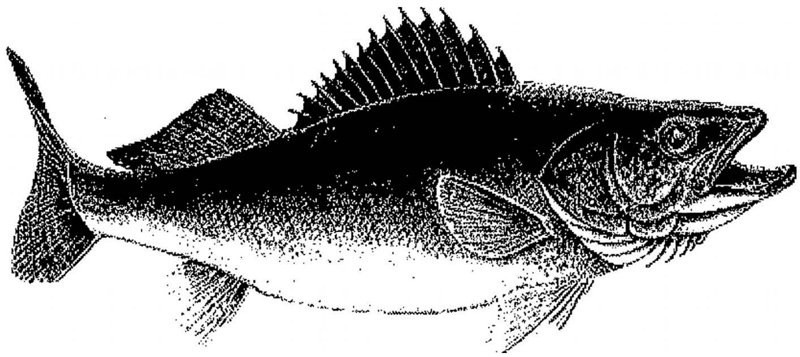

WALLEYE PRODUCTION DYNAMICS IN MID-ELEVATION RESERVOIRS IN UTAH: IMPACTS ON FORAGE FISH IN STARVATION AND YUBA RESERVOIRS

2002

by

Nick Bouwes

Department of Fisheries and Wildlife

Utah State University

Logan, Utah 84332

A report to the Division of Wildlife Resources,

F-47-R, XVI

June 1, 2003

Table of Contents

Executive Summary

Creating self-sustaining predator-prey interactions with a combination of native and exotic predators in highly altered reservoir systems, has been a difficult challenge to fisheries managers (Noble 1986). The inability to accurately assess predator and prey abundance and production is partially responsible for the difficulties in managing reservoirs. Recently, however, several techniques are available that have improved our ability to understand predator- prey interactions, including hydroacoustics, bioenergetics models, and stable isotope analyses (Yule and Luecke 1993, Luecke et al. 2000).

Walleye has often been chosen as a predator to stock in western reservoirs to enhance angling opportunities because life history characteristics of this species are conducive to the coolwaters of mountain reservoirs. However, walleye productivity in Utah reservoirs has not met the expectations of anglers nor fisheries managers (Slater and Luecke 1997). Starting in 1996, research has been conducted using several techniques mentioned above to understand walleye-prey interactions in several mid-elevation reservoirs (Luecke et al. 2000). These studies have documented that walleyes are responsible for the depletion of forage fish abundance in these reservoirs, which ultimately has reduced walleye production. Results from these studies led to the recommendation to actively reduce walleye abundance in Starvation and Yuba reservoirs in hopes to recover the forage fish populations and increase walleye production.

From 2000 to 2002 the Utah Division of Wildlife Resources (UDWR) has been aggressively removing walleyes in Starvation Reservoir through selective gill netting. The UDWR has removed 2,758, 6,482, 6,967 200-350 mm walleyes in 2000, 2001, and 2002, respectively. The objective of this study was to document forage fish population responses to these predator removals.

In 2001 and 2002, we used a combination of alternative fish sampling techniques to document changes in the abundance of 0+ and 1+ forage fish, specifically Utah chubs, in Starvation Reservoir. In 2002, we used seines, gill nets, trapnets, mid-water trawls, and

hydroacoustics to assess the abundance of forage fish. Perhaps the most striking result from the 2002 surveys was widespread presence of yellow perch in both the pelagic and littoral zone. This species appears to have been established in the reservoir in a very short time period. However, results from this effort suggested that even with the presence of yellow perch, forage fish were present in very low densities in the reservoir. We did not observe 1+ Utah chubs nor 0+ Utah chubs in the later sampling dates indicating that this species cannot survive to the end of their first year. Another factor that may be contributing to the low abundance of juvenile Utah chubs is the apparent poor health of the adults. In 2001, we documented a stress-related bacterial pathogen in a large proportion of female chubs. In addition, in 2001 and 2002, we observed multiple signs of physical deformities. These health conditions may ultimately reduce fecundity.

Yuba Reservoir has a population of walleyes that has exhibited low growth rates and production although greater than observed in Starvation Reservoir in recent years (Luecke et al. 2000). Recommendations were made to reduce walleye populations because observed walleye production could not be sustained in this system (Luecke et al. 2000). Based on these recommendations, the UDWR has changed walleye catch regulations to encourage higher removal rates of these predators. The objective of this study was to document changes in forage fish abundance as a result of these new fishing regulations.

Based on trawl and hydroacoustic sampling in early July 2002, forage fish are present in Yuba reservoir but, as in 2001, at very low densities. Comparisons with information collected since 1996 suggest that densities are lower now than has been observed since sampling began on this reservoir. In fact, yellow perch numbers have declined dramatically since 1998. The combination of intense walleye predation and lack of littoral vegetation could explain the patterns of recruitment observed in Yuba Reservoir.

Introduction

In both lacustrine and riverine systems, manipulation of piscivorous fishes has led to decreases in prey fishes (Shapiro and Wright 1984, Carpenter and Kitchell 1984, Power et al. 1985). In several cases the introduction of exotic piscivores has led to a collapse in their prey populations (Zaret and Paine 1973, Kitchell et al. 1994, Kaufman 1992). Reservoir foodwebs are generally managed from this top-down approach often without success (Noble 1986). Creating self-sustaining predator-prey interactions with a combination of native and exotic predators in these highly altered systems, uniquely different than either lakes or rivers, has been a difficult challenge to fisheries managers (Noble 1986). The inability to accurately assess predator and prey abundance and production is partially responsible for the difficulties in managing reservoirs. Recently, however, several techniques have been available that have improved our ability to understand predator- prey interactions, including hydroacoustics, bioenergetics models, and stable isotope analyses (Yule and Luecke 1993, Luecke et al. 2000).

Walleyes have often been chosen as a predator to stock in western reservoirs to enhance angling opportunities because life history characteristics of this species are conducive to the coolwaters of mountain reservoirs. Walleyes are highly fecund, have short egg incubation periods, and rapid larval and juvenile growth (Scott and Crossman 1973) that allow them to quickly establish in reservoir systems. The Utah Division of Wildlife Resources (UDWR) has stocked this highly prized sport fish in several mid elevation reservoirs throughout Utah. However, walleye productivity in Utah reservoirs has not met the expectations of anglers nor fisheries managers (Slater and Luecke 1997). Over the past few decades, walleye productivity has undergone large fluctuations, often characterized as boom or bust population cycles in several of these reservoirs (Luecke et al. 2000).

Starting in 1996, research has been conducted using several techniques mentioned above to understand walleye-prey interactions in several reservoirs (Luecke et al. 2000). These reservoirs ranged in walleye production between Starvation Reservoir exhibiting the lowest production and Yuba Reservoir the highest production. These two reservoirs have received the bulk of attention of the walleye reservoirs studied because they represent the range of walleye productivities. These studies have documented that walleyes are responsible for the depletion of forage fish abundance in both of these reservoirs, which ultimately has reduced walleye production. Results from these studies led to the recommendation to actively reduce walleye abundance in Starvation Reservoir in hopes of recovering the Utah chub population. For the past 3 years the UDWR has been removing walleyes with gill nets to reduce predatory pressure on Utah chubs. In Yuba Reservoir, walleye limits have increased from 2 to 6 in an effort to increase yellow perch production by reducing predator abundance.

The objective of this study was to document changes in forage fish abundance as a result of walleye reduction in Starvation and Yuba reservoirs. We used a combination of sampling gear and hydroacoustics during the summer of 2002 to determine the abundance of the different forage fishes of these reservoirs.

STARVATION RESERVOIR

Starvation Dam was constructed in 1969, creating Starvation Reservoir, a 1,255 ha reservoir with a mean depth of 19.9 m (max depth 47.2 m) with a total volume 162,798 acre ft at full pool. Starvation Reservoir is located at an elevation of 5,712 ft near Duchesne, Utah in Duchesne County. Water storage in this reservoir is used primarily to augment irrigation demands from the Central Utah Project (Crosby and Johnson 1994). Water withdrawals result in large water level fluctuations, which limits the establishment of aquatic macrophytes in the littoral zone (Chase 2000). The main tributaries to the reservoir are the Strawberry River and the Duchesne River, which is diverted into the reservoir via the Knight Diversion.

Originally, Starvation Reservoir was managed as a rainbow trout fishery, but shortly afterwards Utah chubs increased dramatically and walleyes, smallmouth bass, brown trout, and lake trout were introduced as the major sport fishes that could potentially utilize the abundant chub population (Crosby and Johnson 1994). Walleyes, smallmouth bass, and brown trout are now established in Starvation Reservoir. Cutthroat trout, mountain whitefish, Utah suckers, and carp are also found throughout the reservoir (Slater and Luecke1997).

Utah chub catches in UDWR gill net surveys have been declining since the establishment of the major sport fishes introduced into the reservoir. However, the mean length of Utah Chubs has been increasing, suggesting that the lower catches represented a lack of recruitment to mature adults (Crosby and Johnson 1996). Because of spawning timing, slow growth rates, and fusiform, soft-rayed body features, Utah chubs are highly susceptible to walleye predation (Luecke et al. 2000). This led to studies evaluating the role of predation in the recruitment dynamics of Utah chubs.

Chase (2000) estimated population abundance, growth and production of walleyes and smallmouth bass in Starvation Reservoir in 1997-1999. This information coupled with diets and stable isotope data suggested that walleyes were capable of consuming more than the entire forage fish production in the reservoir. Because walleyes relied heavily on alternative prey such as crayfish, forage fish populations have likely entered a 'predator pit', where walleyes are preventing recovery of forage fish numbers.

Walleye production in Starvation Reservoir has been low relative to production in other Utah reservoirs. Based on the results of these studies, Luecke et al. (2000) recommended removal of walleyes less than 350 mm as an effective approach to recovering forage fish and increasing walleye production. During the summers of 2000-2002, the UDWR has been aggressively removing walleye of this size range through selective gill netting. The UDWR has removed 2,758, 6,482, 6,967 200-350 mm walleyes in 2000, 2001, and 2002, respectively. The objective of this study was to document forage fish population responses to these predator removals. This information can be used to gage the effort required to keep predator and prey populations at levels that optimize predator and prey production.

Methods

Limnology

We measured limnological variables on July 12 and October 7, 2002 at Starvation Reservoir to provide background information to this study. Temperature and oxygen profiles of the water column were measured in the deepest area of the reservoir (approximately 28 m) with a Yellow Springs Instrument Model 58 Dissolved Oxygen Meter. We also measured water transparency with a 30 cm Secchi disk. In addition, we sampled zooplankton with an 80 micron Wisconsin net 30 cm in diameter to a depth of 0-15 m. Zooplankton samples were preserved in 95% EtOH.

Walleye population estimate and diet analysis

Gill nets were used by the UDWR to remove 200-350 mm walleye throughout the summer of 2002. Gill nets were set overnight over 20 dates between July 8-August 20, 2002. Mean total catch per net was recorded on each date. From this information we estimated the population abundance of this size class using depletion estimate techniques (Krebs 1999).

A sample of walleyes captured from the gill nets on July 12 were immediately frozen on dry ice and brought back to the lab for diet analysis. After walleyes were thawed the stomachs were removed and all invertebrate prey items were identified to order and weighed *en masse* by classification to the nearest 0.001 g.

Assessment of forage fish populations

In 2001-2002, we began an evaluation of alternative gear to document changes in the abundance of 0+ and 1+ forage fishes, specifically Utah chubs, in Starvation Reservoir. We used a combination of passive and active nets, electroshocking and hydroacoustics over most of the reservoir in an attempt to capture forage fishes. In 2001, we conducted surveys using neuston nets, beach seines, trap nets, minnow traps, gill nets, electroshocking, mid-water trawls, and hydroacoustics. In 2002, we used the same sampling gear except we did not utilize neuston nets, minnow traps, and electroshockers.

Hydroacoustics

Utah chubs have been observed in the pelagic zone of other Utah reservoirs (Yule and Luecke 1993). Hydroacoustics is an effective method to survey fish in the pelagic zone of lakes and reservoirs (Thorne 1983). We conducted hydroacoustic surveys using a Biosonics model 105 echo sounder using a 420-kHz dual beam (6°x15°) transducer to estimate fish density, fish size and depth in the pelagic zone of Starvation Reservoir. We used a similar protocol as surveys conducted in the past (Luecke et al. 2000). Acoustic information was collected at 2 pings/sec, a pulse width of 0.4 ms, between 2 m to the maximum depth, with single target criteria of 0.32-0.48 ms ½ peak amplitude and 0.40-0.80 ¼ peak amplitude. Only single fish within 6° of the acoustic beam axis were used in estimates of density and fish size. Acoustic targets between –58 and –48 were counted as age 0+ and age 1+ forage fish, which represents fish sizes between 30 and 110 mm. The total number of targets sampled divided by the volume sampled in each depth strata provided an estimate of fish density.

Diel hydroacoustic surveys were conducted on July 12-13, 2002 over 4-5 transects (Figure 1). Because the presence of yellow perch was detected in the reservoir we implemented a 7:00-11:00 sampling period as this time period has previously been demonstrated to be the most active time for yellow perch in the pelagic zone in Yuba Reservoir (Ryals et al. 1998). Transects were 10-20 min in duration. Mid-water trawls were used to identify species composition of targets (see below).

Mid-water trawl

Mid-water trawls were conducted in conjunction with the hydroacoustic surveys to sample the pelagic area of Starvation Reservoir for forage fish. On July 12-13, 2002, we performed 5 daytime and 5 nighttime 10-20 min mid-water trawls (Figure 1). The mid-water trawl measured 3 m wide by 7 m deep and could be deployed at a chosen depth.

The mid-water trawl was able to cover a majority of the water column in some areas of the reservoir. On July 12-13 we sampled between 2-17 m in depth.

Seine

Seining was used to capture 0+ and 1+ forage fishes utilizing the littoral zone of Starvation Reservoir. We conducted 31 10-75 m seine hauls on July, 12-13, and October 7-8 for a total of 940 m or 9245 m^2 sampled throughout the reservoir (Figure 1). The seine measured a 20 x 2 m with ¼ inch mesh seine. Two people were used to haul the seine. The distance between the beginning and end of the transect and the width between the two seiners was estimated to define the area seined.

Trap net

We also deployed a trap net to sample the littoral area for forage fishes in Starvation Reservoir. The trap net was equipped with 2 2x10 m leads that guided fish into a 2-chambered funnel trap. One lead was set at a 45° from shore and the other lead mirrored the shore lead in 1-2 m of water. We conducted 2 overnight sets on October 7-8 (Figure 1).

Gill nets

Gill nets were used to sample forage fishes in deeper areas of the littoral zone not accessed by the methods described above. We set 6 overnight gill nets perpendicular to shore 2-4 m in depth on July 12-13, 2002 and 12 overnight sets on October 7-9 (Figure 1). Gill nets were 18 m x 2 m with ¾" dimension stretch mesh.

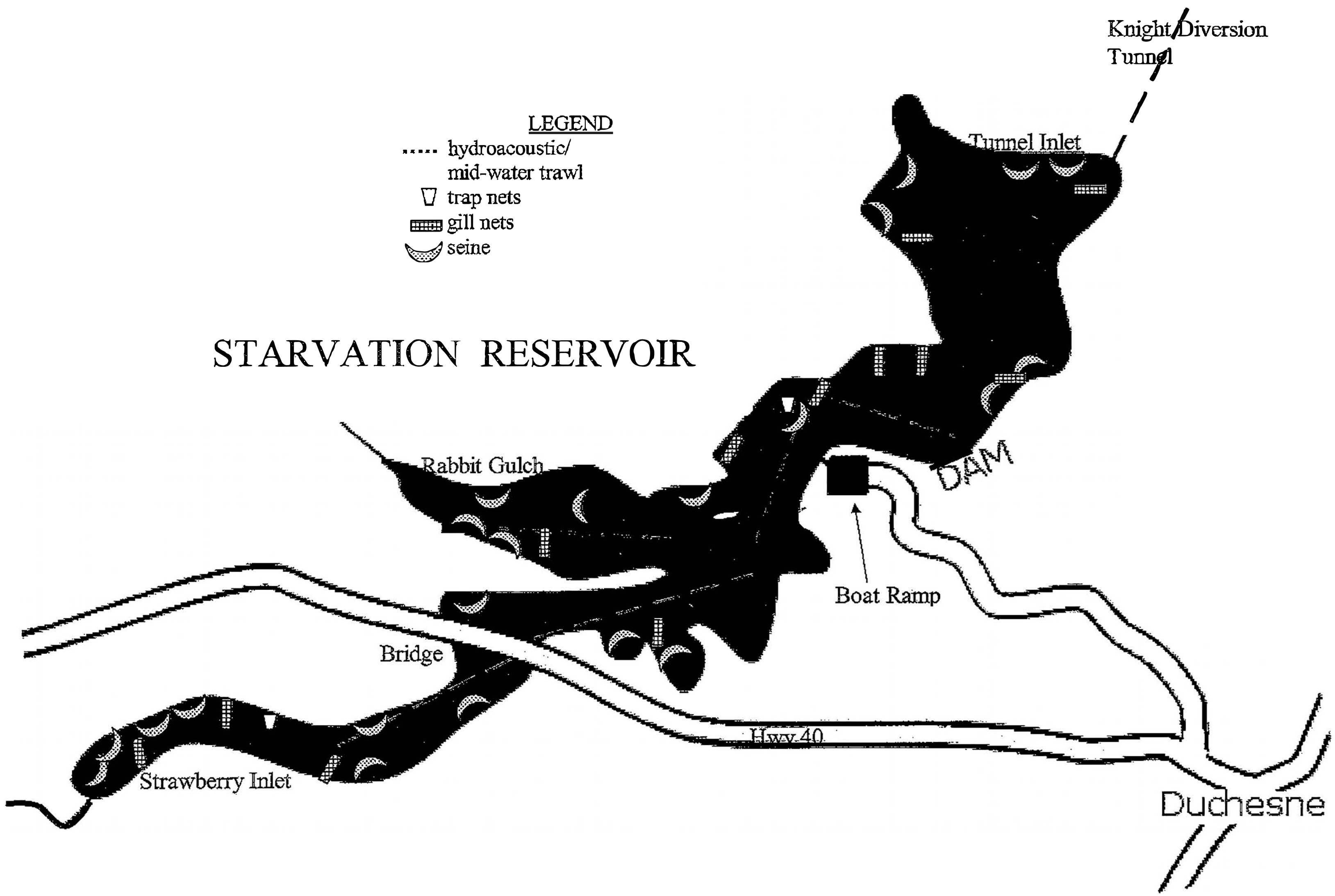

Figure 1. Location of sites where sampling occurred between July 12, 13, October 7,8, 2002 in Starvation Reservoir. Gear types and symbols are listed in the legend.

Results and Discussion

We measured temperature, dissolved oxygen, and Secchi depth to qualitatively demonstrate that physical variables were not preventing recruitment of forage fish in Starvation Reservoir in 2001 and 2002. As in 2001, temperatures were near optimal levels for Utah chubs and other forage fishes across all depths, and dissolved oxygen was near 100% saturation in the top 10 m in 2002 (Figure 2). Assuming that Secchi depth has a similar relationship to primary productivity in many other lakes, Starvation Reservoir would be considered mesotrophic with Secchi depths ranging from 4-6.25 m (Figure 2). Qualitative assessment of zooplankton samples suggests that large Cladocerans, a common food item for Utah chubs, are abundant in the reservoir. The conditions in Starvation Reservoir appear to be suitable for Utah chub recruitment during the time we sampled. Conditions over other times during the year possibly may limit recruitment; however, this seems unlikely given that the adult chubs in this reservoir are up to 25+ yrs old (Chase 2001) suggesting suitable conditions have existed for this species since the reservoir was created.

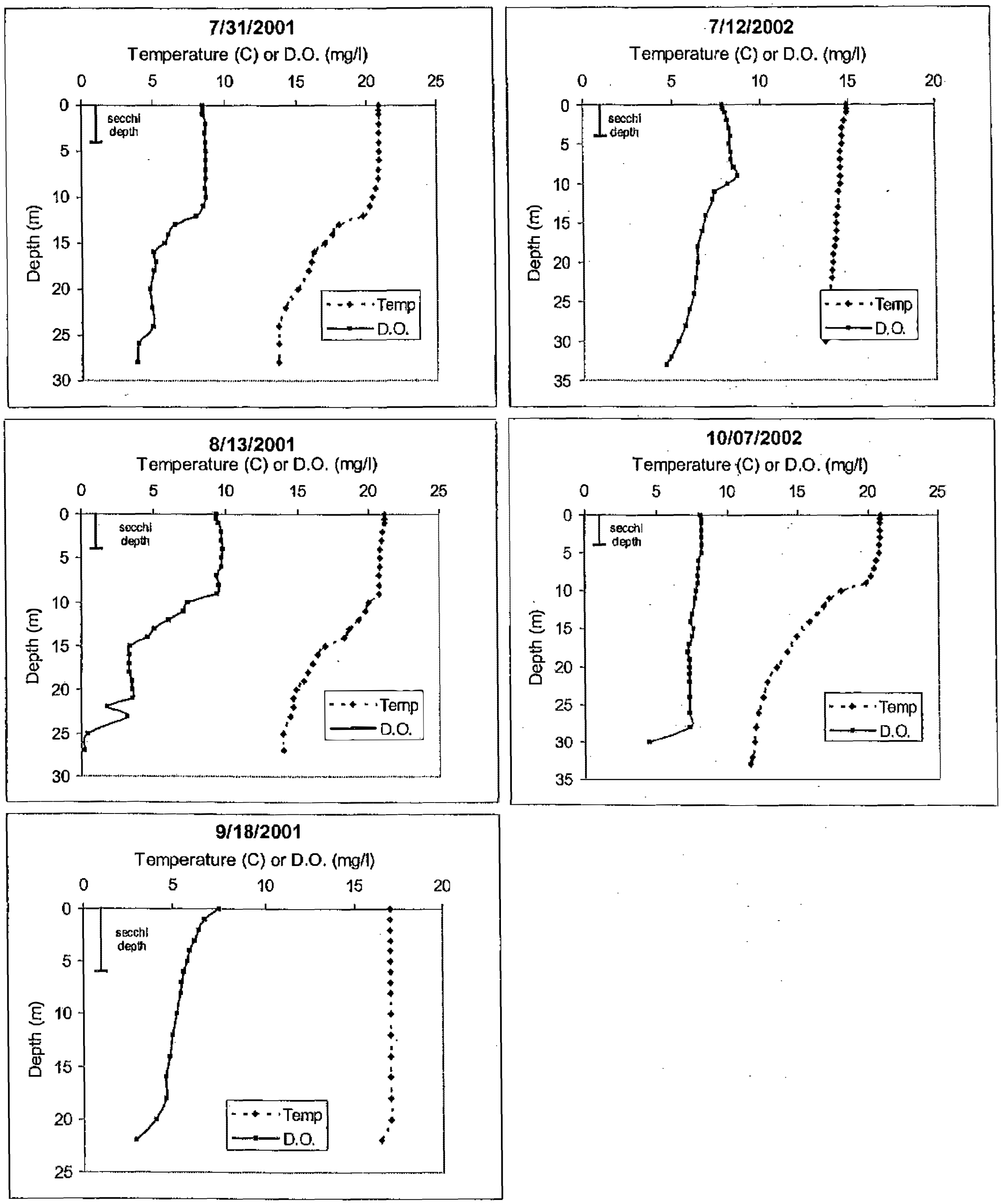

Figure 2. Temperature and dissolved oxygen profiles and secchi depths over 3 of the 2001 sampling dates and 2 of the 2002 sample dates in Starvation Reservoir.

A concern over the walleye fishery in Starvation Reservoir is that the large population of 200-350 mm is depleting forage fish abundance to a level that reduces walleye production and recruitment to larger size classes. A strategy employed in Starvation Reservoir to increase these goals is to reduce the number of walleyes in the 200-350 mm size class, allowing forage fish to recover. Gill nets have been used to remove walleyes over the last three summers. This information was used to estimate the size of the population in this size class in 2002. Theoretically, the rate of the number of walleyes caught per net should decrease as the population becomes smaller from removal of individuals (Krebs 1999). The number of walleyes captured per net decreased throughout the summer allowing for an extrapolation of the number of walleyes that need to be removed until they are no longer able to be captured (presumably because no walleye would be left given enough effort) (Figure 3). Using methods described by Krebs (2000), we estimated the number of walleyes in Starvation Reservoir to be 13,337 (95% confidence intervals between 7,633 and 19,121).

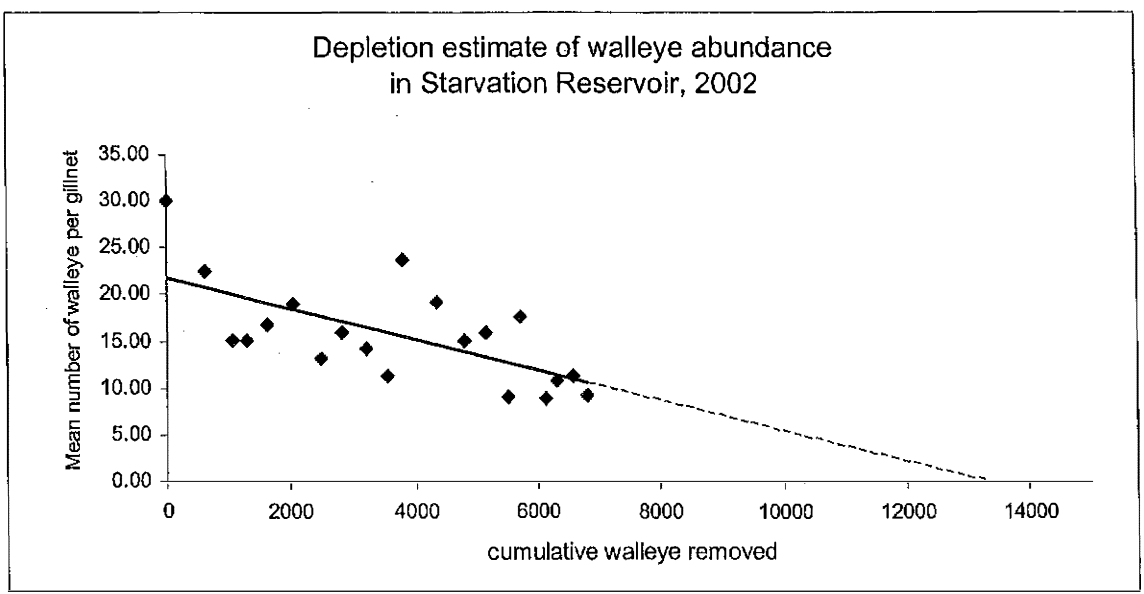

Figure 3. The number of walleye captured, on average, in gill nets as a function of the total number of walleyes removed by UDWR gill nets in Starvation Reservoir, 2002. Red dotted line is used to extrapolate to the total walleye population estimate.

We analyzed the stomachs of 20 walleyes collected on July 12, 2002 to determine how much of their prey items were composed of fish, in particular, Utah chub. Of the 20 stomachs analyzed, 3 were empty and the rest contained aquatic invertebrates. No fish were found in any of the stomachs analyzed, and thus bioenergetics models could not be used to estimate total consumption of forage fishes due to walleye predation. Odonates and chironomids were the dominant prey items in the stomachs of these walleyes (Figure 4). Although no fish were observed in these diets on this particular date does not indicate that walleyes do not rely on forage fish in Starvation Reservoir. Walleyes collected by the UDWR on other dates were not preserved for additional analyses, thus only a snapshot of the predatory behavior of walleyes was observed. Analyses of walleye stomachs from other dates, especially later in the season when 0+ chub and yellow perch have obtained greater size and have begun to utilize the pelagic area, may have revealed that fish are an important component of the walleye diet.

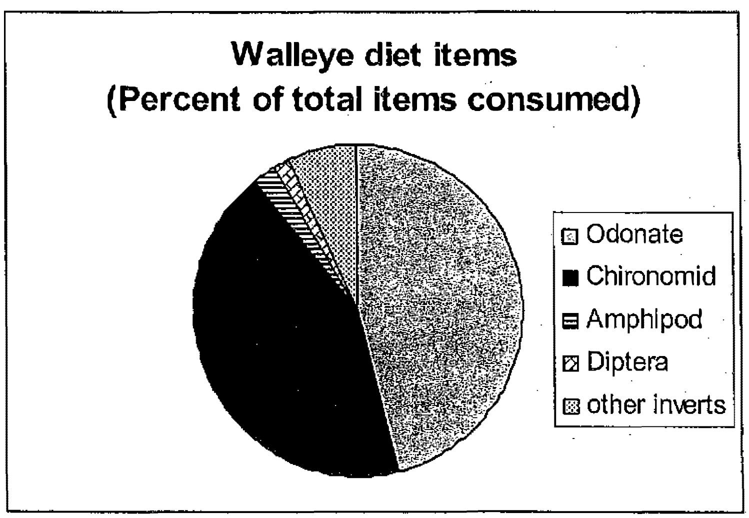

Figure 4. Percent of prey items from total prey observed in 17 walleye stomachs collected July 12, 2002.

The goal of this study was to document changes in forage fish abundance, mainly Utah chubs, following the removal of several walleyes, the major piscivore in Starvation Reservoir. As in 2001, results from our sampling suggest that forage fish abundance, especially Utah chubs, remains low. Assuming all targets were Utah chubs, the hydroacoustic survey indicated that fish between 30-110 mm were low in abundance in the pelagic zone (Figure 5 and 6). Luecke et al. (1999) found Utah chub densities ($g \cdot 1000m^{-3}$) in Flaming Gorge up to 20 fold greater than the average biomass density found in Starvation Reservoir. Their study included chubs from 80-350 mm and may partially explain this discrepancy. Biomass density targets in this size range in Starvation Reservoir were even lower (average of 0.44 $g \cdot 1000m^{-3}$) than the average biomass density observed for the 30-110 mm size class, therefore, if we included all chub sizes, densities were still much lower than in Flaming Gorge.

The assumption that all targets in 30-110 mm size category are chubs is not valid based on the data collected from the trawling survey. All fish caught in this size category were yellow perch. Thus, it is more likely that most targets were indeed yellow perch. Out of the entire sampling conducted in 2001, only 2 0+ yellow perch were observed. In 2002, yellow perch were observed in both the mid-water trawls and the beach seines throughout the reservoir. The establishment of yellow perch in such a short time period is perhaps the most significant difference between previous years and 2002.

Densities of fish in the hydroacoustic transects were similar throughout the reservoir although higher densities were found in the Strawberry River inlet and near the dam during the day (Figure 5). Average fish densities were higher during the day than at night in Starvation Reservoir although this was not true throughout the reservoir (Figures 5 and 6). Discrepancies in densities between day and night were greater in 2002 than in 2001 and likely reflect the foraging patterns of yellow perch, more abundant in 2002 (Ryals et al. 1999).

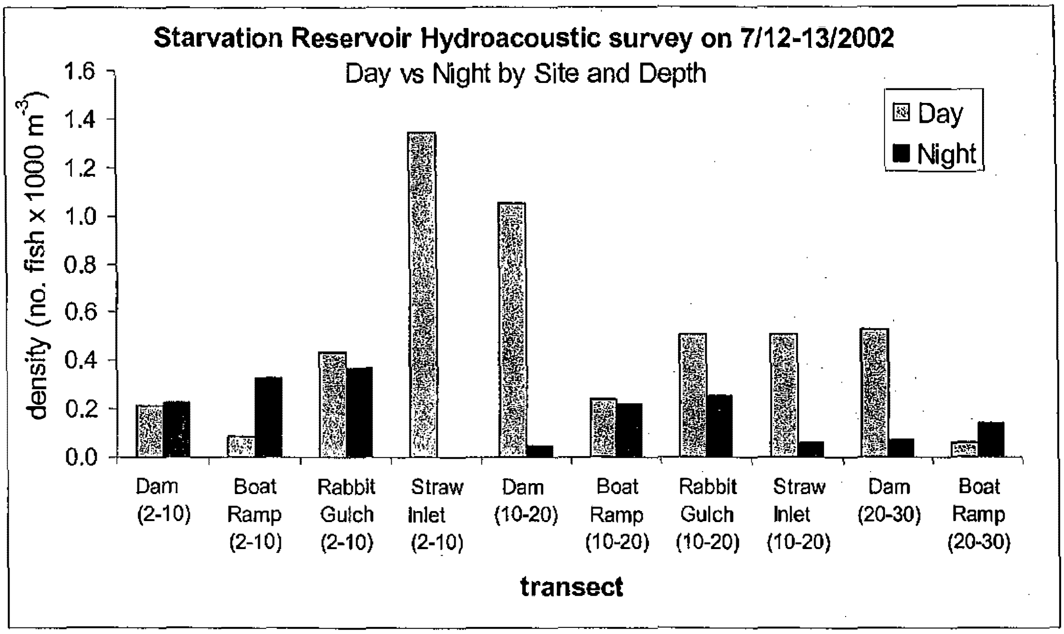

Figure 5: Estimates of 30-110 mm fish density (number · 1000 m^{-3}) using day and night hydroacoustic surveys in the 2-10m, 10-20m, and 20-30m depth strata of Starvation Reservoir in 2002 (see Figure 1 for location of transects).

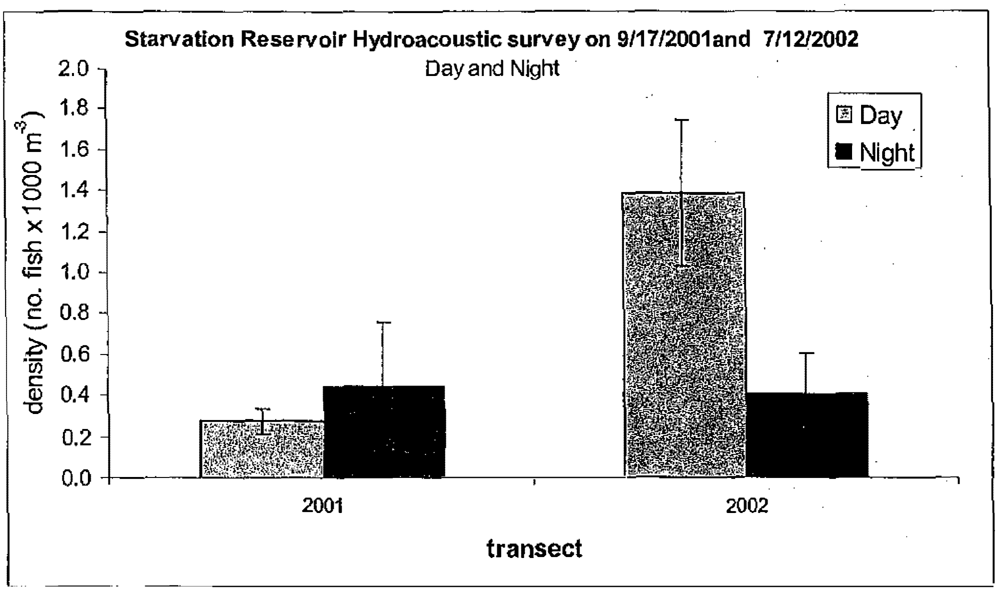

Figure 6. Estimates of average 30-110 mm fish density (g · 1000 m^{-3}) using day and night hydroacoustic surveys across all depth strata and transects of Starvation Reservoir (see Figure 1 for location of transects). Error bars represent ± 1 standard error.

During the day many cyprinids are found in the littoral zone of lakes, and therefore we put forth efforts to sample this area in 2001 and 2002. Beach seining proved to be effective at capturing all species of forage fishes although densities were low throughout the reservoir. In 2002, many 0+ fish were able to escape through the seine mesh during sampling, and thus a density estimate was not possible. However, using only fish that were captured in spite of the large mesh, densities were still quite high early in the year (Figure 7). As in 2001, catches of all 0+ and 1+ fishes were higher earlier in the season than later in the season (Figure 7). This may reflect an ontogenetic switch in habitat use, a decrease in the vulnerability to the seine as they became larger, and/or a reduction in the density of these species. Because nearly all species show high natural mortality in their first year, the latter is likely partially responsible for decline in densities. Because we do not have a reference, we cannot determine how much of this reduction is due to walleye and smallmouth bass predation. From a predator perspective, past bioenergetics and stable isotope analyses suggest that a majority of this reduction could potentially be attributed to predation (Luecke et al. 2000). Diet analyses conducted in 2002 does not support this conclusion, however, the analysis was limited to earlier in the year and may not represent the change in densities in forage fish due to walleye predation.

Smallmouth bass, carp, and chubs had the highest density of 0+ fish captured in the seine early in the season (Figure 7). Past analyses suggested that smallmouth bass are not utilized as a food source by walleye, but if the main prey items for walleyes continue to become scarce, smallmouth bass may provide an alternative prey item. Carp and chubs were abundant earlier in the season but declined dramatically by later in the season (Figure 7). Perch were also present earlier in the season but declined by later in the season. The only forage fish to not display this trend were suckers. Suckers may have spawned late enough as to not be vulnerable to seines during the early sample period, however, they do appear to have recruited to the later sample date (Figure 7).

In general, more forage fish were observed earlier in the season in 2002 than in 2001. However, more forage fish were observed later in the season in 2001, with the exception of suckers. A majority of suckers were observed near the Strawberry Inlet, in 2002. Because of the low water in 2002, the current extended further into the reservoir, than in 2001. If suckers are associated with the Strawberry River, the increase sucker abundance in 2002 may be explained by the differences in water level. Because water levels dropped dramatically throughout the 2002 sample season, this may also explain why more suckers were observed in the later sample date than earlier sample date.

Trap nets were used as a passive sampler in the littoral zone. Gill nets were used to sample deeper littoral water than sampled by other gears. Neither of the methods was effective at sampling forage fish during the 2002 sampling season.

The low occurrence of 0+ Utah chubs, and carp in seines later in the season suggests that recruitment was very low for forage fish in Starvation Reservoir. Although greater than 16,000 walleyes have been removed in the last 3 yrs, consumption by this large predator population coupled with consumption from brown trout and smallmouth bass, common in the reservoir, likely exceeds the forage fish production in Starvation Reservoir. Further predator removal may be necessary for forage fish populations to reestablish. However, given the rapid increase in perch numbers, this species may provide adequate forage to the current walleye population.

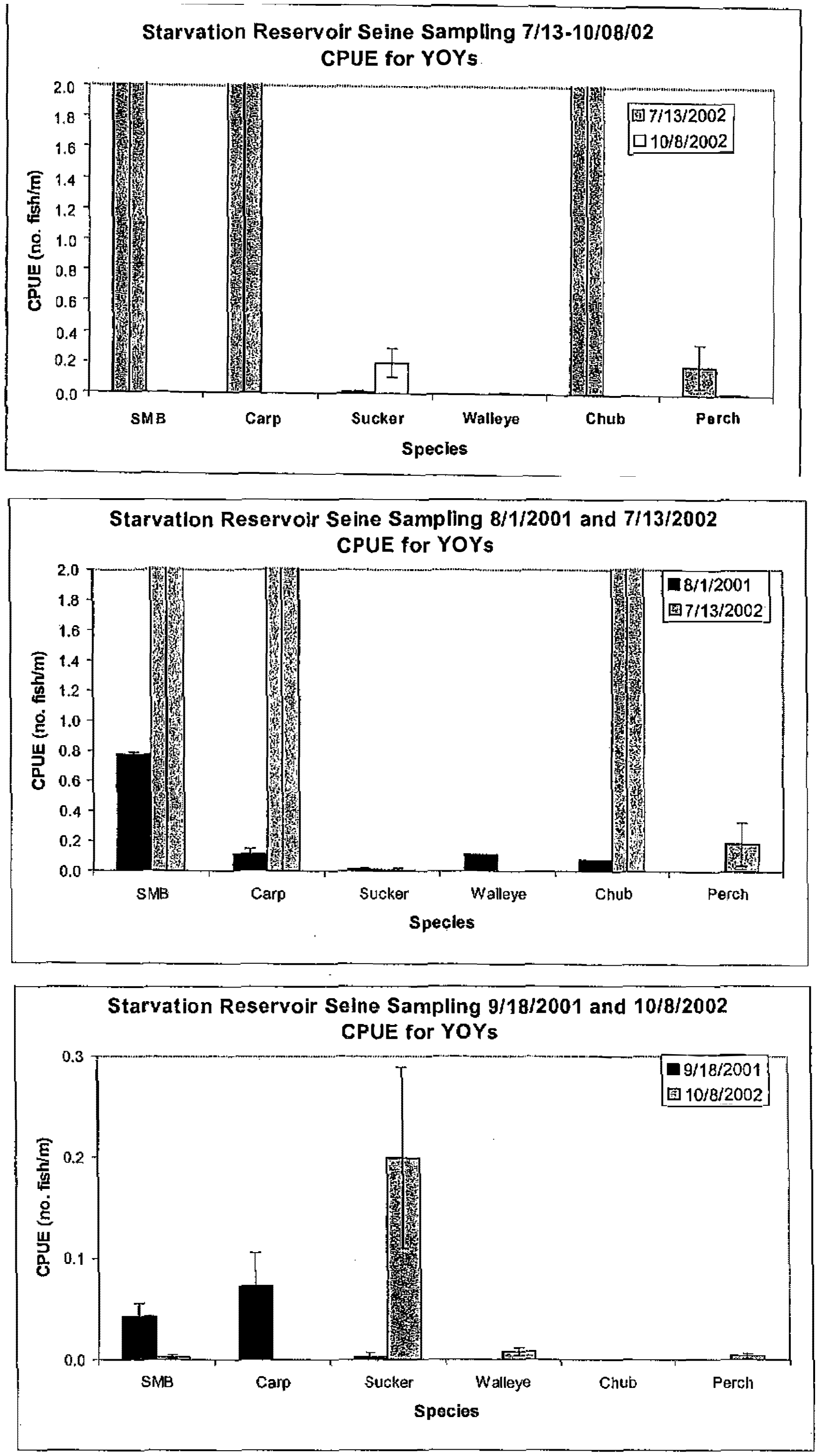

Figure 7. Density of fishes (number · m^{-2}) as determined from beach seine sampling. Top panel compares density of fishes between July 12 and October 8 sample dates of 2002 (extended blue bars represent minimum densities). The middle panel compares forage fish densities in the early sample dates of 2001 and 2002 (extended blue bars represent minimum densities). The bottom panel compares forage fish densities in the late sample dates of 2001 and 2002. Error bars represent ± 1 standard error.

Adult chubs still appear to be abundant in Starvation Reservoir as evidenced by the large numbers observed in the gill nets used for the predator removal (UDWR personal communication). The ability to produce a large year class without the pressure of predation appears possible with a large population of adult chubs that average 300 mm in length (Chase 2000). Another factor that may be contributing to the low abundance of juvenile Utah chubs is the apparent poor health of the adults, indicated by the presence of physical deformities we observed in a large portion of the population.

During the electroshocking survey of 2001, we began to note the presences of tumors, lesions, and deformities such as bloatedness, missing opercula, and crooked spines in large adult Utah chubs. We estimated 30-50% of the 33 chubs we collected during electroshocking had some extreme visual deformities (Figure 8). Although we did not capture many adult chubs in 2002, all chubs observed showed signs of physical deformities. We suspect that the percentage may be higher if some fish are experiencing similar problems that have not manifested obvious visual symptoms. In addition, if this condition is ultimately fatal we may be observing the survivors and past infection rates may have been much higher. In 2001, we brought back live specimens to be examined by the Fisheries Experiment Station in Logan, UT. Analyses suggest that *Pseudomonas fluorescens*, a stress-related bacterial pathogen, was present in the sample of chubs evaluated (C. Wilson personal communication). Tumors were found in abdominal cavities and on ovaries. Curiously, all samples brought back for pathological analyses were female. If this is specific to female chubs and the percent of infection is as high as noted, then the impact to the adult population could be catastrophic. Alternatively, these symptoms may not be harmful and could signify that chubs of this age (20+ years old; Chase 2000) are nearing senescence. Further attention should be given to this matter because this could explain the lack of recruitment of chubs in recent years.

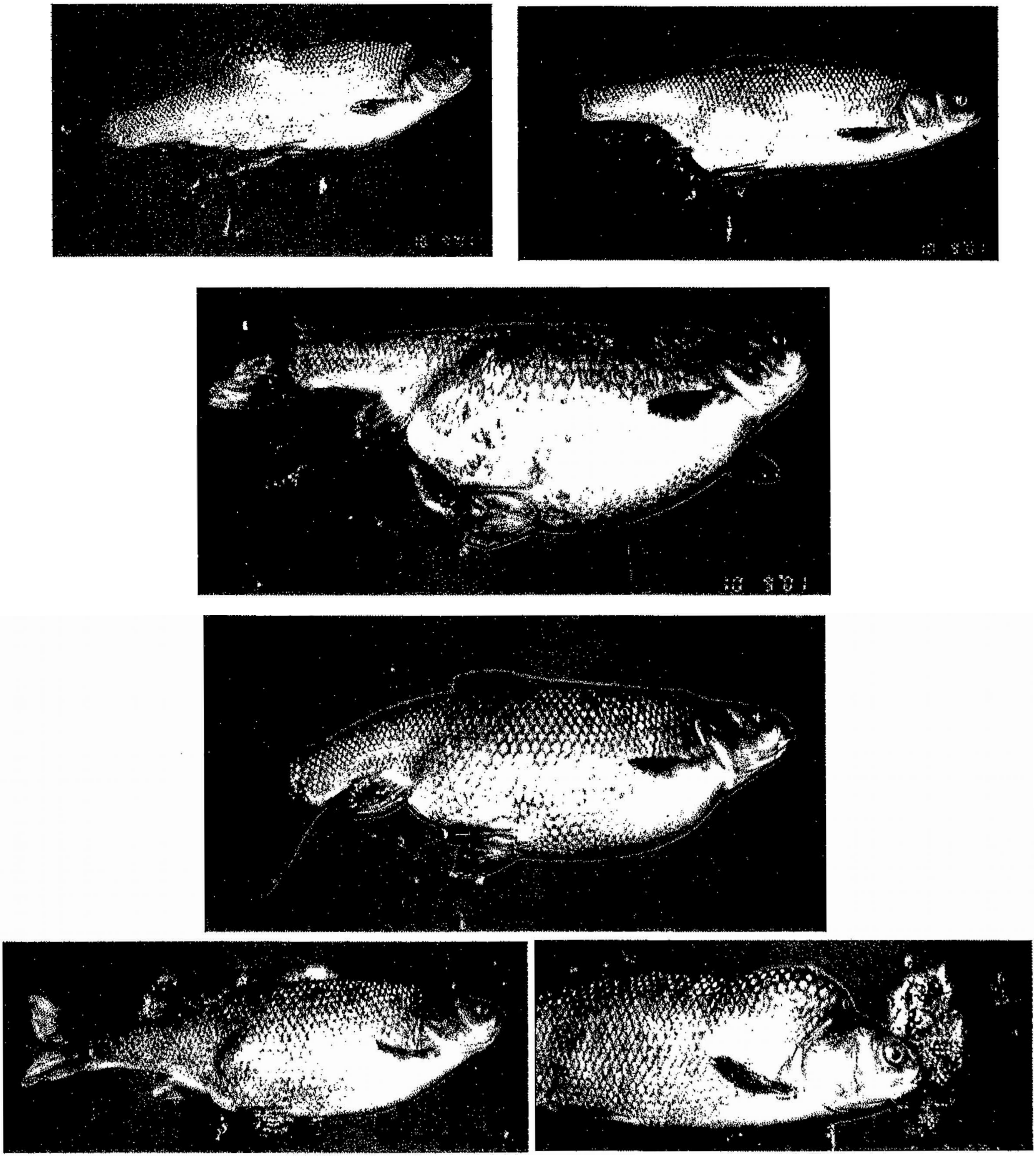

Figure 8. Examples of tumors and deformities found in several adult Utah chub in Starvation Reservoir. Middle two chubs exhibited signs of severe bloatedness.

YUBA RESERVOIR

Yuba Reservoir is an impoundment of the Sevier River that ultimately drains into Sevier Lake located in the Great Basin, Utah. The reservoir at full capacity is 4,415 ha and has an average depth 6.5 m (max depth is 22.6 m) for a total volume of 236,145 acre ft (Slater 1997). Reservoir elevation is 4,978 ft. Water storage in this reservoir is used primarily for irrigation. Water withdrawals result in large fluctuations, which limit the establishment of aquatic macrophytes in the littoral zone. Low water elevations in this reservoir have led to the collapse of fish populations in the past (Sakaguchi and Thompson 1982).

Walleyes are the major predators in Yuba Reservoir with northern pike (*Esox lucius*), channel catfish (*Ictalurus punctatus*), and rainbow trout found in lower relative abundance.
Yellow perch are the major forage fish with Utah suckers and carp also present in the reservoir (Slater 1997). Walleyes were originally stocked in Yuba Reservoir in 1952. The population collapsed in 1977-1978 due to extremely low water levels. In 1978-1979 approximately 9 million walleye fry were reintroduced into the reservoir (Sakaguchi and Thompson 1982). Yuba Reservoir has a population of walleye that exhibit growth rates and production greater than Starvation Reservoir in recent years (Luecke et al. 2000). In the past, yellow perch was the main prey item for walleye. Past bioenergetics modeling, stable isotope analysis, and population estimates suggested that walleye consumption of yellow perch equals perch production (Luecke et al. 2000). The objective of this study was to document yellow perch population dynamics in Yuba Reservoir

Methods

Limnology

We measured limnological variables on July 9, 2002 to provide background information to this study. We measured temperature and oxygen profiles of the water column in the deepest area of the reservoir with a Yellow Springs Instrument Model 58 Dissolved Oxygen Meter. We also measured water transparency with a 30 cm Secchi disk. In addition, we sampled zooplankton with an 80 micron Wisconsin net 30 cm in diameter to a depth of 15 m. Zooplankton samples were preserved in 95% EtOH.

Assessment of forage fish abundance

Hydroacoustics

We conducted hydroacoustic surveys using a Biosonics model 105 echo sounder using a 420-kHz dual beam (6°x15°) transducer to estimate fish density, fish size and depth in the pelagic zone of Yuba Reservoir. We used a similar protocol as surveys conducted in the past (Luecke et al. 2000). Acoustic information was collected at 2 pings/sec, a pulse width of 0.4 ms, between 2-maximum depth, with single target criteria of 0.32-0.48 ms ½ peak amplitude and 0.40-0.80 ¼ peak amplitude. Only single fish within 6° of the acoustic beam axis were used in estimates of density and fish size. Acoustic targets between –58 and –48 were counted as age 0+and age 1+ forage fish, which represents fish sizes between 30 and 110. The total number of targets divided by the volume sampled in each depth strata provided an estimate of fish density.

Hydroacoustic surveys were conducted between 7:00-11:00 AM on July 9-10, 2002 over 6 transects (Figure 9). This time period has previously been demonstrated to be the most active time for yellow perch in the pelagic zone (Ryals et al. 1999). Transects were 10-20 min in duration. Mid-water trawls were used to identify species composition of targets (see below).

Mid-water trawl

Mid-water trawls were also used in conjunction with the hydroacoustic survey to sample the pelagic area of Yuba Reservoir for forage fish. Mid-water trawls were also conducted over the same six transects between 7:00-11:00 AM (Figure 9). The mid-water trawl measured 3 m wide by 7 m deep and could be deployed at a chosen depth. The mid-water trawl was able to cover a majority of the water column in some areas of the reservoir. We sampled the upper 10 m of the water column, as a majority of the reservoir was less than this depth.

Results and Discussion

Temperature and oxygen profiles suggested that conditions were suitable for recruitment of forage fishes in Yuba Reservoir (Figure 10). Temperatures throughout the reservoir in mid-July were conducive to high growth rates for both perch and walleyes. Dissolved oxygen levels in the upper 10 m were greater than 80% saturation. Secchi disks measurements were 0.55 m on July 9, 2002 suggesting that the reservoir is highly productive. Leptodora were found in large quantities in the mid-water trawls, which provide an abundant food source for young forage fish.

Limnological conditions were similar in 2002 as in 2001 although temperatures were warmer in the deeper strata in 2002. This may suggest that the reservoir warmed earlier in 2002 than in 2001. Comparison of fish lengths between the two years suggests that yellow perch reproduction occurred earlier or growth rates were higher in 2002. Yellow perch averaged approximately 43 mm in length on July 12, 2001, whereas average lengths were approximately 60.5 mm on July 9, 2002. In fact, July 9, 2002 yellow perch lengths were more similar to the September 5, 2001, lengths averaging 64.5 mm.

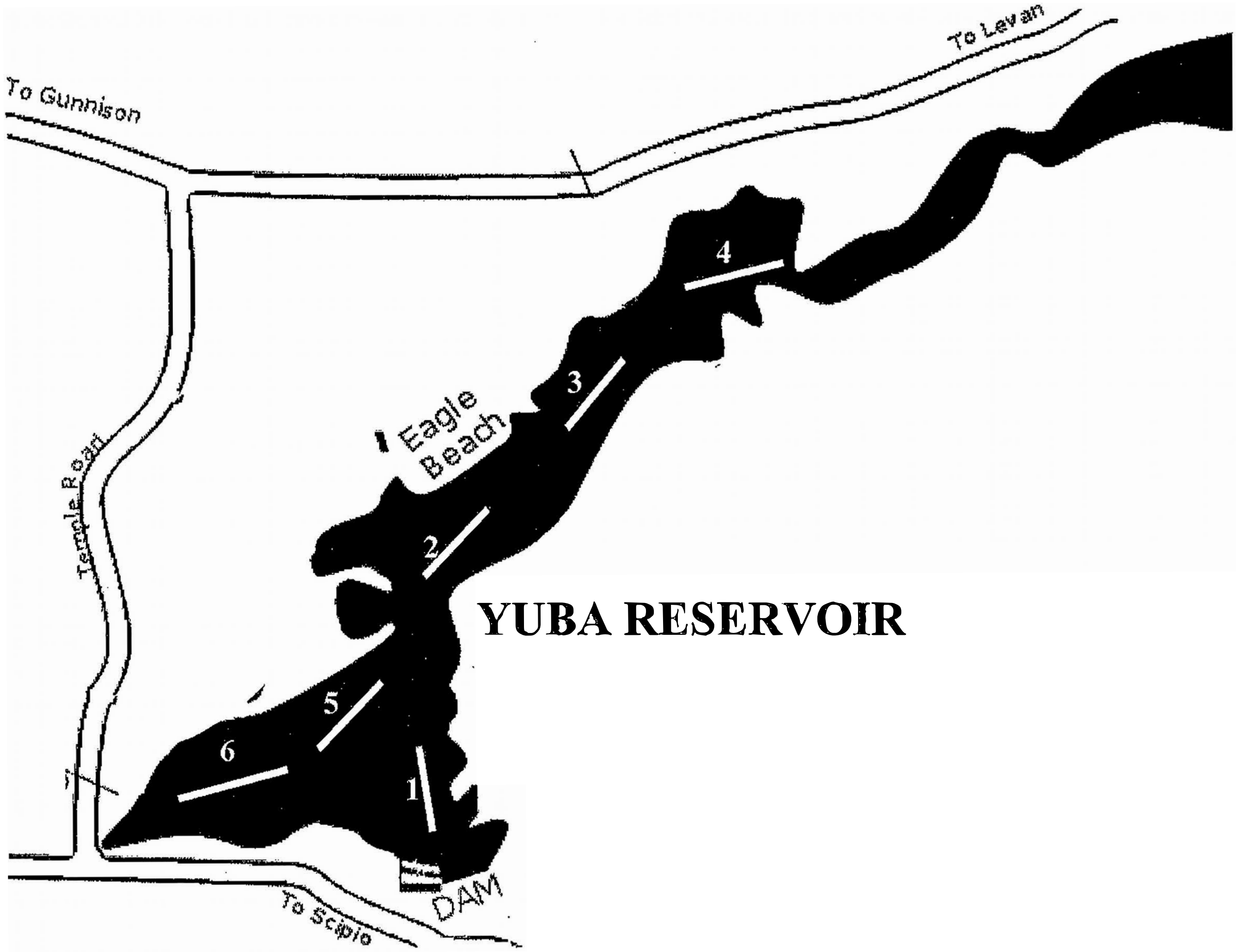

Figure 9: A map of Yuba Reservoir detailing the location of the hydroacoustic and mid-water trawl transects sampled on July 9-10, 2002.

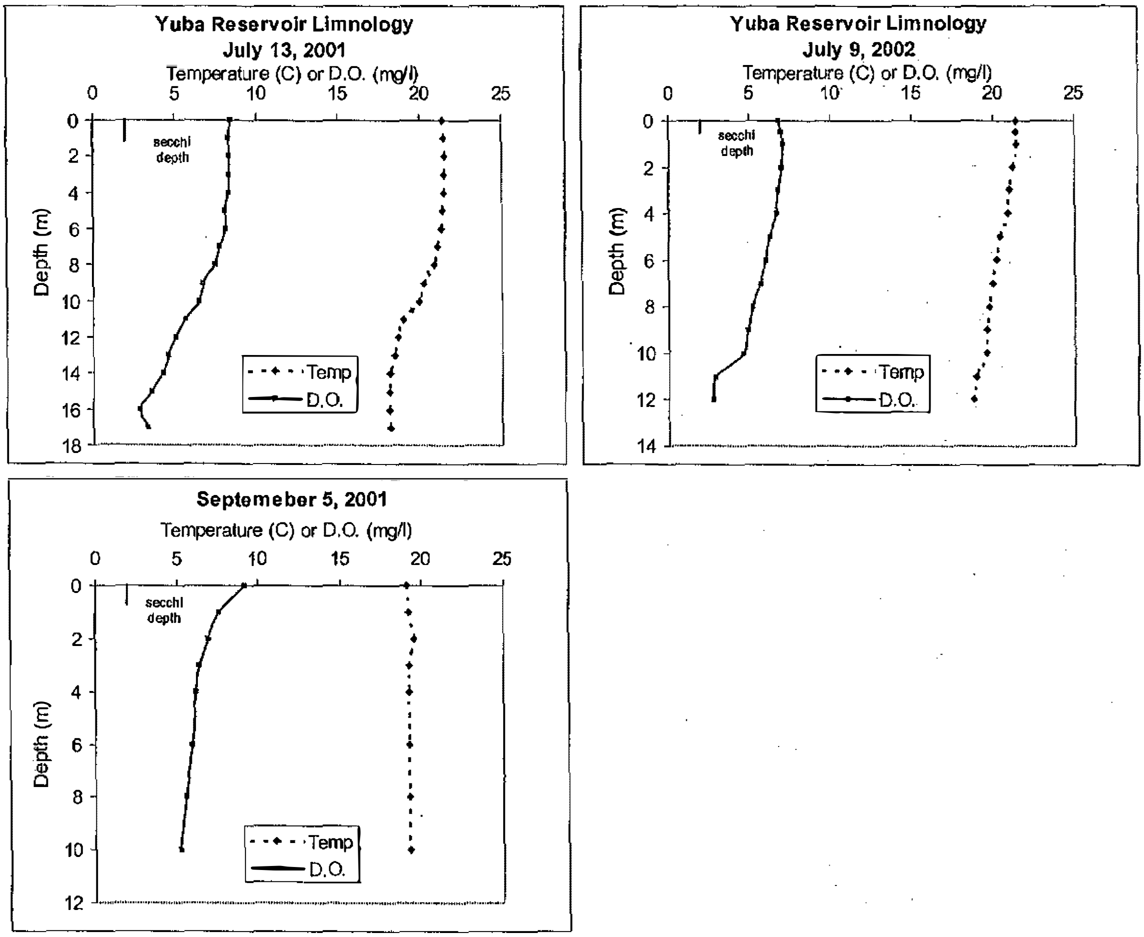

Figure 10. Temperature, dissolved oxygen profiles and Secchi depths over 2 sampling dates of 2001 and one sample date in 2002 in Yuba Reservoir.

Estimates from the hydroacoustic survey on July 9-10, 2002 indicated that the average forage fish density was low (2.0 fish · $1000m^{-3}$, SE 0.6) although nearly 5 fold higher than in Starvation Reservoir during the same time period. Density estimates from the July 9 and 10 mid-water trawls were generally lower than the hydroacoustics (Figure 11); however, these differences were small compared to the interannual differences (Figure 12). On this scale, trawl and hydroacoustics estimates were similar suggesting that either method would detect annual trends of this magnitude.

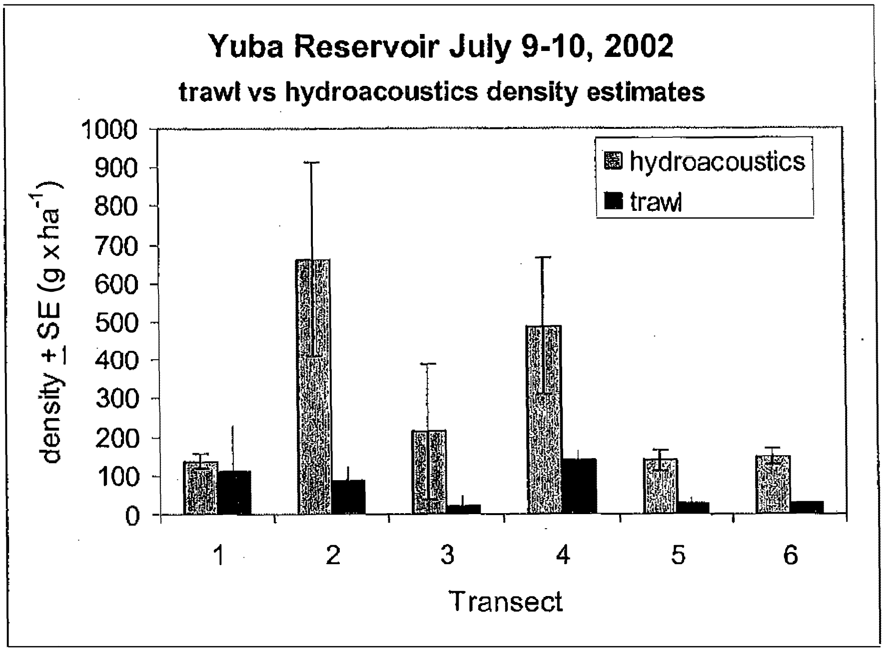

Figure 11. Estimates of 30-110 mm fish density (g · $hectare^{-1}$) from hydroacoustic and mid-water trawl surveys on July 9-10, 2002 in Yuba Reservoir (see Figure 1 for location of transects). Error bars represent ± 1 standard error in mid-water trawls.

In 2002, hydroacoustic estimates of biomass densities were similar to 2001 (Figure 12). Trawl biomass densities appear slightly higher in 2001 than 2002 although this difference was not significant and was largely driven by the large catch of yellow perch on first day of sampling in transect 1 (Figure 13).

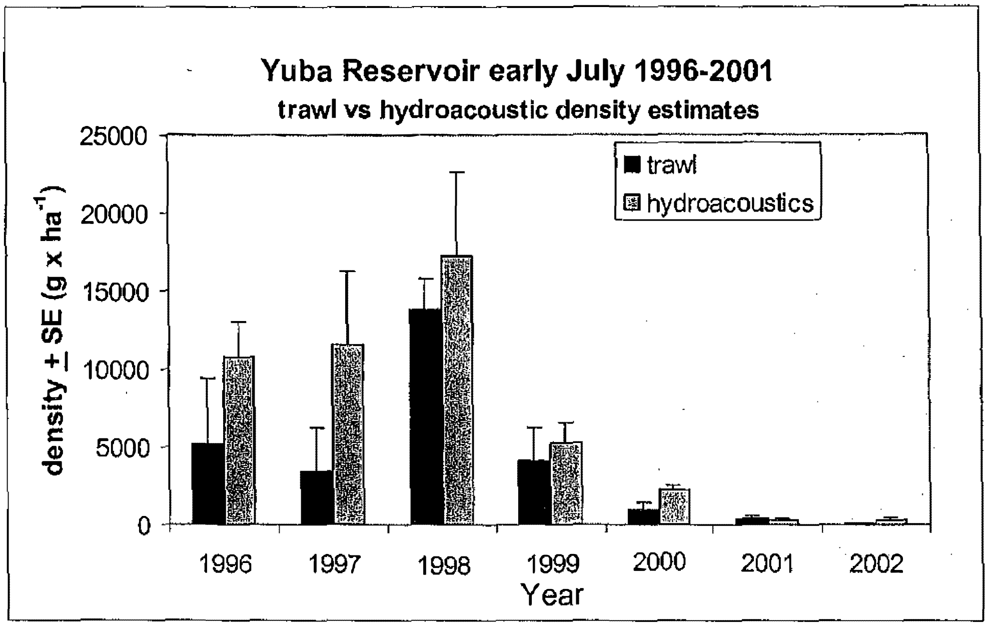

Figure 12. Estimates of 30-110 mm fish average density (g · hectare^{-1}) from hydroacoustic and mid-water trawl surveys conducted in July from 1996- 2002 in Yuba Reservoir (see Figure 1 for location of transects). Error bars represent ± 1 standard error in mid-water trawls.

As in 2001, the biomass and numbers of perch observed in the early July sample period were lower in 2002 than in the previous years when surveys were conducted (Figures 12). The sampling strategy for 2002, was to conduct only the July survey unless densities appear as high as the mid- to late-1990s. The low densities in 2002 indicate that the yellow perch population has not recovered in Yuba Reservoir despite changes in walleye management. We also did not capture 1+ perch in all trawls in 2001 and 2002. This suggests that either this age class is occupying areas of the reservoir that we do not sample with our mid-water trawls or that recruitment over their first winter was minimal. Age 1+ perch have been captured in previous years (although in low numbers) implying that they can be collected in our sampling regime. Therefore, recent trawl information indicates that recruitment of perch to age 1+ was very low.

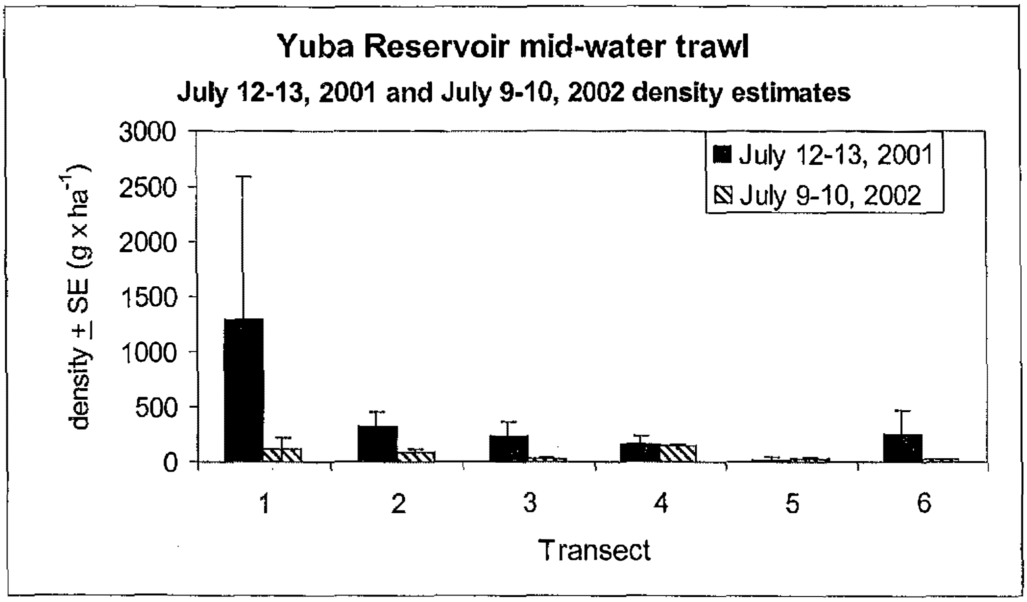

Figure 13. Yellow perch biomass density (g per ha) estimated over six established transects based on midwater trawls in early July 2001 and 2002 in Yuba reservoir.

Based on trawl and hydroacoustic sampling in 2001 and 2002, we believe that forage fish are present in Yuba reservoir but at very low densities. Comparisons to information collected since 1996 suggest that densities are lower now than have been observed since sampling began on this reservoir. In fact, yellow perch numbers have been declining dramatically since 1998. More alarming is the increased rates of decline found at the lower densities in recent years (Bouwes and Luecke 2002). This increased rate of decline, however, may also be partially an artifact of our sampling design and actually reflect changes in 0+ perch behavioral patterns (Bouwes and Luecke 2002).

Slater (1997) also suggested that if aquatic vegetation is not available in the littoral zone due to a decrease in water levels then poor recruitment of yellow perch could result. Water levels have been lower in recent years and may be partially responsible for the decrease in recruitment observed in these years. Aquatic vegetation often provides a refuge from predation that can allow a prey population to persist under intense predatory pressure (Hall and Werner 1977). The combination of intense walleye predation and lack of littoral vegetation would explain the patterns of recruitment observed in Yuba Reservoir.

References

Bouwes, N. and C. Luecke. 2002. Walleye production dynamics in mid-elevation reservoirs in Utah: impacts to forage fish in Starvation and Yuba Reservoirs. A report to the Utah Division of Wildlife Resources F-47-R, XVI.

Carpenter, S. R., J. F. Kitchell, and J. R. Hodgson. 1985. Cascading trophic interactions and lake primary productivity. BioScience 35:634-649.

Chase, P. D. 2000. Effects of walleye (*Stizostedion vitreum*) predation on Utah chub (*Gila atraria*) recruitment in Starvation Reservoir, Utah. MS Thesis, Utah State University, Logan, Utah.

Crosby, C. W., and E. K. Johnson. 1994. Starvation Reservoir Fishery: Annual gill net and electofishing trend report for 1994. Pages 6. Division of Wildlife Resources, Salt Lake City.

Crosby, C. W., and E. K. Johnson. 1996. Starvation Reservoir Fishery: Annual gill net and electofishing trend report for 1996. Pages 6. Division of Wildlife Resources, Salt Lake City.

Hall, D. J., and E. E. Werner. 1977. Seasonal distribution and abundance of fishes in the littoral zone of a Michigan Lake. Transactions of the American Fisheries Society 106: 545-555.

Kaufman, L. 1992. Catastrophic change in species-rich freshwater ecosystems. BioScience 42:846-858.

Kitchell, J. F., L. A. Eby, X. He, D. E. Schindler, and R. A. Wright. 1994. Predator-prey dynamics in an ecosystem context. Journal of Fish Biololgy 45 (Supplement A):209-226.

Krebs, C.J. 1999. Ecological Methodology. 2nd ed. Benjamin Cummings, Menlo Park, California. 620 pp.

Luecke, C., M. W. Wengert, R. W. Schneidervin. 1999. Comparing results of a spatially explicit growth model changes in length-weight relationship of lake trout (*Salvelinus namaycush*) in Flaming Gorge Reservoir. Canadian Journal of Fisheries and Aquatic Sciences 56 (Suppl. 1):162-169.

Luecke, C., P. Chase, and K. Ryals. 2000. Walleye production dynamics in mid-elevation reservoirs in Utah, 1996-2000. A report to the Utah Division of Wildlife Resources F-47-R, XV.

Nobel, R. L. 1986. Management of reservoir fish communities by influencing species interactions. pgs 137-143 *in* G. E. Hall and M.J. Van Den Avyle, eds. Reservoir fisheries management: strategies for the 80's. Reservoir Committee, Southern Division American Fisheries Society, Bethesda, Maryland.

Power, M. E., W. J. Matthews, and A. J. Stewart. 1985. Grazing minnows, piscivorous bass and stream algae: dynamics of strong interactions. Ecology 66:1448-1456.

Ryals, K, P. Chase, and C. Luecke. 1998. Walleye production dynamics in mid-elevation reservoirs in Utah, 1998. A report to the Utah Division of Wildlife Resources F-47-R, XI.

Sakaguachi, D. K. and C. W. Thompson. 1982. Report of the fishery investigation on Sevier Bridge (Yuba) Reservoir, 1982.

Scott, W. B., and E. J. Crossman. 1973. Freshwater Fishes of Canada. Fisheries Research Board of Canada Bulletin 184: 767-774.

Shapiro, J. and D. I. Wright. 1984. Lake Restoration by biomanipulation. Freshwater Biology. 14: 371-383.

Slater, M 1997. Walleye population dynamics in three mid-elevation reservoirs in central Utah. MS Thesis, Utah State University, Logan, Utah.

Slater, M., and C. Luecke. 1997. Walleye population characteristics and the ecosystems that support them in Yuba, Deer Creek, and Starvation Reservoirs. Pages 38. Department of Fisheries and Wildlife, Utah State University, Logan, Utah 84322.

Thorne, R. E. 1983. Chapter 12, Hydroacoustics, p. 239-259. In L. A. Nielsen and D. L. Johnson [eds.] Fisheries Techniques. American Fisheries Society, Bethesda, MD.

Yule, D. L., and C. Luecke. 1993. Lake trout consumption and recent changes in the fish assemblage of Flaming George Reservoir. Transactions of the American Fisheries Society 122: 1058-1069.

Zaret, T. M., and R. T. Paine. 1973. Species introduction in a tropical lake. Science, N. Y. 182:449-455.