor annual variation in year class strength of crappie *Pomoxis spp.* and smallmouth bass *Micropterus dolomieui* in several water bodies in Idaho. Sampling consisted of summer trawling and fall electrofishing and trap netting at Brownlee and CJ Strike reservoirs in southwest Idaho, and Hayden, Hauser, and Mann lakes in northern Idaho. Larval trawling was more effective for crappie than bass or other warmwater species. The period of peak larval abundance for crappie at Brownlee and CJ Strike reservoirs was early to mid-July, whereas no peak was identified in the northern Idaho waters since the initial sampling dates occurred after the peak. Fall electrofishing was more efficient at capturing warmwater species than was trap netting. Combining collection methods, crappie CPUE ranged from a low of 1.0 fish/hr at Hauser Lake to 167.9 fish/hr at CJ Strike Reservoir. Smallmouth bass CPUE ranged from a low of 75.3 fish/hr at Hayden Lake to 187 fish/hr at Brownlee Reservoir.

Authors:

Arthur E. Butts
Senior Fishery Research Biologist

Patrick Kennedy
Fishery Technician

Kevin A. Meyer
Principal Fisheries Research Biologist

INTRODUCTION

Idaho's warmwater fisheries are receiving increased interest from anglers and it is becoming increasingly important for Idaho Department of Fish and Game (IDFG) managers to monitor these populations and understand the factors that influence these fisheries. According to the 1999 angler opinion survey, angler preference for warmwater species has increased from 7% in 1977 to 20% in 1999 (IDFG 2001). Species often targeted by anglers include smallmouth bass *Micropterus dolomieui*, largemouth bass *M. salmoides*, black crappie *Pomoxis nigromaculatus* and white crappie *P. annularis*, bluegill *Lepomis macrochirus*, yellow perch *Perca flavescens*, walleye *Stizostedion vitreum*, and channel catfish *Ictalurus punctatus*. These species provide sport fisheries in approximately one-third of the surface waters in Idaho (IDFG 2001).

One of the primary benefits of warmwater fisheries is that they can successfully reproduce in most lentic habitats, making them relatively inexpensive to manage in comparison to some trout fisheries, where stocking is often needed to maintain quality. However, because these warmwater fisheries are self-supporting, managers generally know less about the status, characteristics, and factors that influence these fisheries. Knowledge of important factors such as age, growth, density, and mortality are generally unknown for most of the populations in the state.

Warmwater species can be difficult to successfully manage because they often exhibit extreme fluctuations in year class strength and size (Allen 1997; Boxrucker and Irwin 2002; Martin and Maceina 2004). These variations are likely a result of environmental characteristics such as temperature, water volume, and lake or reservoir bathymetry, and also biological variables such as food supply and fish density (Mitzner 1991; Pope et al. 2004). In fact, much has been published on the effects of these variables on crappie populations in Midwestern and Southeastern U.S. waters. However, because the popularity of warmwater fisheries is such a recent phenomenon in Idaho, investigations on the influences of biotic and abiotic factors in temperate regions such as Idaho, where many populations experience short growing seasons in addition to inhabiting less productive systems, have been infrequent.

A better understanding of the factors that affect recruitment, growth, mortality, and thus, year class strength (YCS), in Idaho crappie populations would be beneficial for a number of reasons. First, a statewide perspective of population characteristics such as size structure and growth would help IDFG managers and anglers understand the variation between populations, and set reasonable expectations for fisheries in an area. Second, increased knowledge of the biological and environmental factors that influence these population characteristics would allow biologists to determine which combinations of recruitment, growth, and mortality result in desirable fisheries, and whether they can be influenced by some form of management practice such as harvest regulations. Furthermore, increased knowledge and understanding of these warmwater fisheries would allow managers to effectively communicate with anglers regarding the status of fisheries, the reasons for changes in a particular fishery, defense for regulation changes, and might allow managers some predictive ability in terms of the quality of a fishery.

Standardized methods to assess population characteristics of crappie populations have been developed by other states (Gablehouse 1984; Hill 1984; Hammers and Miranda 1991; Guy and Willis 1995; Allen et al. 1998; St. John and Black 2004; McInerny and Cross 2005). Notably, Colvin and Vasey (1986) describe a method where information collected during annual fall sampling with trap nets in Missouri allowed biologists to evaluate and qualitatively describe five important parameters, including population density, growth rate, age structure, size structure, and recruitment. These parameters, along with descriptive indices like proportional stock density

(PSD), relative stock density (RSD), and relative weight indices (W*r*), can be used not only to describe the status of a fishery but also to adequately describe the causes of potential problems such as stunting or poor catch rates. Measuring these parameters on an annual basis can lead to other potential benefits as well. For example, catch rates of age-2 and older crappie during fall collections at four reservoirs were significantly correlated with angler harvest estimates during the following year (Colvin 1991). This correlation allowed both predictive abilities as to when anglers can expect a quality harvest and the composition of the harvest in terms of fish age and size.

Accurately predicting YCS is essential to successful fisheries management, and understanding the factors that influence YCS allows managers to implement management strategies (Sammons and Bettoli 1998). However, assessing YCS of crappie using standard methods such as trap nets and electrofishing can be problematic. For example, crappies are difficult to successfully sample in steep-sided basins that are often characteristic of Idaho reservoirs. Also, extreme fluctuations in YCS can hinder efforts to effectively sample a population, and weak or missing year classes may not be detected until the fish have already entered the fishery. Because of these problems, some researchers have suggested utilizing larval sampling to index YCS and relate YCS back to abiotic and biotic factors. Sammons and Bettoli (1998) found that although larval crappie were only briefly available to capture by neuston netting, peak larval density accurately predicted the geometric mean density of age-1 crappie (r^2 = 0.99, P = 0.0001). Under the assumption that YCS is fixed before the end of the first growing season, larval sampling may offer a reliable method in which problems are detected early, offering managers the time and ability to take remedial actions. Sampling larval crappie would also allow for a better understanding of factors that influence successful reproduction and recruitment in Idaho waters. Water level, discharge, temperature, wind, and zooplankton abundance have all been linked to successful spawning and growth (Beam 1983; Pope and Willis 1998; Sammons et al. 2002a, 2002b; St. John and Black 2004).

The use of larval sampling as an index of YCS for crappie is beneficial only when YCS is set during the first growing season (Sammons and Bettoli 1998). If for instance, substantial mortality occurs during the first winter, then YCS estimates based on larval sampling will be misleading. Winter conditions have been demonstrated to be important for largemouth bass in northern Idaho, where fish <50 mm did not survive (Bowles 1985). This may be the result of depletion of energy stores or increased risk to predation (Miranda and Hubbard 1994a; 1994b; Garvey et al. 1998). The severity of winter conditions has been shown to have a profound impact on survival of age-0 white crappies through physiological stress when water temperatures drop below 4°C (McCollum et al. 2003).

Because winter may often act as the bottleneck that defines YCS, year classes need to be followed for a period to determine if survival during the first winter is equally as important in determining YCS as reservoir conditions during the spawn and first growing season. Gaining a better understanding of limiting factors in Idaho's crappie fisheries likely requires a commitment to follow a number of year classes for 3-4 years.

MANAGEMENT GOAL

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

OBJECTIVES

1. Determine if larval abundance of crappie can be used to predict year class strength and fishing quality in Idaho waters.

2. Examine if a qualitative assessment of crappie population characteristics developed by Colvin and Vasey (1986) can benefit the management of various crappie fisheries in the state of Idaho.

3. Identify collection techniques (trap netting, gillnetting, and electrofishing) for obtaining adequate samples of crappies across all age groups in Idaho lakes and reservoirs.

4. Examine these population characteristics in relation to environmental conditions to assess which factors have the strongest influence on crappie fisheries.

METHODS

Larval Trawling

Larval fish were collected at Hayden and Hauser lakes in region 1, Mann Lake in region 2, and CJ Strike and Brownlee reservoirs in region 3 in 2005. We attempted to collect samples on a biweekly basis from July through August with the goal of identifying peak larval abundance. A minimum of ten fixed sites that were randomly selected prior to the survey were sampled at night by towing a 1-m x 2-m floating neuston net of 1-mm bar mesh equipped with a flow meter (Sammons and Bettoli 1998; St. John and Black 2004). At Brownlee and CJ Strike reservoirs and Hayden Lake, where temperature and habitat variation occurs along the longitudinal axes of each water body, sampling was stratified to three sections within each lake. The net was towed for 5 minutes at each station with a 6.4 m boat powered by a 175-hp outboard motor. Mean tow volume was 362.12 m^3 and mean boat speed was 0.60 m/s. Samples were immediately preserved in a 10% formalin solution and later transferred to ethanol (St. John and Black 2004) and identified in the laboratory using meristics described by Auer (1982). All larval fish were identified, counted, and measured except when large samples (>200 fish) required sub-sampling. Larval crappies were not identified to species because the differences in meristic characteristics at that size were unreliable (Sammons and Bettoli 1998; McDonough and Buchanan 1991). Trawling sample locations for each water body are shown in the Appendices.

To assess potential differences in catch rates of larval and adult crappie, environmental data were collected. During all sampling periods at each reservoir, vertical temperature and dissolved oxygen profiles were measured along with Secchi depths and ZPR/ZQI measurements.

Fall Index Sampling

Sampling older year classes of crappie and other warmwater species was accomplished from September through October 2005. For comparison purposes, spring sampling was conducted in May 2005 at Hayden Lake, and Brownlee and CJ Strike reservoirs. Sampling consisted of trap nets and electrofishing and was conducted at Hauser Lake, Hayden Lake, Mann Lake, Winchester Lake, Brownlee Reservoir, and CJ Strike Reservoir. Trap nets consisted of 13-mm treated black mesh, a 0.9 x 1.8-m frame, and a 22.9-m lead. Shoreline set locations were randomly selected and depths ranged from 2 to 10 m. The amount of effort varied between water bodies, and ranged from 18 to 44 trap net nights and 1 to 11.3 hours of electrofishing.

Electrofishing was conducted using a 5.5 m long Smith Root boat equipped with a Smith Root GPP 5.0 electrofisher. Work was conducted during the night and a DC pulsed current was used. One hour of current-on electrofishing equaled one unit of effort. Electrofishing was conducted along the shoreline using a combination of short parallel and perpendicular boat movements for any given distance of shoreline. Two persons netted stunned fish from the front of the boat.

All fish were identified and measured and we attempted to collect at least 10 otoliths from every 10-mm size group for all warmwater sportfish (largemouth and smallmouth bass, bluegill, pumpkinseed, and yellow perch). The majority of fish were frozen and taken to the laboratory at Nampa Research where they were subsequently removed. Otoliths were removed via an incision through the roof of the mouth, identical to the techniques described by Schneidervin and Hubert (1986).

RESULTS

Larval Trawling

Larval trawling began at all water bodies by late June 2005, with subsequent sampling occurring every 2-3 weeks through August. Peak larval crappie abundance was only detected at Brownlee and CJ Strike reservoirs, as it appeared that peak densities occurred prior to the first sampling at the remaining water bodies.

Sampling at Brownlee Reservoir began on June 21 2005 and peak densities of crappie were observed the following sampling date of July 12 2005 (Figure 13). The lower sites, from Sturgill Creek to Brownlee Creek, contained the highest measured CPUE of 229 fish/net. Although crappie were observed during all sampling periods, crappie densities declined dramatically by the 15 August sampling date. Aside from crappie, bluegill were the second most frequently sampled species and appeared to peak a few weeks after the crappie. Strong peaks in bluegill CPUE were observed at both the upper and lower sites at the reservoir. Smallmouth bass and channel catfish were also observed in catches, albeit less frequently.

CJ Strike Reservoir was sampled beginning on June 22 2005 and continued through September 7 2005. The Bruneau arm of the reservoir contained the highest densities of larval crappie where a mean peak of 28 fish per net was captured on July 13 2005 (Figure 14). Bluegill were by far the most abundant fish captured at CJ Strike Reservoir with 174.3 fish per net in the main bay on August 22 2005. Peak densities for channel catfish and pumpkinseed were also observed in 2005.

Peak larval crappie abundance was not measured at Hauser (Figure 15), Hayden (Figure 16), and Mann lakes (Figure 17) because the highest counts of fish occurred during the first sampling trip. However, seasonal larval density information was attained for bluegill at these waters as well.

When larval sampling began in 2005, surface water temperatures had already approached 20°C (Table 7). Unfortunately, because of equipment malfunctions, water temperatures were not recorded at Hayden, Hauser, and Mann lakes during the first sampling period. Water temperatures at all waters approached or exceeded 25°C in mid August and had begun to cool by September. ZPR and ZQI values were adequate to high throughout the summer and fall at Brownlee and CJ Strike reservoirs (Table 8). However, at the three northern lakes, values were much lower, indicating that food resources for larval fish have the potential to be a limiting factor in growth and survival at these waters.

Fall Index Sampling

Crappie, smallmouth bass, largemouth bass, bluegill, pumpkinseed, and yellow perch were all captured with frequency at most water bodies in 2005. Fall sampling occurred while surface water temperatures ranged from 15.1˚C at Hauser Lake to 19.5˚C at Mann Lake (Table 7). Electrofishing was far more effective at capturing fish than trap nets. In fall, effort for electrofishing ranged from 1 hr at Hauser Lake to 11.3 hrs at Brownlee Reservoir (Table 9). Crappie CPUE ranged from a low of 1.0 fish/hr at Hauser Lake to 167.9 fish/hr at CJ Strike Reservoir. Smallmouth bass ranged from a low of 75.3 fish/hr at Hayden Lake to 187 fish/hr at Brownlee Reservoir. CPUE of the other species can be found in Table 9.

Trap nets yielded fewer fish despite a reasonably large number of net sets at most waters (Table 10). Trap nets primarily caught crappie, bluegill, pumpkinseed, and yellow perch. However, trap nets were not an effective means of capture for bass. In fall, the total number of trap nets set ranged from 18 at Hauser Lake to 44 at Brownlee Reservoir. For crappie, CPUE ranged from 0 fish/net at Hauser Lake to 10.5 fish/net at CJ Strike Reservoir. CPUE for the other species can be found in Table 10.

In order to build length-frequency histograms for each species, fish collected by both sampling techniques were combined. Size differences between collection techniques were not examined for this report. Differences in species-specific length data were observed between all populations. For example, age-0 crappie (fish <100 mm) appear to grow faster at Brownlee and CJ Strike reservoirs than at the more northern waters (Figure 18). Length frequency histograms were also compiled for smallmouth bass (Figure 19).

Differences between CPUE for spring and fall sampling was apparent in the three study waters that we investigated. Fall sampling resulted in higher catch rates of crappie for both electrofishing and trap netting (Tables 9-10). However, the results seem to vary more for bass. CPUE of smallmouth bass at Brownlee Reservoir increased substantially between spring and fall, whereas at CJ Strike Reservoir, spring CPUE was slightly higher than fall catch rates. However, when examining all species together, it appears that fall may be the best period to collect warmwater fish for indexing populations. Another advantage is that fall offers the ability to assess reproduction for that year, using catch rates of age-0 fish.

DISCUSSION

Larval Trawling

At three of the five water bodies, sampling began too late to effectively monitor larval crappie densities. Despite this, we did observe much about the seasonality of larval fish abundance in pelagic areas. Peak densities of yellow perch and crappie occurred prior to June, while peaks for bluegill and catfish occurred in July and August. It also appears that peak bass densities occurred prior to sampling, but larval bass may not be effectively sampled with neuston netting. Clearly, sampling will likely need to begin earlier in the season, so that peak densities can be detected. Sampling began after water temperatures had either reached or exceeded 20°C in 2005, and at Brownlee and CJ Strike reservoirs, peak crappie densities occurred when surface temperatures were 24.2°C and 22.8°C, respectively. Sammons et al. (2002a) observed that hatching began when surface temperatures were between 14°C to 17°C, and peak hatching occurred in the range of 20°C to 22°C. Because the beginning of the hatching period must also be estimated to determine peak densities, larval trawling will need to begin as water temperature approaches 15°C.

Fall Index Sampling

An effective fall index for warmwater species, particularly crappie, clearly requires more than one type of sampling technique. Trap netting alone will not yield the necessary information needed to analyze in detail length-frequency histograms using the techniques described by Colvin and Vasey (1986).

A major limitation to developing a sampling protocol to index fall crappie abundance is the lack of knowledge regarding when crappie become shoreline oriented, so that they are susceptible to sampling techniques. Colvin and Vasey (1986) described trap nets set in October when surface water temperatures were between 13°C to 20°C. In this study, sampling occurred in September and August when water temperatures were between 15°C and 20°C. Therefore, surface water temperatures were similar between the two studies. However, crappies were not captured at high enough numbers in trap nets for meaningful analysis. The total sample size goal for the Colvin and Vasey (1986) analysis was 1,500 age-1 and older crappies, which would probably equate to two weeks of sampling even at the highest catch rates observed during fall 2005. Better knowledge of seasonal crappie behavior and movement in Idaho would greatly enhance the development of this index.

ACKNOWLEDGEMENTS

We would like to thank Nick Sawyer for his role in collecting all data. We also thank Chris Sullivan, Liz Mamer, Andy Knight, Sarah Nelson, Steve Elle, and other IDFG personnel for their assistance in the field and laboratory. Cheryl Leben did an outstanding job of formatting the report.

LITERATURE CITED

Allen, M. S. 1997. Effects of variable recruitment on catch-curve analysis for crappie populations. North American Journal of Fisheries Management 17(1):202-205.

Allen, M. S., M. V. Hoyer, and D. E. Canfield, Jr. 1998. Factors related to black crappie occurrence, density, and growth in Florida lakes. North American Journal of Fisheries Management 18:864-871.

Auer, N. A. (ed.). 1982. Identification of larval fishes of the Great Lakes basin with emphasis on the Lake Michigan drainage. Great Lakes Fishery Commission. Ann Arbor, Michigan 48105. Special Publication 82-3:744 pp.

Beam, J. H. 1983. The effect of annual water level management on population trends of white crappie in Elk City Reservoir, Kansas. North American Journal of Fisheries Management 3:34-40.

Bowles, E. C. 1985. Recruitment and survival of young-of-the-year largemouth bass (Micropterus *salmoides*) in the Coeur d'Alene Lake system. M.S. thesis, University of Idaho. Moscow, Idaho.

Boxrucker, J., and E. Irwin. 2002. Challenges of crappie management continuing into the 21st century. North American Journal of Fisheries Management 22:1334-1339.

Colvin, M. A. 1991. Population characteristics and angler harvest of white crappies in four large Missouri reservoirs. North American Journal of Fisheries Management 11:572-584.

Colvin, M. A., and F. W. Vasey. 1986. A method of qualitatively assessing white crappie populations in Missouri reservoirs. Pages 79-85 *in* G. E. Hall and M. J. Van Den Avyle, editors. Reservoir Fisheries Management: Strategies for the 80's. Reservoir Committee, Southern Division American Fisheries Society. Bethesda, Maryland.

Gablehouse Jr., D. W. 1984. An assessment of crappie stocks in small Midwestern private impoundments. North American Journal of Fisheries Management 4:371-384.

Garvey, J. E., R. A. Wright, and R. A. Stein. 1998. Overwinter growth and survival of age-0 largemouth bass *Micropterus salmoides*: revisiting the role of body size. Canadian Journal of Fisheries and Aquatic Sciences 55:2414-2424.

Guy, C. S. and Willis, D. W. 1995. Population characteristics of black crappies in South Dakota waters: a case for ecosystem-specific management. North American Journal of Fisheries Management 15:754-765.

Hammers, B. E., and Miranda, L. E. 1991. Comparison of methods for estimating age, growth, and related population characteristics of white crappies. North American Journal of Fisheries Management 11(4):492-498.

Hill, K. R. 1984. Correlation of total and "angler acceptable" crappie standing stocks with lake basin slopes and siltation indexes. North American Journal of Fisheries Management 4:350-354.

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

Martin, A. D., and M. J. Maceina. 2004. Assessment of detecting minimum length limit changes for crappie in two Alabama reservoirs. Fisheries Research 68: 293-303.

McCollum, A. B., D. B. Bunnell, and R. A. Stein. 2003. Cold, northern winters: the importance of temperature to overwinter mortality of age-0 white crappies. Transactions of the American Fisheries Society 132:977-987.

McInerny, M. C., and T. K. Cross. 2005. An evaluation of mark-recapture estimates of black crappie population size determined by trap netting during fall and spring in Minnesota lakes. North American Journal of Fisheries and Aquatic Sciences 25:475-490.

Miranda, L. E., and W. D. Hubbard. 1994a. Length-dependent winter survival and lipid composition of age-0 largemouth bass in Bay Springs Reservoir, Mississippi. Transactions of the American Fisheries Society 123:80-87.

Miranda, L. E., and W. D. Hubbard. 1994b. Winter survival of age-0 largemouth bass relative to size, predators, and shelter. North American Fisheries Management 14:790-796.

Mitzner, Larry. 1991. Effect of environmental variables upon crappie young, year-class strength, and the sport fishery. North American Journal of Fisheries Management 11(4):534-542.

Pope, K. L., and D. W. Willis. 1998. Larval black crappie distribution: implications for sampling impoundments and natural lakes. North American Journal of Fisheries Management 18:470-474.

Pope, K. L., G. R. Wilde, and B. W. Durham. 2004. Age-specific patterns in density-dependent growth of white crappie, Pomoxis annularis. Fisheries Management and Ecology 11:33-38.

Sammons, S. M., and P. W. Bettoli. 1998. Larval sampling as a fisheries management tool: early detection of year-class strength. North American Journal of Fisheries Management 18:137-143.

Sammons, S. M., P. W. Bettoli, and V. A. Greear. 2001. Early life history characteristics of age-0 white crappies in response to hydrology and zooplankton densities in Normandy Reservoir, Tennessee. Transactions of the American Fisheries Society 130:442-449.

Sammons, S. M., P. W. Bettoli, D. A. Isermann, and T. N. Churchill. 2002a. Recruitment variation of crappies in response to hydrology of Tennessee reservoirs. North American Journal of Fisheries Management 22:1393-1398.

Sammons, S. M., D. A. Isermann, and P. W. Bettoli. 2002a. Variation in population characteristics and gear selection between black and white crappies in Tennessee reservoirs: potential effects on management decisions. North American Journal of Fisheries Management 22:863-869.

Schneidervin, R. W., and W. A. Hubert. 1986. A rapid technique for otolith removal from salmonids and catastomids. North American Journal of Fisheries Management 6:287.

St. John, R. T., and W. P. Black. 2004. Methods for predicting age-0 crappie year-class strength in J. Percy Priest Reservoir, Tennessee. North American Journal of Fisheries Management 24:1300-1308.

Table 7. Surface water temperatures during larval and fall sampling at 2005 study waters.

Water Body	Date	Site	Surface Temp °C
Brownlee Reservoir	6/21/2005	BL01	21.07
	07/12/2005	BL11	24.22
	07/28/2005	BL01	25.37
		BL11	25.1
	08/15/2005	BL01	25.9
		BL11	26.54
	06/09/2005	BL01	23.3
		BL11	23.7
	06/10/2005	BL11	17.2
CJ Strike Reservoir	06/23/2005	CJLimno	19.5
	07/13/2005	CJLimno	22.83
	08/16/2005	CJLimno	24.99
	07/09/2005	CJLimno	21.5
	10/12/2005	CJLimno	15.8
Hayden Lake	07/19/2005	HYLim1	23.14
		HYLim2	21.94
	08/11/2005	HYLim1	24.37
		HYLim2	24.14
	09/01/2005	HYLim1	21.5
		HYLim2	21.44
	09/21/2005	HYLim1	17.53
		HYLim2	17.9
Hauser Lake	07/18/2005	HRLim	24.27
	08/10/2005	HRLim	25.46
	08/31/2005	HRLim	20.75
	09/28/2005	HRLim	15.1
Mann Lake	07/21/2005	MNLim	25.4
	08/09/2005	MNLim	25.93
	08/30/2005	MNLim	20.4
	09/13/2005	MNLim	19.5

Table 8. Mean biomass (g/m), zooplankton ration index (ZPR), and zooplankton quality index (ZQI) values for water bodies sampled during the 2005 field season.

			Mean biomass (g/m)			ZPR	ZQI
Water	**Date**	**Station**	**153 um**	**500 um**	**750 um**	**750 um / 500 um**	**(750 um + 500 um)ZPR**
Brownlee Reservoir	6/21/2005	Dam	3.42	3.3	1.75	0.53	2.68
	7/12/2005	BL01	*	9.13	9.03	0.99	17.96
	7/28/2005	Dam	*	4.96	2.98	0.60	4.77
		BL01	2.15	1.4	0.93	0.66	1.55
	8/15/2005	BL01	*	10.9	5.71	0.52	8.70
		Dam	*	5.35	4.47	0.84	8.20
	9/6/2005	BL01	*	12.37	11.42	0.92	21.96
		Dam	15.35	9.86	11.43	1.16	24.68
	10/5/2005	Dam	*	0.3	0.18	0.60	0.29
CJ Strike Reservoir	6/16/2005	Dam	7.83	2.67	2.4	0.90	4.56
	6/22/2005	Dam	15.5	8.91	6.8	0.76	11.99
	7/13/2005	Dam	5.46	2.38	1.31	0.55	2.03
	8/2/2005	Dam	*	*	7.85	—	—
	8/22/2005	Dam	*	3.8	3.47	0.91	6.64
	9/7/2005	Dam	*	0.65	0.46	0.71	0.79
	10/12/2005	Dam	*	0.94	0.42	0.45	0.61
Hauser Lake	7/18/2005	HRLIM	2.09	0.77	0.23	0.30	0.30
	8/10/2005	HRLIM	1.53	1.2	0.5	0.42	0.71
	8/31/2005	HRLIM	4.2	2.4	0.8	0.33	1.07
	9/28/2005	HRLIM	2.44	0.21	0.02	0.10	0.02
Hayden Lake	7/19/2005	HYLIM1	2.36	1.2	1.09	0.91	2.08
		HYLIM2	1.5	1.11	0.77	0.69	1.30
	8/11/2005	HYLIM1	0.59	0.4	0.12	0.30	0.16
		HYLIM2	0.6	0.34	0.16	0.47	0.24
	9/1/2005	HYLIM1	0.4	0.17	0.02	0.12	0.02
		HYLIM2	0.77	0.52	0.31	0.60	0.49
	9/21/2005	HYLIM1	0.63	0.55	0.2	0.36	0.27
		HYLIM2	1.3	0.79	0.41	0.52	0.62
Manns Lake	7/21/2005	MLIM1	4.82	1.98	0.02	0.01	0.02
	8/9/2005	MLIM1	16.4	4.25	0.3	0.07	0.32
	8/30/2005	Near Ramp	6.2	1.12	0.41	0.37	0.56
	9/13/2005	MLIM1	7	0.9	0.1	0.11	0.11
Winchester	10/18/2005	1	11.11	0.7	0.02	0.03	0.02

*Samples were not preserved adequately

Table 9. Electrofishing catch-per-unit-effort (CPUE) for various warmwater species at 2005 study sites.

Water body	Sampling Period	Units of effort (hrs)	Species					
			Crappie (var. sp.)	Smallmouth bass	Largemouth bass	Bluegill	Pumpkin-seed	Yellow perch
Brownlee Res.	Spring	2.63	14.4	117.1	0.4	17.5	0	1.5
	Fall	11.31	20.2	187	2.1	69.5	1.1	9.8
CJ Strike Res.	Spring	2.73	8.8	140.3	7	45.4	1.5	4
	Fall	3.52	167.9	129	64.2	249.7	10.8	25.6
Hauser Lake	Fall	1.0	1	-	92	263	—	—
Hayden Lake	Spring	2.0	78.5	119.5	50.5	—	112	44.5
	Fall	2.96	79.4	75.3	24	—	—	—
Mann Lake	Fall	2.0	77	—	231.5	201	114.5	—
Winchester Lake	Fall	2.02	17.3	—	277.7	473.3	—	161.4

Table 10. Trap net catch-per-unit-effort (CPUE) for various warmwater species at 2005 study sites.

Water body	Sampling Period	Number of nets	Species					
			Crappie (var. sp.)	Smallmouth bass	Largemouth bass	Bluegill	Pumpkin-seed	Yellow perch
Brownlee Res.	Spring	6	7.7	0	0	0.5	0.33	0.33
	Fall	44	2.9	0.11	0	1.5	0.02	0.11
CJ Strike Res.	Spring	20	6.5	1	0	0.2	0.15	1.7
	Fall	38	10.5	0.63	0.05	11.8	0.16	4.6
Hauser Lake	Fall	18	0.11	-	0	4.8	10.3	2
Hayden Lake	Spring	16	0	0	0	0	1.3	0.06
	Fall	30	0.98	0.01	0.44	0.08	4.4	1.8
Mann Lake	Fall	21	3.5	-	2.5	6.9	12.8	-
Winchester Lake	Fall	32	0.19	-	0.13	1.5	-	6.7

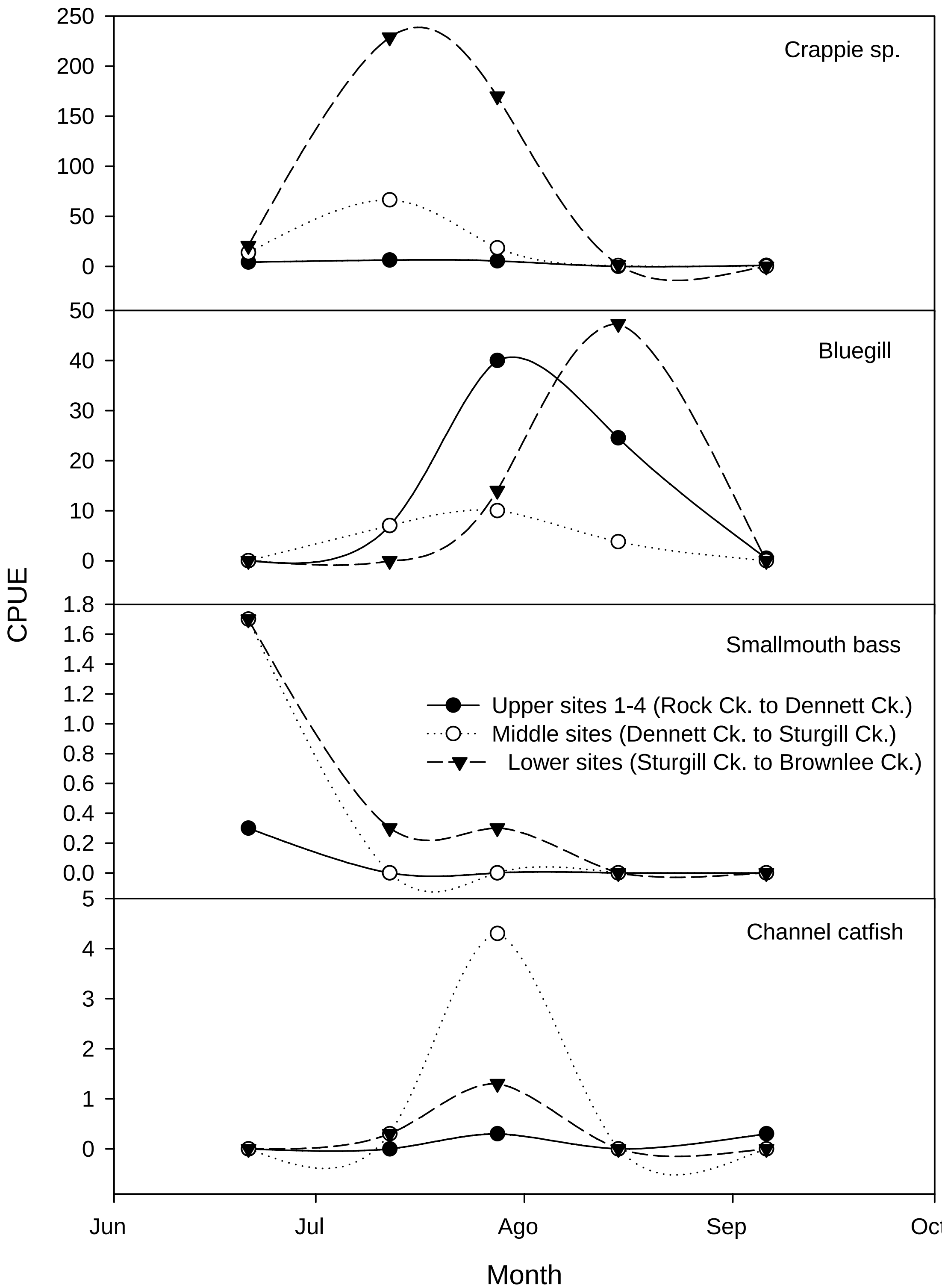


Figure 13. Catch-per-unit-effort for larval fish at Brownlee Reservoir in 2005.

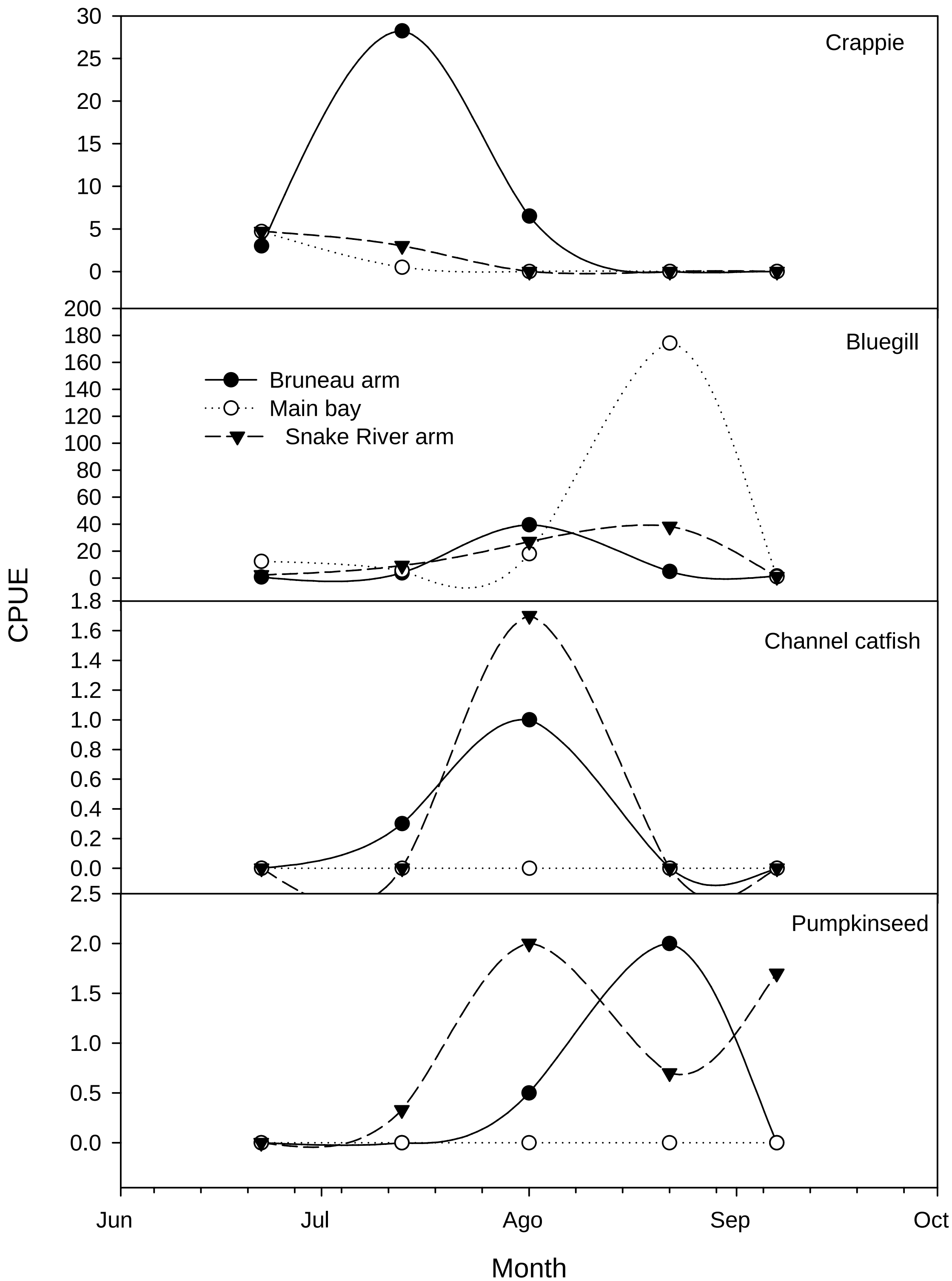


Figure 14. Catch-per-unit-effort for larval fish at CJ Strike Reservoir in 2005.

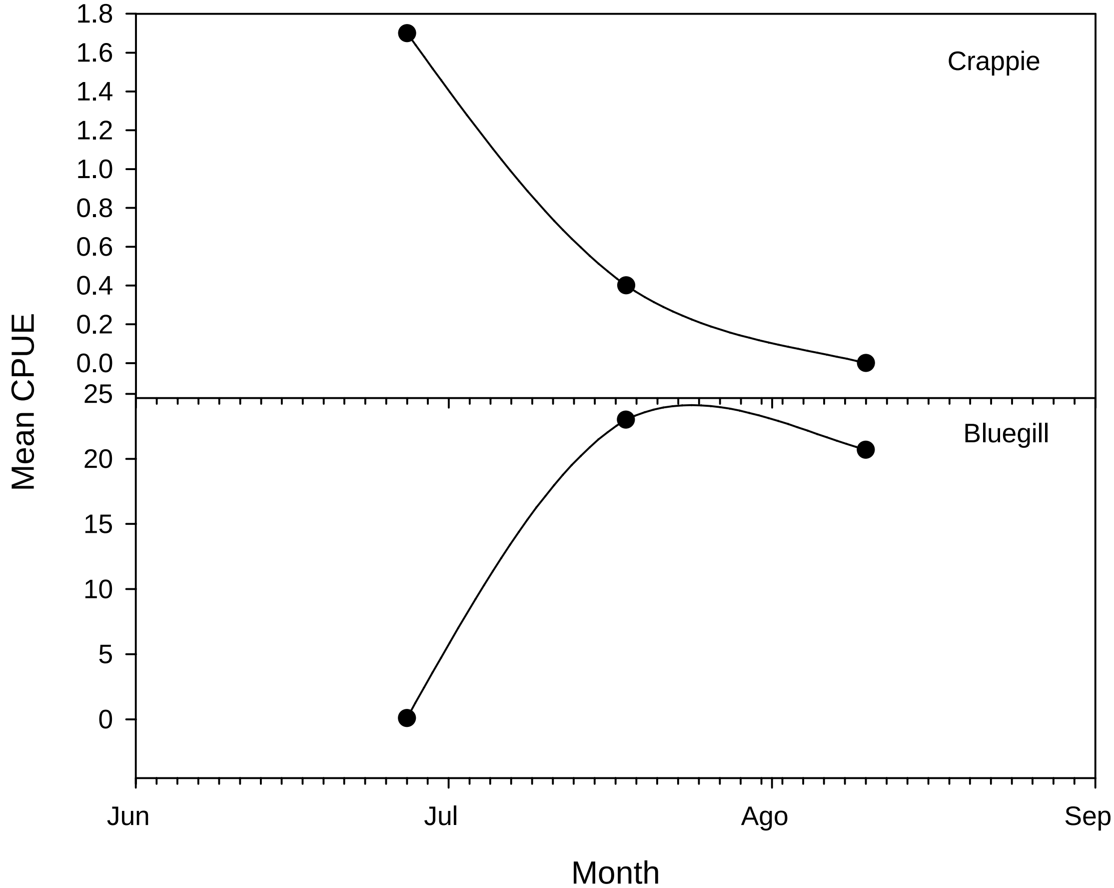


Figure 15. Catch-per-unit-effort for larval fish at Hauser Lake in 2005.

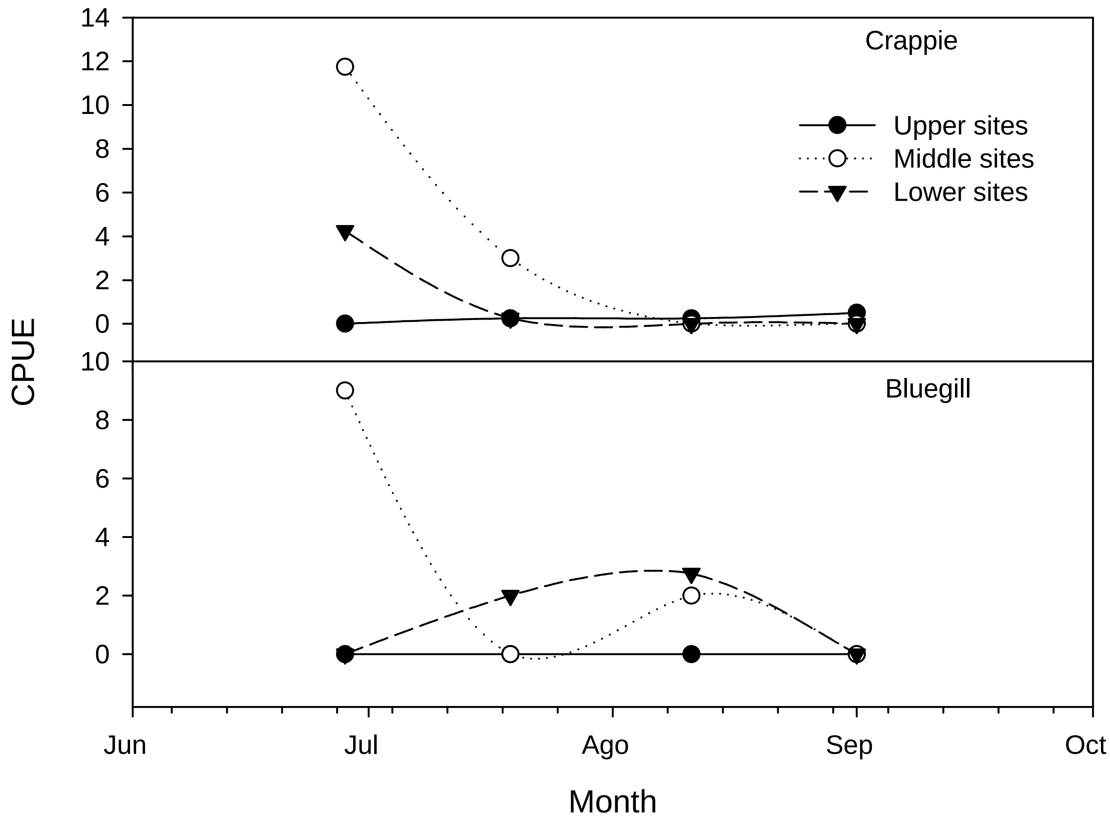


Figure 16. Catch-per-unit-effort for larval fish at Hayden Lake in 2005.

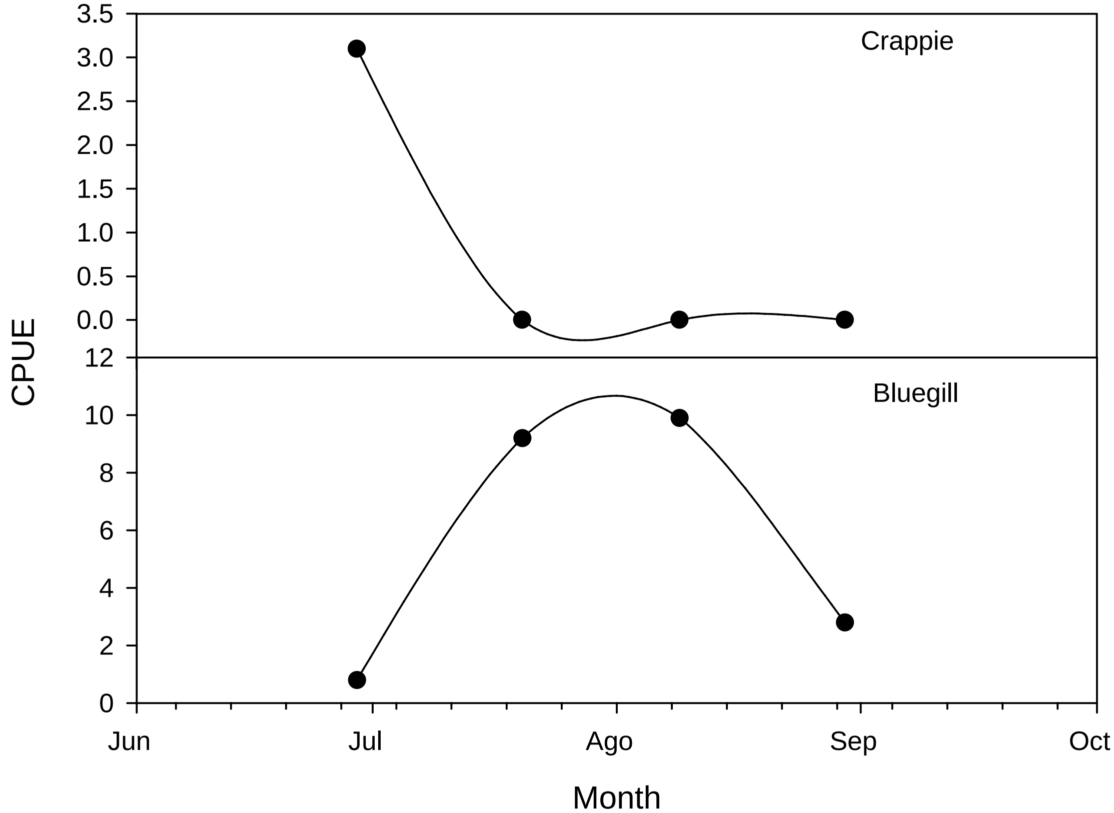


Figure 17. Catch-per-unit-effort for larval fish at Mann Lake in 2005.

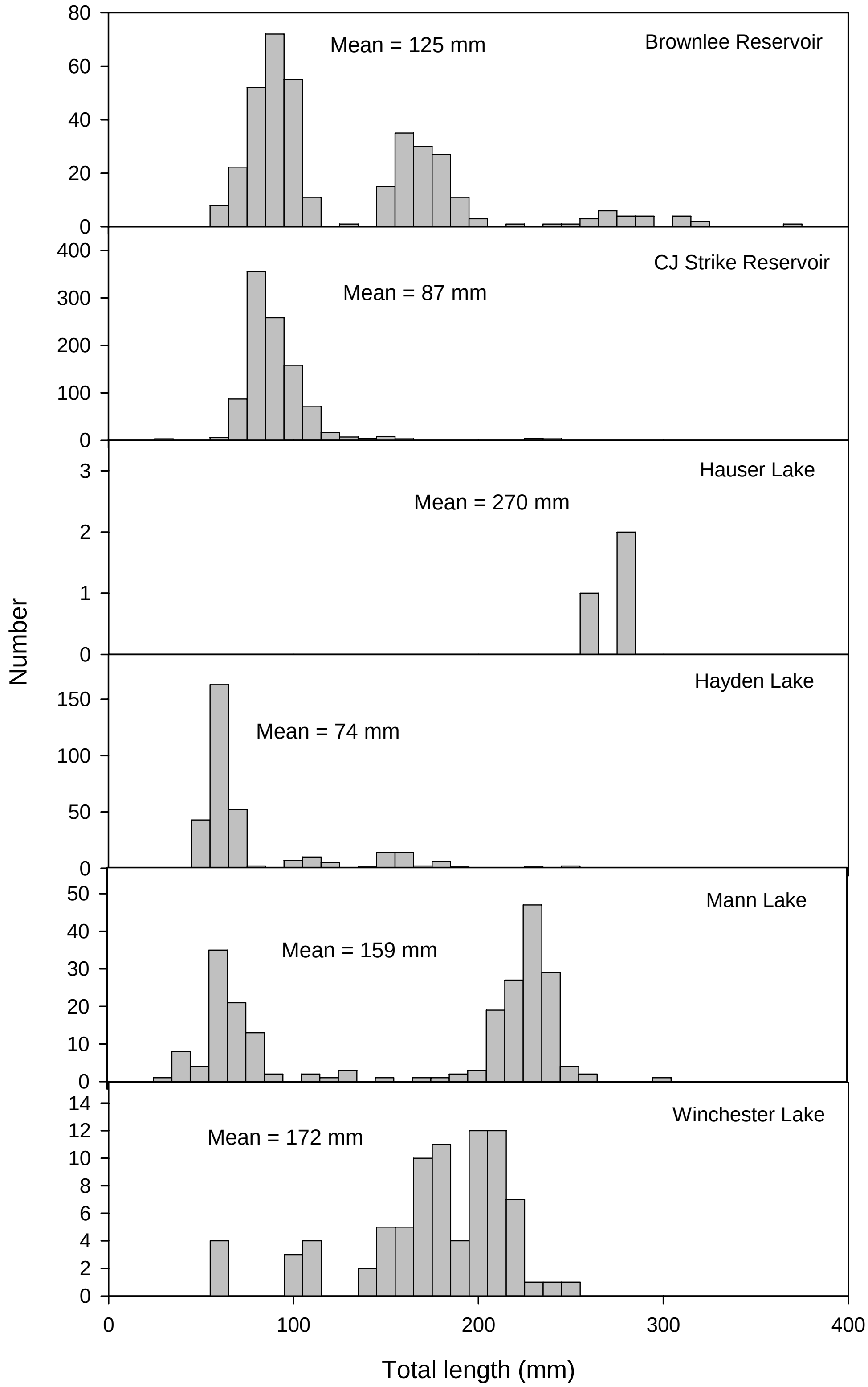


Figure 18. Length frequency distribution for crappie species at 2005 sample sites.

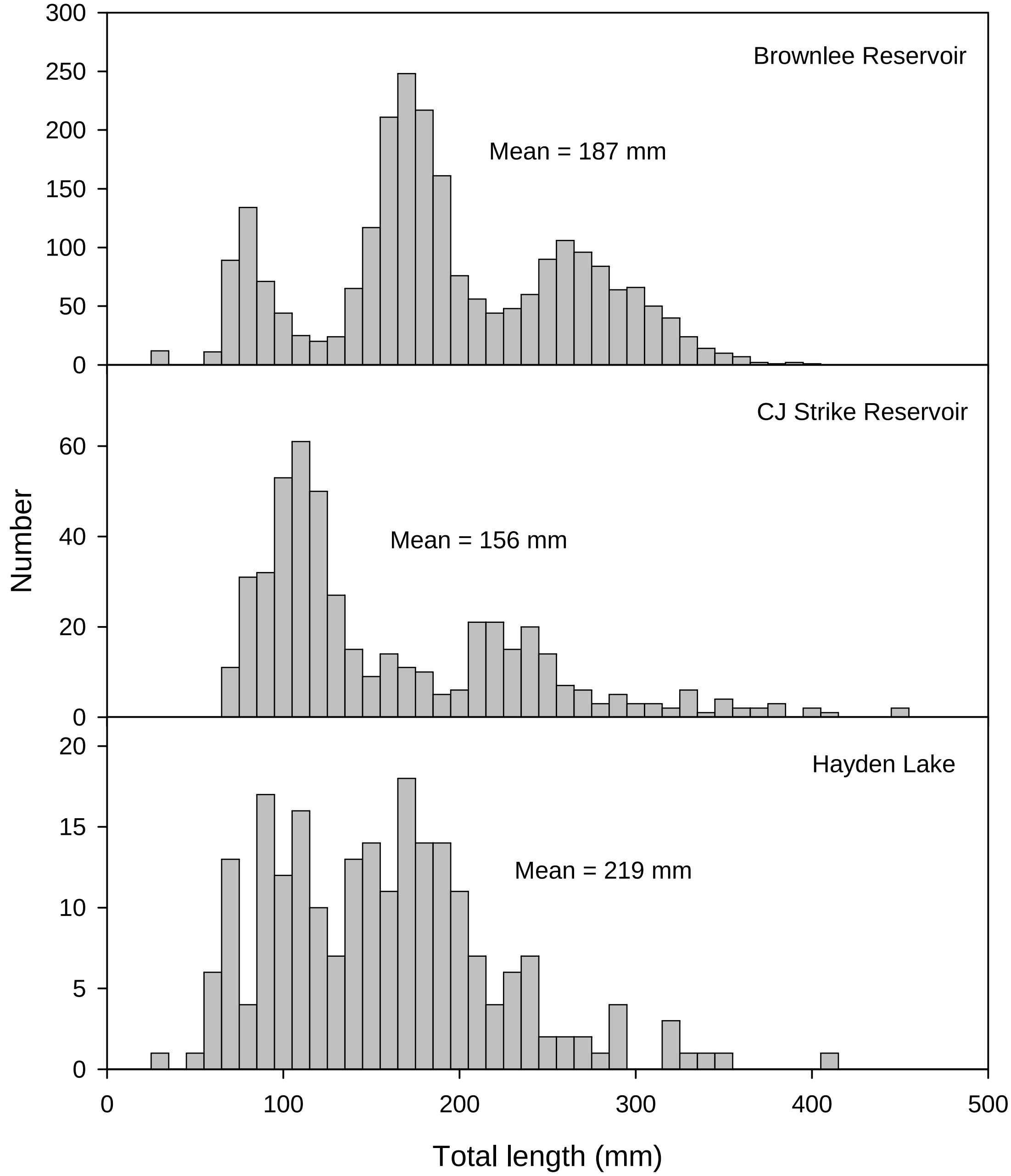
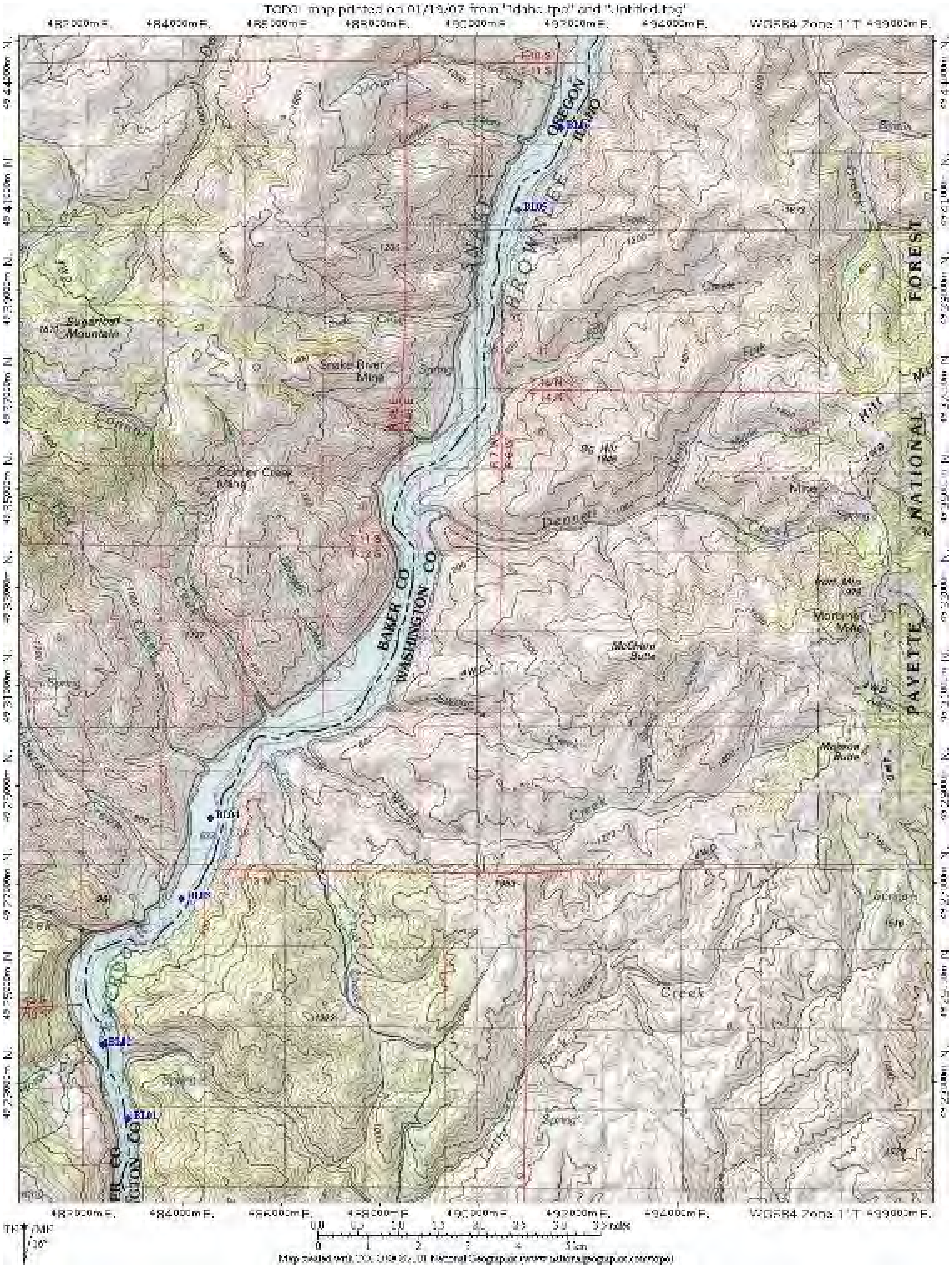


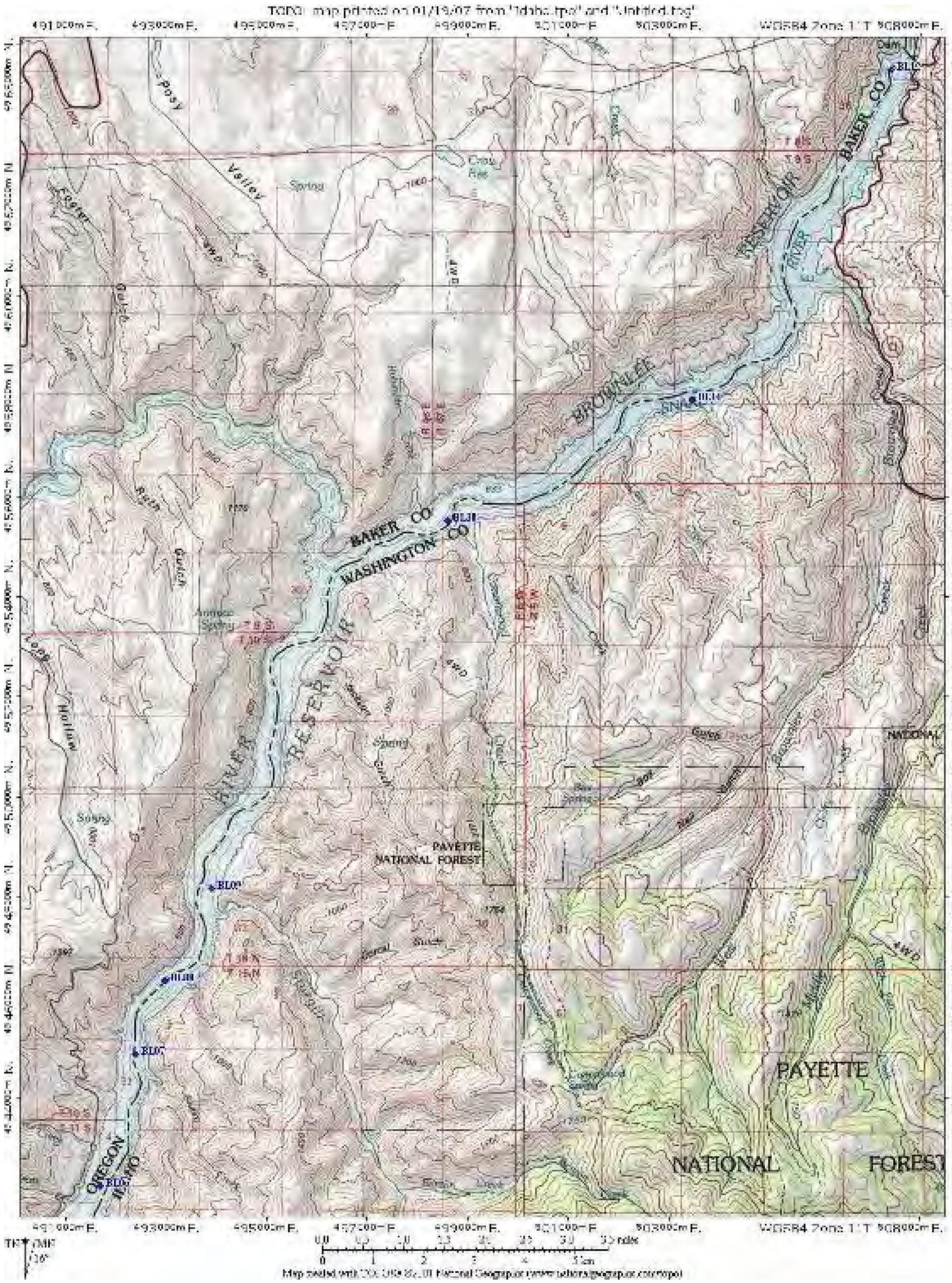
Figure 19. Length frequency distribution for smallmouth bass at 2005 sample sites.

APPENDICES

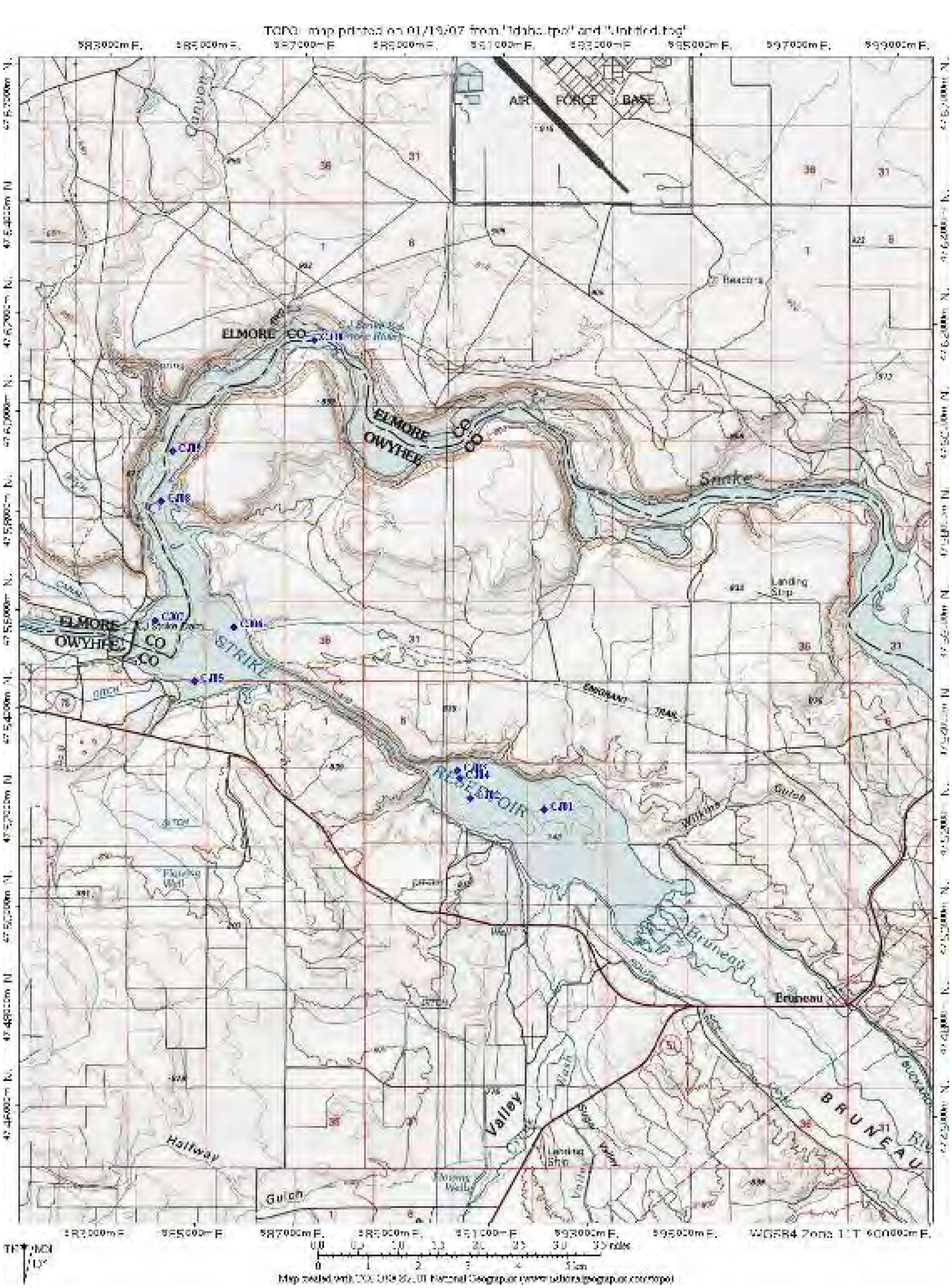
Appendix E1. Map of fixed larval netting sites on the upper portion of Brownlee Reservoir.



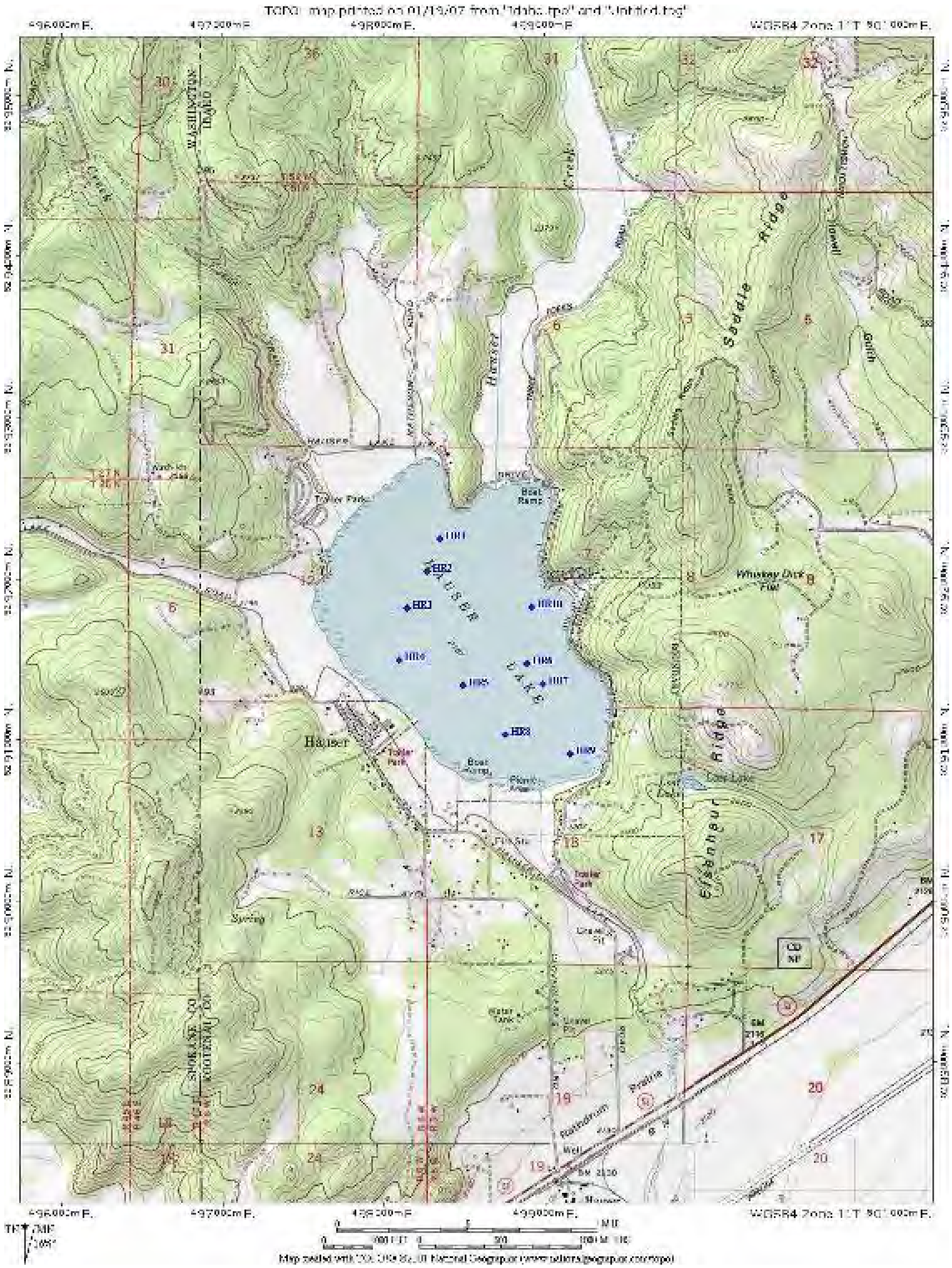
Appendix E2. Map of fixed larval netting sites on the lower portion of Brownlee Reservoir.



Appendix F. Map of fixed larval netting sites at CJ Strike Reservoir.

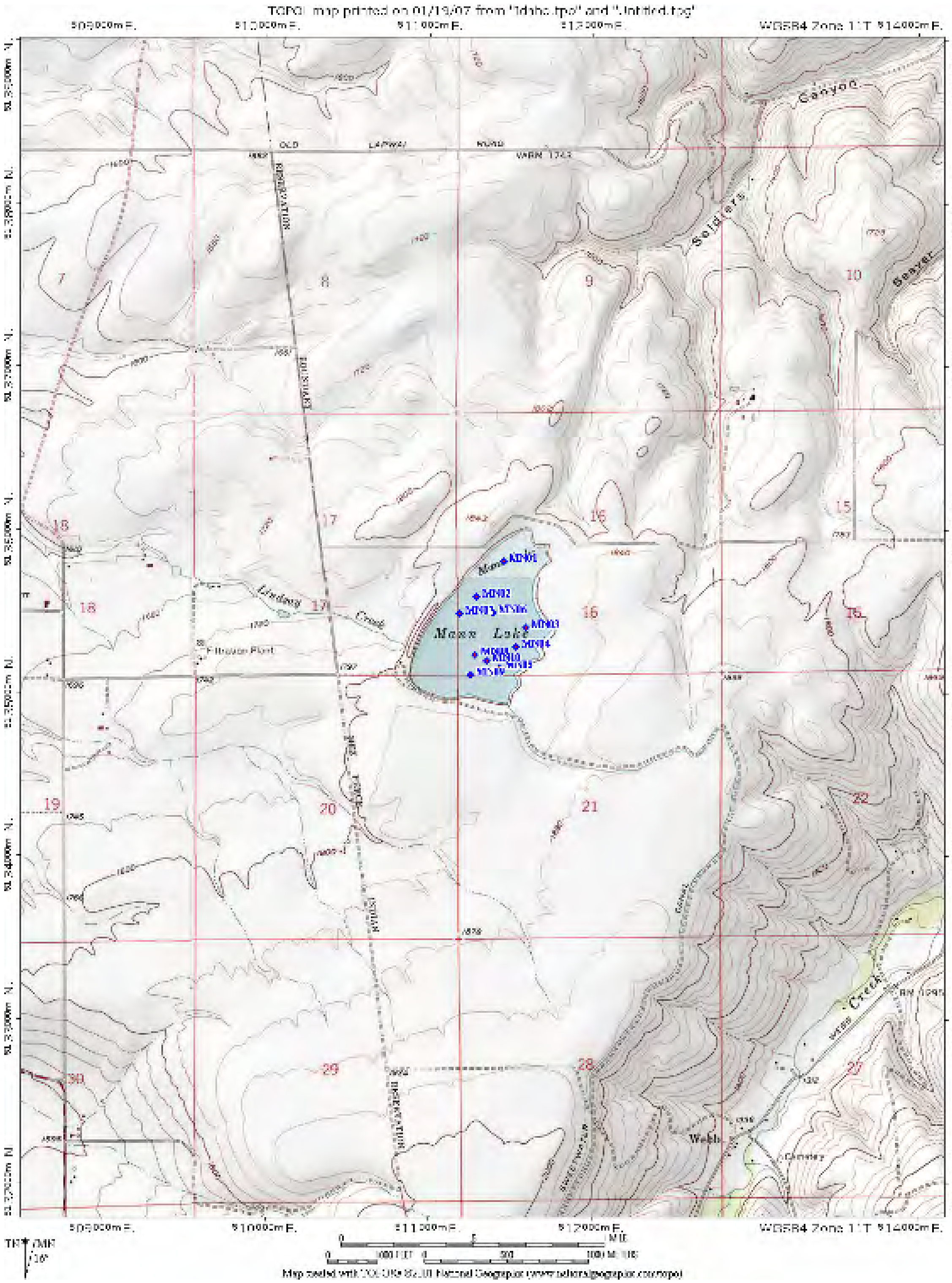


Appendix G. Map of fixed larval netting sites at Hauser Lake.



Appendix H. Map of fixed larval netting sites at Hayden Lake.

Appendix I. Map of fixed larval netting sites at Mann Lake.



ANNUAL PERFORMANCE REPORT
SUBPROJECT 3: ANGLER EXPLOITATION EVALUATIONS

State of: Idaho

Grant No.: F-73-R-27 Fishery Research

Project No.: 5

Title: Lake and Reservoir Research

Subproject #3: Angler Exploitation Evaluations

Contract Period: July 1, 2005 to June 30, 2006

ABSTRACT

A pilot study on angler exploitation of smallmouth bass *Micropterus dolomieui* and largemouth bass *M. salmoides* was conducted at four Idaho reservoirs along the Snake River. Bass were collected via electrofishing, trap netting, and angler tournaments and were marked with floy tags with a tag identification number and toll free phone number printed on the side. Tags returns, as a percentage of the number of releases, ranged from 4% at Gem Lake to 16% at CJ Strike Reservoir. Of the 76 total fish reported, 50% of the fish were reported as harvested. Assuming a 32% angler compliance rate, estimated exploitation rates ranged from 4% at Gem Lake to 17% at CJ Strike Reservoir. A great deal of information was learned from the 2005 pilot study, including difficulty in collecting bass, utilizing fishing tournaments, signing individual water bodies, and obtaining complete angler reports. This information will assist in the development of a study design for the largescale research project scheduled to begin in 2006.

Author:

Arthur E. Butts
Senior Fishery Research Biologist

Patrick Kennedy
Fishery Technician

Kevin A. Meyer
Principal Fisheries Research Biologist

INTRODUCTION

Angler exploitation can be a critical influence on the structure of sportfish communities through the effects on recruitment, mortality, and growth. Even when exploitation is considered to be minimal from a biologist's standpoint, angler perception is often different. Even when it is considered negligible, knowing the exploitation rate of a fishery is often useful for fishery managers to address public concerns and track changes over time. However, estimating exploitation can be extremely difficult and labor intensive. Furthermore, techniques to estimate exploitation include numerous assumptions that, when violated, render a great deal of uncertainty into estimates.

The most common technique consists of releasing a known number of marked fish and relying on angler returns to estimate the proportion harvested. This method requires that the actual tag reporting rate be estimated, which can be extremely problematic since the number of tags encountered by anglers and not reported is typically unknown. Thus the willingness of an angler to report a tag from a harvested fish, termed compliance, is often the most important facet of an exploitation study, although it is generally the variable with the highest uncertainty.

During the Idaho Department of Fish and Game (IDFG) resident fisheries research prioritization meeting in April 2004, developing better estimates of angler compliance was identified as a high priority research topic. Therefore, beginning in 2006, a large study that focuses on developing reward-response curves for a variety of species, fisheries, and geographic regions within Idaho will be initiated. However, a number of regional managers studied smallmouth bass *Micropterus dolomieui* exploitation in a number of waters across southern Idaho in 2005. This afforded us the opportunity to assist the managers and use the results as a set of pilot studies to examine angler compliance for bass, where no-reward was offered for tag returns. Because tag return rates cannot be truly estimated without uncertainty when rewards are not offered, compliance estimates generated during the 2006 study will be used to estimate final exploitation estimates for the 2005 study sites.

The overall objective of this study is to develop standardized methods to estimate angling exploitation and reward-response curves for a variety of species and fisheries across a broad geographical and sociological range in Idaho. The preliminary objective for 2005 is to initiate this research on five bass populations and to use the findings to assist in the design and implementation of the broader study beginning in 2006.

MANAGEMENT GOAL

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

OBJECTIVES

1. Develop standardized methods to estimate angling exploitation and reward-response curves for a variety of species and fisheries across a broad geographical and sociological range in Idaho. The study waters and species will be partitioned across a four-year period.

2. Evaluate and characterize the variation in observed tag reporting rates by species, and geographical and sociological differences in angler behavior.

METHODS

We marked smallmouth bass at CJ Strike Reservoir, Gem Lake, and a section of the Snake River between American Falls Reservoir and Lake Walcott. Largemouth bass *M. salmoides* were marked at Bell Rapids Reservoir. Fish were collected through angling, electrofishing, and trap nets. Every effort was made to capture, mark, and release the targeted number of fish within a short time period so that all fish experienced the same levels of potential exploitation. Only fish that were of harvestable size within the state regulations (≥ 12 inches; 305 mm) were marked. Fish were collected and released throughout the study areas to ensure that tagged fish are well mixed and representative of the entire population. We did this by tracking where fish were captured and released, and as the day progressed, decisions were made to shift efforts to different areas of the reservoir as needed.

At CJ Strike Reservoir, electrofishing and trap netting yielded few fish captures, so three bass tournaments were used to mark additional fish. Fish were collected during the weigh, were tagged and placed into the tournament live well, and subsequently were randomly dispersed throughout the reservoir by tournament workers.

Fish were marked with T-Bar anchor tags (Floy FD-94). Each tag was yellow 60-mm polyolefin tubing protected by a clear polyolefin covering to prevent wear and abrasion on the text of the tag. Each tag was inscribed with a unique tag number and “Return IDFG: 1-866-258-0338,” which is a toll free hotline set up to collect information from anglers.

Tagging was conducted by IDFG personnel. Prior to the event, each tagger was briefed on the methods to be used, the tagging location, and equipment and procedures so that the marking method was standardized. Each tagging station, whether on vessel or on shore contained necessary tagging equipment and data sheets. Each tagging station had two holding containers for pre- and post-tagged fish (holding and recovery). Efforts were made to ensure freshwater of ambient reservoir temperatures were used throughout the tagging event. Fish were measured for total length (nearest mm) and judged on condition and response to handling. Based on the judgment of the tagger, fish that displayed abnormal behavior were moved to the recovery tank, and were instead released without the tag. Fish received one or two anchor tags on the left side of the fish under the dorsal fin. Tags were applied from the rear of the fish at a 45º angle to the body’s long axis so that the tag would lie next to the body when the fish was swimming (Nielsen 1992). Subsequent to tagging, each tag was tested by gently tugging on each tag. If a tag was easily removed, the tagger would made a decision regarding placing another tag in the fish or moving it to the recovery tank. This decision was based on whether or not the fish was displaying abnormal behavior as a result of stress. The use of anesthesia and sterilization practices between fish did not appear to be necessary for this study.

Tag retention was assessed using two methods: a short-term (1 week) holding experiment and double tagging a known proportion of fish. Vreeland (1990) recommended a sample size of 300 fish for addressing tag retention and mortality studies. However, this was not possible for this study because collections of bass ≧305 mm were difficult to obtain and there was a need to ensure that our sample objectives for overall marking numbers be met.

Therefore, 22 fish were marked and held for 7 days in one net pen at CJ Strike Reservoir. Each fish was double tagged (n = 44) and the net pen was checked once during the 7 days to make sure pens were still deployed correctly and had not been vandalized. After 7 days, fish were removed and acute tag loss was assessed.

In addition to the short-term experiment, 19% of the marked fish received a double tag at CJ Strike and Bell Rapids reservoirs. Double-tagged fish were marked with two adjacent anchor tags (with tag numbers recorded) and the presence of one or two tags was one of the questions asked on the form/questionnaire that accompanied returned tags. There was still the possibility that a fish could lose both tags and bias results but the chances of an angler not recognizing a clipped fin was likely a larger bias. The possibility of an angler encountering two tags was also included on publicity postings.

Short-term mortality as a result of handling and tagging was assessed using the same experiment described above (tag retention section). At least 20 fish were held for 7 days at CJ Strike in an appropriate number of net pens for both tag retention and mortality estimates. Untagged fish were collected and measured so that handling was similar between the two groups. Any mortality that occurred among untagged fish was attributed to stress from holding and tagging mortality rates were accordingly adjusted.

All known access points were signed with information on the study, the color and location of the tag, and the information needed if an angler encounters a tagged fish. Signings at access points were checked every few weeks to ensure against vandalism. It was made clear that if an angler did not wish to harvest the fish, they could release the animal after writing down the tag number, or clip the tag itself and return it, while releasing the fish. We also provided a stack of removable 3 x 3 inch cards with return information as well as a questionnaire to assist anglers with reporting tags. The questionnaire included the following questions: 1. What was the approximate size of the fish and location of where it was caught? 2. Did you harvest or keep the fish? 3. Would you have kept this fish if it wasn't tagged? 4. Did the fish have two tags? and 5. Do you wish to have the tag returned to you? A space for angler contact information (name, telephone number, and address) was also provided.

A toll free hotline and voice mail system was set up to collect angler reports. The voicemail message contained a greeting and listed the information needed from the angler. In addition, anglers were also given the option of simply reporting tags via mail or at regional offices.

Because compliance was not estimated in 2005, exploitation estimates for the five study waters was calculated using the 32% compliance rate estimated by Nichols et al. (1991). Annual exploitation rates (µ) were estimated as the fraction of tags returned by anglers after adjusting for tag retention and angler compliance. The equation for calculating exploitation rate, described by Slipke and Maceina (2000), was modified to account for tagging mortality as well:

$$\mu = \frac{R/\lambda}{M\left[(1-Tag_l)+(1-Tag_m)\right]}$$

where *R* is the number of fish that were reported harvested, λ is the tag reporting rate, or the probability that a tag will be recovered and reported by an angler, *M* is the number of fish tagged and released, Tag_l is the rate of tag loss, and Tag_m is tagging mortality.

RESULTS

As of January 1, 2006, a total of 598 fish were tagged in four reservoirs, ranging from 45 smallmouth bass in Gem Lake to 300 smallmouth bass in CJ Strike Reservoir (Table 11). The number of reported tags as a percentage of the number of fish marked ranged from 4% on the Snake River to 16% at CJ Strike Reservoir.

We estimated a 5% tagging mortality using the net pen experiment at CJ Strike Reservoir, as 1 of the 22 fish died after 7 days holding (Table 12). A tag loss rate of 2% was also estimated using the net pen experiment, as 1 of 44 tags were lost during the 7-day experiment (Table 12). However, using the reports of double-tagged fish from anglers, where fish were released with two tags but only reported with one, a tag loss rate of 12% was estimated (Table 12). This latter value was the estimate used for tag loss for exploitation estimates.

Vandalism of signs was almost nonexistent after the first week of the study. However, signs were replaced monthly because of fading from weather conditions. CJ Strike Reservoir was the most intensive water body in terms of sign maintenance as it took approximately 4 hours to visit the 15 signs that were placed around the water body.

Estimated exploitation rates varied between waters and species. At both CJ Strike Reservoir and the section of the Snake River below American Falls, we estimated exploitation rates of 17% for smallmouth bass (Table 11). At Gem Lake, we estimated exploitation to be 4% for smallmouth bass. At Bell Rapids Reservoir, which is managed under trophy regulations, no fish were reported as harvested and, therefore, the exploitation rate was 0%.

The voice mail system used for the collection of angler reports proved to be problematic as anglers rarely reported all of the necessary information. This was likely because we were asking for a lot of information in the greeting and there was difficulty remembering all of the information that was needed for the tag report. Therefore we had to follow up on a high percentage (>50%) of angler reports to obtain complete information.

DISCUSSION

The work conducted during 2005 served as an excellent pilot study for the department's research on angler exploitation and tag reporting rates. Aside from developing recommendations for a largescale study in 2006, perhaps the most important objective of the 2005 work was to develop a sense for how difficult it would be to collect and tag bass in a variety of habitats. Our ability to collect fish was somewhat mixed in 2005. For example, at CJ Strike Reservoir, we utilized electrofishing, trap netting, and angler tournaments to collect smallmouth bass for tagging. A total of 710 fish were collected, of which, only 300 (42%) were of legal size or deemed healthy enough to tag (Table 13). When broken down by collection method, 87% were from angler tournaments, 25% from trap nets, and 7% from electrofishing. Because of concerns over tournament mortality, there may be concerns over using tournament-caught fish in the study. However, without these fish, only 32 smallmouth bass would have been tagged.

The practice of maintaining signs at the water bodies was a time consuming process even with the lack of vandalism. Weather alone caused significant degradation of the signs despite having been laminated with plastic. In many instances, the commitment of sign maintenance may be a deterrent to using tagging studies for some fish managers. Therefore, it may be worth sacrificing angler awareness of the tagging program for the simplicity of not maintaining signs at every water body. If angler reporting rates were estimated without signing at individual waters and instead, a more general approach with signs at license vendors or in fish rule books was used, sign maintenance would not be required.

Clearly, the voice mail system needs to be improved from the simple voice message system used in 2005. Anglers were expected to remember to report information such as catch date, species, tag number, whether or not the fish was harvested, and whether or not the tag influenced the angler's decision to harvest the fish. Asking for all of this information during a simple voice mail greeting was likely the cause for the paucity of complete angler reports. A system that has the capability of addressing each of these questions individually should greatly enhance the quality of the tag reports received from anglers. Also, a webpage so that anglers could report tags using the internet may be a desired option for many anglers. Both should be investigated prior to the beginning of the 2006 study.

ACKNOWLEDGEMENTS

We would like to thank Nick Sawyer for his role in collecting all data. We also thank Chris Sullivan, Liz Mamer, Andy Knight, Sarah Nelson, Steve Elle, and other IDFG personnel for their assistance in the field and laboratory. Cheryl Leben did an outstanding job of formatting the report.

LITERATURE CITED

Nichols, J. D., R. J. Blohm, R. E. Reynolds, R. E. Trost, J. E. Hines, and J. P. Bladen. 1991. Band reporting rates for mallards with reward bands of different dollar values. Journal of Wildlife Management 55:119-126.

Nielsen, L. A. 1992. Methods of marking fish and shellfish. American Fisheries Society Special Publication 23, Bethesda, Maryland.

Slipke, J. W., and M. J. Maceina. 2000. Fishery analyses and simulation tools (FAST). Auburn University. Auburn, Alabama.

Vreeland, R. R. 1990. Random-sampling design to estimate hatchery contributions to fisheries. Pages 691-707 *in* N. C. Parker, A. E. Giorgi, R. C. Heidinger, D. B. Jester, Jr., E. D. Prince, and G. A. Winans, editors. Fish-marking techniques. American Fisheries Society, Symposium 7, Bethesda, Maryland.

Table 11. Summary of tagging data for bass at four water bodies in 2005.

Location	Total Marked	Returns (% of marked)	Harvested	Released w/tag	Released w/out tag	Estimated exploitation
CJ Strike	300	47 (16%)	29	10	8	0.17
Bell Rapids	171	17 (10%)	0	15	2	0.00
Snake River	82	10 (12%)	8	2	0	0.17
Gem Lake	45	2 (4%)	1	1	0	0.04
Total	598	76 (13%)	38	28	10	0.11

Table 12. Summary of tag loss and tag mortality data collected from smallmouth bass at CJ Strike Reservoir and largemouth bass at Bell Rapids Reservoir during 2005.

	CJ Strike Reservoir	Bell Rapids Reservoir
Net pen experiment		
Total fish	22	-
Total Tags	44	-
7 day mortality	1 (0.05)	-
7 day tag loss	1 (0.02)	-
Double tag experiment		
Total Fish tagged	300	171
Total fish released with 2 tags	57	32
Total tags released	357	203
Total 2-tag fish recaptured	13	4
Total fish recaptured	47	17
Expected tag count	60	21
Observed tag count	53	21
Tag loss rate	0.12	0

Table 13. Number of legally harvestable versus all smallmouth bass collected at CJ Strike Reservoir with three types of collection methods.

	Electrofish	Tournament	Trap net	Total
Legal Fish	27	268	5	300
All Fish	383	307	20	710
% Legal	7%	87%	25%	42%

Prepared by:

Arthur E. Butts
Senior Fishery Research Biologist

Patrick Kennedy
Fishery Technician

Kevin A. Meyer
Principal Fisheries Research Biologist

Approved by:

IDAHO DEPARTMENT OF FISH AND GAME

Steve Yundt, Chief
Bureau of Fisheries

Daniel J. Schill
Fisheries Research Manager