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# AN ECOLOGICAL COMPARISON OF TWO ENDEMIC SPECIES OF WHITEFISH IN BEAR LAKE, UTAH/IDAHO

by

Brett W. Thompson

A thesis submitted in partial fulfillment
of the requirement for the degree

of

MASTER OF SCIENCE

in

Fisheries Biology

Approved:

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# ABSTRACT

## An Ecological / Life History Comparison of Two Whitefish Species in Bear Lake, Utah/Idaho

by

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Utah State University, 2003

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Department: Aquatic Watershed and Earth Resources

Ecological traits of the endemic Bear Lake whitefish *Prosopium abyssicola* and the Bonneville whitefish *Prosopium spilonotus* were investigated. Spatial distributions indicated distinctive differences in depth contour preference. Catch per unit effort data indicated that Bonneville whitefish prefer shallow depths and warmer water temperatures, whereas Bear Lake whitefish prefer deep, cold water.

Diet differences between the two species were large. Differences in both age distribution and growth rate patterns were also observed. The Bonneville whitefish population was predominantly composed of juvenile age classes. Very large adults reached ages of 12-14 years. Bear Lake whitefish exhibited a different population structure with few young fish and larger proportions of older age classes. Some of these fish were aged over 35 years old. Both analyses suggest that the population structure of each species is the result of a stable or growing population.

(131 pages)

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Brett W. Thompson

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# CHAPTER 1

# INTRODUCTION AND STUDY OBJECTIVES

Fishes adapt to perpetuate the history of their kind and maximize fitness. These adaptations allow them to occupy an extraordinary array of habitats, ranging from the tiniest desert springs, to deep ocean trenches. The diversity of fish (>25,000 species) and the habitats they occupy reflects their extremely long evolutionary history (Moyle and Cech 2000).

Fishes in Bear Lake, Utah/Idaho exemplify this diversity and adaptability. The whitefish group (Subfamily *Coregoninae*) has been regarded as being among the most intriguing and controversial group of animals from an evolutionary and taxonomic standpoint (Lindsey and Woods 1970). Three endemic *Coregonid* whitefish species of the genus *Prosopium* are currently recognized in Bear Lake: Bonneville whitefish *Prosopium spilonotus*, Bear Lake whitefish *Prosopium abyssicola*, and the Bonneville Cisco *Prosopium gemmiferum* Snyder (1921). However, only the Bonneville Cisco is affably distinguished from the others by means of simple morphological identification. Extensive research on the Bonneville cisco has previously been conducted (Perry 1943; Bouwes and Luecke 1997). Therefore, this species was not evaluated in the present study. The other two whitefish species exhibit different life history traits, including the separation of spawning times and size at age characteristics. These traits allow researchers to distinguish the Bear Lake and Bonneville whitefishes as spawning adults.

The whitefish complex in Bear Lake is particularly interesting in that they have been geographically isolated, at least since the Pleistocene. Although the mountain whitefish *Prosopium williamsoni* is ubiquitous throughout the west, no other endemic and sympatric morphotypes of whitefish occur in the region. Thus most taxonomists surmise that *P. williamsoni* is the ancestor to the three whitefish species in Bear Lake.

In North America and Europe similar complexes of lake whitefish have been reported in several disjunct localities including the Laurentian Great Lakes. Normally these complexes have one or more pairs of whitefish that are closely related. They are most often referred to as dwarf and normal morphotypes displaying distinct differences in behavioral and ecological traits (Pigeon et al. 1997). The origins of these "dwarf and normal" whitefish pairs remains uncertain. Some evidence suggests that both allopatric divergence followed by secondary contact and sympatric radiation may be involved. Other various modes of speciation have been hypothesized to account for coregonid complexes, including sympatric speciation within lakes, and micro-geographic speciation during deglaciation (Bodaly et al. 1992). Others have suggested that glacial refugia could be attributed where sympatric pairs of lake whitefish occur in geographically isolated areas (Svardson 1970).

It is not completely understood what mechanisms drove the relatively recent speciation of the Bear Lake whitefish complex. Geologic evidence suggests that the whitefishes in Bear Lake could have allopatric origins, which supports the widely accepted notion that complete geographic isolation is necessary to drive speciation (Behnke 1972). Alternatively, sympatric divergence may have occurred as a result of partitioning of food resources and or spawning habitat in space and time (Mann and McCart 1981; Schluter and Mcphail 1992). This mechanism may be plausible since all three species utilize the same limited spawning habitat during different times of the year.

Regardless of their origins the sympatric pair of whitefish in Bear Lake possess similar characteristics to those of the Eastern United States, Canada, and Europe. The Bonneville whitefish can reach total lengths of over 450 mm whereas the Bear Lake whitefish have never been collected at sizes greater than 280 mm (B. Nielson and S. Tolentino, Utah Division of Wildlife Resources, personal communication). The present study proposes that these two species are analogous to other sympatric pairs of whitefish where normal and dwarf morphotypes are present.

Difficulties in identification of the Bonneville and Bear Lake whitefishes outside of spawning times and at early life stages has precipitated research investigating possible differences in morphological traits and meristic counts (Ward 2000). Results of this study indicate that both lateral line/dorsal and total lateral line scale counts provide a means of distinguishing individuals of these species. All life stages of whitefish were separated in an effort to investigate the inherent ecological and biological differences that are present between the two species.

Prior to the present study it was unknown if each species demonstrated different population dynamics, food habits, seasonal habitat preference, and spatial distribution. Attaining some understanding of these factors is imperative since both species are endemic to Bear Lake and their preservation may depend on these ecological relationships.

Chapter 2 will detail the intrinsic ecological traits of both whitefish species. More specifically this chapter will describe the evolution of these two species and how they have successfully persisted in Bear Lake under sympatric conditions. To understand these traits, specific ecological characteristics were investigated, including; (1) their diet preferences during the summer, when the lake is thermally stratified, and during the winter-early spring when the lake is iso-thermic; (2) Their spatial distribution during these same time periods. The data collected will provide important insight into the life history differences of both species, and will assist with the criteria of a management plan.

In Chapter 3, size, age at length, and fecundity were explored to understand the life history both populations. Sectioned otoliths were used to determine age structures and growth characteristics. These data were then used to parameterize a life table and Leslie matrix to gain a better understanding of important population growth characteristics, and sensitive stages in each species life history.

## Study Objectives

1. To assess the differences in food resources used by the two whitefish species. Stomach contents were examined to determine if they are utilizing different sources of food. If spatial separation is established, differences in food preferences will be expected. Different species of fish often evolve feeding structures and mechanisms that allow them to exploit a vast array of food resources. White (1974) documented differences in maxillary length and positioning of the mouth in some known specimens of Bear Lake whitefish. The mouth of the Bear Lake whitefish is often inferior and pointing in a sub-terminal direction when compared to the Bonneville whitefish. A preference for benthic dwelling organisms would correspond with this morphological difference and could be an evolutionary adaptation.

The information provided will give us a better understanding about which trophic levels the whitefish are feeding at within the lake. Diet analysis will provide important information to fisheries managers trying to make decisions that may directly or indirectly precipitate unwanted population changes.

2. To identify spatial distribution (by depth contour) differences between Bear Lake and Bonneville whitefish. Because known morphological differences permitted the identification of non-spawning individuals, habitat partitioning during both the summer months when the lake is thermally stratified, and also after fall mixing when the lake is iso-thermic was investigated. Mazur (1999) failed to collect a significant number of Bear Lake whitefish in depths deeper than 30 m. Depths greater than 30 m were thus sampled extensively in the present study. The proportion of Bear Lake / Bonneville whitefish reported in his (Mazur 1999) intensive gill net study were very low, indicating that the Bear Lake whitefish were not being sampled effectively. Folklore and old reports produced by pioneering investigators on Bear Lake have mentioned that Bear Lake whitefish dwell in deep water. Snyder (1921) may have had some semblance of their distribution when he described the Bear Lake whitefish as *abyssicola* meaning "of the deep." However, prior to this study, no substantial data existed concerning habitat use and or spatial distribution of whitefish in Bear Lake deeper than 35 m. Utah Division of Wildlife Resources (U.D.W.R.) samples the lake annually up to 35-40 m. The examination of these data suggests that a separate smaller size class of fish is present, which might be the Bear Lake whitefish. These observations suggest that Bear Lake whitefish may prefer deeper, colder water (Elliot 1976; Buckel 1995).

3. Otoliths from both species were sectioned and examined to determine the age structure of both populations. Length at age and growth rate parameters inherent to the life history of both species were then calculated. Through a vertical-static life table analysis,

variation in mortality and fecundity of separate size classes were examined, and the effects on population dynamics reported.

The most reliable method of determining age-specific mortality and fecundity rates for populations that have overlapping generations is to follow the fate of a group of individuals (a cohort) through a complete lifecycle (Begon et al. 1986). Unfortunately is not always possible to monitor the dynamics of a population by constructing such a "fixed cohort" life table. In fact, natural populations of animals are rarely examined in this way, as individuals are highly more mobile and surreptitious to observers. However, an alternative to the cohort life table exists. This is called a static or vertical life table. The static life table involves examining the age structure and survival probabilities of the whole population at one particular time step. In a sense it consists of taking a "snap shot" (sample) or a slice out of a larger population that was constructed over a longer period of time. This type of life table can have practical uses when trying to describe populations and can provide a number of important life history parameters that can be calculated based on survivorship and fecundity schedules. Lowe (1969) demonstrated the uses of such a life table with deer populations in Scotland. He was more concerned, as is the present study, with general trends rather than with particular changes occurring from one year to the next. Certain assumptions apply to the use of static life tables:

1. The populations are closed. Changes in population size are dependent on local births and deaths.
2. There is no genetic structure within the populations. There cannot be any underlying genetic variation in the populations that affect the birth and death rates.
3. This life table assumes that the population has reached its stable age distribution.

The latter assumption is rarely met when sampling natural populations. However the goal of this study was not to use the data generated by the life table to accurately project population sizes or trends several generations into the future, but rather use the information derived by the life table to perform a sensitivity analysis. In general the purpose of using such a life-table, as the model that Lowe constructed, is to discover patterns of birth and mortality, which are repeated year to year under a variety of circumstances. In this study static life table approaches were used to assess the shared or un-shared properties of the whitefish species in Bear Lake.

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# CHAPTER 2

# ECOLOGICAL CHARACTERISTICS: FOOD HABITS, DIET PREFERENCES, AND SPATIAL DISTRIBUTION OF BONNEVILLE WHITEFISH *PROSOPIUM SPILONOTUS*, AND BEAR LAKE WHITEFISH *PROSOPIUM ABYSSICOLA* IN BEAR LAKE, UTAH / IDAHO

*Abstract*. – Bonneville and Bear Lake whitefish were sampled using gill nets throughout the summer of 2000, early spring 2001, and the summer of 2001. Samples were taken from the stomachs of whitefish and analyzed in the lab to investigate differences in food preferences between the two species. Spatial distributions were analyzed using the catch per unit effort (CPUE) data collected during the gill netting survey. Large differences in the diets of the two species were found at nearly every size class indicating apparent resource partitioning within the lake. Whitefish captured in the gill nets during every sampling period showed that not only do the two species differ in relative abundance, but their spatial distribution was also significantly different. Bonneville whitefish were more abundant in shallower depths with 96% caught in water depths of 5-35 m. Bear Lake whitefish were more abundant in deeper water with 90% caught in depths ranging from 40-60 m.

## Introduction

The diets and feeding habits reveal many distinguishable characteristics attributed to a species ecology. They help provide information as what trophic level a fish occupies and define species that occupy often complex food chains.

The mouth morphology of fish is one factor that dictates what they can and will eat. Ultimately through a fishes morphological and physiological evolution they settle into respective niches within ecosystems. The Bonneville and Bear Lake whitefish in Bear Lake employ an inferior mouth morphology. This is evident by their aberrant pre-maxilla, which distinguishes their genus from all other *Coregonid* species. They are neither specialized for feeding on prey associated with the benthos, or for preying heavily on forage fish, and or zooplankton suspended in the pelagic zone. This generalist feeding strategy may provide some advantage in competing with effective planktivores (Bonneville Cisco), piscivores (Cutthroat Trout), and benthic feeders (Utah Sucker and Utah Chub) that are also native to Bear Lake.

Seasonal diets of each whitefish species were examined to detect any differences in the feeding ecology of Bonneville and Bear Lake whitefish throughout their entire life history. Spatial distribution was also explored using a gill net survey of benthic habitats. The distribution of the whitefish complex in Bear Lake has been evaluated by previous investigators (Snyder 1921; B. Neilson and S. Tolentino, Utah Division of Wildlife Resources, personal communication; Mazur 1999), however none of these investigators sampled all depth strata of the lake. The goal of this study was to systematically sample the abundance of Bonneville and Bear Lake whitefish throughout the available benthic habitat present in Bear Lake.

Many factors drive varying fish distribution, including predation avoidance, food resources, and patterns of thermal stratification. Other closely related Coregonid species are known to segregate habitats sympatrically. Randi (1999) showed differences in the distribution of length groups and morphotypes of whitefish within a Norwegian lake.

Small individuals (dwarf) were caught in deeper areas of the lake, whereas larger species were found in the shallower depths.

Increasing human development in the Bear Lake watershed has the potential to change nutrient inputs and subsequently influence the food resources and spatial distributions of fishes. Changes in water use patterns may also affect fish habitat. Results of our study will help in understanding the potential consequences of these environmental changes and can assist in the management of Bear Lake and the preservation of these endemic species.

## Study Area

Bear Lake is a long, elliptical-shaped lake located in a moderately elevated mountainous area in northeastern Utah and southeastern Idaho. The valley that harbors the lake is relatively narrow and runs in a north-south direction surrounded by the Bear River range of mountains on the west (elevation 3048 m) and the Bear Lake plateau on the east (elevation 2440 m). The lake is large, and comparatively deep with a fluctuating surface area of approximately 282 km$^2$ and a mean depth of 30.5 m. Maximum depth can reach over 63 m approximately one-fourth of a mile off the eastern shore and just south of the South Eden creek delta. Its total length is nearly 30 km with 19 km in Utah and the remainder in Idaho with width ranging from 12 km to 6.4 km.

Since the construction of a hydroelectric facility on the northern shore of the lake, the main uses for the lake have been the production of electricity, and use of water storage for agriculture practices. Bear Lake is a natural lake, thus no dam was ever built. However, the natural outlet where the Bear River once historically left the lake has been reopened and a controlled canal constructed. The Bear River was also diverted to enter the lake to compensate for water leaving through the canal. Prior to these developments the lake was considered a closed system. All water that entered the lake from its small in-flowing streams and benthic springs stayed in the lake. The geology of the lake is of special interest. An active fault runs north and south along its eastern shore. Tectonic uplifting has been credited for the lake's deepest hole and signs of fault activity are detectable at the North and South Eden stream deltas (Kalister 1972). The sediments of Bear Lake are very deep (> 100 m) and consist mostly of $CaCO^3$ precipitate, extinct gastropod shells, and cobble sized stone. The current form of the lake has been present since the Pleistocene, but the lake basin has likely existed for several million years (Perry 1943).

Bear Lake is oligotrophic with mean chlorophyll a levels never exceeding 0.2 $mg/m^3$ at the surface during summer months. Secci depth measurements range from 3-10 m (Wurtsbaugh and Hawkins 1990). The lake is full of minerals and a plethora of calcium carbonate precipitate, which gives the lake a turquoise-blue color. The water column is typically saturated with dissolved oxygen and has not been observed to drop below 4µg/L at the surface (Lamarra et al. 1987). Surface temperatures in the summer can reach 20 C with temperatures at 55 m never exceeding 5 C (figure 2-1). The water column displays distinct summer stratification, and an obvious thermocline exists at 12-15 m, which forms as early as June, and persists through October.

Perry (1943) reported that "very seldom does the lake pass through a winter without freezing over." However, Bear Lake did have complete ice cover the three years prior to this study (1996-1999). Despite the recent trend of mild winters, complete ice cover of Bear Lake was experienced during the winters of 2000 and 2001.

The limnetic zooplankton community is dominated primarily by low densities of copepoda and *Bosmina*; however, yearly sporadic pulses of daphnia can also be measured in the lake (Mazur 1999; Morreno 1989). These low densities are likely the main limitation to low levels of fish production experienced by the lake.

The invertebrate fauna of Bear Lake is not diverse, nor abundant, and most species are associated with the benthos. These species include: Nematoda, Annelidea, Ostracoda, Sphaeridae, and Chironomidae (Wurtsbagh and Hawkins 1990). However, species of larval trichoptera, ephemeroptera, and adult coleoptera have also been observed in the stomachs of whitefish.

Bear Lake ichthyiofauna is fairly complex and includes four endemic species: Bonneville whitefish, Bear Lake whitefish, Bonneville cisco, and the Bear Lake sculpin *Cottus extensus*. Healthy populations of indigenous Utah sucker *Catostomus ardens*, Utah Chub *Gila atraria,* and Bonneville cutthroat trout *Oncorynchus clarki utah* also reside in the lake. The sport-fishery in Bear Lake is primarily managed for the highly picsivorous strain of cutthroat trout, and exotic lake trout *Salvelinus namaycush.* Both have been documented as voracious predators and rely heavily on the whitefish complex (primarily Bonneville cisco) for food throughout the year (Orme et al. 1998; Mazur 1999). Other introduced fish that have been recently collected include: rainbow trout *Oncorhynchus mykiss*, redside shiner *Richardsonius baltiatus*, speckled dace *Rhinichthys osculus* green sunfish *Lepomis cyanellus*, yellow perch *Perca flavenscens* , and the common carp *Cyprinus carpio*.

## Methods

*Sample Design*

Gill net collections of whitefish were taken in July/August of 2000 and 2001, and in April/May 2001. Samples were collected during summer stratification of the lake and during isothermic conditions. Bear Lake was divided into six separate sections, starting on the north end of the lake running laterally to the south end, and then back in a north (figure 2-2). Preliminary investigations of habitat types located within the lake were performed in June 2000 using an eckman dredge to sample the benthic substrate. Lake sections were then delineated according to depth strata and substrate habitat type. Each sample location and its depth were recorded by taking a UTM coordinate derived from a Global Positioning System (GPS). Benthic substrate within the lake consists mostly of a fine calcium carbonate precipitate. All lake sections are dominated by this substrate type with the exception of sections 4 and 6, which contain small patches of macrophyte beds. Other types of habitat in the lake are gastropod shell beds (section 2), and rock-cobble (sections 3 and 5). Sections were then projected in Arc View and the position of each transect recorded so we could know exactly which section we were in while on the lake (figure 2-2). All depth strata of the lake were sampled starting at 5 m, or 10 m, depending on section and habitat type, and running parallel to shore along each depth contour (figure 2-3).

Gill nets were deployed for 12 hours each night from dusk to dawn in an effort to sample both crepuscular periods. Sections 1 and 6 were sampled starting at 5 m and extending down to 30 m, which is the deepest depth found in these sections. Sections 2, 3, and 4 were sampled starting at 10 m and extending to 40 m utilizing a total of seven separate nets. Section 5 was sampled starting at 10m and ending with a 60 m set utilizing a total of 11 separate nets. During the summer of 2000 sampling of each depth strata within each section was replicated twice with an exception in section 5. Here depths 45 m, 50 m, 55 m, and 60 m were replicated four times each. This was done because these depths are only found in section 5 and a good representation of fish was needed for statistical inference. During the spring and summer of 2001, each depth strata within each section was sampled once. As gill nets were deployed, a GPS reading was taken. These net deployment sites were then mapped in Arc View 3.2 to get an idea of sample coverage across the lake (figure 2-4).

The gill nets used were the experimental-sinking type and utilized a number of different sized mesh panels. They consisted of nine panels (4.6 meters in length) starting at 1.27 cm stretch measurement and increasing by .64 cm increments up to 5.17 cm. Panels then increased by 1.27 cm up to 7.6 cm stretch. The very small mesh sizes increased by .64 cm increments (.08 mm diameter). The numerous panels were in an effort to reduce bias in catching only larger size classes of fish, which is usually the norm when sampling with gill nets. The small mesh sizes were included so we could catch a good proportion of age-1 whitefish that are often hard to sample using mono-filament gill nets.

A gill net selectivity analysis was then conducted to assess the bias in our sampling procedure and to correct for any that was experienced (Rudstam et al. 1984). Details of this analysis are documented in chapter 3.

### *Diet Analysis*

Lengths and weights were measured from all whitefish for descriptive relationships of both species. Ten stomach samples for each size class of whitefish, at least 100 mm in total length, were taken within each depth strata and preserved in 95% ethanol for future laboratory examination. Stomach contents were sorted by terrestrial, and aquatic taxonomic groups and volumetric percentages were calculated. Any prey fish found in the samples were identified to the lowest taxonomic level using skin, bones, and scales as described by (Hansel et al. 1988).

Whitefish were separated into predetermined size classes based on previous diet information (Wurtsbaugh and Hawkins 1990; Orme et al. 1998). Bonneville whitefish size classes consisted of: 100-150 mm, 150-200 mm, 200-250, 250-300 mm, 300-350 mm, and > 350 mm TL. Bear Lake whitefish size classes consisted of: 100-150 mm, 150-200 mm, 200-250 mm, and > 250 mm TL.

A multiple analysis of covariance (MANCOVA) was used to assess differences between the diets of the two whitefish species (Wilkinson 1990). The diet data were combined into four or five prey types with prey types comprising less than 10% of the diet and prey of terrestrial origin being lumped into a prey type called "other." To enhance the normality of the data an arcsine transformation was conducted by taking the arcsin of the square root of the volumetric proportion of each diet type (Zar 1999). We used total length of the fish as a covariate to account for potential effects related to size differences between the two whitefish species. If the Wilks' Lamda f-statistic indicated significant differences between the species for the multivariate diet analysis, then univariate F tests were used to assess significance of individual prey types in diets.

### *Distribution*

Collected whitefish were positively identified using methods described by White (1974) and Ward (2000). Identification involves meristic scale counts cross diagonally from the lateral line dorsally to the opposite lateral line. A more positive identification can be achieved with a complete lateral line count starting at the first scale near the opercular opening and ending with the last countable scale at the base of the caudal fin. Fish can be identified with extreme accuracy (99%) using this methodology. Ward (2000) tested and validated these identification methods using laboratory reared fish of known species origin. Bonneville whitefish count 18-21 scales across the back where Bear Lake whitefish count 15-17, normally 16. Any fish that counted 17 across the back were double-checked using the more definitive lateral line count. Bonneville whitefish count 75 and greater while Bear Lake whitefish count 65-72. To ensure identification accuracy, each fish was identified by two independent observers. Any discrepancies in scale counts were noted and recounted to make positive identification.

A Komolgrov-Smirnov non-parametric test was used to evaluate the significance of spatial distribution. I tested the null hypothesis: Depth contour and species are independent. This is a relatively simple test and is based on the absolute differences between observed and expected cumulative frequency distributions (Zar 1999).

## **Results**

### *Length Weight Relationships*

During the summer of 2000, 1212 total netting hours were logged. One thousand forty one Bonneville whitefish and 290 Bear Lake whitefish were caught in the gill nets.

The resulting length-weight relationships were very similar for both species with slopes near 3.0 (figure 2-5).

*Diet Analysis*

Examination of the whitefish stomach contents revealed distinctive differences in feeding habits of the two whitefish species. Two hundred ten Bonneville whitefish stomachs and 126 Bear Lake whitefish stomachs were examined from the summer of 2000 sampling period.

The MANCOVA indicated significant differences in the stomach contents from the summer of 2000 sampling period ($F_{5,45}$=3.32, p = 0.012). Univariate comparisons of each prey type indicated that Chironomid larvae were more abundant in the diet of Bonneville whitefish ($F_{1,49}$=5.29, p=0.026) and that ostracods were more abundant in the diet of Bear Lake whitefish ($F_{1,49}$=11.4, p=0.001). Significant differences in the other category were also apparent ($F_{1,49}$=4.78, p=0.034) and likely derived from a greater abundance of terrestrial insects in the diet of Bonneville whitefish. The covariate fish length also had significant effects on the proportion of chiromids ($F_{1,49}$=10.02, p=0.003) and fish ($F_{1.49}$=4.08, p=0.049) in the diets. In both cases, larger whitefish had greater proportions of these prey in their diets.

Smaller size classes of Bonneville whitefish (100-150 mm, 150-200 mm) primarily utilized ostracod, chrinomid, and spharid prey. Once these Bonneville whitefish exceeded a total length of 200 mm, they fed more heavily on terrestrial insects from the surface, and ostracods in the sediments. A few Bonneville whitefish over 250 mm fed on smaller sizes of sculpin, most of which were young of the year (YOY). Once

Bonneville whitefish reached lengths greater than 300 mm they fed almost exclusively on fish. Stomach contents for size classes 300-350 mm and greater than 350 mm largely consisted of sculpin (98 %) during summer months and 2 % terrestrial insects (figure 2-6).

A large proportion of the Bear Lake whitefish diet consisted of benthic taxa (figure 2-7). Bear Lake whitefish exhibited a more homogeneous diet throughout size classes than did the Bonneville whitefish. Small individuals (100-150 mm) utilized an array of food items including ostracods, chironomids, and limited amounts of copepod zooplankton. By the time Bear Lake whitefish reached 150 mm their diets were dominated by ostracods. They continued this diet selectivity throughout their life history and did not exhibit any prey switching after the first size class of fish. Size classes 150-200 mm, 200-250 mm, and >250 mm contained 75 %, 83 %, and 99 % ostracods within their stomachs respectively (figure 2-7).

Stomach samples from the summer 2001 sampling period were also examined to verify data from the previous year. This was also done to detect any differences that may have been related to lower lake levels in 2001. On July 20th, 2001 Bear Lake was 4 meters lower than it was the previous year and we suspected some diet changes might be precipitated. However, following the examination of 100 stomachs from each species it was determined that the patterns were similar to the 2000 observations for both species.

Differences in diets of the two whitefish species were also apparent in the spring 2001 sampling. Early in March (6 days following ice off), stomachs from 61 Bear Lake whitefish and 251 Bonneville whitefish were collected to detect any differences between summer and winter/spring diet preferences.

Diet analysis for stomach samples collected during the spring of 2001 also indicated significant differences between the two species of whitefish as indicated by the MANCOVA ($F_{1,311}=48.45$, $p<0.001$). Univariate comparisons of each prey type showed similar patterns to those present during summer with Bonneville whitefish feeding more frequently on chironomid larvae ($F_{1,311}=14.4$, $p<0.001$) and Bear Lake whitefish feeding predominantly on ostracods ($F_{1,311}=713$, $p<0.001$). Oligocheates were also more abundant in the diet of Bear Lake whitefish compared to Bonneville whitefish during this period ($F_{1,311}=11.8$, $p=0.001$). As in the summer sampling period, fish prey were more abundant in the stomachs of larger individuals ($F_{1,311}=52.1$, $p<0.001$).

In comparing spring to summer diets, Bonneville whitefish demonstrated greater dependence on ostracods in the spring. Tererrestrial insects were less abundant but still present in all size classes with the exception of the >350 mm size class. This size class fed almost exclusively on sculpin. Coleopterans, in the family Elmidae, were also much more common in the spring stomachs than summer (figure 2-8).

Bear Lake whitefish diets examined from the spring sample were very similar to those from the summer with two exceptions. Large masses of oligochate worms were found in many fish within the two largest size classes. Fish between 150-200 mm and 200-250 mm complemented their ostracod diet with 15% and 25% of these worms respectively. The Bear Lake whitefish were also utilizing more Coleoptera during spring in comparison to the summer sampling period (figure 2-9).

### *Distribution and Relative Abundance*

Bonneville whitefish were the predominant whitefish captured during every sampling period. During the summer of 2000, spring 2001, and summer 2001 sampling periods, Bonneville whitefish made up 78%, 75%, and 77% of the catch, respectively.

Spatial distribution differences among the populations' cumulative CPUE frequencies were statistically significant during all sampling periods. The Komolgrov-Smirnov tests yielded highly significant results at the 0.05 alpha level with summer 2000: d(max) = 0.796, spring 2001: d(max) = .841, and summer 2001: d(max) = 0.832. Significance was reached if d(max) > .068.

Bonneville whitefish were more abundant in shallower depths. Pooled catch per unit effort (CPUE) data over the three sampling periods revealed that 96% were caught in depths of 5-35 m while only 4% were caught in depths 40-60 m. Bear Lake whitefish were more abundant in deeper depths. Ninety percent were caught in depths ranging from 40-60 m while only 10% were found at depths of 5-35 m (figures 2-10, 2-11, and 2-12).

## Discussion

Population estimates, in terms of individuals, were not a goal in this study. However, when you look at CUPE the intensive gill net survey indicates that Bear Lake supports a larger population of Bonneville whitefish than Bear Lake whitefish. Bear Lake whitefish comprised only 22% of the total catch during all sampling periods, which covered all possible depths and habitat substrates. Intuitively higher predation rates on the smaller species could account for the large difference. However, Mazur (2000) failed to document a significantly higher proportion of Bear Lake whitefish than Bonneville whitefish in the stomachs of large picsivores, namely lake trout and large cutthroat trout.

A more plausible explanation is apparent from the spatial distribution data. Definitive separation of the two species within the lake limits the habitat availability of the Bear Lake whitefish. This species preferred depths greater than 30 m and the highest CPUE was recorded at 50-60 m. This depth preference limits them to a very small portion of the lake, which contain these depths

The interesting question that has yet to be explored is why the Bear Lake whitefish prefer to live in the dark abyss. Life histories of other smaller species, including juvenile Bonneville whitefish, have been observed to prefer littoral, warmer habitats. Predator avoidance and diet capabilities normally drive such behavior, yet it appears that Bear Lake whitefish have evolved a different strategy. But why the evolution of a smaller species? Decreased metabolism at deeper depths, driven by year round temperatures of 4-5 C (figure 2-1), support suppressed growth rates, and could explain the evolution of the smaller Bear Lake whitefish "dwarf" form. The speciation mechanism may have been driven by the partitioning of available benthic habitat in the lake.

Diet differences between the two species can also be explained by their spatial separation. The diet analysis revealed an almost exclusive dependence on ostracoda by Bear Lake whitefish especially in sub-adult to adult size classes. Benthic samples taken with an eckman dredge suggest that these small crustaceans are also found in high densities at these depths. Although Oligochaeta make up most of the biomass at these depths (Wurtsbaugh and Hawkins 1990) ostracoda become readily available to the whitefish when they release from the sediments to feed (Thorpe and Covich 1998). The

Bear Lake whitefish preference or specialization for ostracoda may be a contributing factor to the spatial separation of the two whitefish species

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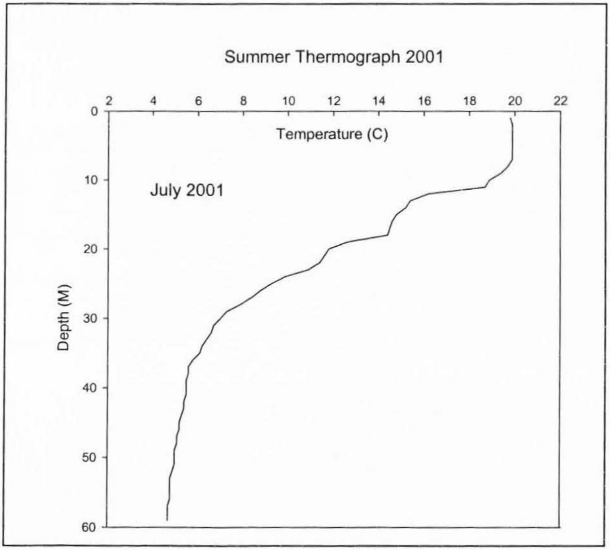

Figure 2-1.—Thermograph taken of Bear Lake during the summer of 2001 showing distinct thermocline beginning at 10 m.

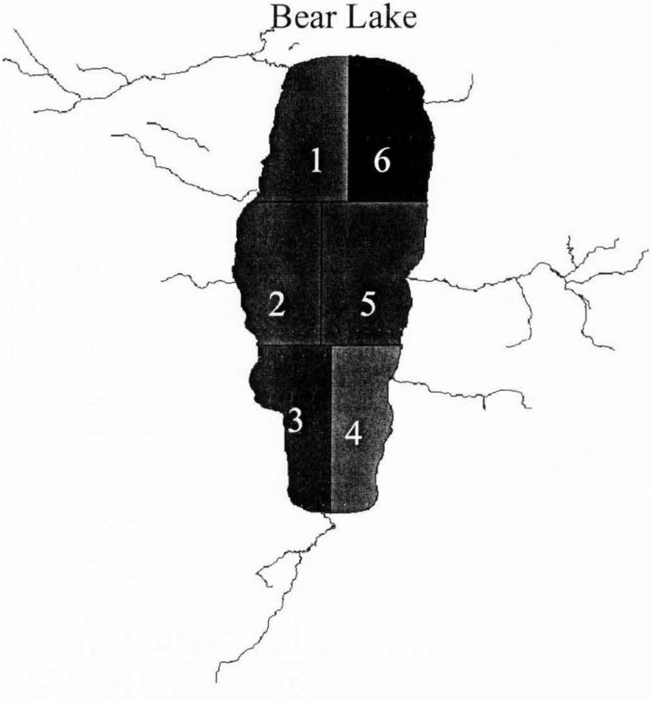

Figure 2-2.—Map generated in Arc View 3.2 showing sections of the lake that were sampled.

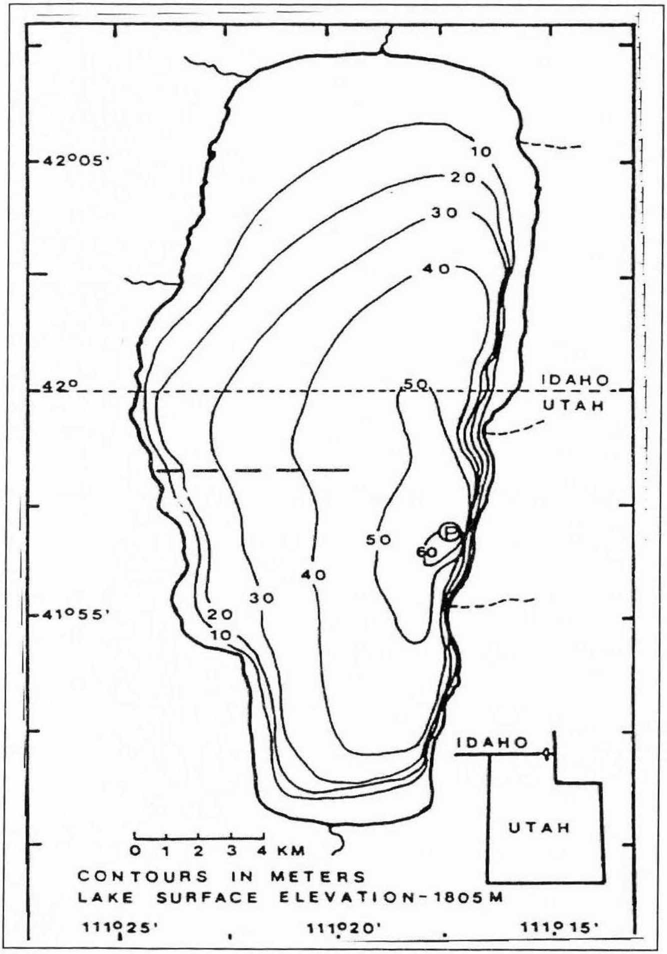

Figure 2-4.— Bathymetric map of Bear Lake showing depth contours sampled.

Figure 2-4.—Map of Bear Lake showing netting sites and sample coverage. White dots indicate first replication sites, and yellow dots indicate sites sampled during the second replication. Netting sites were recorded using a GPS during the summer of 2000.

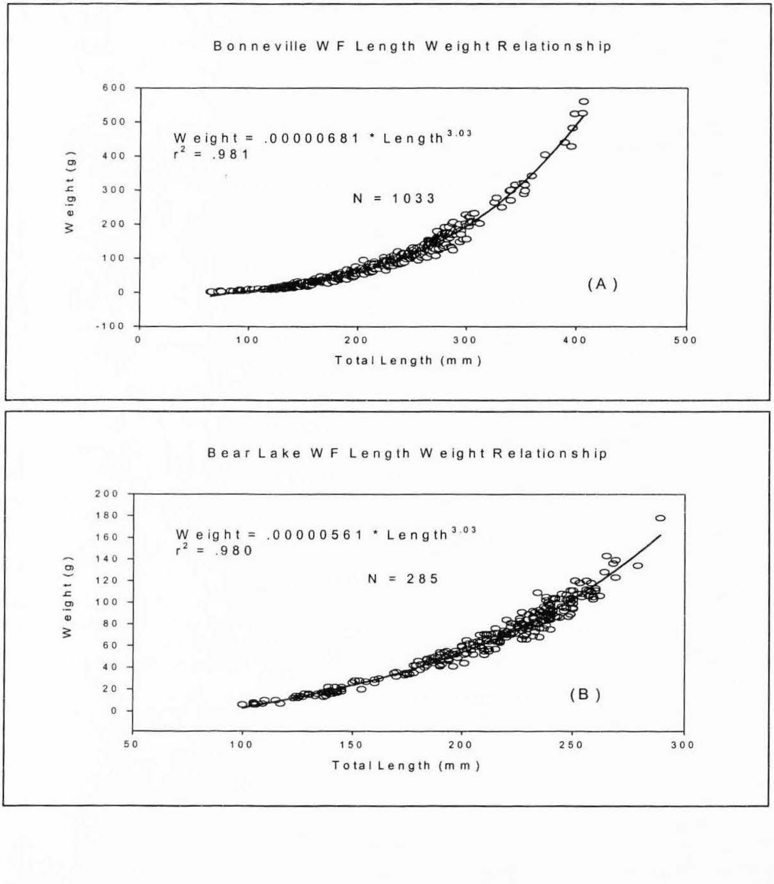

Figure 2-5.—Length-Weight relationships for (A) Bonneville whitefish and (B) Bear Lake whitefish sampled during the summer 2000 sampling period.

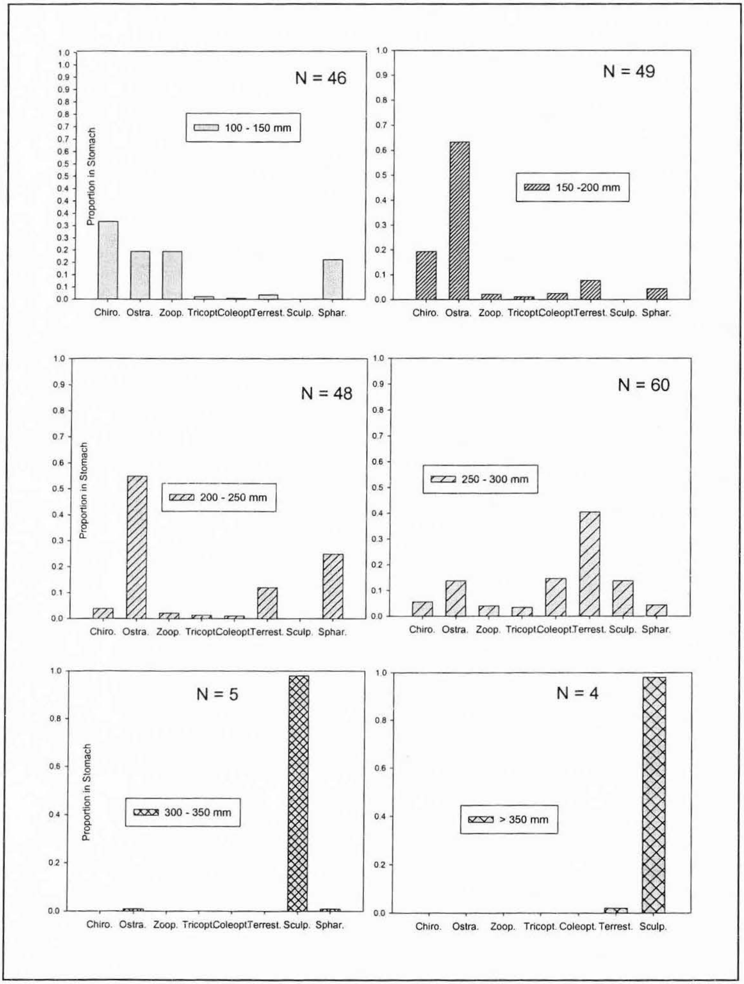

Figure 2-6.—Summer Bonneville whitefish diet. Data collected during the summer of 2000.

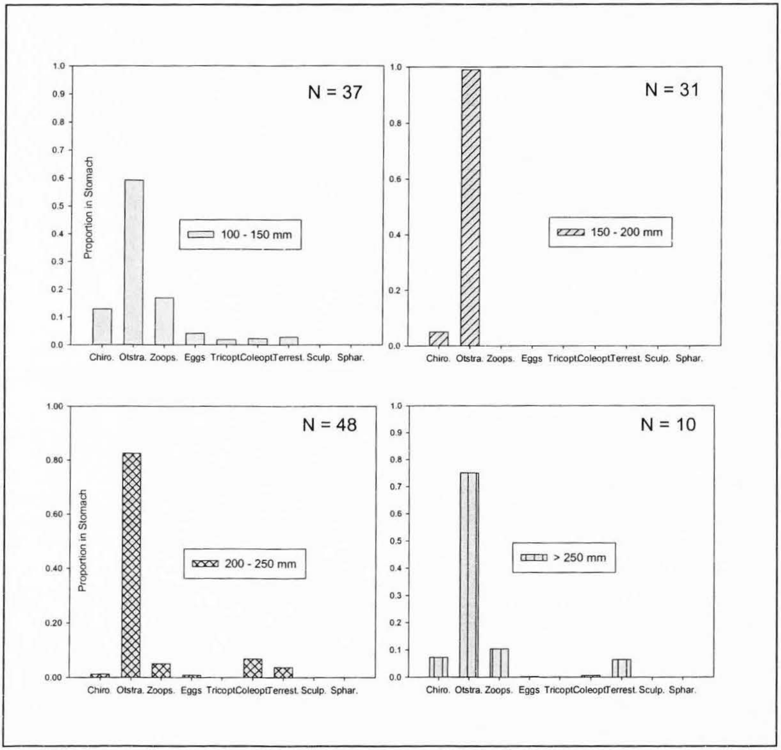

Figure 2-7.—Summer Bear Lake whitefish diet. Data collected during the summer of 2000.

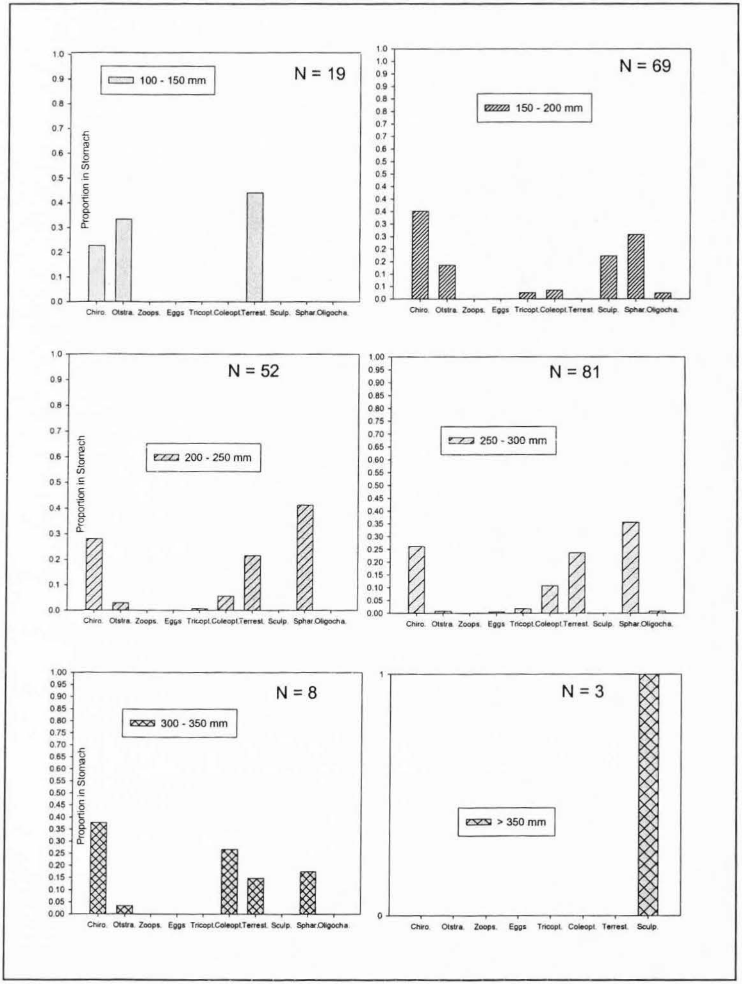

Figure 2-8.—Early Spring Bonneville whitefish Diet. Data collected during April of 2001.

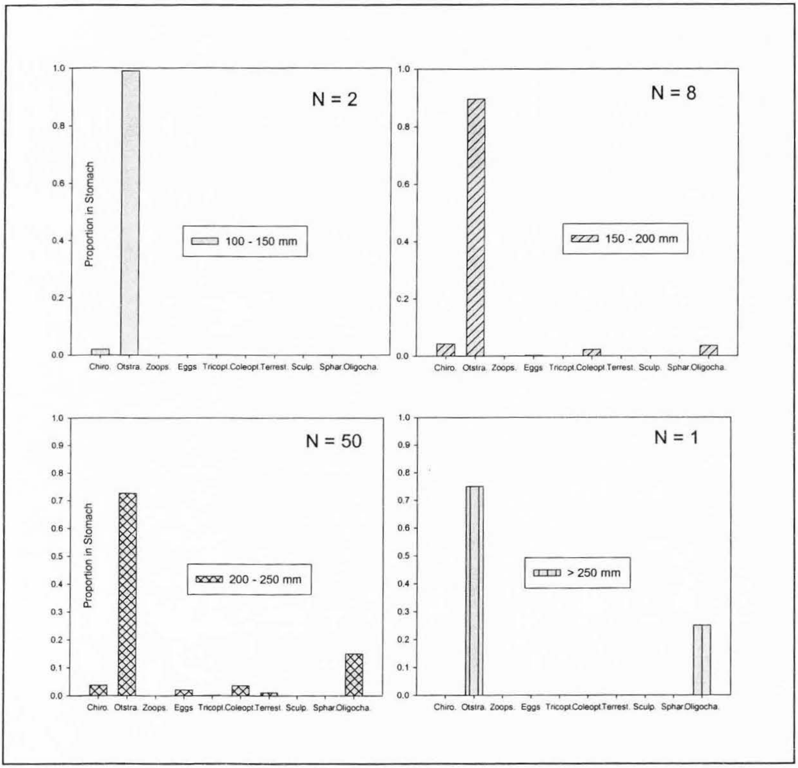

Figure 2-9.—Early Spring Bear Lake whitefish diet. Data collected during April of 2001.

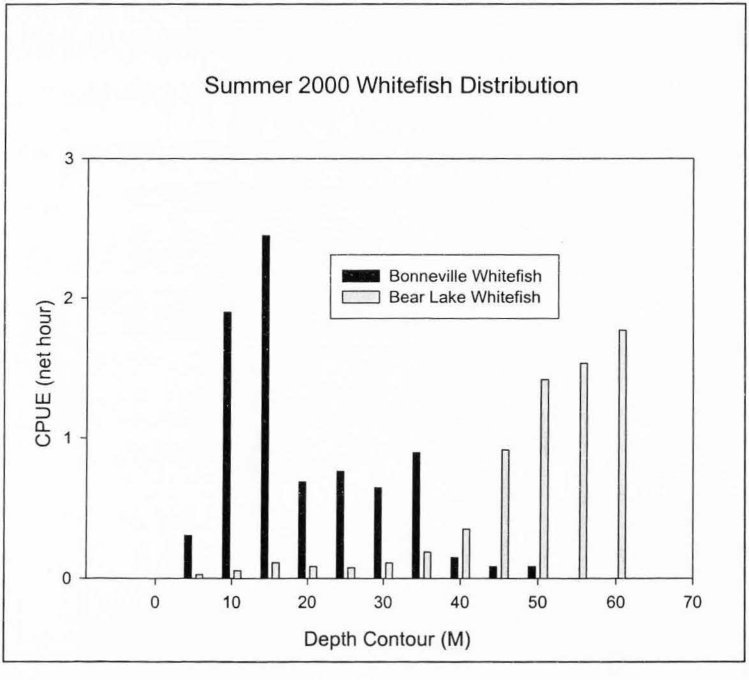

Figure 2-10.—Distribution of Bonneville and Bear Lake whitefish during the summer 2000 sampling period.

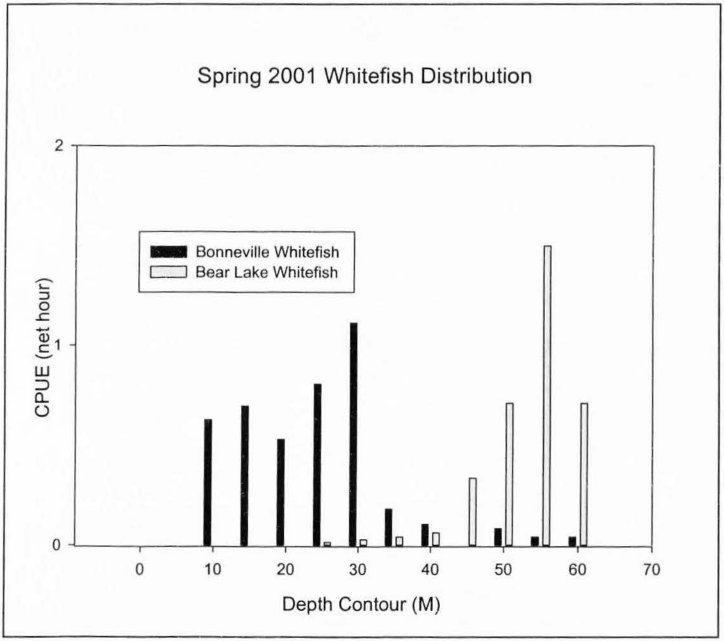

Figure 2-11.—Distribution of Bonneville and Bear Lake whitefish during the spring 2001 sampling period.

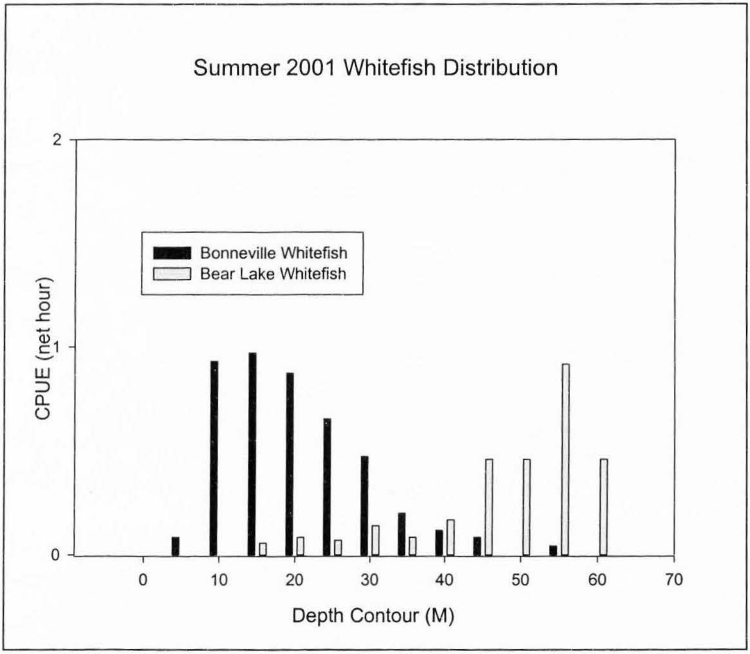

Figure 2-12.—Distribution of Bonneville and Bear Lake whitefish during the summer 2001 sampling period.

# CHAPTER 3

# LIFE HISTORY CHARACTERISTICS: GROWTH, LENGTH AT AGE, POPULATION DYNAMICS, AND SENSITIVITY ANALYSIS OF BONNEVILLE WHITEFISH *PROSOPIUM SPILONOTUS* AND BEAR LAKE WHITEFISH *PROSOPIUM ABYSSICOLA* IN BEAR LAKE, UTAH / IDAHO

*Abstract*. – Bonneville and Bear Lake whitefish were sampled using gill nets during the summer of 2000, and throughout the early spring and summer of 2001. Sectioned otoliths were used to age fish and calculate annual growth rates. Definitive differences in both age distribution, and growth rate patterns were observed. Age-1 and 2 Bonneville whitefish were most abundant. Adults greater than 350 mm in total length reached ages of 12-14 years. A smaller proportion of young Bear Lake whitefish were collected in relation to older age classes. The Bear Lake whitefish population consisted mostly of medium to large sized adults, some of which were aged 30 years and beyond .

All Bonneville whitefish larger than 225 mm in total length, and all Bear Lake whitefish larger than 200 mm total length were aged and placed into respective age classes for a subsequent sensitivity analysis of population growth patterns. Survivorship and fecundity values were placed into a simple life-table model assuming both populations of whitefish had reached a stable age distribution. The sensitivity analysis was conducted on the age structure of both populations to identify which age classes are most important to positive population growth. Ages (0-3) were most important to Bonneville whitefish, while perturbations of the model to ages (4-7) precipitated the greatest change in Bear Lake whitefish.

Leslie matrix exercises were also performed to project future trends, and estimate the finite rate of increase ($\lambda$). Although the life table model inherently assumes a stable age distribution, recursions of the matrix were carried out until stability was achieved and predicted stable age distributions were compared to current age structures. Proportions in each age class for both species were different than model projections at a stable age distribution.

## Introduction

The Bonneville and Bear Lake whitefish are endemic to Bear Lake. Intrinsic population characteristics need to be explored in order to assess the population status of these two species. In addition, knowledge of their somatic growth, survival, and reproduction will assist with the development of management plans for the endemic fish of Bear Lake.

The growth of individual fish, has long been the subject of intensive investigation concerning the biology of fish. By the end of the 19th century it was apparent that the growth of individual fish might frequently and accurately be estimated from the relative position of annulus on scales or other calcified tissues. The first record of using annuli to determine growth patterns was conducted on common carp in 1898 (Summerfelt and Hall 1987). As scale reading became more and more refined, it became increasingly feasible to determine the individual growth histories of fish. This technique has greatly improved population analysis by increasing the precision of data on length at-age, age at maturity, and yearly growth rates (Weatherley and Gill 1987).

The most reliable method of determining age-specific mortality and fecundity rates for populations that have overlapping generations is to follow the fate of a group of individuals (a cohort) through a complete lifecycle (Begon et al. 1986). This approach is called a cohort life table. Unfortunately it is not always possible to monitor the dynamics of a population by constructing such a "fixed cohort" life table. Since individuals from natural populations are highly more mobile and surreptitious to observers, they are rarely examined in this way. An alternative to the cohort life table exists, a static or vertical life table can also be developed. This technique involves examining the age structure and survival probabilities of the whole population at one particular point in time. The final product is much like taking a 'snap shot' sample, or a slice out of a larger population that was constructed over a long period of time. This type of life table can have practical uses when trying to describe populations and can provide estimates of a number of important life history parameters. A vertical life table has three principal assumptions: (1) the population is currently at its stable-age distribution; (2) the recruitment rate and age-specific mortality rates are relatively constant; and, (3) there is no ingress or egress of individuals at each age group (Gotelli 1996).

It should be stressed that the vertical life-table represents only a crude generalization of the populations probable age structure at the time the sample was taken (Emmel 1976). Despite the often violation of assumptions, this type of life table can have practical uses when investigating natural populations. Efforts in constructing the life-tables were not to project true population growth over time, but rather to look at what effects current age structure would have on the basic trends of both populations. Lowe (1969) demonstrated the uses of such a life table with deer populations in Scotland. The purpose of using a life-table is to allow patterns of birth and mortality to be investigated. In turn this allows us to uncover the shared or un-shared properties of closely related populations such as the whitefish in Bear Lake.

The two most important life history characteristics that can be calculated using the life table model are: (1) Fecundity Schedules. Given the disparities in maximum total length, both species should have separate reproductive rates and allocate different amounts of energy to reproduction. Specific values assigned to each age class on their reproductive contribution to the whole population can then be analyzed (Fisher 1930). (2) Survivorship Schedules. Individuals of older age classes may produce thousands of offspring. However if few individuals survive to mature ages, the effect on the population as a whole could be negligible. Survivorship data will also provide an assessment of the potential predation risk associated with the two whitefish species. Other life history characteristics derived from the life-tables were the intrinsic rate of increase (r) and the net reproductive rate (Ro). The population growth statistic (r) is defined as the difference between the instantaneous birth rates and death rates. The value of (r) determines whether a population has the potential to increase ($r > 0$), remain stationary ($r = 0$), or decay to extinction ($r < 0$). (Ro) is simply defined as the number of offspring produced per female over her lifetime. These calculations will provide an estimation of both species population trends.

An important question in the analysis of population dynamics is the extent to which a slight change in survival at a certain age changes the relative numbers of individuals in other age classes. Such elasticity or sensitivity analyses are useful and popular tools in conservation biology. They are used to categorize populations according to their response to different perturbations that affect vital growth parameters. An elasticity pattern is composed of the relative contributions of essential entities pertaining to population growth that are grouped in biologically meaningful ways for comparative analysis (Heppell et al. 2000). Elasticity analyses can also be a qualitative guide for research and management, particularly for poorly known species, and a useful first step in a larger modeling effort to determine population viability (Grant and Benton 2000). Comparison of the relative contributions of fertility, and juvenile survival were calculated using the life table information for the two species of whitefish in Bear Lake.

The survival and fecundity probabilities were derived through the life-table, and algebraic matrix analysis was performed as described by Leslie (1945). This analysis described the changes in population size due to mortality and reproduction. The model tested for the stable age distribution of both species and recursions of the model provided an estimation of their respective theoretical age distributions. Lambda ($\lambda$) was the other important life history characteristic evaluated through a Leslie matrix.

Life history strategies are directly linked to these vital rates and there is a need to explore population response to environmental perturbations. Once these factors have been explored managers can then formulate conservation and management plans that are tailored to specific populations. The goal of the elasticity-sensitivity analysis in the present study was to examine the response of the Bonneville and Bear Lake whitefish's population dynamics when subjected to disturbance. An example of such a disturbance may include decreased spawning habitat, which would reduce egg to fry recruitment and young of the year (YOY) survival. Increased predation pressure due to elevated levels of stocked piscivores, could in turn have ramifications on juvenile to middle-aged classes of fish. And an increase in fishing pressure might also reduce the number of matured spawning adults resulting in a decreased (YOY) recruitment. All such situations were examined by manipulating survivorship schedules in the life table, yielding different hypothetical responses.

## Study Area

Bear Lake is a long elliptical shaped lake located in a moderately elevated mountainous area in northeastern Utah and southeastern Idaho. The valley that harbors the lake is relatively narrow and runs in a north-south direction surrounded by the Bear River range of mountains on the west (elevation 3048 m) and the Bear Lake plateau on the east (elevation 2440 m). The lake is large, and comparatively deep with a fluctuating surface area of approximately 282 $km^2$ and a mean depth of 30.5 m. Maximum depth can reach over 63 m approximately one-fourth of a mile off the eastern shore and just south of the South Eden creek delta. Its total length is nearly 30 km with 19 km in Utah and the remainder in Idaho with width ranging from 12 km to 6.4 km.

Since the construction of a hydroelectric facility on the northern shore of the lake, the main uses for the lake have been the production of electricity, and use of water storage for agriculture practices. No dam was ever built, but the natural outlet where the Bear River once left the lake was re-opened and a controlled canal was constructed. The Bear River was also diverted to enter the lake to compensate for water leaving through the canal. Prior to these developments the lake was considered a closed system. All water that entered the lake from its small in-flowing streams and benthic springs stayed in the lake. The geology of the lake is of special interest. An active fault runs north and south along its eastern shore. Tectonic uplifting has been credited for the lake's deepest hole and signs of fault activity are detectable at the North and South Eden stream deltas (Kalister 1972). The sediments of Bear Lake are very deep (> 100 m) and consist mostly of $CaCO^3$ precipitate, extinct gastropod shells, and cobble sized stone. The current form of the lake has been present since the Pleistocene, but the lake basin has likely existed for several million years (Perry 1943).

Bear Lake is oligotrophic with mean chlorophyll a levels never exceeding 0.2 $mg/m^3$ at the surface during summer months. Secci depth measurements range from 3-10 m (Wurtsbaugh and Hawkins 1990). The lake is full of minerals and a plethora of calcium carbonate precipitate, which gives the lake a turquoise-blue color. The water column is typically saturated with dissolved oxygen and has not been observed to drop below 4µg/L at the surface (Lamarra et al. 1987). Surface temperatures in the summer can reach 20 C with temperatures at 55 m never exceeding 5 C (figure 2-1). The water column displays distinct summer stratification, and an obvious thermocline exists at 12-15 m, which forms as early as June, and persists through October.

Perry (1943) reported that "very seldom does the lake pass through a winter without freezing over." However, Bear Lake did not have complete ice cover the three years prior to this study (1996-1999). Despite the recent trend of mild winters, complete ice cover of Bear Lake was experienced during the winters of 2000 and 2001.

The limnetic zooplankton community is dominated primarily by low densities of copepoda and *Bosmina*; however, yearly sporadic pulses of daphnia can also be measured in the lake (Mazur 1999; Morreno 1989). These low densities are likely the main limitation to low levels of fish production experienced by the lake.

The invertebrate fauna of Bear Lake is not diverse, nor abundant, and most species are associated with the benthos. These species include: Nematoda, Annelidea, Ostracoda, Sphaeridae, and Chironomidae. (Wurtsbagh and Hawkins 1990). However, species of larval trichoptera, ephemeroptera, and adult coleoptera have also been observed in the stomachs of whitefish.

Bear Lake ichthyiofauna is fairly complex and includes four endemic speices: Bonneville whitefish, Bear Lake whitefish, Bonneville cisco, and the Bear Lake sculpin *Cottus extensus*. Healthy populations of indigenous Utah sucker *Catostomus ardens*, Utah Chub *Gila atraria,* and Bonneville cutthroat trout *Oncorynchus clarki utah* also reside in the lake. The sport-fishery in Bear Lake is primarily managed for the highly picsivorous strain of cutthroat trout, and exotic lake trout *Salvelinus namaycush.* Both have been documented as voracious predators and rely heavily on the whitefish complex (primarily Bonneville cisco) for food throughout the year (Orme et al. 1998; Mazur 1999). Other introduced fish that have been recently collected include: rainbow trout *Oncorhynchus mykiss*, redside shiner *Richardsonius baltiatus*, speckled dace *Rhinichthys osculus* green sunfish *Lepomis cyanellus*, yellow perch *Perca flavenscens* , and the common carp *Cyprinus carpio*.

## Methods

### *Aging and Growth*

Methodology of the extraction, preservation, and aging of whitefish otoliths followed those described by Brothers (1987). Both sagittal otoliths were extracted from freshly killed fish and placed in micro-centrifuge containers where they were immediately preserved in 95% ethanol. The left otolith form each fish was then embedded in a glass resin mold and cataloged according to its corresponding fish number. Subsequently, embedded otoliths were sectioned and placed on microscope slides for final age and growth observations. A Leica® computer-camera imaging system was next used for the examination of annulus counts and growth rate measurements. Annuli were counted by an experienced technician, and confirmed by a second witness. Where discrepancies became apparent the otolith was re-examined and a determinate age established.

Since the first systematic studies on fish growth, both inter and intraspecific comparisons have been made (Moreau 1987). Measurements for the growth comparison of species were taken from the center of each otolith and extended outwards towards its longest point. At least 10 otoliths of each age for both species were measured for growth rate ranging from ages 1-11. Each annuli was measured in terms of millimeter units (mm) and reported accordingly.

The Von-Bertalanffy growth function (VBGF) $L = L_\infty [\ 1\text{-}e^{(-K(t-to))}]$ was used to mathematically and theoretically describe growth relationships of the two species of whitefish (Von-Bertalanffy 1938). Ricker (1975) defined $L_\infty$ as the mean length a fish would reach in a given population if they lived and grew indefinitely. Simple Walford plots (figures 3-1 and 3-2) were used to predict asymptotic growth values ($L_\infty$) and provide an estimate of K. These values were then used in the VBGF.

### *Population Modeling and Sensitivity Analysis*

Length-frequency histograms constructed for both Bonneville whitefish and Bear Lake whitefish show distinct peaks at early lengths and can be interpreted as age classes (figure 3-3 and 3-4). Numbers of Bonneville whitefish in age classes 1-4, and Bear Lake whitefish in age classes 1-2 were determined using this method. Subsamples of these length (age) classes were subsequently aged using previously described methodology for verification (Ricker 1975). Since not all age classes could be deciphered from the length-frequency histograms, all Bonneville whitefish > 250 mm and all Bear Lake whitefish > 200 mm were aged to achieve a reliable data set. Consequently, over 500 Bonneville otoliths and 200 Bear Lake otoliths were sectioned and read for age using previously described methodology.

All sizes of fish encounter gill nets at different rates. This is mainly attributed to differences in swimming speeds. Their probability of being retained in the net once they encounter a net is related to girth. Because of this the relative numbers of fish captured in each age class were corrected using equations derived by Rudstam et al. (1984). Relative selectivity coefficients were calculated and applied to the catch/effort data to achieve a more accurate estimation. The corrected data describe the relative abundance of different size classes of fish, if all fish swam at constant speeds, and had constant probabilities of being retained in the net (figure 3-5). Figure 3-5 depicts the gill net selectivity function and implies the probability of capturing all size classes of fish. Since no large gaps between functions were apparent, the chance of capturing all size classes of fish was high.

The actual calculations for correcting the data involves a function of both length and girth measurements. Girth is an important component of the correction in determining the probability of a fish being retained when it encounters a net of a certain mesh size. Fifty samples of a broad range of lengths were measured for girth and were used in the corrective equations (figure 3-6).

The correction equation ultimately produces a corrected catch per unit effort (CUPE), which can then be multiplied by the actual effort to gain corrected numbers of fish within each size class. Figures 3-7 and 3-8 illustrate the comparison of fish caught in the gill netting survey (field data) and corrected numbers using the (Rudstam et al. 1984) equations. Relationship curves of the corrected fish data were then used to predict the numbers of fish within each respective age class and later into the life table model.

Fecundity values for both species were estimated by examining ripe females of each species during their respective spawning periods. Bonneville whitefish were collected in November-December and Bear Lake whitefish in March-February. Collections were made using gill nets designed to catch multiple sizes of mature spawning females. The Bear lake whitefish winter collections necessitated sampling through ice cover. These winter collections involved attaching gill nets to a small diameter PVC pipe and a rope then threading it underneath the ice between two disparate holes. The net can then be pulled through from one hole and the net set normally. Since spawning whitefish were very dense during these periods the sets were only 1-3 hours in duration.

Egg masses were counted from each sampled ripe female. The number of young of the year (age 0) offspring were estimated by regressing the number of eggs produced by a female against its total length (figure 3-9). Egg samples from both species were weighed and individual eggs measured to detect discrepancies between the two species. Upon this analysis it was determined that there was no significant difference in the density and overall shape of the eggs.

The life-table model was constructed using data derived from the corrected length frequency histograms, and the aging analysis. A smooth curve was applied to the data and fish numbers from the exponential fit calculations were ultimately used in the life table (Figure 3-10 A&B). Age (0) fish were estimated from the fecundity analysis. It was assumed that 50% of all fish caught were females and mature ones spawn every year. Therefore all mature females were multiplied by their respective fecundity value to achieve a total age (0) estimate (Figure 3-9). Methods for the model construction followed those described by Gotelli (1996) and Begon et al. (1986).

Two separate analyses were carries out to predict ages of sampled whitefish. First, using mathematical equations, the Von-Bertalanffy growth function (VBGF) was used to determine theoretical ages. Second, length at age calculations produced during the otolith analysis were used to bolster VBFG estimations and produce known age at length data. Age-0 production values (egg # or fecundity value) were applied to fish caught in our gill netting survey that were determined to have been mature the previous spawning period. We assumed that all mature females spawned each year and fecundity rates were constant.

The sensitivity analysis was performed by manipulating the survivorship schedule values across a suite of different possibilities. Ultimately this changes the value of the intrinsic rate of increase (r), and the net reproductive rate Ro. Values of r similar to those from the life-table analysis were used. Three distinct situations for each species were analyzed with the life table model, which would include all life history stages and would analyze the age at maturity break points for both species. Survival of age classes (0-3) were increased by 10% and then decreased by the same value. Subsequent manipulations of the same type were calculated for ages (4-7) and (9-12). Recursions of the sensitivity analysis were performed in a similar hypothetical life-table built in a spreadsheet program. A subsequent Leslie matrix was also constructed and recursions of the model were carried out to reach stable age distributions and finite rates of increase values ($\lambda$).

## Results

### *Aging and Growth*

Age specific mortality can be expressed in the form a survivorship curve by plotting the number of individuals in a particular cohort against time. Natural survivorship curves fall into three main types with all degrees of intermediacy. These curve types include: convex, linear, and J-shaped.

Bonneville and Bear Lake whitefish have somewhat similar age structures and very similar survivorship curves. In the Bonneville population many young individuals were sampled with very few older classes of fish being present. This type of concave (J-shaped) mortality pattern is common amongst most populations of fish because the probability of being preyed upon by a larger predator is much greater at smaller sizes and thus mortality is frequently high for smaller individuals (figure 3-10 A) (Emmel 1976). The average instantaneous annual mortality was –0.312.

The Bear Lake population had a relatively smaller number of age-1 fish, but the average survivorship pattern was similar to the Bonneville whitefish. Gill net catches for Bear Lake whitefish suggests higher mortality of older age classes resulting in an average mortality rate of –0.319. This rate is very similar to the rate estimated for Bonneville whitefish (figure 3-10 B).

Both Bonneville and Bear Lake whitefish growth was relatively consistent with growth patterns described using the Von-Bertalanffy growth equation. Equations were manipulated until the best fit for the age at length data was achieved (figures 3-11 and 3-12 ).

Length at age analysis revealed that Bonneville whitefish grow at faster rates and were larger in every age class than Bear Lake whitefish. Bear Lake whitefish growth seemed to asymptote between ages 6 and 8 where Bonneville whitefish growth was realized past the last age analyzed (11) (figures 3-13 and 3-14).

During the aging analysis differences in otolith growth patterns were also apparent. (one-tailed t test for slopes, $t = 3.51$, $P = .0039$, $df = 8$) Mean annuli increment length for the first year for Bonneville whitefish was .47 mm compared to Bear Lake whitefish at .34 mm. Bear Lake whitefish otolith growth appears to asymptote at age 8 where Bonneville whitefish otoliths showed rates of growth past the last age analyzed (11) (figures 3-15 and 3-16)

Images taken through the Leica® camera clearly show the differences in otolith growth and age at length relationships for the two whitefish species. (figure 3-17) illustrates four whitefish that were aged, all of the same approximate length. Some of the Bear Lake whitefish examined aged were over 30 years old, reaching lengths never exceeding 280 mm TL, while the oldest Bonneville whitefish caught in the gill net survey aged 14 years and measured over 400 mm TL.

### *Population Modeling and Sensitivity Analysis*

Using the survivorship curve relationships produced during the aging analysis a multiple cohort life table was constructed for each species analyzing ages 1-12 (Tables 3-1 & 3-2). The results of these models suggest that at current age structure the whitefish populations are maintaining very different population dynamics. This result was expected considering the large discrepancies in their respective age structures. The relevant population statistics are reported in Table 3-8.

Using the life-table data, Leslie matricies were constructed and appropriate algebra applied to the first population vector, assuming a 50% male / female ratio (Tables 3-5 and 3-6). Recursions of the model were carried out until both populations reached a stable age distribution C(x). The proportions of fish in each age class were then compared to those contained in the actual corrected catch data (Table 3-7). Lambda values ($\lambda$) stabilized for Bonneville whitefish after eight recursions at 0.45, and Bear Lake whitefish stabilized after nine recursions at 0.68.

The sensitivity analysis suggested that the most important age classes for Bonneville whitefish are (0-3). For the Bear Lake whitefish age classes 4-7 were most sensitive to perturbations. Increasing and decreasing survivorship schedules for these ages produced the most change in population parameters r and Ro (Tables 3-3 and 3-4).

## Discussion

Many lake whitefish complexes display two closely related species of whitfish. Usually one is a large robust species, which if allowed can reach very old age, and the other a smaller shorter lied species (Bodaly et al. 1991). However, the species in Bear Lake seem to follow an oposite life history. The larger species (Bonneville whitefish) grows very large and has a shorter life cycle than the smaller Bear Lake whitefish.

Asymtotic length for both species was corroborated using both the (VBGF) and length at age data. Growth analysis indicated that Bonneville and Bear Lake whitefish follow distictly differenent growth patterns. Normally this idicates a sharp divergence in life history strategies between two closely related species. The Bonneville whitefish (large form) grows extremely fast comparativley and can reach lenghts that nearly double those of mature Bear Lake whitefish.

Unlike examples from the literature, Bear Lake whitefish follow much different survivorship patterns. The oldest Bonneville whitefish that was collected aged to 14 years and was over 450 mm in total length, where as one particular Bear Lake whitefish aged to 37 years old and measured only 247 mm TL. In addition to this many individual Bear Lake whitefish aged to over 25 years old and never exceeded 270 mm TL.

Fecundity was also markedly different due to survivorship and age at length differences. A mature female Bonneville whitefish can reach lengths exceeding 450 mm TL and produce upwards of 1100 eggs when gravid. Bear Lake whitefish females were never collected larger than 270 mm TL and produced approximately 790 eggs when gravid.

Age at maturity was also different for the two species of whitefish and factored into their fecundity. Bonneville whitefish normally reached lengths > 180 mm by age-2 when maturity was reached and ripe eggs were observed in the scanes of collected females. Ripe females from the Bear Lake whitefish population were not collected until lengths approaced those associated with age-3 class fish.

Bonneville whitefish recruit many individuals and experience heavy predation at young ages. The Bear Lake whitefish seem to recruit a comparatively small number of young which do not experience a great deal of predation. During our sampling for mature spawing adults it was observed that not only was the Bonneville whitefish population more fecund due to body size and age at maturity, but a higher proportion of females to males were actively staged on spawning sites. Although nets were run periodically during entire respective spawning periods and during all times of the day, out of 69 mature Bear Lake whitefish caught only 16 were gravid females. However, an approximate 50:50 male/female ratio for the Bonnevilles were sampled.

Trying to explain the large differnences in age and growth only raises more questions. Although these questions were not investigated in the present study there may be plausible explanations to the observed phenomenon. It became clear from the netting data that Bear Lake whitefish spend most of their lives in very deep water. Temperatures at 40 meters in the summer do not exceed 5.5 degrees centigrade. Metabolic processes at these depths would be slowed due to temperature, which would in turn produce very slow metabolic rates for somatic growth. Animals which exhibit slower metabolism are usually associated with longer life spans and generation times. Additionally, during the extensive gill netting survey we failed to collect any large predators in depths exceeding 40 m. More than likely this is due to a lack of ciscoe, the main prey species, occurring at the deep depths. In light of this one might expect the Bear Lake whitefish to reach older ages. The survivorship curves clearly illustrated lesser predation rates in this population.

The apparent refuge of the deep water may provide an explantion to fecundity differences also. In the absence of heavy predation, and possible habitat limitaions (depth strata), Bear Lake whitefish may have evolved in a way that females only spawn every other year, or mature females may senecse at older ages and are therefore reproductively inactive for the balance of their life history. The large amount of food resources required for the production of reproductive gametes may not be available and thermal conditions not condusive for annual gamete assimilation. Further investigations are needed to determine the frequency of spawning females within both whitefish populations.

Implications of the life-table analyses were that both whitefish populations are capable of positive growth given their current age-structures. Bonneville whitefish intrisic rate of increase (r) proved much higher than Bear Lake whitefish, indicating potential for rapid increases in abundnaces if environmental carrying capacity is not reached at the present time. Although the Bear Lake whitefish life-table produced a possitive (r) value it was very low. At current age structure this population is persisting with the possiblility of dimunitive increases in abundance over time.

Resulting (r) values from the Sensitivity analysis were integrated into a simple exponential growth population model ( $Nt = Noe^{-rt}$ ). It is understood that both populations do not exhibit natural exponential growth. However, the model was used to illustrate what effects the different values of r would have on population trends not projections.

When survival probabilities of Bonneville whitefish age classes (0-3) were increased by 10% an 11% increase in final population size was experienced. When these age classes were then decreased by the same amount a 10% decrease was realized. Other manipulations of older age classes yielded a change of less than 5% in exponential growth (figure 3-18 A).

When survival of Bear Lake whitefish age classes were increased by 10% a resulting 14% rise in population growth occurred. Decreasing these age classes by 10% produced a 13% reduction in overall exponential growth (figure 3-18 B).

Although it was assumed that both populations were at their respecitve theoretical stable age distribution, the Leslie matrix analysis suggests that they are not. This is not surprising however because the model does not account for stachastic environmental factors such predation, fishing harvest, and climate. Theoretical modeling of natural populations is extremley difficult and the results from the present study indicate that something was missing from the model. These gaps could be linked to the unknown percent of spawning females. Or because the model incorporated only one year of data, the effects of recent strong/weak year classes of fish could be affecting model output.

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Table 3-1.—Life table constructed for Bonneville whitefish sampled during the summer of 2000.

| x | b(x) | s(x) | l(x) | g(x) | l(x)b(x) | l(x)b(x)x |
|---|---|---|---|---|---|---|
| 0 | 0 | 210563 | 1.000000 | 0.00 | 0.00 | 0.00 |
| 1 | 0 | 259 | 0.001230 | 0.79 | 0.00 | 0.00 |
| 2 | 573 | 204 | 0.000970 | 0.79 | 0.56 | 1.11 |
| 3 | 776 | 161 | 0.000765 | 0.79 | 0.59 | 1.78 |
| 4 | 838 | 127 | 0.000603 | 0.79 | 0.51 | 2.02 |
| 5 | 885 | 100 | 0.000475 | 0.79 | 0.42 | 2.10 |
| 6 | 916 | 79 | 0.000375 | 0.79 | 0.34 | 2.06 |
| 7 | 932 | 62 | 0.000295 | 0.79 | 0.28 | 1.93 |
| 8 | 963 | 49 | 0.000233 | 0.79 | 0.22 | 1.79 |
| 9 | 979 | 39 | 0.000184 | 0.79 | 0.18 | 1.62 |
| 10 | 1010 | 30 | 0.000145 | 0.79 | 0.15 | 1.46 |
| 11 | 1088 | 24 | 0.000114 | 0.79 | 0.12 | 1.37 |
| 12 | 1103 | 19 | 0.000090 | | 0.10 | 1.19 |
| | | | | ***Sum*** | **3.47** | **18.43** |

Table 3-2.—Life table constructed for Bear Lake whitefish sampled during the summer of 2000.

| x | b(x) | s(x) | l(x) | g(x) | l(x)b(x) | l(x)b(x)x |
|---|---|---|---|---|---|---|
| 0 | 0 | 58710 | 1.000000 | | 0.00 | 0.00 |
| 1 | 0 | 52 | 0.000887 | 0.78 | 0.00 | 0.00 |
| 2 | 0 | 41 | 0.000696 | 0.78 | 0.00 | 0.00 |
| 3 | 573 | 32 | 0.000546 | 0.78 | 0.31 | 0.94 |
| 4 | 698 | 25 | 0.000428 | 0.78 | 0.30 | 1.20 |
| 5 | 729 | 20 | 0.000336 | 0.78 | 0.25 | 1.23 |
| 6 | 760 | 15 | 0.000264 | 0.78 | 0.20 | 1.20 |
| 7 | 776 | 12 | 0.000207 | 0.78 | 0.16 | 1.12 |
| 8 | 776 | 10 | 0.000162 | 0.78 | 0.13 | 1.01 |
| 9 | 776 | 7 | 0.000127 | 0.78 | 0.10 | 0.89 |
| 10 | 791 | 6 | 0.000100 | 0.78 | 0.08 | 0.79 |
| 11 | 791 | 5 | 0.000078 | 0.78 | 0.06 | 0.68 |
| 12 | 791 | 4 | 0.000061 | 0.00 | 0.05 | 0.58 |
| | | | | ***Sum*** | **1.63** | **9.64** |

x = Age class of fish.
b(x) = fecundity schedule for each age class of fish.
s(x) = Numbers of fish in each age class.
l(x) = Probability of survival to age x.
g(x) = Probability of survival from age x to x + 1.

Table 3-3.—Results of the sensitivity analysis for Bonneville whitefish. Life-table population parameters r and Ro were both analyzed by manipulating survivorship schedules.

| Age class manipulation | r | Ro |
|---|---|---|
| Start | .337 | 5.50 |
| **Inc. (0-3)** | **.352** | **5.72** |
| **Dec. (0-3)** | **.321** | **5.26** |
| Inc. (4-7) | .344 | 5.69 |
| Dec. (4-7) | .330 | 5.29 |
| Inc. (9-12) | .334 | 5.58 |
| Dec. (9-12) | .331 | 5.37 |

Table 3-4.—Results of the sensitivity analysis for Bear Lake whitefish. Life-table population parameters r and Ro were both analyzed by manipulating survivorship schedules.

| Age class manipulation | r | Ro |
|---|---|---|
| Start | .112 | 1.99 |
| Inc. (0-3) | .121 | 2.03 |
| Dec. (0-3) | .114 | 1.97 |
| **Inc. (4-7)** | **.128** | **2.15** |
| **Dec. (4-7)** | **.105** | **1.88** |
| Inc. (9-12) | .123 | 2.12 |
| Dec. (9-12) | .117 | 1.99 |

Table 3-5.—Leslie Matrix constructed for Bonneville whitefish. Fecundity schedules are plotted across the top row and survival probabilities in the cross diagonal. Numbers of spawning females in each age class (assuming a 50:50 sex ratio) are listed in the far left column.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 235 | 1.751 | 430.071 | 622.359 | 712.152 | 775.273 | 816.922 | 852.009 | 885.627 | 915.827 | 972.625 | 1025.215 |
| 87 | 0.006 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 49 | 0 | 0.370 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 32 | 0 | 0 | 0.559 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23 | 0 | 0 | 0 | 0.662 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | 0 | 0 | 0 | 0 | 0.726 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | 0 | 0 | 0 | 0 | 0 | 0.770 | 0 | 0 | 0 | 0 | 0 |
| 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0.802 | 0 | 0 | 0 | 0 |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.826 | 0 | 0 | 0 |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.845 | 0 | 0 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.860 | 0 |

Table 3-6.—Leslie Matrix constructed for Bear Lake whitefish. Fecundity schedules are plotted across the top row and survival probabilities in the cross diagonal. Numbers of spawning females in each age class (assuming a 50:50 sex ratio) are listed in the far left column.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | 0 | 225.106 | 603.683 | 701.256 | 718.394 | 696.176 | 740.546 | 678.834 | 757.230 | 565.294 | 725.460 |
| 16.5 | 0.001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | 0 | 0.786 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14.5 | 0 | 0 | 0.909 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13.5 | 0 | 0 | 0 | 0.967 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | 0 | 0 | 0 | 0 | 0.931 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 0 | 0 | 0 | 0 | 0 | 0.815 | 0 | 0 | 0 | 0 | 0 |
| 7.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0.909 | 0 | 0 | 0 | 0 |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.750 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.933 | 0 | 0 |
| 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.429 | 0 |

Table 3-7.—Comparison between the proportions within each age class (once a stable age distribution was reached) with proportions caught during the gill net survey.

| AGE (BN) | C(x) | Caught | AGE (BL) | C(x) | Caught |
|---|---|---|---|---|---|
| **1** | 0.81509 | 0.46634 | **1** | 0.414 | 0.173 |
| **2** | 0.13530 | 0.17276 | **2** | 0.225 | 0.136 |
| **3** | 0.03426 | 0.09664 | **3** | 0.139 | 0.123 |
| **4** | 0.01016 | 0.06400 | **4** | 0.092 | 0.119 |
| **5** | 0.00336 | 0.04649 | **5** | 0.058 | 0.111 |
| **6** | 0.00114 | 0.03580 | **6** | 0.033 | 0.091 |
| **7** | 0.00043 | 0.02871 | **7** | 0.021 | 0.082 |
| **8** | 0.00014 | 0.02371 | **8** | 0.010 | 0.062 |
| **9** | 0.00007 | 0.02003 | **9** | 0.006 | 0.058 |
| **10** | 0.00002 | 0.01722 | **10** | 0.002 | 0.025 |
| **11** | 0.00002 | 0.01502 | **11** | 0.002 | 0.021 |

Age (BN) = Bonneville whitefish age classes.
Age (BL) = Bear Lake whitefish age classes.
C(x) = Calculated stable age distribution from Leslie matrix proportions.
Caught = Proportion within each age class caught during the gill netting survey.

Table 3-8.—Life-table parameters calculated for Bonneville and Bear Lake whitefish using catch and age data from the summer 2000 sampling period.

| Species | r | G | Ro |
|---|---|---|---|
| Bonneville | 0.234 | 5.32 | 3.47 |
| Bear Lake | 0.083 | 5.91 | 1.63 |

r = intrinsic rate of increase = ln(Ro) \ G
G = Generation time = $\sum l(x)b(x)x \setminus \sum l(x)b(x)$
Ro = Net reproductive rate = $\sum l(x)b(x)$

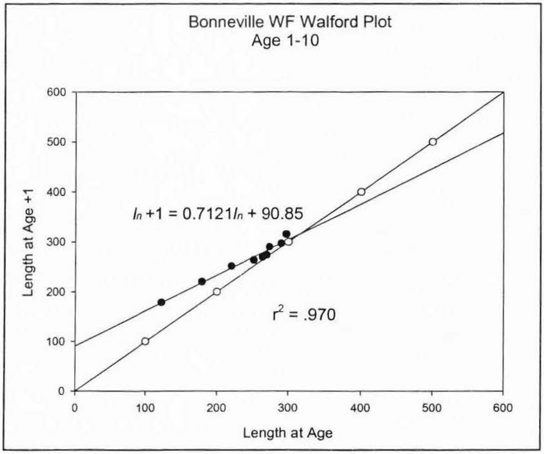


Figure 3-1.—Walford plot for Bonneville whitefish sampled during the summer of 2000.

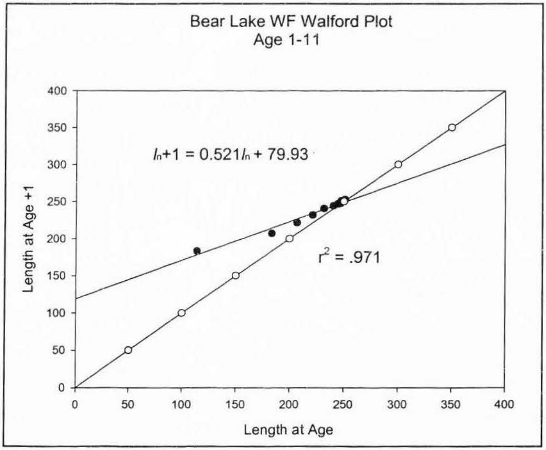


Figure 3-2.—Walford plot for Bear Lake whitefish sampled during the summer of 2000.

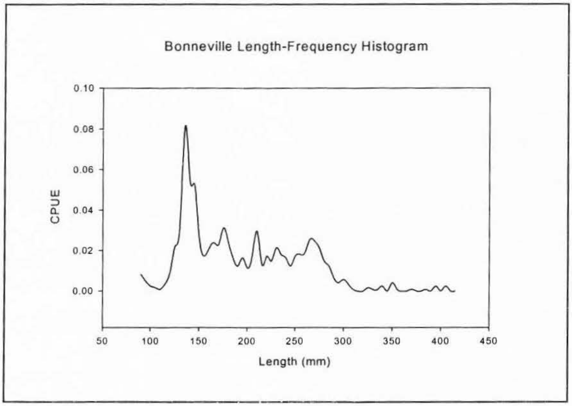


Figure 3-3.—Bonneville whitefish length frequency relationship.

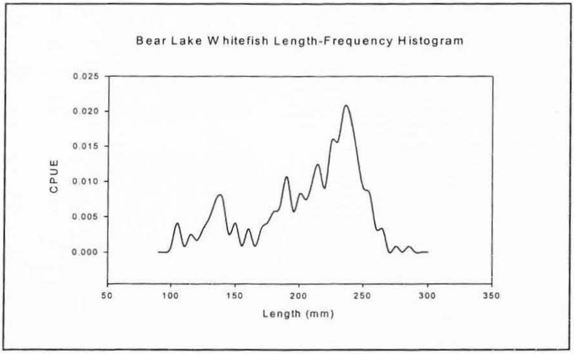


Figure 3-4.—Bear Lake whitefish length frequency relationship.

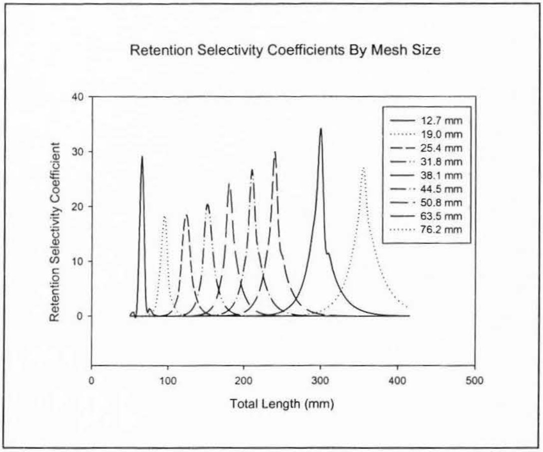


Figure 3-5.—Gill net retention selectivity coefficient by mesh size.

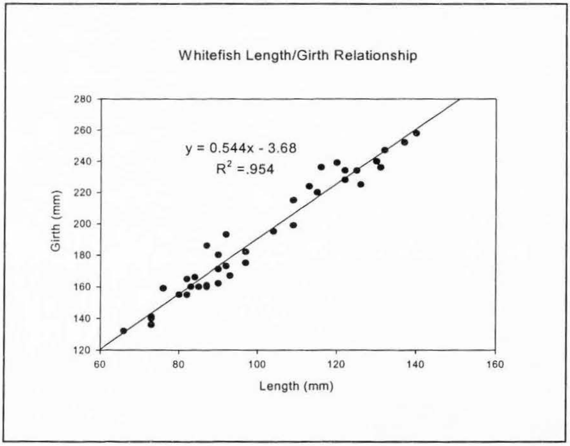


Figure 3-6.—Whitefish Length/Girth relationship for Bonneville and Bear Lake whitefish.

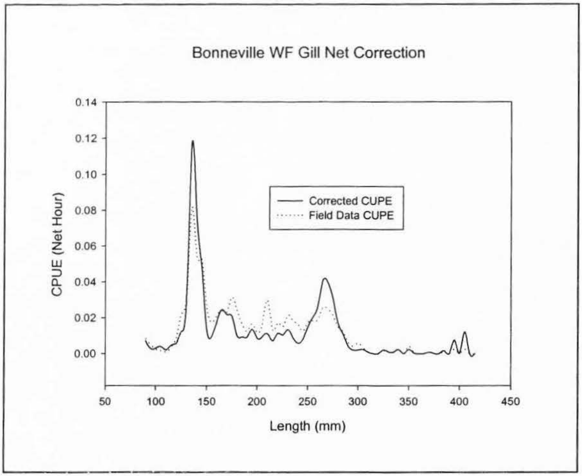


Figure 3-7.—Gill net corrected vs. field CPUE data for Bonneville whitefish.

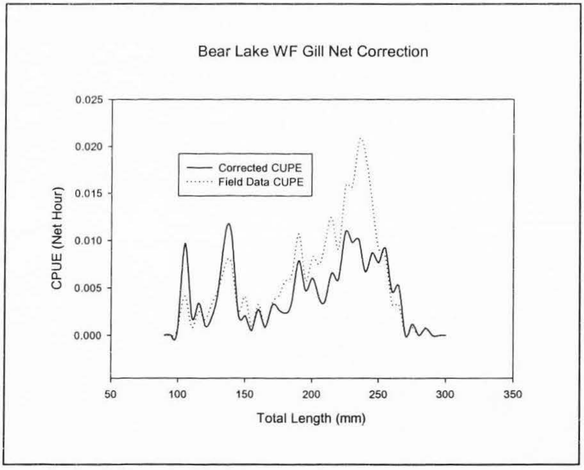


Figure 3-8.—Gill net corrected vs. field CPUE data for Bear Lake whitefish.

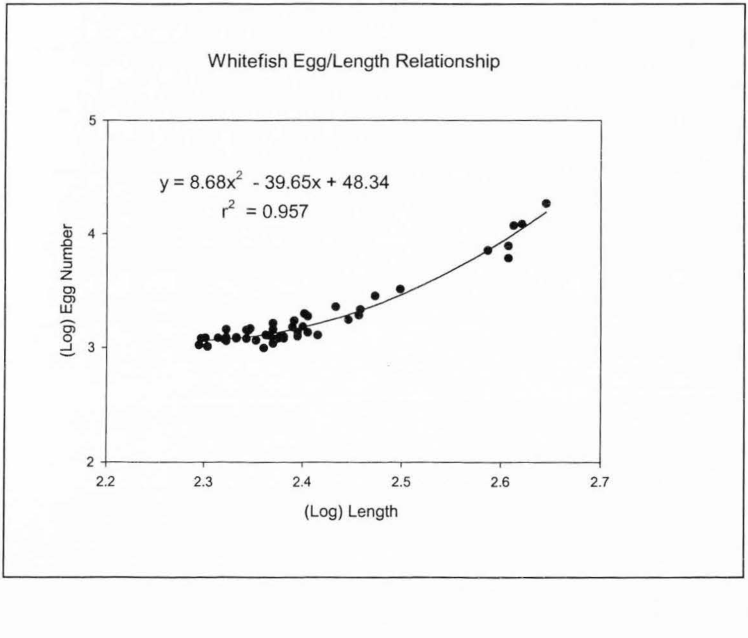


Figure 3-9.—Egg-Length relationship for Bonneville and Bear Lake whitefish.

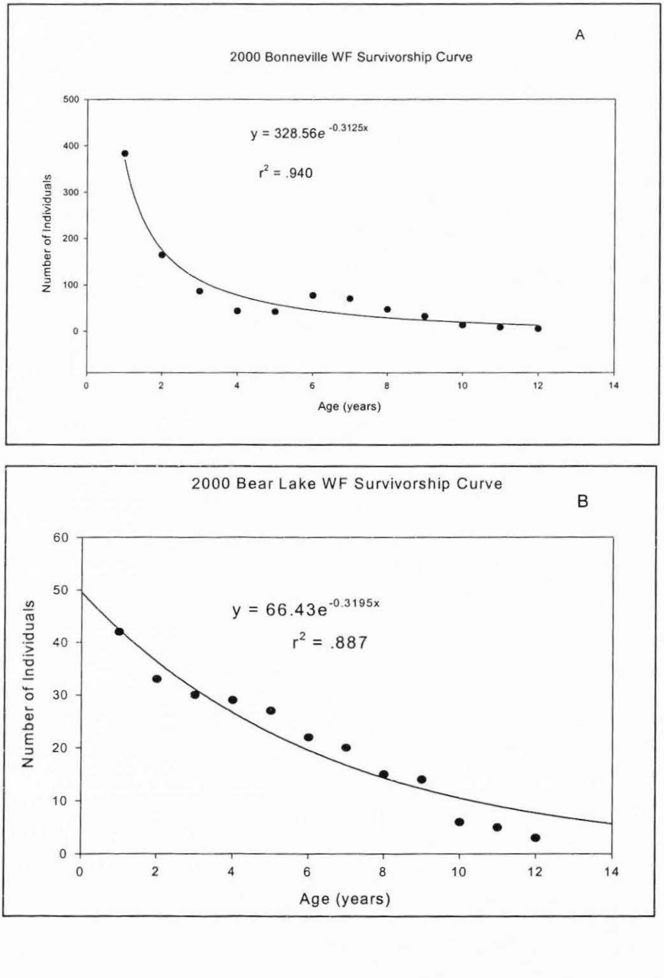


Figure 3-10.—Survivorship curves of Bonneville (A) and Bear Lake (B) whitefish collected summer 2000.

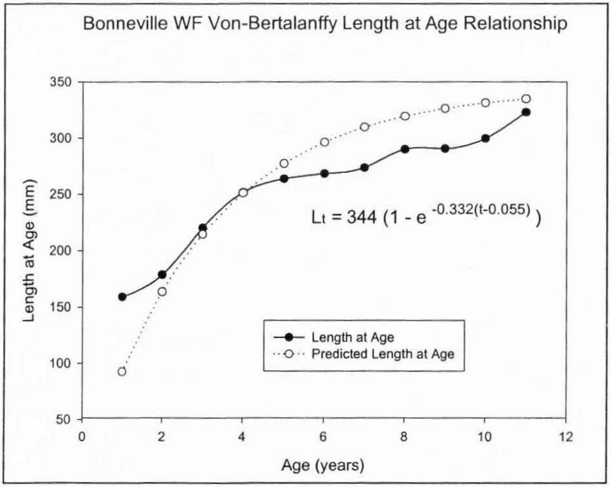


Figure 3-11.—Von-Bertalanffy growth function utilizing aged Bonneville whitefish caught during the summer 2000 sampling period.

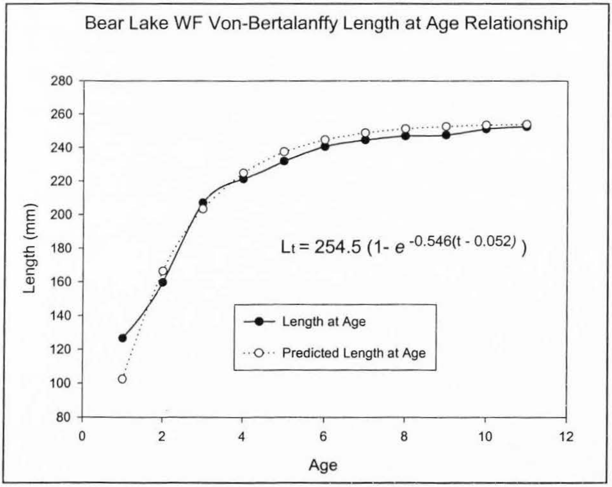


Figure 3-12.—Von-Bertalanffy growth function utilizing aged Bear Lake whitefish caught during the summer 2000 sampling period.

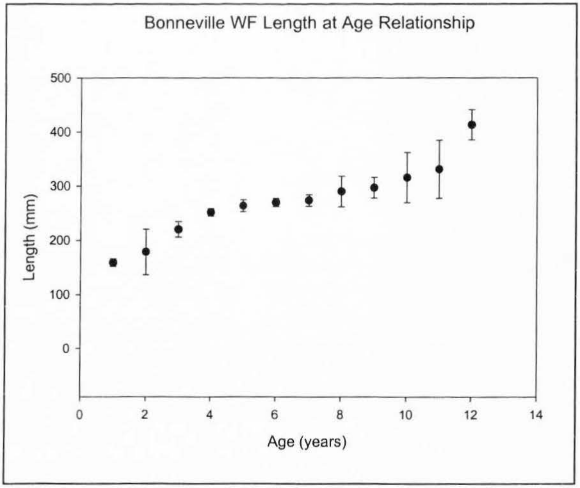


Figure 3-13.—Bonneville whitefish length at age relationship.

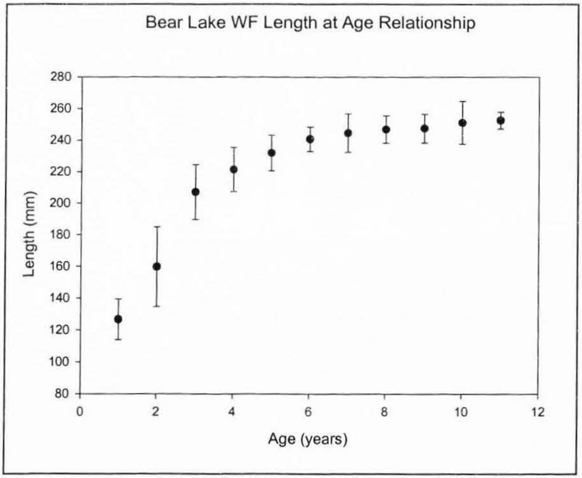


Figure 3-14.—Bear lake whitefish length at age relationship.

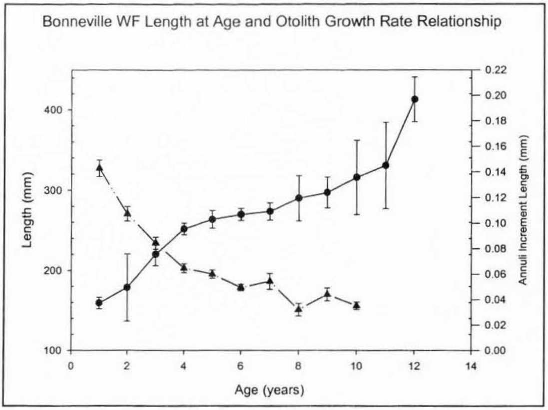


Figure 3-15.—Bonneville whitefish length at age and otolith annuli measurement relationship.

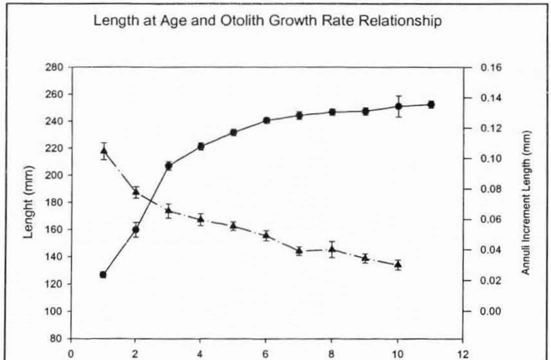
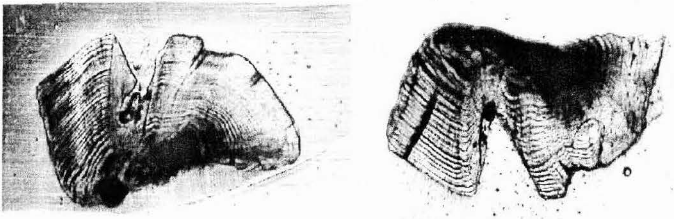
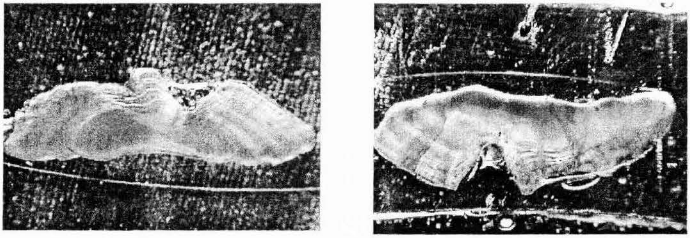


Figure 3-16.—Bear Lake whitefish length at age and otolith annuli measurement relationship.



Bear Lake Whitefish: 247mm
Approximately 37 years old

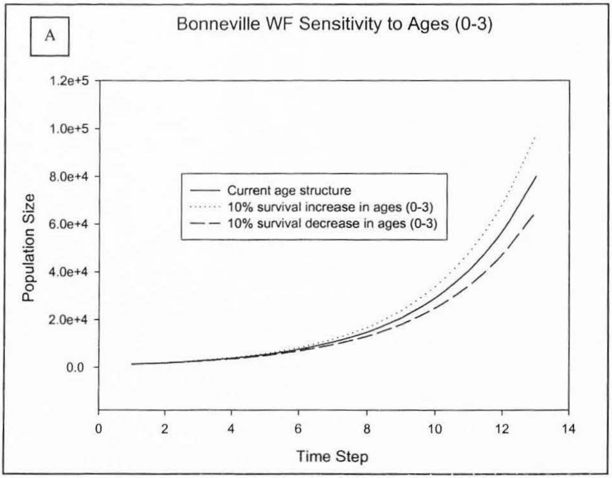
Bear Lake Whitefish: 240mm
Approximately 21 years old



Bonneville Whitefish: 256 mm
4+ years old.

Bonneville Whitefish: 278 mm
4+ years old.

Figure 3-17.—Slide images comparing the otoliths of both whitefish species of approximately the same length.



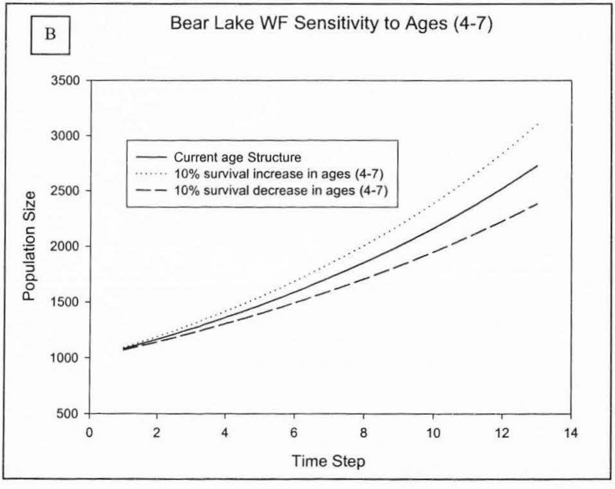


Figure 3-18.—Sensitivity analysis output for Bonneville whitefish ages (0-3) (A), and Bear Lake whitefish ages (4-7) (B).

# CHAPTER 4

# CONCLUSION

In this study, ecological and life history characteristics of Bonneville and Bear Lake whitefish were investigated through an intensive gill netting survey. Diet preferences, relative abundance, spatial distribution, survivorship, age structure, fecundity, somatic growth, population trends, and sensitivity analyses were explored. The following is a summary of the major findings of the completed study.

1. Examination of stomach contents revealed distinctive differences in the feeding habits of the two whitefish species. MANCOVA indicated significant differences in the stomach contents of the two whitefish species collected during the summer of 2000 and during the spring of 2001. In comparing spring to summer diets Bonneville whitefish demonstrated a great dependence on ostracods in spring. Tererrestrial insects were less abundant but still present in all size classes with the exception of the >350 mm size class. This size class fed almost exclusively on sculpin.

2. Bonneville whitefish were the predominant species captured during every sampling period. During the summer of 2000, spring 2001, and summer 2001 sampling periods Bonneville whitefish made up 78%, 75%, and 77% of the catch, respectively. The Komolgrov-Smirnov test yielded highly significant differences in relative distribution at the .05 alpha level. Bonneville whitefish were more abundant in shallower depths during all sampling periods. Pooled catch per unit effort (CPUE) data over the three sampling periods revealed that 96% of all whitefish caught in depths of 5-35 m were Bonneville

whitefish. Bear Lake whitefish were more abundant in deeper depths. Ninety percent of all whitefish caught in depths ranging from 40-60 m were Bear Lake whitefish.

3. Bonneville and Bear Lake whitefish have distinctly different age structures and hence very different survivorship curves. The Bonneville whitefish population follows a somewhat normal survivorship curve for fish populations in that many young individuals were sampled with very few older classes of fish being present. The Bear Lake whitefish population did not follow this same type of mortality pattern. These whitefish displayed a (constant), or linear type of survivorship curve. Although only 22% of the total catch were Bear Lake whitefish, CPUE in their preferred depths was nearly equal to that of Bonneville whitefish in 15-25 m. Given these data I would surmise that, although significantly less Bear Lake whitefish were sampled, there is no evidence to indicate a decaying or threatened population.

4. Major differences in fecundity schedules were pronounced and are attributed to differences in body size at mature ages, age at maturity differences, and relative abundances of the two species. Bonneville whitefish grow larger, mature younger, and are more abundant than Bear Lake whitefish.

5. Average annual growth was different for all age classes and was described by a von Bertalanffy growth equation. Length at age was greater for the Bonneville whitefish, which can reach total lengths nearly double that of the Bear Lake whitefish.

6. At current age structure, the whitefish populations examined are following different population trends. Large discrepancies in respective age structures produced very different model outputs. The life-table model suggested that Bonneville whitefish have potential for significant population growth with lower potentials evident for Bear Lake

whitefish. Leslie matrix modeling suggested that both populations are not currently at their theoretical stable age distributions and revealed large differences in finite rates of increase ($\lambda$).

7. Sensitivity analysis suggested that the most important age classes of Bonneville whitefish are ages (0-3) and most important to the Bear Lake whitefish population are ages (4-7). Increasing and decreasing both of these age classes survival from x to x +1 had the most positive and negative effect on life-table parameters (r), and (Ro).

# APPENDIX

Appendix (A.) Netting Data.

Summer 2000 Bonneville Whitefish Collection Data.

| Net Site | Depth (M) | Fish # | Length | Weight |
|---|---|---|---|---|
| 3 | 35 | 1 | 288 | 123.5 |
| 3 | 35 | 2 | 288 | 178 |
| 3 | 35 | 3 | 254 | 114.8 |
| 3 | 35 | 4 | 205 | 56 |
| 3 | 35 | 5 | 177 | 34 |
| 3 | 30 | 6 | 246 | 110 |
| 3 | 30 | 7 | 243 | 97 |
| 3 | 30 | 8 | 302 | 221 |
| 3 | 30 | 9 | 268 | 143 |
| 3 | 30 | 10 | 205 | 61 |
| 3 | 30 | 11 | 196 | 45 |
| 3 | 30 | 12 | 312 | 202 |
| 3 | 30 | 13 | 277 | 137 |
| 3 | 30 | 14 | 194 | 56 |
| 3 | 30 | 15 | 283 | 163 |
| 3 | 30 | 16 | 185 | 48 |
| 3 | 30 | 17 | 288 | 173 |
| 3 | 30 | 18 | 288 | 206 |
| 3 | 30 | 19 | 276 | 155 |
| 3 | 30 | 20 | 275 | 158 |
| 3 | 30 | 21 | 230 | 87 |
| 3 | 30 | 22 | 230 | 88 |
| 3 | 30 | 23 | 162 | 34 |
| 3 | 30 | 24 | 259 | 129 |
| 3 | 30 | 25 | 194 | 45 |
| 3 | 30 | 26 | 202 | 61 |
| 3 | 25 | 27 | 282 | 173 |
| 3 | 25 | 28 | 275 | 139 |
| 3 | 25 | 29 | 224 | 103 |
| 3 | 25 | 30 | 287 | 168 |
| 3 | 25 | 31 | 242 | 98 |
| 3 | 25 | 32 | 158 | 27 |
| 3 | 25 | 33 | 274 | 141 |
| 3 | 25 | 34 | 197 | 56 |
| 3 | 25 | 35 | 266 | 148 |
| 3 | 25 | 36 | 167 | 34 |
| 3 | 25 | 37 | 126 | 14 |
| 3 | 25 | 38 | 131 | 14 |
| 3 | 25 | 39 | 120 | 92 |
| 3 | 25 | 40 | 113 | 8 |
| 3 | 20 | 41 | 223 | 87 |
| 3 | 20 | 42 | 266 | 144 |
| 3 | 20 | 43 | 214 | 67 |

| | | | | |
|---|---|---|---|---|
| 3 | 20 | 44 | 152 | 23 |
| 3 | 20 | 45 | 195 | 46 |
| 3 | 20 | 46 | 225 | 84.5 |
| 3 | 20 | 47 | 131 | 14 |
| 3 | 15 | 48 | 211 | 67.5 |
| 3 | 15 | 49 | 219 | 75 |
| 3 | 15 | 50 | 197 | 48 |
| 3 | 15 | 51 | 196 | 60 |
| 3 | 15 | 52 | 180 | 53 |
| 3 | 15 | 53 | 224 | 85 |
| 3 | 15 | 54 | 179 | 44 |
| 3 | 15 | 55 | 175 | 40 |
| 3 | 15 | 56 | 146 | 25.5 |
| 3 | 15 | 57 | 176 | 37 |
| 3 | 15 | 58 | 183 | 44 |
| 3 | 15 | 59 | 215 | 80 |
| 3 | 15 | 60 | 196 | 51.5 |
| 3 | 15 | 61 | 225 | 90 |
| 3 | 15 | 62 | 202 | 66 |
| 3 | 15 | 63 | 189 | 48 |
| 3 | 15 | 64 | 256 | 97 |
| 3 | 15 | 65 | 200 | 59 |
| 3 | 15 | 66 | 137 | 21 |
| 3 | 15 | 67 | 144 | 20.5 |
| 3 | 15 | 68 | 152 | 26 |
| 3 | 15 | 69 | 140 | 22 |
| 3 | 15 | 70 | 175 | 38 |
| 3 | 15 | 71 | 125 | 15 |
| 3 | 15 | 72 | 129 | 15 |
| 3 | 15 | 73 | 143 | 17 |
| 3 | 15 | 74 | 134 | 16 |
| 3 | 15 | 75 | 139 | 18 |
| 3 | 15 | 76 | 128 | 13.5 |
| 3 | 15 | 77 | 135 | 13 |
| 3 | 15 | 78 | 105 | 9 |
| 3 | 15 | 79 | 135 | 19 |
| 3 | 15 | 80 | 139 | 15 |
| 3 | 15 | 81 | 131 | 18 |
| 3 | 15 | 82 | 136 | 19 |
| 3 | 15 | 83 | 130 | 16 |
| 3 | 15 | 84 | 129 | 13 |
| 3 | 15 | 85 | 115 | 10 |
| 3 | 15 | 86 | 170 | 35 |
| 3 | 15 | 87 | 220 | 74 |
| 3 | 15 | 88 | 186 | 48 |
| 3 | 15 | 89 | 171 | 40 |
| 4 | 35 | 90 | 271 | 153 |
| 4 | 35 | 91 | 249 | 103 |
| 4 | 35 | 92 | 260 | 112.5 |

| | | | | |
|---|---|---|---|---|
| 4 | 35 | 93 | 251 | 107 |
| 4 | 35 | 94 | 262 | 110 |
| 4 | 35 | 95 | 305 | 206 |
| 4 | 35 | 96 | 272 | 144 |
| 4 | 35 | 97 | 285 | 166 |
| 4 | 35 | 98 | 292 | 178 |
| 4 | 35 | 99 | 261 | 131 |
| 4 | 35 | 100 | 268 | 316 |
| 4 | 30 | 101 | 275 | 136 |
| 4 | 30 | 102 | 251 | 102 |
| 4 | 30 | 103 | 249 | 99 |
| 4 | 30 | 104 | 244 | 104 |
| 4 | 30 | 105 | 266 | 122 |
| 4 | 30 | 106 | 194 | 49 |
| 4 | 30 | 107 | 271 | 144 |
| 4 | 30 | 108 | 169 | 34 |
| 4 | 25 | 109 | 271 | 145 |
| 4 | 25 | 110 | 286 | 172 |
| 4 | 25 | 111 | 257 | 110 |
| 4 | 25 | 112 | 224 | 78 |
| 4 | 25 | 113 | 266 | 116 |
| 4 | 25 | 114 | 213 | 71 |
| 4 | 25 | 115 | 185 | 42 |
| 4 | 25 | 116 | 180 | 39 |
| 4 | 25 | 117 | 231 | 88 |
| 4 | 20 | 118 | 233 | 105 |
| 4 | 20 | 119 | 213 | 60 |
| 4 | 20 | 120 | 209 | 77 |
| 4 | 20 | 121 | 212 | 80 |
| 4 | 20 | 122 | 189 | 53 |
| 4 | 20 | 123 | 163 | 33 |
| 4 | 20 | 124 | 135 | 20 |
| 4 | 20 | 125 | 121 | 11 |
| 4 | 20 | 126 | 66 | 1.5 |
| 4 | 15 | 127 | 267 | 117 |
| 4 | 15 | 128 | 251 | 123 |
| 4 | 15 | 129 | 220 | 80 |
| 4 | 15 | 130 | 135 | 18 |
| 4 | 15 | 131 | 131 | 16 |
| 4 | 15 | 132 | 137 | 18 |
| 4 | 10 | 133 | 196 | 66 |
| 4 | 10 | 134 | 136 | 18 |
| 4 | 10 | 135 | 155 | 26 |
| 2 | 10 | 136 | 65 | 1 |
| 2 | 10 | 137 | 138 | 20 |
| 2 | 10 | 138 | 128 | 15 |
| 2 | 10 | 139 | 142 | 22.5 |
| 2 | 10 | 140 | 126 | 14 |
| 2 | 10 | 141 | 136 | 18 |

| | | | | |
|---|---|---|---|---|
| 2 | 10 | 142 | 139 | 20 |
| 2 | 10 | 143 | 171 | 42 |
| 2 | 10 | 144 | 176 | 41 |
| 2 | 10 | 145 | 182 | 44 |
| 2 | 10 | 146 | 176 | 44 |
| 2 | 10 | 147 | 164 | 34 |
| 2 | 10 | 148 | 158 | 33 |
| 2 | 10 | 149 | 149 | 28 |
| 2 | 10 | 150 | 175 | 40 |
| 2 | 10 | 151 | 150 | 24 |
| 2 | 10 | 152 | 150 | 27 |
| 2 | 10 | 153 | 148 | 24 |
| 2 | 10 | 154 | 160 | 37 |
| 2 | 10 | 155 | 205 | 67 |
| 2 | 10 | 156 | 184 | 49 |
| 2 | 10 | 157 | 176 | 40 |
| 2 | 10 | 158 | 158 | 31 |
| 2 | 10 | 159 | 144 | 23 |
| 2 | 10 | 160 | 145 | 26 |
| 2 | 10 | 161 | 141 | 22.5 |
| 2 | 10 | 162 | 144 | 22 |
| 2 | 10 | 163 | 135 | 18.5 |
| 2 | 10 | 164 | 242 | 116 |
| 2 | 10 | 165 | 215 | 72 |
| 2 | 10 | 166 | 240 | 99 |
| 2 | 10 | 167 | 209 | 73 |
| 2 | 10 | 168 | 209 | 73 |
| 2 | 10 | 169 | 208 | 64.5 |
| 2 | 10 | 170 | 190 | 58 |
| 2 | 10 | 171 | 213 | 69 |
| 2 | 10 | 172 | 235 | 87 |
| 2 | 10 | 173 | 176 | 45 |
| 2 | 15 | 174 | 137 | 21 |
| 2 | 15 | 175 | 129 | 18 |
| 2 | 15 | 176 | 142 | 22 |
| 2 | 15 | 177 | 144 | 19 |
| 2 | 15 | 178 | 145 | 20 |
| 2 | 15 | 179 | 138 | 21 |
| 2 | 15 | 180 | 136 | 19 |
| 2 | 15 | 181 | 134 | 20 |
| 2 | 15 | 182 | 145 | 26 |
| 2 | 15 | 183 | 161 | 30 |
| 2 | 15 | 184 | 178 | 39 |
| 2 | 15 | 185 | 182 | 48 |
| 2 | 15 | 186 | 211 | 70 |
| 2 | 15 | 187 | 218 | 76 |
| 2 | 15 | 188 | 160 | 34 |
| 2 | 15 | 189 | 205 | 67 |
| 2 | 15 | 190 | 176 | 43 |

| | | | | |
|---|---|---|---|---|
| 2 | 15 | 191 | 190 | 55 |
| 2 | 15 | 192 | 207 | 70 |
| 2 | 15 | 193 | 273 | 153 |
| 2 | 15 | 194 | 246 | 103 |
| 2 | 15 | 195 | 181 | 56 |
| 2 | 15 | 196 | 182 | 47 |
| 2 | 15 | 197 | 246 | 110 |
| 2 | 15 | 198 | 213 | 86 |
| 2 | 15 | 199 | 233 | 99 |
| 2 | 15 | 200 | 155 | 30 |
| 2 | 15 | 201 | 177 | 42 |
| 2 | 15 | 202 | 168 | 36 |
| 2 | 15 | 203 | 176 | 45 |
| 2 | 15 | 204 | 174 | 40 |
| 2 | 20 | 205 | 285 | 169 |
| 2 | 20 | 206 | 270 | 148 |
| 2 | 20 | 207 | 209 | 78 |
| 2 | 20 | 208 | 184 | 50 |
| 2 | 25 | 209 | 214 | 78 |
| 2 | 25 | 210 | 227 | 87 |
| 2 | 25 | 211 | 294 | 188 |
| 2 | 25 | 212 | 272 | 149 |
| 2 | 25 | 213 | 234 | 89 |
| 2 | 30 | 214 | 265 | 153 |
| 2 | 30 | 215 | 259 | 136 |
| 2 | 30 | 216 | 281 | 168 |
| 2 | 30 | 217 | 238 | 98 |
| 2 | 30 | 218 | 160 | 29 |
| 2 | 35 | 219 | 252 | 126 |
| 5 | 20 | 220 | 168 | 28 |
| 5 | 20 | 221 | 170 | 31 |
| 5 | 20 | 222 | 168 | 32 |
| 5 | 20 | 223 | 141 | 12.5 |
| 5 | 20 | 224 | 227 | 96 |
| 5 | 20 | 225 | 203 | 63 |
| 5 | 20 | 226 | 198 | 58 |
| 5 | 20 | 227 | 186 | 44 |
| 5 | 20 | 228 | 211 | 58 |
| 5 | 5 | 229 | 135 | 14.5 |
| 5 | 5 | 230 | 134 | 14 |
| 5 | 5 | 231 | 132 | 10 |
| 5 | 20 | 232 | 165 | 30 |
| 5 | 20 | 233 | 165 | 30 |
| 5 | 20 | 234 | 205 | 65 |
| 5 | 20 | 235 | 230 | 85 |
| 5 | 20 | 236 | 130 | 12 |
| 5 | 20 | 237 | 140 | 17 |
| 5 | 20 | 238 | 142 | 19.5 |
| 5 | 20 | 239 | 230 | 97 |

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|---|---|---|---|---|
| 5 | 20 | 240 | 280 | 135 |
| 5 | 20 | 241 | 267 | 122 |
| 5 | 20 | 242 | 240 | 85 |
| 5 | 20 | 243 | 293 | 181 |
| 5 | 20 | 244 | 272 | 107 |
| 5 | 20 | 245 | 238 | 100 |
| 5 | 15 | 246 | 186 | 47 |
| 5 | 15 | 247 | 150 | 26 |
| 5 | 15 | 248 | | |
| 5 | 15 | 249 | 170 | 33.5 |
| 5 | 15 | 250 | 160 | 32 |
| 5 | 15 | 251 | 125 | 11 |
| 5 | 15 | 252 | 150 | 26.5 |
| 5 | 15 | 253 | 140 | 18 |
| 5 | 15 | 254 | 226 | 93 |
| 5 | 15 | 255 | 234 | 92 |
| 5 | 15 | 256 | 245 | 101 |
| 5 | 15 | 257 | 212 | 76 |
| 5 | 15 | 258 | 127 | 13 |
| 5 | 15 | 259 | 294 | 200 |
| 5 | 25 | 260 | 275 | 124 |
| 5 | 25 | 261 | 275 | 135 |
| 5 | 25 | 262 | 284 | 132 |
| 5 | 25 | 263 | 274 | 138 |
| 5 | 25 | 264 | 260 | 123 |
| 5 | 25 | 265 | 285 | 162 |
| 5 | 25 | 266 | 258 | 110 |
| 5 | 25 | 267 | 186 | 44 |
| 5 | 25 | 268 | 183 | 37 |
| 5 | 25 | 269 | 154 | 17 |
| 5 | 25 | 270 | 125 | 8 |
| 5 | 25 | 271 | 118 | 9 |
| 5 | 30 | 272 | 295 | 181 |
| 5 | 30 | 273 | 279 | 141 |
| 5 | 30 | 274 | 276 | 148 |
| 5 | 30 | 275 | 276 | 140 |
| 5 | 30 | 276 | 241 | 85 |
| 5 | 30 | 277 | 297 | 155 |
| 5 | 30 | 278 | 273 | 179 |
| 5 | 30 | 279 | 266 | 127 |
| 5 | 30 | 280 | 210 | 64 |
| 5 | 30 | 281 | 228 | 75 |
| 5 | 30 | 282 | 240 | 98 |
| 5 | 30 | 283 | 190 | 45 |
| 5 | 30 | 284 | 200 | 54 |
| 5 | | | | |
| 5 | 35 | 286 | 268 | 133 |
| 5 | 35 | 287 | 235 | 99 |
| 5 | 35 | 288 | 233 | 78 |

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|---|---|---|---|---|
| 5 | 35 | 289 | 237 | 101 |
| 5 | 35 | 290 | 230 | 84 |
| 5 | 35 | 291 | 166 | 30 |
| 1 | 5 | 292 | 137 | 23 |
| 1 | 10 | 293 | 237 | 101 |
| 1 | 10 | 294 | 233 | 88 |
| 1 | 10 | 295 | 165 | 37 |
| 1 | 10 | 296 | 167 | 38 |
| 1 | 10 | 297 | 141 | 25 |
| 1 | 10 | 298 | 134 | 19 |
| 1 | 10 | 299 | 142 | 21 |
| 1 | 10 | 300 | 125 | 14 |
| 1 | 10 | 301 | 138 | 24 |
| 1 | 10 | 302 | 136 | 20 |
| 1 | 10 | 303 | 129 | 18 |
| 1 | 10 | 304 | 136 | 18 |
| 1 | 10 | 305 | 155 | 30 |
| 1 | 10 | 306 | 138 | 19 |
| 1 | 10 | 307 | 139 | 21 |
| 1 | 10 | 308 | 146 | 25 |
| 1 | 10 | 309 | 121 | 14 |
| 1 | 10 | 310 | 134 | 19 |
| 1 | 10 | 311 | 135 | 16 |
| 1 | 10 | 312 | 139 | 24 |
| 1 | 10 | 313 | 134 | 20 |
| 1 | 10 | 314 | 123 | 14 |
| 1 | 10 | 315 | 137 | 17 |
| 1 | 10 | 316 | 136 | 18 |
| 1 | 10 | 317 | 137 | 20 |
| 1 | 10 | 318 | 136 | 17 |
| 1 | 10 | 319 | 152 | 24 |
| 1 | 10 | 320 | 175 | 41 |
| 1 | 10 | 321 | 169 | 32 |
| 1 | 10 | 322 | 190 | 67 |
| 1 | 10 | 323 | 201 | 66 |
| 1 | 15 | 324 | 235 | 98 |
| 1 | 15 | 325 | 215 | 91 |
| 1 | 15 | 326 | 197 | 64 |
| 1 | 15 | 327 | 230 | 92 |
| 1 | 15 | 328 | 203 | 62 |
| 1 | 15 | 329 | 212 | 79 |
| 1 | 15 | 330 | 170 | 37 |
| 1 | 15 | 331 | 161 | 29 |
| 1 | 15 | 332 | 152 | 25 |
| 1 | 15 | 333 | 134 | 16 |
| 1 | 15 | 334 | 140 | 19 |
| 1 | 15 | 335 | 140 | 20 |
| 1 | 15 | 336 | 134 | 19 |
| 1 | 15 | 337 | 137 | 20 |

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| 1 | 15 | 338 | 144 | 23 |
| 1 | 15 | 339 | 139 | 20 |
| 1 | 15 | 340 | 132 | 16 |
| 1 | 15 | 341 | 122 | 14 |
| 1 | 15 | 342 | 146 | 27 |
| 1 | 15 | 343 | 143 | 21 |
| 1 | 15 | 344 | 160 | 32.5 |
| 1 | 15 | 345 | 132 | 18 |
| 1 | 15 | 346 | 140 | 21 |
| 1 | 15 | 347 | 139 | 21 |
| 1 | 15 | 348 | 124 | 16 |
| 1 | 15 | 349 | 140 | 18 |
| 1 | 15 | 350 | 125 | 13 |
| 1 | 20 | 351 | 146 | 23 |
| 1 | 20 | 352 | 130 | 16 |
| 1 | 20 | 353 | 147 | 24 |
| 1 | 20 | 354 | 154 | 26 |
| 1 | 20 | 355 | 158 | 31 |
| 1 | 25 | 356 | 300 | 195.5 |
| 1 | 25 | 357 | 210 | 58 |
| 1 | 25 | 358 | 237 | 96 |
| 1 | 25 | 359 | 252 | 113 |
| 1 | 25 | 360 | 277 | 155 |
| 1 | 25 | 361 | 169 | 35 |
| 1 | 25 | 362 | 169 | 35 |
| 1 | 25 | 363 | 148 | 21.5 |
| 1 | 25 | 364 | 139 | 16.5 |
| 1 | 25 | 365 | 167 | 29 |
| 1 | 30 | 366 | 280 | 191 |
| 1 | 30 | 367 | 267 | 141 |
| 1 | 30 | 368 | 235 | 87.5 |
| 6 | 5 | 367 | 260 | 108 |
| 6 | 5 | 368 | 161 | 41 |
| 6 | 5 | 369 | 154 | 31 |
| 6 | 5 | 370 | 115 | 12 |
| 6 | 5 | 371 | 145 | 28 |
| 6 | 5 | 372 | 159 | 37 |
| 6 | 5 | 373 | 194 | 61 |
| 6 | 10 | 374 | 239 | 90 |
| 6 | 10 | 375 | 231 | 106 |
| 6 | 10 | 376 | 214 | 81 |
| 6 | 10 | 378 | 197 | 60 |
| 6 | 10 | 379 | 225 | 82 |
| 6 | 10 | 380 | 226 | 65 |
| 6 | 10 | 381 | 179 | 31 |
| 6 | 10 | 382 | 189 | 56 |
| 6 | 10 | 383 | 171 | 31 |
| 6 | 10 | 384 | 212 | 70 |
| 6 | 10 | 385 | 199 | 62 |

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|---|---|---|---|---|
| 6 | 10 | 386 | 169 | 35 |
| 6 | 10 | 387 | 135 | 15 |
| 6 | 10 | 388 | 153 | 26 |
| 6 | 10 | 389 | 139 | 21 |
| 6 | 10 | 390 | 146 | 25 |
| 6 | 10 | 391 | 144 | 22 |
| 6 | 10 | 392 | 141 | 23 |
| 6 | 10 | 393 | 173 | 41 |
| 6 | 10 | 394 | 128 | 16 |
| 6 | 10 | 395 | 195 | 44 |
| 6 | 10 | 396 | 137 | 18 |
| 6 | 10 | 397 | 156 | 29 |
| 6 | 10 | 398 | 135 | 20 |
| 6 | 10 | 399 | 147 | 22 |
| 6 | 10 | 400 | 137 | 20.3 |
| 6 | 10 | 401 | 140 | 19 |
| 6 | 10 | 402 | 140 | 20.2 |
| 6 | 10 | 403 | 129 | 15 |
| 6 | 10 | 404 | 155 | 28 |
| 6 | 10 | 405 | 124 | 15 |
| 6 | 10 | 406 | 125 | 13 |
| 6 | 10 | 407 | 126 | 14 |
| 6 | 15 | 408 | 304 | 209 |
| 6 | 15 | 409 | 352 | 289 |
| 6 | 15 | 410 | 352 | 320 |
| 6 | 15 | 411 | 283 | 158 |
| 6 | 15 | 412 | 270 | 131 |
| 6 | 15 | 413 | 273 | 146 |
| 6 | 15 | 414 | 247 | 105.5 |
| 6 | 15 | 415 | 185 | 59 |
| 6 | 15 | 416 | 215 | 68 |
| 6 | 15 | 417 | 210 | 68 |
| 6 | 15 | 418 | 210 | 73 |
| 6 | 15 | 419 | 229 | 80 |
| 6 | 15 | 420 | 224 | 88 |
| 6 | 15 | 421 | 185 | 48 |
| 6 | 15 | 422 | 176 | 44 |
| 6 | 15 | 423 | 156 | 30 |
| 6 | 15 | 424 | 146 | 26 |
| 6 | 15 | 425 | 136 | 21.5 |
| 6 | 15 | 426 | 150 | 24 |
| 6 | 15 | 427 | 139 | 20 |
| 6 | 15 | 428 | 129 | 17 |
| 6 | 15 | 429 | 135 | 20 |
| 6 | 15 | 430 | 135 | 21 |
| 6 | 15 | 431 | 133 | 15 |
| 6 | 15 | 432 | 145 | 24 |
| 6 | 20 | 433 | 340 | 270 |
| 6 | 20 | 434 | 273 | 161 |

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|---|---|---|---|---|
| 6 | 20 | 435 | 234 | 92 |
| 6 | 20 | 436 | 139 | 106 |
| 6 | 20 | 437 | 179 | 42 |
| 6 | 20 | 438 | 176 | 44 |
| 6 | 20 | | | |
| 6 | 20 | 440 | 170 | 38 |
| 6 | 20 | 441 | 265 | 154 |
| 6 | 20 | 442 | 254 | 111 |
| 6 | 20 | 443 | 215 | 86 |
| 6 | 20 | 444 | 224 | 95 |
| 6 | 20 | 445 | 178 | 42 |
| 6 | 20 | 446 | 145 | 27 |
| 6 | 20 | 447 | 145 | 27 |
| 6 | 20 | 448 | 136 | 19 |
| 6 | 20 | 448 | 134 | 18 |
| 6 | 20 | 449 | 124 | 15 |
| 6 | 20 | 450 | 159 | 30 |
| 6 | 20 | 451 | 121 | 15 |
| 6 | 20 | 452 | 137 | 20 |
| 6 | 20 | 453 | 140 | 20.5 |
| 6 | 25 | 454 | 353 | 315 |
| 6 | 25 | 455 | 279 | 144 |
| 6 | 25 | 456 | 225 | 71 |
| 6 | 25 | 457 | 218 | 78 |
| 6 | 25 | 458 | 215 | 83 |
| 6 | 25 | 459 | 175 | 43 |
| 6 | 25 | 460 | 175 | 43 |
| 6 | 25 | 461 | 142 | 23 |
| 6 | 25 | 462 | 131 | 20 |
| 6 | 25 | 463 | 109 | 11 |
| 6 | 30 | 464 | 247 | 115 |
| 6 | 30 | 465 | 278 | 172 |
| 6 | 30 | 466 | 265 | 136 |
| 6 | 30 | 467 | 280 | 154 |
| 6 | 30 | 468 | 237 | 93 |
| 6 | 30 | 469 | 251 | 127 |
| 6 | 30 | 470 | 225 | 85 |
| 6 | 30 | 471 | 202 | 61 |
| 6 | 30 | 472 | 202 | 61 |
| 6 | 30 | 473 | 210 | 73 |
| 6 | 30 | 474 | 232 | 87 |
| 5 | 50 | 475 | 206 | 53 |
| 5 | 60 | 476 | 279 | 138 |
| 5 | 60 | 477 | 233 | 85 |
| 5 | 50 | 478 | 205 | 95 |
| 3(b) | 15 | 479 | 194 | 52 |
| 3(b) | 15 | 480 | 158 | 32 |
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| 3(b) | 15 | 482 | 137 | 17 |

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| 3(b) | 15 | 491 | 147 | 22 |
| 3(b) | 15 | 492 | 149 | 24 |
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| 3(b) | 15 | 496 | 125 | 11 |
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| 3(b) | 15 | 500 | 188 | 55 |
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| 3(b) | 20 | 507 | 165 | 33 |
| 3(b) | 20 | 508 | 167 | 32 |
| 3(b) | 25 | 509 | 179 | 42 |
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| 3(b) | 25 | 511 | 160 | 28 |
| 3(b) | 25 | 512 | 147 | 21 |
| 3(b) | 25 | 513 | 150 | 23 |
| 3(b) | 25 | 514 | 137 | 18 |
| 3(b) | 30 | 515 | 285 | 173 |
| 3(b) | 30 | 516 | 287 | 202 |
| 3(b) | 30 | 517 | 282 | 166 |
| 3(b) | 30 | 518 | 260 | 124 |
| 3(b) | 30 | 519 | 259 | 123 |
| 3(b) | 30 | 520 | 254 | 110 |
| 3(b) | 30 | 521 | 159 | 30 |
| 3(b) | 30 | 522 | 127 | 16 |
| 3(b) | 35 | 523 | 305 | 231 |
| 3(b) | 35 | 524 | 265 | 123 |
| 3(b) | 35 | 525 | 240 | 105 |
| 3(b) | 35 | 526 | 251 | 116 |
| 3(b) | 35 | 527 | 257 | 132 |
| 3(b) | 35 | 528 | 222 | 88 |
| 3(b) | 35 | 529 | 240 | 109 |
| 4(b) | 10 | 530 | 136 | 22 |
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| 4(b) | 10 | 532 | 137 | 20 |

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| 4(b) | 10 | 534 | 139 | 20 |
| 4(b) | 10 | 535 | 131 | 14 |
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| 4(b) | 15 | 559 | 133 | 12 |
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| 4(b) | 15 | 562 | 145 | 20 |
| 4(b) | 15 | 563 | 154 | 24 |
| 4(b) | 15 | 564 | 155 | 18 |
| 4(b) | 15 | 565 | 151 | 22 |
| 4(b) | 15 | 566 | 158 | 22 |
| 4(b) | 15 | 567 | 156 | 22 |
| 4(b) | 15 | 568 | 151 | 20 |
| 4(b) | 15 | 569 | 149 | 20 |
| 4(b) | 15 | 570 | 148 | 24 |
| 4(b) | 15 | 571 | 170 | 34 |
| 4(b) | 15 | 572 | 182 | 38 |
| 4(b) | 15 | 573 | 190 | 38 |
| 4(b) | 15 | 574 | 220 | 70 |
| 4(b) | 15 | 575 | 243 | 88 |
| 4(b) | 15 | 576 | 264 | 102 |
| 4(b) | 15 | 577 | 264 | 124 |
| 4(b) | 15 | 578 | 287 | 130 |
| 4(b) | 15 | 579 | 295 | 170 |
| 4(b) | 15 | 580 | 396 | 482 |
| 4(b) | 15 | 581 | 389 | 440 |

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| 4(b) | 15 | 583 | 299 | 228 |
| 4(b) | 15 | 584 | 302 | 194 |
| 4(b) | 15 | 585 | 293 | 190 |
| 4(b) | 15 | 586 | 280 | 144 |
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| 4(b) | 15 | 590 | 251 | 132 |
| 4(b) | 15 | 591 | 227 | 92 |
| 4(b) | 15 | 592 | 237 | 120 |
| 4(b) | 15 | 593 | 220 | 84 |
| 4(b) | 15 | 594 | 225 | 92 |
| 4(b) | 15 | 595 | 211 | 86 |
| 4(b) | 15 | 596 | 213 | 74 |
| 4(b) | 15 | 597 | 214 | 80 |
| 4(b) | 15 | 598 | 195 | 60 |
| 4(b) | 15 | 599 | 190 | 50 |
| 4(b) | 15 | 600 | 201 | 68 |
| 4(b) | 15 | 601 | 166 | 40 |
| 4(b) | 15 | 602 | 174 | 46 |
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| 4(b) | 15 | 614 | 132 | 16 |
| 4(b) | 15 | 615 | 140 | 20 |
| 4(b) | 15 | 616 | 149 | 24 |
| 4(b) | 15 | 617 | 145 | 22 |
| 4(b) | 15 | 618 | 138 | 20 |
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| 4(b) | 15 | 621 | 92 | 6 |
| 4(b) | 15 | 622 | 72 | 2 |
| 4(b) | 15 | 623 | 74 | 5 |
| 4(b) | 25 | 624 | 159 | 32 |
| 4(b) | 25 | 625 | 138 | 20 |
| 4(b) | 25 | 626 | 145 | 24 |
| 4(b) | 25 | 627 | 135 | 18 |
| 4(b) | 25 | 628 | 146 | 24 |
| 4(b) | 25 | 629 | 173 | 38 |
| 4(b) | 25 | 630 | 180 | 46 |

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| 4(b) | 25 | 631 | 170 | 36 |
| 4(b) | 25 | 632 | 161 | 34 |
| 4(b) | 25 | 633 | 176 | 42 |
| 4(b) | 25 | 634 | 194 | 62 |
| 4(b) | 25 | 635 | 174 | 40 |
| 4(b) | 25 | 636 | 219 | 78 |
| 4(b) | 25 | 637 | 184 | 54 |
| 4(b) | 25 | 638 | 266 | 140 |
| 4(b) | 25 | 639 | 278 | 160 |
| 4(b) | 30 | 640 | 136 | 18 |
| 4(b) | 30 | 641 | 144 | 24 |
| 4(b) | 30 | 642 | 146 | 20 |
| 4(b) | 30 | 643 | 135 | 18 |
| 4(b) | 30 | 644 | 138 | 20 |
| 4(b) | 30 | 645 | 166 | 32 |
| 4(b) | 30 | 646 | 174 | 42 |
| 4(b) | 30 | 647 | 187 | 48 |
| 4(b) | 30 | 648 | 270 | 134 |
| 4(b) | 30 | 649 | 258 | 110 |
| 4(b) | 30 | 650 | 299 | 202 |
| 4(b) | 30 | 651 | 264 | 126 |
| 4(b) | 30 | 652 | 237 | 94 |
| 4(b) | 30 | 653 | 248 | 108 |
| 4(b) | 30 | 654 | 257 | 116 |
| 4(b) | 30 | 655 | 264 | 132 |
| 4(b) | 35 | 656 | 250 | 122 |
| 4(b) | 35 | 657 | 238 | 82 |
| 4(b) | 35 | 658 | 232 | 96 |
| 4(b) | 35 | 659 | 244 | 104 |
| 4(b) | 35 | 660 | 240 | 104 |
| 4(b) | 35 | 661 | 234 | 96 |
| 4(b) | 35 | 662 | 256 | 118 |
| 4(b) | 35 | 663 | 279 | 158 |
| 4(b) | 35 | 664 | 259 | 126 |
| 4(b) | 35 | 665 | 275 | 138 |
| 4(b) | 35 | 666 | 285 | 164 |
| 4(b) | 35 | 667 | 286 | 176 |
| 3 | 35 | 668 | 184 | 46 |
| 3 | 35 | 669 | 166 | 47 |
| 3 | 35 | 670 | 166 | 46 |
| 3 | 35 | 671 | 139 | 18 |
| 3 | 35 | 672 | 127 | 14 |
| 3 | 35 | 673 | 122 | 16 |
| 3 | 35 | 674 | 140 | 20 |
| 3 | 35 | 675 | 145 | 24 |
| 3 | 35 | 676 | 143 | 22 |
| 3 | 35 | 677 | 136 | 18 |
| 3 | 35 | 678 | 136 | 17 |
| 3 | 35 | 679 | 91 | 6 |

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|---|---|---|---|---|
| 3 | 35 | 680 | 91 | 6 |
| 3(b) | 10 | 681 | 353 | 298 |
| 3(b) | 10 | 682 | 284 | 192 |
| 3(b) | 10 | 683 | 141 | 18 |
| 3(b) | 10 | 684 | 145 | 26 |
| 3(b) | 10 | 685 | 146 | 24 |
| 3(b) | 10 | 686 | 147 | 20 |
| 3(b) | 10 | 687 | 99 | 5 |
| 5 | 10 | 688 | 269 | 130 |
| 5 | 10 | 689 | 211 | 78 |
| 5 | 10 | 690 | 172 | 46 |
| 5 | 10 | 691 | 174 | 44 |
| 5 | 10 | 692 | 173 | 40 |
| 5 | 10 | 693 | 169 | 34 |
| 5 | 10 | 694 | 162 | 32 |
| 5 | 10 | 695 | 137 | 18 |
| 5 | 10 | 696 | 136 | 18 |
| 5 | 10 | 697 | 142 | 24 |
| 5 | 10 | 698 | 149 | 22 |
| 5 | 10 | 699 | 150 | 28 |
| 5 | 10 | 700 | 135 | 18 |
| 5 | 10 | 701 | 145 | 22 |
| 5 | 10 | 702 | 137 | 18 |
| 5 | 10 | 703 | 140 | 20 |
| 5 | 10 | 704 | 158 | 28 |
| 5 | 10 | 705 | 153 | 26 |
| 5 | 10 | 706 | 137 | 19 |
| 5 | 10 | 707 | 141 | 20 |
| 5 | 10 | 708 | 97 | 6 |
| 5 | 10 | 709 | 93 | 6 |
| 5 | 10 | 710 | 98 | 6 |
| 5 | 10 | 711 | 97 | 6 |
| 5 | 10 | 712 | 97 | 6 |
| 4 | 35 | 713 | 259 | 102 |
| 4 | 35 | 714 | 237 | 104 |
| 4 | 35 | 715 | 221 | 82 |
| 4 | 35 | 716 | 200 | 62 |
| 4 | 35 | 717 | 179 | 43 |
| 4 | 35 | 718 | 168 | 36 |
| 2(b) | 15 | 719 | 398 | 524 |
| 2(b) | 15 | 720 | 332 | 250 |
| 2(b) | 15 | 721 | 294 | 148 |
| 2(b) | 15 | 722 | 300 | 156 |
| 2(b) | 15 | 723 | 265 | 130 |
| 2(b) | 15 | 724 | 220 | 80 |
| 2(b) | 15 | 725 | 230 | 80 |
| 2(b) | 15 | 726 | 214 | 62 |
| 2(b) | 15 | 727 | 224 | 82 |
| 2(b) | 15 | 728 | 189 | 50 |

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| 2(b) | 15 | 729 | 206 | 64 |
| 2(b) | 15 | 730 | 179 | 46 |
| 2(b) | 15 | 731 | 174 | 40 |
| 2(b) | 15 | 732 | 184 | 44 |
| 2(b) | 15 | 733 | 177 | 38 |
| 2(b) | 15 | 734 | 183 | 42 |
| 2(b) | 15 | 735 | 163 | 30 |
| 2(b) | 15 | 736 | 186 | 46 |
| 2(b) | 15 | 737 | 170 | 34 |
| 2(b) | 15 | 738 | 163 | 30 |
| 2(b) | 15 | 739 | 155 | 24 |
| 2(b) | 15 | 740 | 140 | 18 |
| 2(b) | 15 | 741 | 139 | 14 |
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| 2(b) | 15 | 746 | 145 | 22 |
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| 2(b) | 15 | 748 | 134 | 12 |
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| 2(b) | 15 | 752 | 135 | 12 |
| 2(b) | 15 | 753 | 144 | 22 |
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| 2(b) | 15 | 756 | 137 | 18 |
| 2(b) | 15 | 757 | 127 | 14 |
| 2(b) | 15 | 758 | 146 | 16 |
| 2(b) | 15 | 759 | 90 | 4 |
| 2(b) | 15 | 760 | 90 | 4 |
| 2(b) | 15 | 761 | 86 | 3 |
| 2(b) | 15 | 762 | 75 | 2.5 |
| 2(b) | 10 | 763 | 198 | 76 |
| 2(b) | 10 | 764 | 70 | 40 |
| 2(b) | 10 | 765 | 147 | 26 |
| 2(b) | 10 | 766 | 145 | 32 |
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| 2(b) | 10 | 772 | 145 | 16 |
| 2(b) | 10 | 773 | 147 | 20 |
| 2(b) | 10 | 774 | 127 | 16 |
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| 2(b) | 10 | 777 | 144 | 18 |

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| 2(b) | 10 | 779 | 133 | 22 |
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| 5(b) | 40 | 783 | 344 | 316 |
| 5(b) | 40 | 784 | 307 | 232 |
| 5(b) | 40 | 785 | 267 | 142 |
| 5(b) | 40 | 786 | 245 | 102 |
| 5(b) | 40 | 787 | 252 | 112 |
| 5(b) | 40 | 788 | 260 | 128 |
| 5(b) | 40 | 789 | 178 | 44 |
| 5(b) | 35 | 790 | 273 | 154 |
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| 5(b) | 35 | 792 | 264 | 130 |
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| 5(b) | 35 | 794 | 243 | 104 |
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| 5(b) | 35 | 796 | 241 | 98 |
| 5(b) | 35 | 797 | 236 | 98 |
| 5(b) | 35 | 798 | 221 | 80 |
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| 5(b) | 35 | 800 | 204 | 66 |
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| 5(b) | 35 | 802 | 211 | 66 |
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| 5(b) | 25 | 822 | 265 | 134 |
| 5(b) | 25 | 823 | 260 | 114 |
| 5(b) | 25 | 824 | 252 | 118 |
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| 5(b) | 25 | 826 | 215 | 70 |

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| 5(b) | 20 | 833 | 136 | 18 |
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| 2(b) | 30 | 837 | 270 | 128 |
| 2(b) | 25 | 838 | 309 | 206 |
| 2(b) | 25 | 839 | 210 | 68 |
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| 2(b) | 25 | 841 | 210 | 68 |
| 2(b) | 25 | 842 | 180 | 50 |
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| 2(b) | 20 | 844 | 280 | 170 |
| 2(b) | 20 | 845 | 277 | 140 |
| 2(b) | 20 | 846 | 248 | 118 |
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| 2(b) | 20 | 848 | 267 | 140 |
| 2(b) | 20 | 849 | 242 | 100 |
| 2(b) | 20 | 850 | 224 | 90 |
| 2(b) | 20 | 851 | 197 | 56 |
| 2(b) | 20 | 852 | 177 | 44 |
| 2(b) | 20 | 853 | 142 | 22 |
| 2(b) | 20 | 854 | 131 | 14 |
| 6(b) | 10 | 855 | 283 | 156 |
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| 6(b) | 10 | 857 | 279 | 130 |
| 6(b) | 10 | 858 | 268 | 142 |
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| 6(b) | 10 | 864 | 259 | 136 |
| 6(b) | 10 | 865 | 275 | 142 |
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| 6(b) | 10 | 867 | 268 | 112 |
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| 6(b) | 10 | 869 | 255 | 132 |
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| 6(b) | 10 | 871 | 265 | 132 |
| 6(b) | 10 | 872 | 240 | 104 |
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| 6(b) | 10 | 874 | 239 | 90 |
| 6(b) | 10 | 875 | 238 | 84 |

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| 6(b) | 10 | 883 | 179 | 46 |
| 6(b) | 10 | 884 | 170 | 36 |
| 6(b) | 10 | 885 | 166 | 30 |
| 6(b) | 10 | 886 | 170 | 36 |
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| 6(b) | 10 | 893 | 139 | 16 |
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| 6(b) | 15 | 907 | 270 | 130 |
| 6(b) | 15 | 908 | 270 | 134 |
| 6(b) | 15 | 909 | 276 | 144 |
| 6(b) | 15 | 910 | 278 | 152 |
| 6(b) | 15 | 911 | 256 | 94 |
| 6(b) | 15 | 912 | 255 | 108 |
| 6(b) | 15 | 913 | 260 | 118 |
| 6(b) | 15 | 914 | 253 | 108 |
| 6(b) | 15 | 915 | 222 | 80 |
| 6(b) | 15 | 916 | 225 | 76 |
| 6(b) | 15 | 917 | 208 | 64 |
| 6(b) | 15 | 918 | 192 | 52 |
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| 6(b) | 15 | 921 | 186 | 46 |
| 6(b) | 15 | 922 | 180 | 42 |
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| 6(b) | 15 | 924 | 161 | 32 |

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| 6(b) | 15 | 926 | 150 | 30 |
| 6(b) | 15 | 927 | 164 | 36 |
| 6(b) | 15 | 928 | 141 | 22 |
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| 6(b) | 15 | 930 | 137 | 20 |
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| 6(b) | 15 | 933 | 135 | 16 |
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| 6(b) | 20 | 939 | 269 | 120 |
| 6(b) | 20 | 940 | 275 | 156 |
| 6(b) | 20 | 941 | 258 | 110 |
| 6(b) | 20 | 942 | 216 | 70 |
| 6(b) | 25 | 943 | 280 | 144 |
| 6(b) | 25 | 944 | 268 | 132 |
| 6(b) | 25 | 945 | 253 | 114 |
| 6(b) | 25 | 946 | 229 | 78 |
| 6(b) | 25 | 947 | 219 | 78 |
| 6(b) | 25 | 948 | 208 | 66 |
| 6(b) | 25 | 949 | 183 | 36 |
| 6(b) | 25 | 950 | 184 | 38 |
| 6(b) | 25 | 951 | 173 | 26 |
| 6(b) | 25 | 952 | 120 | 8 |
| 6(b) | 35 | 953 | 290 | 184 |
| 6(b) | 35 | 954 | 285 | 160 |
| 6(b) | 35 | 955 | 272 | 156 |
| 6(b) | 35 | 956 | 243 | 114 |
| 6(b) | 35 | 957 | 210 | 70 |
| 6(b) | 35 | 958 | 206 | 64 |
| 6(b) | 35 | 959 | 203 | 54 |
| 6(b) | 35 | 960 | 180 | 40 |
| 6(b) | 10 | 961 | 327 | 278 |
| 6(b) | 10 | 962 | 274 | 150 |
| 6(b) | 10 | 963 | 274 | 158 |
| 6(b) | 10 | 964 | 271 | 150 |
| 6(b) | 10 | 965 | 265 | 150 |
| 6(b) | 10 | 966 | 270 | 142 |
| 6(b) | 10 | 967 | 265 | 136 |
| 6(b) | 10 | 968 | 255 | 124 |
| 6(b) | 10 | 969 | 264 | 136 |
| 6(b) | 10 | 970 | 249 | 108 |
| 6(b) | 10 | 971 | 241 | 114 |
| 6(b) | 10 | 972 | 260 | 126 |
| 6(b) | 10 | 973 | 250 | 104 |

| | | | | |
|---|---|---|---|---|
| 6(b) | 10 | 974 | 231 | 98 |
| 6(b) | 10 | 975 | 241 | 98 |
| 6(b) | 10 | 976 | 234 | 110 |
| 6(b) | 10 | 977 | 249 | 126 |
| 6(b) | 10 | 978 | 230 | 96 |
| 6(b) | 10 | 979 | 215 | 76 |
| 6(b) | 10 | 980 | 220 | 86 |
| 6(b) | 10 | 981 | 224 | 88 |
| 6(b) | 10 | 982 | 224 | 84 |
| 6(b) | 10 | 983 | 218 | 76 |
| 6(b) | 10 | 984 | 207 | 70 |
| 6(b) | 10 | 985 | 194 | 66 |
| 6(b) | 10 | 986 | 193 | 60 |
| 6(b) | 10 | 987 | 196 | 60 |
| 6(b) | 10 | 988 | 180 | 50 |
| 6(b) | 10 | 989 | 183 | 52 |
| 6(b) | 10 | 990 | 174 | 46 |
| 6(b) | 10 | 991 | 178 | 52 |
| 6(b) | 10 | 992 | 179 | 48 |
| 6(b) | 10 | 993 | 160 | 38 |
| 6(b) | 10 | 994 | 169 | 38 |
| 6(b) | 10 | 995 | 175 | 44 |
| 6(b) | 10 | 996 | 185 | 54 |
| 6(b) | 10 | 997 | 180 | 46 |
| 6(b) | 10 | 998 | 170 | 36 |
| 6(b) | 10 | 999 | 152 | 32 |
| 6(b) | 10 | 1000 | 141 | 26 |
| 6(b) | 10 | 1001 | 142 | 24 |
| 6(b) | 10 | 1002 | 140 | 22 |
| 6(b) | 10 | 1003 | 145 | 22 |
| 6(b) | 10 | 1004 | 135 | 22 |
| 6(b) | 10 | 1005 | 135 | 18 |
| 6(b) | 10 | 1006 | 100 | 10 |
| 1(b) | 10 | 1007 | 97 | 6 |
| 1(b) | 10 | 1008 | 94 | 6 |
| 1(b) | 10 | 1009 | 350 | 320 |
| 1(b) | 10 | 1010 | 340 | 300 |
| 1(b) | 10 | 1011 | 273 | 144 |
| 1(b) | 10 | 1012 | 275 | 148 |
| 1(b) | 10 | 1013 | 245 | 98 |
| 1(b) | 10 | 1014 | 225 | 82 |
| 1(b) | 10 | 1015 | 229 | 90 |
| 1(b) | 10 | 1016 | 210 | 82 |
| 1(b) | 10 | 1017 | 210 | 78 |
| 1(b) | 15 | 1018 | 210 | 74 |
| 1(b) | 15 | 1019 | 177 | 40 |
| 1(b) | 15 | 1020 | 164 | 34 |
| 1(b) | 15 | 1021 | 164 | 34 |
| 1(b) | 15 | 1022 | 169 | 34 |

| | | | | |
|---|---|---|---|---|
| 1(b) | 15 | 1023 | 165 | 34 |
| 1(b) | 15 | 1024 | 164 | 32 |
| 1(b) | 15 | 1025 | 153 | 25 |
| 1(b) | 15 | 1026 | 155 | 32 |
| 1(b) | 15 | 1027 | 155 | 32 |
| 1(b) | 15 | 1028 | 161 | 36 |
| 1(b) | 15 | 1029 | 149 | 28 |
| 1(b) | 15 | 1030 | 145 | 24 |
| 1(b) | 15 | 1031 | 103 | 8 |
| 1(b) | 15 | 1032 | 103 | 8 |
| 1(b) | 20 | 1033 | 277 | 146 |
| 1(b) | 20 | 1034 | 188 | 54 |
| 1(b) | 20 | 1035 | 147 | 24 |
| 1(b) | 20 | 1036 | 144 | 22 |
| 1(b) | 25 | 1037 | 405 | 526 |
| 1(b) | 25 | 1038 | 235 | 104 |
| 1(b) | 25 | 1039 | 214 | 70 |
| 1(b) | 30 | 1040 | 266 | 136 |
| 4 | 40 | 1041 | 272 | 126 |

Summer 2000 Bear Lake Whitefish Collection Data.

| Net Site | Depth | Fish # | Length | Weight |
|---|---|---|---|---|
| 3 | 35 | 1 | 211 | 65 |
| 3 | 35 | 2 | 174 | 35 |
| 3 | 35 | 3 | 174 | 33 |
| 3 | 35 | 4 | 189 | 49 |
| 3 | 35 | 5 | 202 | 53 |
| 3 | 35 | 6 | 186 | 49 |
| 3 | 35 | 7 | 187 | 44 |
| 3 | 25 | 8 | 237 | 76 |
| 3 | 25 | 9 | 125 | 12 |
| 3 | 20 | 10 | 141 | 16 |
| 3 | 15 | 11 | 160 | 26 |
| 3 | 15 | 12 | 105 | 7 |
| 3 | 15 | 13 | 100 | 6 |
| 4 | 30 | 14 | 212 | 55 |
| 4 | 30 | 15 | 136 | 17 |
| 4 | 20 | 16 | 143 | 17 |
| 4 | 15 | 17 | 105 | 8 |
| 2 | 15 | 18 | 169 | 35 |
| 2 | 20 | 19 | 130 | no weight |
| 2 | 20 | 20 | 128 | 16 |
| 2 | 25 | 21 | 239 | 88 |
| 2 | 25 | 22 | 170 | 36 |
| 2 | 30 | 23 | 215 | 64 |

| | | | | |
|---|---|---|---|---|
| 2 | 30 | 24 | 137 | 17 |
| 5 | 10 | 25 | 105 | 6 |
| 5 | 10 | 26 | 137 | 13 |
| 5 | 10 | 27 | 117 | 7 |
| 5 | 20 | 28 | 109 | 7 |
| 5 | 30 | 29 | 190 | 46 |
| 5 | 30 | 30 | 123 | 12 |
| 5 | 35 | 31 | 156 | 27 |
| 1 | 10 | 32 | 134 | 16 |
| 1 | 15 | 33 | 160 | 29 |
| 1 | 15 | 34 | 127 | 13 |
| 1 | 20 | 35 | 195 | 53 |
| 1 | 20 | 36 | 138 | 18 |
| 1 | 25 | 37 | 106 | 6 |
| 1 | 30 | 38 | 185 | 45 |
| 6 | 15 | 39 | 140 | 19 |
| 6 | 15 | 40 | 130 | 15 |
| 6 | 20 | 41 | 136 | 17 |
| 6 | 25 | 42 | 141 | 18 |
| 6 | 30 | 43 | 196 | 41 |
| 5 | 50 | 44 | 233 | 73 |
| 5 | 50 | 45 | 215 | 57 |
| 5 | 50 | 46 | 227 | 66 |
| 5 | 50 | 47 | 246 | 92 |
| 5 | 50 | 48 | 254 | 105 |
| 5 | 50 | 49 | 228 | 77 |
| 5 | 50 | 50 | 226 | 76 |
| 5 | 50 | 51 | 229 | 84 |
| 5 | 50 | 52 | 197 | 55 |
| 5 | 60 | 53 | 240 | 90 |
| 5 | 60 | 54 | 240 | 84 |
| 5 | 60 | 55 | 244 | 86 |
| 5 | 60 | 56 | 257 | 106 |
| 5 | 60 | 57 | 279 | 134 |
| 5 | 60 | 59 | 240 | 93 |
| 5 | 60 | 60 | 238 | 83 |
| 5 | 60 | 61 | 247 | 95 |
| 5 | 60 | 62 | 250 | 99 |
| 5 | 60 | 63 | 269 | 139 |
| 5 | 60 | 64 | 246 | 95 |
| 5 | 60 | 65 | 257 | 106 |
| 5 | 60 | 66 | 178 | 35 |
| 5 | 60 | 67 | 250 | 95 |
| 5 | 60 | 68 | 201 | 44 |
| 5 | 60 | 69 | 260 | 111 |
| 5 | 60 | 70 | 229 | 66 |
| 5 | 60 | 71 | 235 | 93 |
| 5 | 60 | 72 | 258 | 110 |
| 5 | 60 | 73 | 233 | 91 |

| | | | | |
|---|---|---|---|---|
| 5 | 60 | 74 | 235 | 89 |
| 5 | 60 | 75 | 250 | 99 |
| 5 | 60 | 76 | 228 | 69 |
| 5 | 60 | 77 | 230 | 76 |
| 5 | 60 | 78 | 247 | 107 |
| 5 | 60 | 79 | 191 | 43 |
| 5 | 60 | 80 | 229 | 71 |
| 5 | 60 | 81 | 209 | 58 |
| 5 | 60 | 82 | 190 | 42 |
| 5 | 60 | 83 | 190 | 41 |
| 5 | 60 | 84 | 235 | 76 |
| 5 | 60 | 85 | 234 | 83 |
| 5 | 60 | 86 | 236 | 88 |
| 5 | 60 | 87 | 210 | 71 |
| 5 | 60 | 88 | 184 | 42 |
| 5 | 55 | 89 | 210 | 55 |
| 5 | 55 | 90 | 235 | 68 |
| 5 | 55 | 91 | 208 | 63 |
| 5 | 55 | 92 | 259 | 103 |
| 5 | 55 | 93 | 241 | 89 |
| 5 | 55 | 94 | 238 | 89 |
| 5 | 55 | 95 | 224 | 71 |
| 5 | 55 | 96 | 238 | 79 |
| 5 | 55 | 97 | 202 | 57 |
| 5 | 55 | 98 | 224 | 80 |
| 5 | 50 | 99 | 216 | 64 |
| 5 | 50 | 100 | 184 | 47 |
| 5 | 50 | 101 | 248 | 13 |
| 5 | 45 | 102 | 249 | 103 |
| 5 | 45 | 103 | 268 | 136 |
| 5 | 45 | 104 | 220 | 84 |
| 5 | 45 | 105 | 194 | 47 |
| 5 | 45 | 106 | 204 | 56 |
| 5 | 45 | 107 | 240 | 85 |
| 5(b) | 60 | 108 | 248 | 87 |
| 5(b) | 60 | 109 | 233 | 80 |
| 5(b) | 60 | 110 | 239 | 84 |
| 5(b) | 60 | 111 | 240 | 75 |
| 5(b) | 60 | 112 | 210 | 52 |
| 5(b) | 60 | 113 | 229 | 75 |
| 5(b) | 60 | 114 | 230 | 79 |
| 5(b) | 60 | 115 | 242 | 87 |
| 5(b) | 60 | 116 | 213 | 71 |
| 5(b) | 60 | 117 | 227 | 80 |
| 5(b) | 60 | 118 | 237 | 96 |
| 5(b) | 60 | 119 | 258 | 118 |
| 5(b) | 60 | 120 | 232 | 77 |
| 5(b) | 60 | 121 | 206 | 59 |
| 5(b) | 60 | 122 | 236 | 82 |

| | | | | |
|---|---|---|---|---|
| 5(b) | 60 | 123 | 225 | 77 |
| 5(b) | 60 | 124 | 238 | 87 |
| 5(b) | 60 | 125 | 198 | 49 |
| 5(b) | 55 | 126 | 241 | 93 |
| 5(b) | 55 | 127 | 245 | 96 |
| 5(b) | 55 | 128 | 250 | 94 |
| 5(b) | 55 | 129 | 222 | 72 |
| 5(b) | 55 | 130 | 232 | 81 |
| 5(b) | 55 | 131 | 262 | 106 |
| 5(b) | 55 | 132 | 239 | 92 |
| 5(b) | 55 | 133 | 254 | 108 |
| 5(b) | 55 | 134 | 232 | 69 |
| 5(b) | 55 | 135 | 259 | 105 |
| 5(b) | 55 | 136 | 260 | 113 |
| 5(b) | 55 | 137 | 220 | 70 |
| 5(b) | 55 | 138 | 216 | 72 |
| 5(b) | 55 | 139 | 217 | 63 |
| 5(b) | 55 | 140 | 227 | 74 |
| 5(b) | 55 | 141 | 217 | 64 |
| 5(b) | 55 | 142 | 232 | 81 |
| 5(b) | 55 | 143 | 245 | 108 |
| 5(b) | 55 | 144 | 234 | 81 |
| 5(b) | 50 | 145 | 243 | 87 |
| 5(b) | 50 | 146 | 220 | 73 |
| 5(b) | 50 | 147 | 247 | 107 |
| 5(b) | 50 | 148 | 183 | 40 |
| 5(b) | 50 | 149 | 208 | 70 |
| 5(b) | 50 | 150 | 256 | 112 |
| 5(b) | 50 | 151 | 219 | 72 |
| 5(b) | 50 | 152 | 197 | 52 |
| 5(b) | 45 | 153 | 211 | 71 |
| 5(b) | 45 | 154 | 232 | 85 |
| 5(b) | 45 | 155 | 212 | 55 |
| 5(b) | 45 | 156 | 239 | 92 |
| 5 | 60 | 157 | 212 | 57 |
| 5 | 60 | 158 | 230 | 78 |
| 5 | 60 | 159 | 207 | 64 |
| 5 | 60 | 160 | 239 | 98 |
| 5 | 60 | 161 | 250 | 111 |
| 5 | 60 | 162 | 218 | 71 |
| 5 | 60 | 163 | 240 | 86 |
| 5 | 60 | 164 | 256 | 120 |
| 5 | 60 | 165 | 235 | 91 |
| 5 | 60 | 166 | 232 | 92 |
| 5 | 60 | 167 | 234 | 109 |
| 5 | 60 | 168 | 240 | 85 |
| 5 | 60 | 169 | 250 | 102 |
| 5 | 60 | 170 | 226 | 83 |
| 5 | 60 | 171 | 217 | 63 |

| | | | | |
|---|---|---|---|---|
| 5 | 60 | 172 | 225 | 77 |
| 5 | 60 | 173 | 252 | 108 |
| 5 | 60 | 174 | 234 | 80 |
| 5 | 60 | 175 | 249 | 104 |
| 5 | 60 | 176 | 251 | 120 |
| 5 | 60 | 177 | 239 | 98 |
| 5 | 60 | 178 | 249 | 89 |
| 5 | 60 | 179 | 241 | 92 |
| 5 | 60 | 180 | 265 | 143 |
| 5 | 60 | 181 | 211 | 70 |
| 5 | 60 | 182 | 225 | 78 |
| 5 | 60 | 183 | 232 | 87 |
| 5 | 60 | 184 | 240 | 88 |
| 5 | 60 | 185 | 253 | 118 |
| 5 | 60 | 186 | 257 | 111 |
| 5 | 60 | 187 | 242 | 103 |
| 5 | 60 | 188 | 227 | 81 |
| 5 | 55 | 189 | 238 | 95 |
| 5 | 55 | 190 | 238 | 86 |
| 5 | 55 | 191 | 249 | 111 |
| 5 | 55 | 192 | 264 | 128 |
| 5 | 55 | 193 | 289 | 178 |
| 5 | 55 | 194 | 249 | 100 |
| 5 | 55 | 195 | 228 | 80 |
| 5 | 55 | 196 | 202 | 65 |
| 5 | 55 | 197 | 240 | 88 |
| 5 | 55 | 198 | 245 | 103 |
| 5 | 55 | 199 | 223 | 72 |
| 5 | 55 | 200 | 240 | 99 |
| 5 | 55 | 201 | 256 | 112 |
| 5 | 55 | 202 | 240 | 97 |
| 5 | 55 | 203 | 211 | 67 |
| 5 | 55 | 204 | 242 | 104 |
| 5 | 55 | 205 | 269 | 123 |
| 5 | 45 | 206 | 240 | 97 |
| 5 | 45 | 207 | 198 | 53 |
| 5 | 45 | 208 | 193 | 55 |
| 5 | 45 | 209 | 200 | 60 |
| 5 | 45 | 210 | 222 | 78 |
| 5 | 45 | 211 | 205 | 63 |
| 5 | 45 | 212 | 203 | 62 |
| 5 | 45 | 213 | 189 | 49 |
| 5 | 45 | 214 | 244 | 103 |
| 5 | 45 | 215 | 226 | 85 |
| 5 | 45 | 216 | 222 | 81 |
| 5 | 45 | 217 | 178 | 42 |
| 5 | 50 | 218 | 241 | 104 |
| 5 | 50 | 219 | 245 | 96 |
| 5 | 50 | 220 | 238 | 102 |

| | | | | |
|---|---|---|---|---|
| 5 | 50 | 221 | 232 | 86 |
| 5 | 50 | 222 | 239 | 100 |
| 5 | 50 | 223 | 238 | 105 |
| 5 | 50 | 224 | 247 | 102 |
| 5 | 50 | 225 | 218 | 70 |
| 5 | 50 | 226 | 200 | 59 |
| 5 | 50 | 227 | 230 | 89 |
| 5 | 50 | 228 | 227 | 91 |
| 5 | 50 | 229 | 205 | 61 |
| 5 | 50 | 230 | 181 | 43 |
| 5 | 50 | 231 | 194 | 52 |
| 3(b) | 15 | 232 | 145 | 18 |
| 3(b) | 20 | 233 | 140 | 18 |
| 3(b) | 25 | 234 | 138 | 14 |
| 3(b) | 30 | 235 | 160 | 29 |
| 3(b) | 30 | 236 | 151 | 28 |
| 3(b) | 30 | 237 | 134 | 16 |
| 4(b) | 10 | 238 | 181 | 38 |
| 4(b) | 15 | 239 | 145 | 20 |
| 4(b) | 15 | 240 | 150 | 26 |
| 4(b) | 20 | 241 | 180 | 46 |
| 4(b) | 20 | 242 | 142 | 22 |
| 4(b) | 25 | 243 | 153 | 28 |
| 4(b) | 25 | 244 | 139 | 22 |
| 4(b) | 35 | 245 | 145 | 22 |
| 4(b) | 35 | 246 | 139 | 18 |
| 4(b) | 35 | 247 | 229 | 84 |
| 3 | 10 | 248 | 140 | 16 |
| 4 | 35 | 249 | 162 | 30 |
| 4 | 35 | 250 | 192 | 54 |
| 5(b) | 40 | 251 | 184 | 48 |
| 5(b) | 40 | 252 | 193 | 50 |
| 5(b) | 40 | 253 | 212 | 64 |
| 5(b) | 40 | 254 | 175 | 34 |
| 3 | 40 | 255 | 219 | 74 |
| 3 | 40 | 256 | 222 | 70 |
| 3 | 40 | 257 | 186 | 46 |
| 3 | 40 | 258 | 194 | 46 |
| 3 | 40 | 259 | 201 | 52 |
| 3 | 35 | 260 | 190 | 52 |
| 3 | 35 | 261 | 153 | 28 |
| 3 | 30 | 262 | 215 | 76 |
| 3 | 30 | 263 | 139 | 16 |
| 3 | 25 | 264 | 124 | 14 |
| 6(b) | 10 | 265 | 140 | 18 |
| 6(b) | 15 | 266 | 110 | 10 |
| 6(b) | 15 | 267 | 115 | 10 |
| 6(b) | 20 | 268 | 179 | 42 |
| 6(b) | 30 | 269 | 170 | 32 |

| | | | | |
|---|---|---|---|---|
| 6(b) | 30 | 270 | 143 | 18 |
| 6(b) | 30 | 271 | 126 | 14 |
| 1(b) | 10 | 272 | 130 | 16 |
| 1(b) | 15 | 273 | 154 | 20 |
| 1(b) | 15 | 274 | 133 | 14 |
| 1(b) | 25 | 275 | 215 | 72 |
| 1(b) | 35 | 276 | 237 | 88 |
| 1(b) | 35 | 277 | 188 | 46 |
| 1(b) | 35 | 278 | 176 | 34 |
| 4 | 40 | 279 | 219 | 70 |
| 4 | 40 | 280 | 215 | 66 |
| 4 | 40 | 281 | 240 | 94 |
| 4 | 40 | 282 | 220 | 68 |
| 4 | 40 | 283 | 201 | 52 |
| 4 | 40 | 284 | 116 | 60 |
| 4 | 40 | 285 | 188 | 50 |
| 4 | 40 | 286 | 194 | 48 |
| 4 | 40 | 287 | 208 | 60 |
| 4 | 40 | 288 | 196 | 52 |
| 4 | 40 | 289 | 205 | 52 |
| 4 | 40 | 290 | 190 | 54 |

Summer 2001 Bonneville Whitefish Collection Data.

| Site | Depth | Fish # | Length | Weight |
|---|---|---|---|---|
| 5 | 55 | 1 | 280 | 158 |
| 5 | 40 | 2 | 406 | 611 |
| 5 | 40 | 3 | 247 | 104 |
| 5 | 40 | 4 | 171 | 37 |
| 5 | 45 | 5 | 285 | 160 |
| 5 | 45 | 6 | 299 | 172 |
| 6 | 5 | 7 | 219 | 82 |
| 6 | 10 | 8 | 182 | 50 |
| 6 | 10 | 9 | 185 | 50 |
| 6 | 10 | 10 | 182 | 46 |
| 6 | 10 | 11 | 164 | 32 |
| 6 | 10 | 12 | 125 | 16 |
| 6 | 15 | 14 | 240 | 98 |
| 6 | 15 | 15 | 224 | 82 |
| 6 | 15 | 16 | 215 | 64 |
| 6 | 15 | 17 | 185 | 46 |
| 6 | 15 | 18 | 162 | 32 |
| 6 | 15 | 19 | 124 | 14 |
| 6 | 15 | 20 | 120 | 14 |
| 6 | 15 | 21 | 130 | 16 |
| 6 | 15 | 22 | 125 | 16 |

| | | | | |
|---|---|---|---|---|
| 6 | 20 | 23 | 244 | 112 |
| 6 | 20 | 24 | 185 | 52 |
| 6 | 25 | 25 | 152 | 28 |
| 6 | 30 | 26 | 189 | 56 |
| 6 | 35 | 27 | 197 | 54 |
| 4 | 10 | 28 | 302 | 182 |
| 4 | 10 | 29 | 292 | 160 |
| 4 | 10 | 30 | 269 | 146 |
| 4 | 10 | 31 | 275 | 142 |
| 4 | 10 | 32 | 270 | 130 |
| 4 | 10 | 33 | 275 | 140 |
| 4 | 10 | 34 | 271 | 134 |
| 4 | 10 | 35 | 241 | 112 |
| 4 | 10 | 36 | 238 | 84 |
| 4 | 10 | 37 | 209 | 70 |
| 4 | 10 | 38 | 195 | 58 |
| 4 | 10 | 39 | 165 | 36 |
| 4 | 10 | 40 | 158 | 32 |
| 4 | 10 | 41 | 135 | 18 |
| 4 | 10 | 42 | 136 | 20 |
| 4 | 10 | 43 | 133 | 18 |
| 4 | 15 | 44 | 289 | 180 |
| 4 | 15 | 45 | 279 | 132 |
| 4 | 15 | 46 | 265 | 142 |
| 4 | 15 | 47 | 268 | 130 |
| 3 | 10 | 94 | 167 | 38 |
| 3 | 10 | 95 | 160 | 32 |
| 3 | 10 | 96 | 158 | 32 |
| 3 | 10 | 97 | 149 | 26 |
| 3 | 10 | 98 | 130 | 16 |
| 3 | 10 | 99 | 118 | 12 |
| 3 | 10 | 100 | 117 | 12 |
| 3 | 10 | 101 | 125 | 14 |
| 3 | 10 | 102 | 114 | 12 |
| 3 | 10 | 103 | 128 | 16 |
| 3 | 10 | 104 | 129 | 16 |
| 3 | 10 | 105 | 120 | 12 |
| 3 | 10 | 106 | 125 | 14 |
| 3 | 10 | 107 | 115 | 11 |
| 3 | 15 | 108 | 418 | 596 |
| 3 | 15 | 109 | 269 | 120 |
| 3 | 15 | 110 | 245 | 112 |
| 3 | 15 | 111 | 210 | 74 |
| 3 | 15 | 112 | 200 | 66 |
| 3 | 15 | 113 | 195 | 60 |
| 3 | 15 | 114 | 178 | 48 |
| 3 | 15 | 115 | 185 | 48 |
| 3 | 15 | 116 | 173 | 38 |
| 3 | 15 | 117 | 180 | 42 |

| | | | | |
|---|---|---|---|---|
| 3 | 15 | 118 | 169 | 36 |
| 3 | 15 | 119 | 170 | 38 |
| 3 | 15 | 120 | 157 | 32 |
| 3 | 15 | 121 | 160 | 32 |
| 3 | 15 | 122 | 133 | 16 |
| 3 | 15 | 123 | 110 | 10 |
| 3 | 15 | 124 | 110 | 10 |
| 3 | 15 | 125 | 123 | 14 |
| 3 | 20 | 126 | 291 | 158 |
| 3 | 20 | 127 | 271 | 130 |
| 3 | 20 | 128 | 245 | 100 |
| 3 | 20 | 129 | 252 | 118 |
| 3 | 20 | 130 | 224 | 84 |
| 3 | 20 | 131 | 218 | 70 |
| 3 | 20 | 132 | 191 | 54 |
| 3 | 20 | 133 | 164 | 32 |
| 3 | 25 | 134 | 286 | 156 |
| 3 | 25 | 135 | 257 | 142 |
| 3 | 25 | 136 | 270 | 156 |
| 3 | 25 | 137 | 197 | 58 |
| 3 | 25 | 138 | 170 | 36 |
| 3 | 30 | 139 | 260 | 136 |
| 3 | 30 | 140 | 260 | 132 |
| 3 | 30 | 141 | 241 | 112 |
| 3 | 30 | 142 | 194 | 50 |
| 5 | 15 | 193 | 203 | 66 |
| 5 | 15 | 194 | 185 | 48 |
| 5 | 15 | 195 | 160 | 32 |
| 5 | 15 | 196 | 155 | 28 |
| 5 | 15 | 197 | 160 | 30 |
| 5 | 15 | 198 | 130 | 16 |
| 5 | 15 | 199 | 131 | 16 |
| 5 | 20 | 200 | 366 | 422 |
| 5 | 20 | 201 | 270 | 142 |
| 5 | 20 | 202 | 284 | 152 |
| 5 | 20 | 203 | 265 | 138 |
| 5 | 20 | 204 | 249 | 108 |
| 5 | 20 | 205 | 223 | 84 |
| 5 | 20 | 206 | 212 | 70 |
| 5 | 20 | 207 | 196 | 56 |
| 5 | 20 | 208 | 184 | 46 |
| 5 | 20 | 209 | 186 | 46 |
| 5 | 20 | 210 | 174 | 40 |
| 5 | 20 | 211 | 165 | 32 |
| 5 | 20 | 212 | 166 | 36 |
| 5 | 20 | 213 | 171 | 36 |
| 5 | 20 | 214 | 160 | 30 |
| 5 | 20 | 215 | 170 | 38 |
| 5 | 20 | 216 | 174 | 38 |

| | | | | |
|---|---|---|---|---|
| 5 | 20 | 217 | 181 | 44 |
| 5 | 20 | 218 | 166 | 36 |
| 5 | 20 | 219 | 134 | 18 |
| 5 | 20 | 220 | 144 | 22 |
| 5 | 20 | 221 | 129 | 16 |
| 5 | 20 | 222 | 115 | 12 |
| 5 | 25 | 223 | 375 | 448 |
| 5 | 25 | 224 | 336 | 304 |
| 5 | 25 | 225 | 260 | 118 |
| 5 | 25 | 226 | 249 | 118 |
| 5 | 25 | 227 | 272 | 146 |
| 5 | 25 | 228 | 247 | 112 |
| 5 | 25 | 229 | 187 | 56 |
| 5 | 25 | 230 | 196 | 64 |
| 5 | 25 | 231 | 214 | 76 |
| 5 | 25 | 232 | 181 | 50 |
| 5 | 25 | 233 | 154 | 26 |
| 5 | 25 | 234 | 184 | 44 |
| 5 | 25 | 235 | 176 | 42 |
| 5 | 25 | 236 | 169 | 36 |
| 5 | 25 | 237 | 175 | 40 |
| 5 | 25 | 238 | 184 | 48 |
| 5 | 25 | 239 | 186 | 52 |
| 5 | 25 | 240 | 163 | 30 |
| 5 | 25 | 241 | 180 | 36 |
| 2 | 20 | 291 | 197 | 54 |
| 2 | 20 | 292 | 183 | 42 |
| 2 | 20 | 293 | 171 | 32 |
| 2 | 20 | 294 | 180 | 36 |
| 2 | 20 | 295 | 167 | 32 |
| 2 | 20 | 296 | 157 | 26 |
| 2 | 20 | 297 | 125 | 16 |
| 2 | 25 | 298 | 267 | 122 |
| 2 | 25 | 299 | 268 | 130 |
| 2 | 25 | 300 | 244 | 102 |
| 2 | 25 | 301 | 239 | 86 |
| 2 | 25 | 302 | 213 | 70 |
| 2 | 25 | 303 | 165 | 28 |
| 2 | 30 | 304 | 215 | 66 |
| 2 | 30 | 305 | 193 | 50 |
| 2 | 30 | 306 | 159 | 34 |
| 4 | 15 | 48 | 275 | 136 |
| 4 | 15 | 49 | 225 | 90 |
| 4 | 15 | 50 | 230 | 94 |
| 4 | 15 | 51 | 179 | 40 |
| 4 | 15 | 52 | 135 | 18 |
| 4 | 15 | 53 | 130 | 16 |
| 4 | 15 | 54 | 135 | 20 |
| 4 | 15 | 55 | 125 | 14 |

| | | | | |
|---|---|---|---|---|
| 4 | 15 | 56 | 110 | 10 |
| 4 | 20 | 57 | 325 | 246 |
| 4 | 20 | 58 | 269 | 128 |
| 4 | 20 | 59 | 293 | 166 |
| 4 | 20 | 60 | 267 | 126 |
| 4 | 20 | 61 | 263 | 124 |
| 4 | 20 | 62 | 262 | 132 |
| 4 | 20 | 63 | 263 | 124 |
| 4 | 20 | 64 | 249 | 112 |
| 4 | 20 | 65 | 199 | 62 |
| 4 | 20 | 66 | 190 | 52 |
| 4 | 20 | 67 | 165 | 36 |
| 4 | 20 | 68 | 162 | 36 |
| 4 | 20 | 69 | 149 | 24 |
| 4 | 20 | 70 | 107 | 8 |
| 4 | 25 | 71 | 337 | 324 |
| 4 | 25 | 72 | 325 | 272 |
| 4 | 25 | 73 | 329 | 276 |
| 4 | 25 | 74 | 280 | 172 |
| 4 | 25 | 75 | 284 | 160 |
| 4 | 25 | 76 | 267 | 128 |
| 4 | 25 | 77 | 259 | 110 |
| 4 | 25 | 78 | 260 | 118 |
| 4 | 25 | 79 | 274 | 146 |
| 4 | 25 | 80 | 254 | 108 |
| 4 | 25 | 81 | 227 | 84 |
| 4 | 30 | 82 | 270 | 136 |
| 4 | 30 | 83 | 161 | 32 |
| 4 | 30 | 84 | 139 | 22 |
| 4 | 40 | 85 | 291 | 168 |
| 3 | 10 | 86 | 247 | 116 |
| 3 | 10 | 87 | 218 | 82 |
| 3 | 10 | 88 | 219 | 82 |
| 3 | 10 | 89 | 200 | 56 |
| 3 | 10 | 90 | 193 | 60 |
| 3 | 10 | 91 | 165 | 36 |
| 3 | 10 | 92 | 156 | 32 |
| 3 | 10 | 93 | 183 | 48 |
| 3 | 35 | 143 | 203 | 58 |
| 3 | 35 | 144 | 191 | 46 |
| 3 | 35 | 145 | 183 | 44 |
| 3 | 35 | 146 | 151 | 24 |
| 3 | 40 | 147 | 211 | 60 |
| 3 | 40 | 148 | 205 | 56 |
| 1 | 10 | 150 | 213 | 70 |
| 1 | 10 | 151 | 198 | 60 |
| 1 | 10 | 152 | 186 | 54 |
| 1 | 10 | 153 | 153 | 28 |
| 1 | 10 | 154 | 127 | 18 |

| | | | | |
|---|---|---|---|---|
| 1 | 15 | 155 | 197 | 62 |
| 1 | 15 | 156 | 187 | 56 |
| 1 | 15 | 157 | 130 | 16 |
| 1 | 20 | 158 | 260 | 132 |
| 1 | 20 | 159 | 244 | 106 |
| 1 | 20 | 160 | 235 | 112 |
| 1 | 20 | 161 | 195 | 58 |
| 1 | 20 | 162 | 160 | 36 |
| 1 | 20 | 163 | 159 | 32 |
| 1 | 25 | 164 | 285 | 170 |
| 1 | 25 | 165 | 263 | 130 |
| 1 | 25 | 166 | 194 | 58 |
| 1 | 25 | 167 | 169 | 40 |
| 1 | 30 | 168 | 281 | 142 |
| 1 | 30 | 169 | 275 | 136 |
| 1 | 30 | 170 | 242 | 108 |
| 1 | 30 | 171 | 230 | 90 |
| 1 | 30 | 172 | 195 | 58 |
| 5 | 10 | 173 | 405 | 524 |
| 5 | 10 | 174 | 261 | 134 |
| 5 | 10 | 175 | 211 | 74 |
| 5 | 10 | 176 | 194 | 58 |
| 5 | 10 | 177 | 197 | 70 |
| 5 | 10 | 178 | 200 | 60 |
| 5 | 10 | 179 | 210 | 66 |
| 5 | 10 | 180 | 187 | 46 |
| 5 | 10 | 181 | 155 | 30 |
| 5 | 10 | 182 | 160 | 30 |
| 5 | 10 | 183 | 126 | 14 |
| 5 | 10 | 184 | 125 | 16 |
| 5 | 10 | 185 | 129 | 16 |
| 5 | 15 | 186 | 245 | 112 |
| 5 | 15 | 187 | 250 | 104 |
| 5 | 15 | 188 | 227 | 88 |
| 5 | 15 | 189 | 206 | 66 |
| 5 | 15 | 190 | 200 | 56 |
| 5 | 15 | 191 | 194 | 60 |
| 5 | 15 | 192 | 185 | 46 |
| 5 | 25 | 242 | 153 | 18 |
| 5 | 30 | 243 | 264 | 132 |
| 5 | 30 | 244 | 262 | 118 |
| 5 | 30 | 245 | 269 | 108 |
| 5 | 30 | 246 | 252 | 104 |
| 5 | 30 | 247 | 275 | 146 |
| 5 | 30 | 248 | 260 | 132 |
| 5 | 30 | 249 | 195 | 58 |
| 5 | 30 | 250 | 180 | 38 |
| 5 | 30 | 251 | 202 | 56 |
| 5 | 30 | 252 | 197 | 52 |

| | | | | |
|---|---|---|---|---|
| 5 | 30 | 253 | 181 | 44 |
| 5 | 30 | 254 | 197 | 60 |
| 5 | 30 | 255 | 203 | 60 |
| 5 | 30 | 256 | 170 | 38 |
| 5 | 30 | 257 | 190 | 54 |
| 5 | 30 | 258 | 166 | 36 |
| 5 | 30 | 259 | 175 | 36 |
| 5 | 30 | 260 | 128 | 16 |
| 5 | 35 | 261 | 388 | 462 |
| 5 | 35 | 262 | 282 | 168 |
| 5 | 35 | 263 | 265 | 128 |
| 5 | 35 | 264 | 268 | 148 |
| 5 | 35 | 265 | 270 | 128 |
| 5 | 35 | 266 | 251 | 120 |
| 5 | 35 | 267 | 194 | 48 |
| 5 | 40 | 268 | 284 | 160 |
| 2 | 10 | 269 | 190 | 60 |
| 2 | 10 | 270 | 171 | 36 |
| 2 | 10 | 271 | 182 | 48 |
| 2 | 10 | 272 | 168 | 36 |
| 2 | 10 | 273 | 164 | 36 |
| 2 | 10 | 274 | 120 | 16 |
| 2 | 15 | 275 | 249 | 126 |
| 2 | 15 | 276 | 190 | 62 |
| 2 | 15 | 277 | 185 | 52 |
| 2 | 15 | 278 | 175 | 48 |
| 2 | 15 | 279 | 189 | 50 |
| 2 | 15 | 280 | 180 | 48 |
| 2 | 15 | 281 | 162 | 40 |
| 2 | 15 | 282 | 182 | 50 |
| 2 | 15 | 283 | 128 | 20 |
| 2 | 15 | 284 | 135 | 24 |
| 2 | 15 | 285 | 116 | 12 |
| 2 | 15 | 286 | 126 | 16 |
| 2 | 15 | 287 | 109 | 4 |
| 2 | 20 | 288 | 262 | 130 |
| 2 | 20 | 289 | 215 | 76 |
| 2 | 20 | 290 | 218 | 76 |

Summer 2001 Bear Lake Whitefish Collection Data.

| Site | Depth | Fish # | Length | Weight |
|---|---|---|---|---|
| 1 | 15 | 1 | 109 | 10 |
| 2 | 15 | 2 | 109 | 9 |
| 1 | 25 | 3 | 125 | 14 |
| 2 | 15 | 4 | 125 | 14 |
| 3 | 20 | 5 | 126 | 13 |
| 1 | 30 | 6 | 134 | 16 |
| 6 | 30 | 7 | 136 | 20 |

| | | | | |
|---|---|---|---|---|
| 1 | 25 | 8 | 137 | 18 |
| 2 | 25 | 9 | 137 | 18 |
| 1 | 15 | 10 | 140 | 20 |
| 1 | 25 | 11 | 140 | 18 |
| 1 | 30 | 12 | 141 | 21 |
| 6 | 35 | 13 | 143 | 22 |
| 1 | 20 | 14 | 144 | 22 |
| 1 | 20 | 15 | 149 | 24 |
| 1 | 20 | 16 | 150 | 24 |
| 1 | 30 | 17 | 151 | 28 |
| 2 | 25 | 18 | 154 | 26 |
| 2 | 20 | 19 | 158 | 28 |
| 1 | 35 | 20 | 160 | 28 |
| 5 | 45 | 21 | 171 | 36 |
| 4 | 40 | 22 | 172 | 36 |
| 4 | 40 | 23 | 174 | 38 |
| 3 | 40 | 24 | 175 | 36 |
| 2 | 35 | 25 | 175 | 38 |
| 3 | 40 | 26 | 185 | 42 |
| 1 | 30 | 27 | 186 | 40 |
| 5 | 45 | 28 | 186 | 46 |
| 5 | 50 | 29 | 187 | 40 |
| 3 | 35 | 30 | 190 | 46 |
| 2 | 30 | 31 | 191 | 48 |
| 3 | 40 | 32 | 192 | 56 |
| 5 | 45 | 33 | 194 | 53 |
| 3 | 40 | 34 | 194 | 42 |
| 3 | 30 | 35 | 196 | 50 |
| 5 | 55 | 36 | 197 | 50 |
| 5 | 50 | 37 | 200 | 50 |
| 5 | 50 | 38 | 200 | 56 |
| 5 | 55 | 39 | 200 | 50 |
| 2 | 35 | 40 | 201 | 54 |
| 3 | 30 | 41 | 204 | 52 |
| 5 | 40 | 42 | 205 | 56 |
| 5 | 55 | 43 | 205 | 57 |
| 5 | 45 | 44 | 210 | 60 |
| 3 | 40 | 45 | 210 | 62 |
| 5 | 40 | 46 | 211 | 61 |
| 5 | 60 | 93 | 254 | 111 |
| 2 | 20 | 94 | 255 | 26 |
| 5 | 60 | 95 | 271 | 144 |
| 5 | 45 | 47 | 211 | 64 |
| 5 | 40 | 48 | 214 | 74 |
| 5 | 60 | 49 | 214 | 66 |
| 5 | 55 | 50 | 215 | 60 |
| 5 | 45 | 51 | 219 | 76 |
| 5 | 50 | 52 | 223 | 84 |
| 5 | 60 | 53 | 223 | 82 |

| | | | | |
|---|---|---|---|---|
| 5 | 60 | 54 | 224 | 91 |
| 5 | 55 | 55 | 224 | 70 |
| 5 | 55 | 56 | 225 | 82 |
| 5 | 45 | 57 | 229 | 86 |
| 3 | 30 | 58 | 229 | 82 |
| 1 | 30 | 59 | 229 | 74 |
| 5 | 50 | 60 | 229 | 78 |
| 5 | 45 | 61 | 230 | 83 |
| 5 | 50 | 62 | 230 | 86 |
| 5 | 55 | 63 | 230 | 76 |
| 5 | 55 | 64 | 231 | 83 |
| 5 | 60 | 65 | 231 | 91 |
| 5 | 45 | 66 | 234 | 80 |
| 5 | 50 | 67 | 234 | 88 |
| 5 | 55 | 68 | 234 | 84 |
| 5 | 55 | 69 | 235 | 82 |
| 5 | 60 | 70 | 235 | 84 |
| 5 | 55 | 71 | 237 | 97 |
| 5 | 55 | 72 | 237 | 92 |
| 5 | 50 | 73 | 238 | 94 |
| 5 | 45 | 74 | 239 | 94 |
| 5 | 50 | 75 | 239 | 88 |
| 5 | 50 | 76 | 239 | 88 |
| 5 | 55 | 77 | 239 | 82 |
| 5 | 55 | 78 | 240 | 98 |
| 5 | 55 | 79 | 241 | 87 |
| 5 | 55 | 80 | 241 | 86 |
| 5 | 55 | 81 | 242 | 96 |
| 5 | 45 | 82 | 243 | 100 |
| 5 | 60 | 83 | 244 | 97 |
| 5 | 60 | 84 | 244 | 88 |
| 5 | 55 | 85 | 245 | 100 |
| 5 | 60 | 86 | 246 | 88 |
| 5 | 50 | 87 | 248 | 94 |
| 5 | 60 | 88 | 249 | 105 |
| 5 | 55 | 89 | 249 | 98 |
| 5 | 55 | 90 | 251 | 105 |
| 5 | 55 | 91 | 251 | 101 |
| 5 | 55 | 92 | 254 | 106 |

Spring 2001 Bonneville Whitefish Collection Data.

| Fish # | Depth (M) | Length | Weight |
|---|---|---|---|
| 1 | 10 | 150 | 26 |
| 2 | 15 | 306 | 184 |
| 3 | 15 | 265 | 118 |
| 4 | 15 | 311 | 204 |
| 5 | 15 | 224 | 90 |

| | | | |
|---|---|---|---|
| 6 | 15 | 195 | 52 |
| 7 | 15 | 219 | 78 |
| 8 | 15 | 214 | 76 |
| 9 | 15 | 161 | 32 |
| 10 | 15 | 131 | 18 |
| 11 | 15 | 96 | 8 |
| 12 | 15 | 105 | 8 |
| 13 | 20 | 237 | 96 |
| 14 | 20 | 233 | 102 |
| 15 | 20 | 219 | 74 |
| 16 | 20 | 229 | 84 |
| 17 | 20 | 225 | 74 |
| 18 | 20 | 135 | 18 |
| 19 | 20 | 110 | 8 |
| 20 | 20 | 98 | 6 |
| 21 | 20 | 113 | 10 |
| 22 | 25 | 250 | 108 |
| 23 | 25 | 235 | 98 |
| 24 | 25 | 254 | 114 |
| 25 | 25 | 240 | 90 |
| 26 | 25 | 266 | 136 |
| 27 | 25 | 265 | 124 |
| 28 | 25 | 210 | 80 |
| 29 | 25 | 209 | 72 |
| 30 | 25 | 236 | 94 |
| 31 | 25 | 161 | 32 |
| 32 | 25 | 136 | 18 |
| 33 | 30 | 282 | 158 |
| 34 | 30 | 243 | 106 |
| 35 | 30 | 235 | 94 |
| 36 | 30 | 163 | 34 |
| 37 | 30 | 180 | 46 |
| 38 | 30 | 196 | 60 |
| 39 | 30 | 163 | 30 |
| 40 | 30 | 153 | 26 |
| 41 | 30 | 144 | 22 |
| 42 | 35 | 230 | 88 |
| 43 | 35 | 152 | 24 |
| 46 | 40 | 155 | 26 |
| 48 | 10 | 244 | 116 |
| 49 | 20 | 257 | 122 |
| 50 | 20 | 241 | 96 |
| 51 | 20 | 199 | 60 |
| 52 | 20 | 144 | 18 |
| 53 | 20 | 116 | 10 |
| 54 | 25 | 279 | 140 |
| 55 | 25 | 237 | 94 |
| 56 | 25 | 221 | 74 |
| 57 | 25 | 215 | 74 |

| | | | |
|---|---|---|---|
| 59 | 25 | 100 | 8 |
| 60 | 25 | 100 | 8 |
| 61 | 25 | 97 | 8 |
| 62 | 30 | 437 | 730 |
| 63 | 30 | 324 | 258 |
| 64 | 30 | 331 | 274 |
| 65 | 30 | 288 | 174 |
| 66 | 30 | 280 | 170 |
| 67 | 30 | 271 | 150 |
| 68 | 30 | 274 | 146 |
| 69 | 30 | 296 | 156 |
| 70 | 30 | 275 | 126 |
| 71 | 30 | 267 | 132 |
| 72 | 30 | 271 | 138 |
| 73 | 30 | 244 | 106 |
| 74 | 30 | 242 | 96 |
| 75 | 30 | 232 | 94 |
| 76 | 30 | 224 | 84 |
| 77 | 30 | 246 | 102 |
| 78 | 30 | 219 | 72 |
| 79 | 30 | 191 | 48 |
| 80 | 30 | 180 | 40 |
| 81 | 30 | 155 | 26 |
| 82 | 35 | 285 | 156 |
| 83 | 35 | 257 | 116 |
| 84 | 35 | 252 | 106 |
| 85 | 35 | 229 | 84 |
| 86 | 35 | 242 | 100 |
| 87 | 35 | 190 | 50 |
| 88 | 35 | 140 | 20 |
| 89 | 40 | 280 | 156 |
| 90 | ? | 144 | 20 |
| 91 | 10 | 301 | 190 |
| 92 | 10 | 280 | 158 |
| 93 | 10 | 278 | 150 |
| 94 | 10 | 279 | 150 |
| 95 | 10 | 275 | 146 |
| 96 | 10 | 257 | 118 |
| 97 | 10 | 244 | 90 |
| 98 | 10 | 240 | 98 |
| 99 | 10 | 238 | 98 |
| 100 | 10 | 230 | 86 |
| 101 | 10 | 220 | 80 |
| 102 | 10 | 215 | 72 |
| 103 | 10 | 203 | 64 |
| 104 | 10 | 203 | 60 |
| 105 | 10 | 204 | 60 |
| 106 | 10 | 191 | 48 |
| 107 | 10 | 187 | 54 |

| | | | |
|---|---|---|---|
| 108 | 10 | 170 | 40 |
| 109 | 10 | 143 | 22 |
| 110 | 15 | 289 | 160 |
| 111 | 15 | 268 | 134 |
| 112 | 15 | 290 | 160 |
| 113 | 15 | 265 | 134 |
| 114 | 15 | 268 | 140 |
| 115 | 15 | 265 | 118 |
| 116 | 15 | 249 | 110 |
| 117 | 15 | 250 | 104 |
| 118 | 15 | 237 | 96 |
| 119 | 15 | 218 | 72 |
| 120 | 15 | 177 | 40 |
| 121 | 15 | 182 | 44 |
| 122 | 15 | 173 | 40 |
| 123 | 15 | 155 | 26 |
| 124 | 15 | 145 | 22 |
| 125 | 20 | 272 | 150 |
| 126 | 20 | 275 | 138 |
| 127 | 20 | 270 | 130 |
| 128 | 20 | 261 | 124 |
| 129 | 20 | 215 | 76 |
| 130 | 20 | 187 | 46 |
| 131 | 20 | 163 | 32 |
| 132 | 25 | 261 | 124 |
| 133 | 25 | 263 | 130 |
| 134 | 25 | 262 | 120 |
| 135 | 25 | 247 | 98 |
| 136 | 25 | 232 | 98 |
| 137 | 25 | 217 | 80 |
| 138 | 25 | 185 | 44 |
| 139 | 25 | 169 | 36 |
| 140 | 25 | 157 | 26 |
| 141 | 25 | 149 | 24 |
| 142 | 25 | 149 | 24 |
| 143 | 25 | 164 | 30 |
| 144 | 25 | 146 | 20 |
| 145 | 25 | 99 | 6 |
| 146 | 25 | 98 | 6 |
| 147 | 25 | 96 | 5 |
| 148 | 25 | 101 | 7 |
| 149 | 30 | 300 | 184 |
| 150 | 30 | 288 | 166 |
| 151 | 30 | 276 | 136 |
| 152 | 30 | 253 | 112 |
| 153 | 30 | 260 | 122 |
| 154 | 30 | 248 | 104 |
| 155 | 30 | 247 | 96 |
| 156 | 30 | 250 | 108 |

| | | | |
|---|---|---|---|
| 157 | 30 | 243 | 94 |
| 158 | 30 | 242 | 88 |
| 159 | 30 | 207 | 62 |
| 160 | 30 | 194 | 56 |
| 161 | 30 | 198 | 60 |
| 162 | 30 | 185 | 44 |
| 163 | 30 | 193 | 52 |
| 164 | 30 | 197 | 52 |
| 165 | 30 | 174 | 36 |
| 166 | 30 | 193 | 50 |
| 167 | 30 | 183 | 46 |
| 168 | 30 | 187 | 46 |
| 169 | 30 | 178 | 40 |
| 170 | 30 | 168 | 34 |
| 171 | 30 | 181 | 44 |
| 172 | 30 | 158 | 28 |
| 173 | 30 | 159 | 30 |
| 174 | 30 | 148 | 22 |
| 175 | 30 | 152 | 26 |
| 176 | 30 | 140 | 20 |
| 177 | 30 | 107 | 8 |
| 178 | 30 | 101 | 8 |
| 179 | 15 | 285 | 136 |
| 180 | 15 | 257 | 114 |
| 181 | 15 | 266 | 130 |
| 182 | 15 | 192 | 50 |
| 183 | 15 | 108 | 8 |
| 184 | 20 | 282 | 156 |
| 185 | 20 | 245 | 104 |
| 186 | 20 | 205 | 64 |
| 187 | 20 | 158 | 26 |
| 188 | 25 | 312 | 232 |
| 189 | 25 | 294 | 164 |
| 190 | 25 | 262 | 120 |
| 191 | 25 | 246 | 112 |
| 192 | 25 | 245 | 102 |
| 193 | 25 | 234 | 88 |
| 194 | 25 | 237 | 88 |
| 195 | 25 | 210 | 66 |
| 196 | 25 | 205 | 66 |
| 197 | 25 | 149 | 24 |
| 198 | 25 | 155 | 26 |
| 199 | 25 | 147 | 24 |
| 200 | 30 | 243 | 90 |
| 201 | 35 | 243 | 98 |
| 202 | 40 | 163 | 28 |
| 203 | 10 | 187 | 48 |
| 204 | 20 | 270 | 130 |
| 205 | 20 | 252 | 114 |

| | | | |
|---|---|---|---|
| 206 | 20 | 238 | 96 |
| 207 | 20 | 137 | 18 |
| 208 | 25 | 257 | 116 |
| 209 | 25 | 225 | 90 |
| 210 | 25 | 170 | 34 |
| 211 | 30 | 382 | 460 |
| 212 | 30 | 285 | 172 |
| 213 | 30 | 268 | 132 |
| 214 | 30 | 284 | 158 |
| 215 | 30 | 273 | 144 |
| 216 | 30 | 288 | 158 |
| 217 | 30 | 269 | 140 |
| 218 | 30 | 273 | 136 |
| 219 | 30 | 262 | 132 |
| 220 | 30 | 247 | 94 |
| 221 | 30 | 206 | 64 |
| 222 | 30 | 190 | 52 |
| 223 | 30 | 160 | 30 |
| 224 | 35 | 262 | 134 |
| 225 | 35 | 197 | 62 |
| 226 | 35 | 201 | 60 |
| 227 | 40 | 262 | 126 |
| 228 | 40 | 250 | 106 |
| 229 | 10 | 272 | 144 |
| 230 | 10 | 271 | 146 |
| 231 | 10 | 277 | 144 |
| 232 | 10 | 260 | 136 |
| 233 | 10 | 239 | 102 |
| 234 | 10 | 257 | 114 |
| 235 | 10 | 238 | 90 |
| 236 | 10 | 235 | 94 |
| 237 | 10 | 230 | 84 |
| 238 | 10 | 233 | 78 |
| 239 | 10 | 207 | 68 |
| 240 | 10 | 207 | 64 |
| 241 | 10 | 190 | 50 |
| 242 | 10 | 177 | 40 |
| 243 | 10 | 193 | 48 |
| 244 | 10 | 178 | 42 |
| 245 | 10 | 185 | 48 |
| 246 | 10 | 178 | 38 |
| 247 | 10 | 166 | 36 |
| 248 | 10 | 164 | 28 |
| 249 | 10 | 154 | 26 |
| 250 | 10 | 153 | 26 |
| 251 | 10 | 152 | 26 |
| 252 | 15 | 271 | 144 |
| 253 | 15 | 285 | 156 |
| 254 | 15 | 262 | 144 |

| | | | |
|---|---|---|---|
| 255 | 15 | 265 | 132 |
| 256 | 15 | 256 | 114 |
| 257 | 15 | 255 | 106 |
| 258 | 15 | 262 | 108 |
| 259 | 15 | 242 | 98 |
| 260 | 15 | 217 | 80 |
| 261 | 15 | 235 | 78 |
| 262 | 15 | 184 | 46 |
| 263 | 15 | 184 | 46 |
| 264 | 15 | 168 | 34 |
| 265 | 15 | 171 | 34 |
| 266 | 15 | 161 | 30 |
| 267 | 15 | 153 | 28 |
| 268 | 15 | 158 | 28 |
| 269 | 15 | 154 | 26 |
| 270 | 15 | 148 | 22 |
| 271 | 20 | 296 | 184 |
| 272 | 20 | 282 | 162 |
| 273 | 20 | 278 | 150 |
| 274 | 20 | 251 | 122 |
| 275 | 20 | 230 | 82 |
| 276 | 20 | 160 | 30 |
| 277 | 20 | 154 | 26 |
| 278 | 20 | 97 | 6 |
| 279 | 20 | 101 | 8 |
| 280 | 25 | 289 | 180 |
| 281 | 25 | 257 | 118 |
| 282 | 25 | 230 | 90 |
| 283 | 25 | 225 | 80 |
| 284 | 25 | 161 | 30 |
| 285 | 25 | 98 | 8 |
| 286 | 25 | 106 | 8 |
| 287 | 25 | 99 | 6 |
| 288 | 30 | 333 | 268 |
| 289 | 30 | 308 | 222 |
| 290 | 30 | 267 | 116 |
| 291 | 30 | 238 | 104 |
| 292 | 30 | 214 | 74 |
| 293 | 30 | 182 | 42 |
| 294 | 30 | 181 | 46 |
| 295 | 50 | 410 | 604 |
| 296 | 50 | 196 | 50 |
| 297 | 55 | 220 | 68 |

Spring 2001 Bear Lake Whitefish Collection Data.

| Fish # | Depth | Length | Weight |
|---|---|---|---|
| 1 | 40 | 241 | 88 |
| 2 | 40 | 140 | 16 |

| | | | |
|---|---|---|---|
| 3 | 40 | 154 | 24 |
| 4 | 30 | 209 | 60 |
| 5 | 25 | 203 | 60 |
| 6 | 35 | 243 | 88 |
| 7 | 35 | 206 | 52 |
| 8 | 30 | 220 | 80 |
| 9 | 35 | 149 | 22 |
| 10 | 45 | 195 | 50 |
| 11 | 45 | 154 | 26 |
| 12 | 50 | 261 | 132 |
| 13 | 50 | 248 | 102 |
| 14 | 50 | 230 | 84 |
| 15 | 50 | 212 | 68 |
| 16 | 50 | 231 | 80 |
| 17 | 50 | 222 | 66 |
| 18 | 55 | 247 | 104 |
| 19 | 55 | 253 | 112 |
| 20 | 55 | 249 | 106 |
| 21 | 55 | 263 | 112 |
| 22 | 55 | 231 | 78 |
| 23 | 55 | 235 | 80 |
| 24 | 55 | 217 | 68 |
| 25 | 55 | 219 | 74 |
| 26 | 55 | 222 | 74 |
| 27 | 55 | 220 | 76 |
| 28 | 55 | 248 | 98 |
| 29 | 55 | 216 | 66 |
| 30 | 55 | 228 | 78 |
| 31 | 55 | 223 | 70 |
| 32 | 55 | 212 | 64 |
| 33 | 55 | 214 | 64 |
| 34 | 55 | 220 | 64 |
| 35 | 55 | 214 | 64 |
| 36 | 55 | 210 | 60 |
| 37 | 55 | 195 | 50 |
| 38 | 55 | 186 | 40 |
| 39 | 60 | 241 | 92 |
| 40 | 60 | 244 | 92 |
| 41 | 60 | 236 | 88 |
| 42 | 60 | 254 | 106 |
| 43 | 60 | 206 | 60 |
| 44 | 60 | 204 | 56 |
| 45 | 60 | 205 | 64 |
| 46 | 60 | 196 | 52 |
| 47 | 60 | 214 | 66 |
| 48 | 60 | 193 | 50 |
| 49 | 60 | 204 | 54 |
| 50 | 60 | 190 | 48 |
| 51 | 60 | 179 | 36 |

| | | | |
|---|---|---|---|
| 52 | 45 | 234 | 80 |
| 53 | 45 | 243 | 100 |
| 54 | 45 | 219 | 76 |
| 55 | 45 | 211 | 64 |
| 56 | 45 | 186 | 46 |
| 57 | 45 | 171 | 36 |
| 58 | 50 | 248 | 94 |
| 59 | 50 | 239 | 88 |
| 60 | 50 | 239 | 88 |
| 61 | 50 | 238 | 94 |
| 62 | 50 | 234 | 88 |
| 63 | 50 | 223 | 84 |
| 64 | 50 | 230 | 86 |
| 65 | 50 | 229 | 78 |
| 66 | 50 | 200 | 50 |
| 67 | 50 | 200 | 56 |
| 68 | 50 | 187 | 40 |
| 69 | 55 | 237 | 92 |
| 70 | 55 | 249 | 98 |
| 71 | 55 | 230 | 76 |
| 72 | 55 | 225 | 82 |
| 73 | 55 | 240 | 98 |
| 74 | 55 | 224 | 70 |
| 75 | 55 | 242 | 96 |
| 76 | 55 | 234 | 84 |
| 77 | 55 | 245 | 100 |
| 78 | 55 | 239 | 82 |
| 79 | 55 | 235 | 82 |
| 80 | 55 | 241 | 86 |
| 81 | 55 | 215 | 60 |
| 82 | 55 | 200 | 50 |
| 83 | 55 | 197 | 50 |
| 84 | 60 | 244 | 88 |
| 85 | 60 | 214 | 66 |
| 86 | 60 | 223 | 82 |
| 87 | 60 | 235 | 84 |
| 88 | 60 | 246 | 88 |

Appendix (B.) Diet Data.

Bonneville Whitefish Summer Diet (Proportion in Stomach)

| **100-150** | **150-200** | **200-250** | **250-300** | **300-350** | **> 350** | **Food Item** |
|---|---|---|---|---|---|---|
| 0.194 | 0.021 | 0.021 | 0.040 | 0 | 0 | Zoop. |
| 0.010 | 0.010 | 0.013 | 0.034 | 0 | 0 | Tricopt. |
| 0.004 | 0.024 | 0.011 | 0.147 | 0 | 0 | Coleopt. |
| 0.018 | 0.076 | 0.120 | 0.405 | 0 | 0.020 | Terrest. |
| 0 | 0 | 0 | 0.138 | 0.980 | 0.980 | Sculp. |
| 0.161 | 0.043 | 0.249 | 0.043 | 0.010 | 0 | Sphar. |

Bear Lake Whitefish Summer Diet (Proportion in Stomach)

| **100-150** | **150-200** | **200-250** | **> 250** | **Food Item** |
|---|---|---|---|---|
| 0.129 | 0.072 | 0.012 | 0.05 | Chiro. |
| 0.592 | 0.751 | 0.825 | 0.99 | Otstra. |
| 0.169 | 0.104 | 0.050 | 0 | Zoops. |
| 0.041 | 0.002 | 0.008 | 0 | Eggs |
| 0.019 | 0.001 | 0 | 0 | Tricopt. |
| 0.022 | 0.006 | 0.068 | 0 | Coleopt. |
| 0.028 | 0.064 | 0.037 | 0 | Terrest. |
| 0 | 0 | 0 | 0 | Sculp. |
| 0 | 0 | 0 | 0 | Sphar. |

Bonneville Whitefish Spring Diet (Proportion in Stomach)

| **100-150** | **150-200** | **200-250** | **250-300** | **300-350** | **> 350** | **Food Item** |
|---|---|---|---|---|---|---|
| 0.226 | 0.351 | 0.28 | 0.262 | 0.377 | 0 | **Chiro.** |
| 0.333 | 0.135 | 0.029 | 0.008 | 0.033 | 0 | **Otstra.** |
| 0 | 0 | 0 | 0 | 0 | 0 | **Zoops.** |
| 0 | 0 | 0 | 0.004 | 0 | 0 | **Eggs** |
| 0 | 0.025 | 0.007 | 0.017 | 0 | 0 | **Tricopt.** |
| 0 | 0.035 | 0.055 | 0.107 | 0.267 | 0 | **Coleopt.** |
| 0.441 | 0 | 0.215 | 0.237 | 0.148 | 0 | **Terrest.** |
| 0 | 0.172 | 0 | 0 | 0 | 1 | **Sculp.** |
| 0 | 0.258 | 0.412 | 0.356 | 0.175 | 0 | **Sphar.** |
| 0 | 0.024 | 0 | 0.008 | 0 | 0 | **Oligocha.** |

Bear Lake Whitefish Spring Diet (Proportion in Stomach)

| **100-150** | **150-200** | **200-250** | **>250** | **Food Item** |
|---|---|---|---|---|
| 0.02 | 0.043 | 0.038 | 0 | **Chiro.** |
| 0.99 | 0.896 | 0.727 | 0.75 | **Otstra.** |
| 0 | 0 | 0 | 0 | **Zoops.** |
| 0 | 0.002 | 0.021 | 0 | **Eggs** |
| 0 | 0 | 0.001 | 0 | **Tricopt.** |
| 0 | 0.023 | 0.036 | 0 | **Coleopt.** |
| 0 | 0 | 0.011 | 0 | **Terrest.** |
| 0 | 0 | 0 | 0 | **Sculp.** |
| 0 | 0 | 0 | 0 | **Sphar.** |
| 0 | 0.036 | 0.15 | 0.25 | **Oligocha.** |

Appendix (C.) Spatial Distribution Data.

Spring Distribution Data (CPUE (NET HOUR)) by Depth Contour.

| **Bonneville** | **Bear Lake** | **Depth (m)** |
|---|---|---|
| 0.6250 | 0 | 10 |
| 0.6944 | 0 | 15 |
| 0.5278 | 0 | 20 |
| 0.8056 | 0.0139 | 25 |
| 1.1111 | 0.0278 | 30 |
| 0.1806 | 0.0417 | 35 |
| 0.1042 | 0.0625 | 40 |
| 0 | 0.3333 | 45 |
| 0.0833 | 0.7083 | 50 |
| 0.0417 | 1.5000 | 55 |
| 0.0417 | 0.7083 | 60 |

Summer Distribution Data (CPUE (NET HOUR)) by Depth Contour.

| **Bonneville** | **Bear Lake** | **Depth (m)** |
|---|---|---|
| 0.306 | 0.028 | 5 |
| 1.903 | 0.056 | 10 |
| 2.451 | 0.111 | 15 |
| 0.688 | 0.083 | 20 |
| 0.764 | 0.076 | 25 |
| 0.646 | 0.111 | 30 |
| 0.896 | 0.188 | 35 |
| 0.150 | 0.350 | 40 |
| 0.083 | 0.917 | 45 |
| 0.083 | 1.417 | 50 |
| 0 | 1.533 | 55 |
| 0 | 1.771 | 60 |

Appendix (D.) Thermograph Data.

Thermograph Data Taken during the summer and winter of 2001.

| Depth m | Summer Temp C | Winter Temp C |
|---|---|---|
| 1 | 19.8 | 5 |
| 2 | 19.9 | 5 |
| 3 | 19.9 | 5 |
| 4 | 19.9 | 5 |
| 5 | 19.9 | 5 |
| 6 | 19.9 | 5 |
| 7 | 19.9 | 5 |
| 8 | 19.7 | 5 |
| 9 | 19.4 | 5 |
| 10 | 18.9 | 5 |
| 11 | 18.7 | 5 |
| 12 | 16.2 | 5 |
| 13 | 15.4 | 5 |
| 14 | 15.2 | 5 |
| 15 | 14.8 | 5 |
| 16 | 14.6 | 5 |
| 17 | 14.5 | 5 |
| 18 | 14.4 | 5 |
| 19 | 12.6 | 5 |
| 20 | 11.8 | 5 |
| 21 | 11.6 | 5 |
| 22 | 11.4 | 5 |
| 23 | 10.9 | 5 |
| 24 | 9.9 | 5 |
| 25 | 9.3 | 4.75 |
| 26 | 8.8 | 4.5 |
| 27 | 8.4 | 4 |
| 28 | 7.9 | 4 |
| 29 | 7.3 | 4 |
| 30 | 7 | 4 |
| 31 | 6.7 | 4 |
| 32 | 6.6 | 4 |
| 33 | 6.4 | 4 |
| 34 | 6.2 | 4 |
| 35 | 6.1 | 4 |
| 36 | 5.8 | 4 |
| 37 | 5.6 | 4 |
| 38 | 5.6 | 4 |
| 39 | 5.5 | 4 |
| 40 | 5.5 | 4 |
| 41 | 5.5 | 4 |

| | | |
|---|---|---|
| 42 | 5.4 | 4 |
| 43 | 5.4 | 4 |
| 44 | 5.3 | 4 |
| 45 | 5.2 | 4 |
| 46 | 5.2 | 4 |
| 47 | 5.1 | 4 |
| 48 | 5.1 | 4 |
| 49 | 5 | 4 |
| 50 | 5 | 4 |
| 51 | 5 | 4 |
| 52 | 4.9 | 4 |
| 53 | 4.8 | 4 |
| 54 | 4.8 | 4 |
| 55 | 4.8 | 4 |
| 56 | 4.8 | 4 |
| 57 | 4.7 | 4 |
| 58 | 4.7 | 4 |
| 59 | 4.7 | 4 |

## Appendix (E.) Survivorship Curve Data.

### Bonneville Whitefish Survivorship.

| Age (years) | # Individuals |
|---|---|
| 1 | 383 |
| 2 | 164 |
| 3 | 86 |
| 4 | 43 |
| 5 | 42 |
| 6 | 77 |
| 7 | 70 |
| 8 | 47 |
| 9 | 32 |
| 10 | 13 |
| 11 | 8 |
| 12 | 5 |

### Bear Lake Whitefish Survivorship.

| Age (years) | # Individuals |
|---|---|
| 1 | 42 |
| 2 | 33 |
| 3 | 30 |
| 4 | 29 |
| 5 | 27 |
| 6 | 22 |
| 7 | 20 |
| 8 | 15 |
| 9 | 14 |
| 10 | 6 |
| 11 | 5 |
| 12 | 3 |

Appendix (F.) Catch Per Unit Effort (CPUE) Data.

Bonneville Whitefish Catch Per Unit Effort (CPUE) for both caught and Corrected Data.

| Length (mm) | CPUE (caught) | CPUE (corrected) |
|---|---|---|
| 90 | 0.0071 | 0.0083 |
| 95 | 0.0027 | 0.0050 |
| 100 | 0.0030 | 0.0025 |
| 105 | 0.0039 | 0.0017 |
| 110 | 0.0020 | 0.0008 |
| 115 | 0.0045 | 0.0033 |
| 120 | 0.0056 | 0.0091 |
| 125 | 0.0127 | 0.0223 |
| 130 | 0.0326 | 0.0330 |
| 135 | 0.1177 | 0.0817 |
| 140 | 0.0761 | 0.0545 |
| 145 | 0.0482 | 0.0528 |
| 150 | 0.0133 | 0.0264 |
| 155 | 0.0097 | 0.0173 |
| 160 | 0.0171 | 0.0206 |
| 165 | 0.0244 | 0.0239 |
| 170 | 0.0216 | 0.0231 |
| 175 | 0.0207 | 0.0314 |
| 180 | 0.0099 | 0.0239 |
| 185 | 0.0092 | 0.0165 |
| 190 | 0.0091 | 0.0124 |
| 195 | 0.0135 | 0.0165 |
| 200 | 0.0085 | 0.0116 |
| 205 | 0.0095 | 0.0173 |
| 210 | 0.0110 | 0.0297 |
| 215 | 0.0071 | 0.0132 |
| 220 | 0.0113 | 0.0173 |
| 225 | 0.0103 | 0.0149 |
| 230 | 0.0134 | 0.0215 |
| 235 | 0.0089 | 0.0182 |
| 240 | 0.0058 | 0.0165 |
| 245 | 0.0077 | 0.0124 |
| 250 | 0.0146 | 0.0173 |
| 255 | 0.0202 | 0.0182 |
| 260 | 0.0264 | 0.0190 |
| 265 | 0.0406 | 0.0256 |
| 270 | 0.0398 | 0.0248 |
| 275 | 0.0309 | 0.0215 |
| 280 | 0.0174 | 0.0149 |
| 285 | 0.0110 | 0.0124 |

| | | |
|---|---|---|
| 290 | 0.0043 | 0.0066 |
| 295 | 0.0019 | 0.0041 |
| 300 | 0.0020 | 0.0058 |
| 305 | 0.0023 | 0.0033 |
| 310 | 0.0007 | 0.0008 |
| 315 | 0.0000 | 0.0000 |
| 320 | 0.0000 | 0.0000 |
| 325 | 0.0020 | 0.0017 |
| 330 | 0.0010 | 0.0008 |
| 335 | 0.0009 | 0.0008 |
| 340 | 0.0022 | 0.0025 |
| 345 | 0.0000 | 0.0000 |
| 350 | 0.0023 | 0.0041 |
| 355 | 0.0004 | 0.0008 |
| 360 | 0.0000 | 0.0000 |
| 365 | 0.0000 | 0.0000 |
| 370 | 0.0008 | 0.0008 |
| 375 | 0.0000 | 0.0000 |
| 380 | 0.0000 | 0.0000 |
| 385 | 0.0016 | 0.0008 |
| 390 | 0.0000 | 0.0000 |
| 395 | 0.0076 | 0.0025 |
| 400 | 0.0000 | 0.0000 |
| 405 | 0.0121 | 0.0025 |
| 410 | 0.0000 | 0.0000 |
| 415 | 0.0000 | 0.0000 |

Bear Lake Whitefish Catch Per Unit Effort (CPUE) for both caught and Corrected Data.

| Length (mm) | CPUE (caught) | CPUE (corrected) |
|---|---|---|
| 90 | 0.0000 | 0.0000 |
| 95 | 0.0000 | 0.0000 |
| 100 | 0.0010 | 0.0008 |
| 105 | 0.0097 | 0.0041 |
| 110 | 0.0020 | 0.0008 |
| 115 | 0.0034 | 0.0025 |
| 120 | 0.0010 | 0.0017 |
| 125 | 0.0019 | 0.0033 |
| 130 | 0.0049 | 0.0050 |
| 135 | 0.0107 | 0.0074 |
| 140 | 0.0104 | 0.0074 |
| 145 | 0.0023 | 0.0025 |
| 150 | 0.0021 | 0.0041 |
| 155 | 0.0005 | 0.0008 |
| 160 | 0.0027 | 0.0033 |
| 165 | 0.0008 | 0.0008 |
| 170 | 0.0031 | 0.0033 |
| 175 | 0.0027 | 0.0041 |
| 180 | 0.0024 | 0.0058 |

| | | |
|---|---|---|
| 185 | 0.0037 | 0.0066 |
| 190 | 0.0079 | 0.0107 |
| 195 | 0.0047 | 0.0058 |
| 200 | 0.0061 | 0.0083 |
| 205 | 0.0041 | 0.0074 |
| 210 | 0.0037 | 0.0099 |
| 215 | 0.0066 | 0.0124 |
| 220 | 0.0059 | 0.0091 |
| 225 | 0.0109 | 0.0157 |
| 230 | 0.0098 | 0.0157 |
| 235 | 0.0101 | 0.0206 |
| 240 | 0.0067 | 0.0190 |
| 245 | 0.0087 | 0.0140 |
| 250 | 0.0077 | 0.0091 |
| 255 | 0.0092 | 0.0083 |
| 260 | 0.0046 | 0.0033 |
| 265 | 0.0052 | 0.0033 |
| 270 | 0.0000 | 0.0000 |
| 275 | 0.0012 | 0.0008 |
| 280 | 0.0000 | 0.0000 |
| 285 | 0.0007 | 0.0008 |
| 290 | 0.0000 | 0.0000 |
| 295 | 0.0000 | 0.0000 |
| 300 | 0.0000 | 0.0000 |