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Biology, Reproductive Potential and the Impact of Fishing Pressure on the Bluegill Fishery of Pelican Lake, Uintah County, Utah

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BIOLOGY, REPRODUCTIVE POTENTIAL AND THE IMPACT OF FISHING PRESSURE ON THE BLUEGILL FISHERY OF PELICAN LAKE, UINTAH COUNTY, UTAH

by

Bob D. Burdick

A thesis submitted in partial fulfillment
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of

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Bob D. Burdick

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ABSTRACT

Biology, Reproductive Potential and the Impact of Fishing Pressure on the Bluegill Fishery of Pelican Lake, Uintah County, Utah

by

Bob D. Burdick, Master of Science

Utah State University, 1979

Major Professor: Dr. Richard S. Wydoski
Department: Wildlife Science

Certain aspects of the biology of two species of fish, bluegill (*Lepomis macrochirus*) and largemouth bass (*Micropterus salmoides*), and the assessment of fishing pressure upon the sport fishery of Pelican Lake, Uintah County, Utah, a 680 ha warmwater lake, were studied between April 1, 1976 and June 30, 1978. The growth rate of bluegills (sexes combined) was fairly rapid; the mean back-calculated total lengths from ages one through nine were 55, 112, 166, 194, 211, 229, 245, 256 and 259 mm. The growth of largemouth bass was 104, 194, 271, 316, 350, 405 and 416 mm total length for ages one through seven for the combined sexes. Male bluegills matured earlier in life than females. Bluegills spawned continually from the first of June to the first of September, although the peak spawning occurred in June of both years. Gonadal weight to body weight ratios (maturity index) were greatest in the first of June for both male and female

bluegills. Fecundity estimates ranged from 11,102 mature ova for an age II bluegill to 46,281 mature ova for an age V bluegill. Fecundity estimates for largemouth bass ranged from 4,810 mature ova for a II year old to 31,719 mature ova for a V year old. Largemouth bass spawned primarily in late May in 1976 and early June in 1977.

Angler use of the lake was estimated to be 10,054 angler days fished in 1975, culminating a seven-year increase in use, with subsequent declines in angling to 8,001 angler days in 1976 and 5,027 in 1977. A significant winter fishery developed in 1978. Anglers harvested an estimated 58,277, 44,918 and 22,469 bluegills and 5,791, 2,747 and 4,176 largemouth bass in 1975, 1976 and 1977, respectively. Angler catch rates for bluegills in respective years were 1.520, 1.640 and 1.130 fish/hr and 0.204, 0.094 and 0.213 fish/hr for largemouth bass. Bluegill age groups IV and V and largemouth bass age group III composed the majority of angler harvested fish in 1976 and 1977. Age and size composition of angler harvested bluegills indicated no statistically significant change between 1976 and 1977. Bass harvested by anglers in 1977 were significantly greater in weight than those harvested in 1976. The total annual mortality determined from scale analyses of angler harvested fish was 59.9% for bluegill and 71.6% for bass. A significant number of male bluegills was harvested by anglers in June 1977, the period of peak nesting activity. Anglers released 5,158 bluegills in 1977, of which an estimated 11% (565) were lost to hooking mortality. Of various hook sizes used to assess hooking mortality, number 8 regular shank hooks yielded the highest total mortality (18%). The lowest hooking mortality was with number 6 regular shank jig hooks (0%) and where the leader was cut and the hook allowed to remain (0%). Higher mortality of worm-hooked fish was attributed largely to anatomical location of hooking. Of the total (19) bluegill mortalities, 63% were hooked in the esophagus and 37% in the gill/gill arch.

Postwinter population sampling in May 1977 indicated the estimated standing crop weight was 40% less than the prewinter standing crop weight in August 1976. A similar loss in standing crop (37%) was noted in weight from August 1977 to June 1978. The greatest loss in numbers was in young-of-the-year bluegill that suffered an estimated 98% overwinter mortality. Midwinter water quality analyses indicated that anoxic conditions occurred from 2.0 m below the ice to the bottom. An increase in hydrogen sulfide levels was also detected.

Recommendations for the fishery were (1) adjustment of the daily bag limit for the bluegill sport fishery with fluctuations in angling use; (2) continuation of a creel census from April 1 through July 31 similar to the design used in this study to annually assess angling use, catch rates, total harvest and the size and age composition of this harvest; (3) stomach analyses of potential predators to assess the overwinter mortality of bluegills; (4) retainment of the current bag limit on largemouth bass with future consideration of utilizing a 12-15-in (305-381 mm) total length limit to increase the numbers of larger, older bass in the population; (5) nonrestrictive use of terminal gear by anglers since hooking mortality of bluegills caught and released by anglers in the summer of 1977 was insignificant; (6) no size length restrictions on the bluegills retained by anglers;

and (7) consideration of purchasing additional water storage from the irrigation company.

(256 pages)

INTRODUCTION

Historical Background

Pelican Lake is a 680 ha, 2,089 ha m warmwater storage reservoir located in southwestern Uintah County, eastern Utah (Figure 1). The lake is privately operated by the Ouray Park Irrigation Company, which utilizes the water for agricultural irrigation and stock watering purposes.

The original stocking of largemouth bass (*Micropterus salmoides* Lacepede) and bluegill sunfish (*Lepomis macrochirus* Rafinesque) was made in 1954 by the Randlett Lions Club and Vernal Rod and Gun Club (Utah State Division of Wildlife Resources [Utah DWR] 1970). The actual numbers of these two fish species stocked at that time are unknown and no subsequent stocking of other fish species is recorded. Crayfish (*Orconectes* sp.) were introduced into the lake in 1968 by Utah DWR personnel in an attempt to control aquatic vegetation (Utah DWR 1969).

Until 1966, the lake was primarily utilized for irrigation and other agrarian practices. Between 1954 and 1966, Utah DWR personnel reported that Pelican Lake was not being used extensively for fishing (Utah DWR 1970). Prior to 1966, fishing pressure was probably low because most of the shoreline was inaccessible to anglers, no boat launching facilities were present and objectionable odors were produced by decaying, aquatic vegetation in the summer months due to water

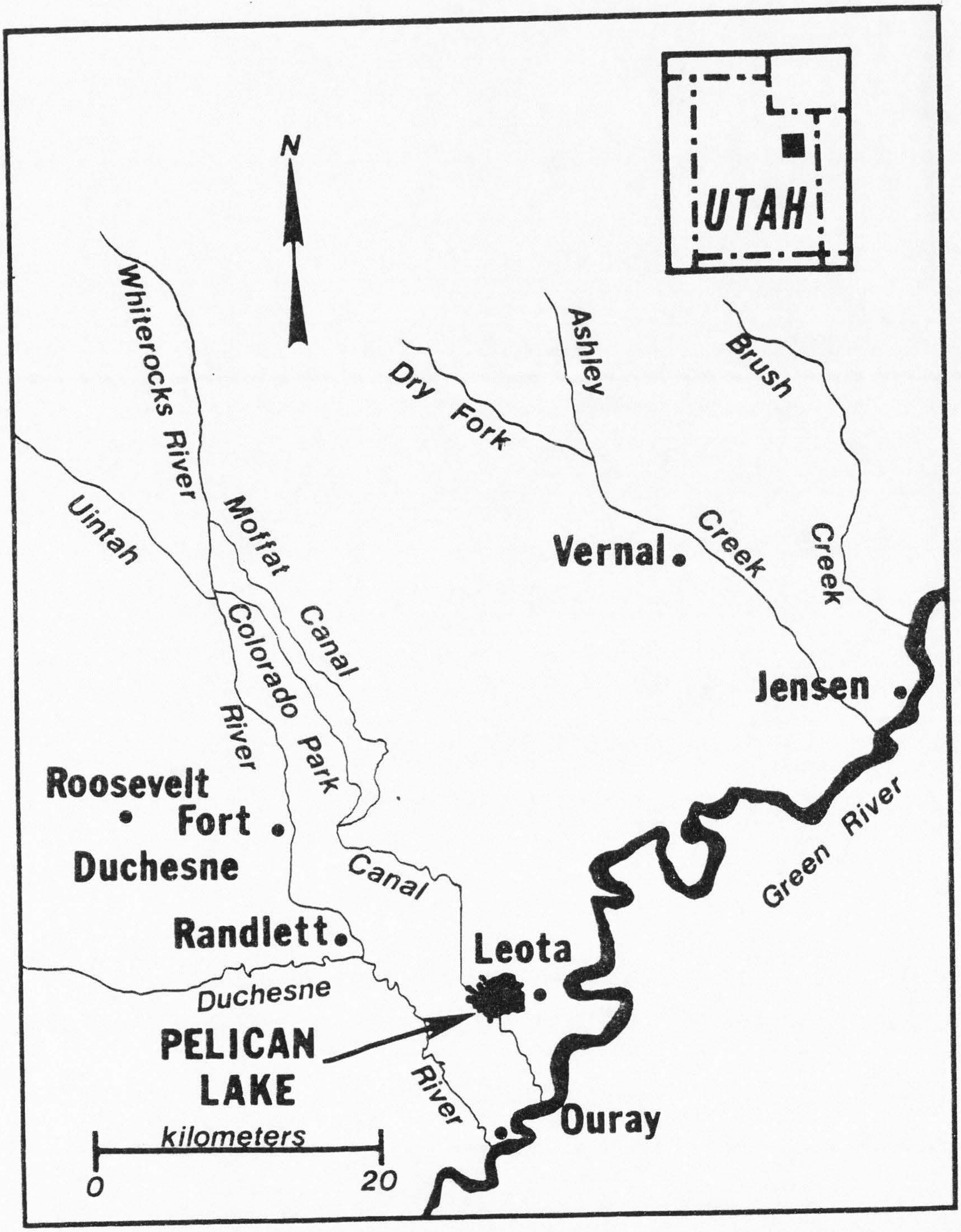


Figure 1. Location of Pelican Lake, Uintah County, Utah.

drawdown for irrigation. Area residents, prior to 1966, described the lake as a swampy mudhole giving off a "marshy odor" (Utah DWR 1969).

Initial fishery investigations of the lake with fish toxicants were conducted in 1964 by Utah DWR biologists. Only two species, largemouth bass and bluegill, were collected at that time. Other species (channel catfish, Ictalurus punctatus Rafinesque; cutthroat trout, Salmo clarki Richardson; green sunfish, Lepomis cyanellus Rafinesque; and fathead minnow, Pimephales promelas Rafinesque) have subsequently been reported in various netting and sampling investigations (Crosby and Shipley 1976, Vernal, Utah, Personal communication). These other species may have been introduced via the Colorado Park Irrigation Canal, a bypass diversion of the Whiterocks River that supplies the lake, although introduction by bait fishermen cannot be entirely ruled out. Annual winterkills of both bluegills and largemouth bass have been investigated following ice breakup in late March and early April, but sufficient data are not available to estimate fish lost to winterkill.

A conservation pool of 493 ha m was purchased in 1967 from the irrigation company that expanded the lake and raised the previous maximum water level of 2.44 m to over 4.90 m (Utah DWR 1969). The inundation of additional land resulted in desirable fishing areas becoming accessible to shore fishermen (Utah DWR 1969). The lake's volume was increased from approximately 987 ha m to the current storage capacity of 2,089 ha m. Water levels fluctuate from near or full capacity in the spring, followed by water drawdown during the summer as water demands dictate, with subsequent midwinter and early spring filling.

Easements on the north and south shoreline, plus the availability of an additional boat ramp, provided fishermen more access, which promoted steadily increasing fishing pressure on the lake. The influx of midwesterners and southerners, who traditionally have originated from areas where warmwater fishing was popular, to the Uintah development basin, coupled with resident angler interest in warmwater fisheries, placed more use on the fishery. Anglers soon realized that Pelican Lake bluegills were rivaled by few other panfish fisheries in Utah in consistently producing quality-sized bluegills (quality-sized bluegills used in this context refers to fish averaging greater than 210 mm total length [TL] and 300 g total body weight).

Investigation of the harvest, catch per unit of effort and angler use patterns on the lake were made between 1969 and 1974 by conservation officer interviews and creel census card questionnaires. Although the lake is open year-round to fishing, most fishing occurs between the first of April and the Labor Day weekend in early September. Until the winter of 1978, few anglers fished through the ice. Creel checks by Utah DWR personnel indicated that fish could not be caught during this period (Shipley and Grandison 1976, Vernal, Utah, Personal communication).

Popularity of the lake as a bluegill fishery was spread via personal communication until national attention was brought to the lake in the July 1974 issue of Outdoor Life (Zumbo 1974). Subsequently, two additional popular magazine articles have been written about Pelican Lake (Zumbo 1977; Lyons 1978). Prior to 1974, creel census information had not distinguished nonresident from resident anglers; but in 1975, creel information indicated out-of-state vehicles frequented the lake (Utah DWR 1975). Information collected between 1969 and 1974 indicated a rather rapid increase in angler day use (A.D.U.) at Pelican Lake from 2,959 A.D.U. to 8,917 A.D.U. (Utah DWR 1969-1974) (Figure 2).

Although bluegill populations often become stunted due to inadequate fishing exploitation and/or predators (Beard 1971; Bennett 1970), the bluegills in Pelican Lake have remained large, even though fishing pressure was apparently low between 1954 and 1967. The population did not become stunted because other natural controls were keeping it in balance. The population of bluegills which existed at Pelican Lake appeared to be balanced naturally; however, a future increase in fishing pressure may cause overexploitation of the population. Since the increased fishing pressure might deplete the large 5- to 6-year-old bluegills (bluegills were aged by Chad Crosby, regional fishery manager, Utah DWR, Vernal, Utah, 1974), a daily bag and possession limit of 20 bluegills was initiated by the Utah DWR in 1975. The rationale behind the establishment of the bag limit was that with increased angling, the older, larger bluegills would be "cropped off" faster than recruitment could replace fish in the population and, therefore, smaller and younger bluegills would dominate the catch. As larger bluegills became scarce, the fishery would deteriorate in quality. The daily bag and possession limit of 20 bluegills and 10 largemouth bass is currently in effect.

Following promulgation of the bluegill bag limit, studies were begun in March 1975 to determine the response of the fishery to the

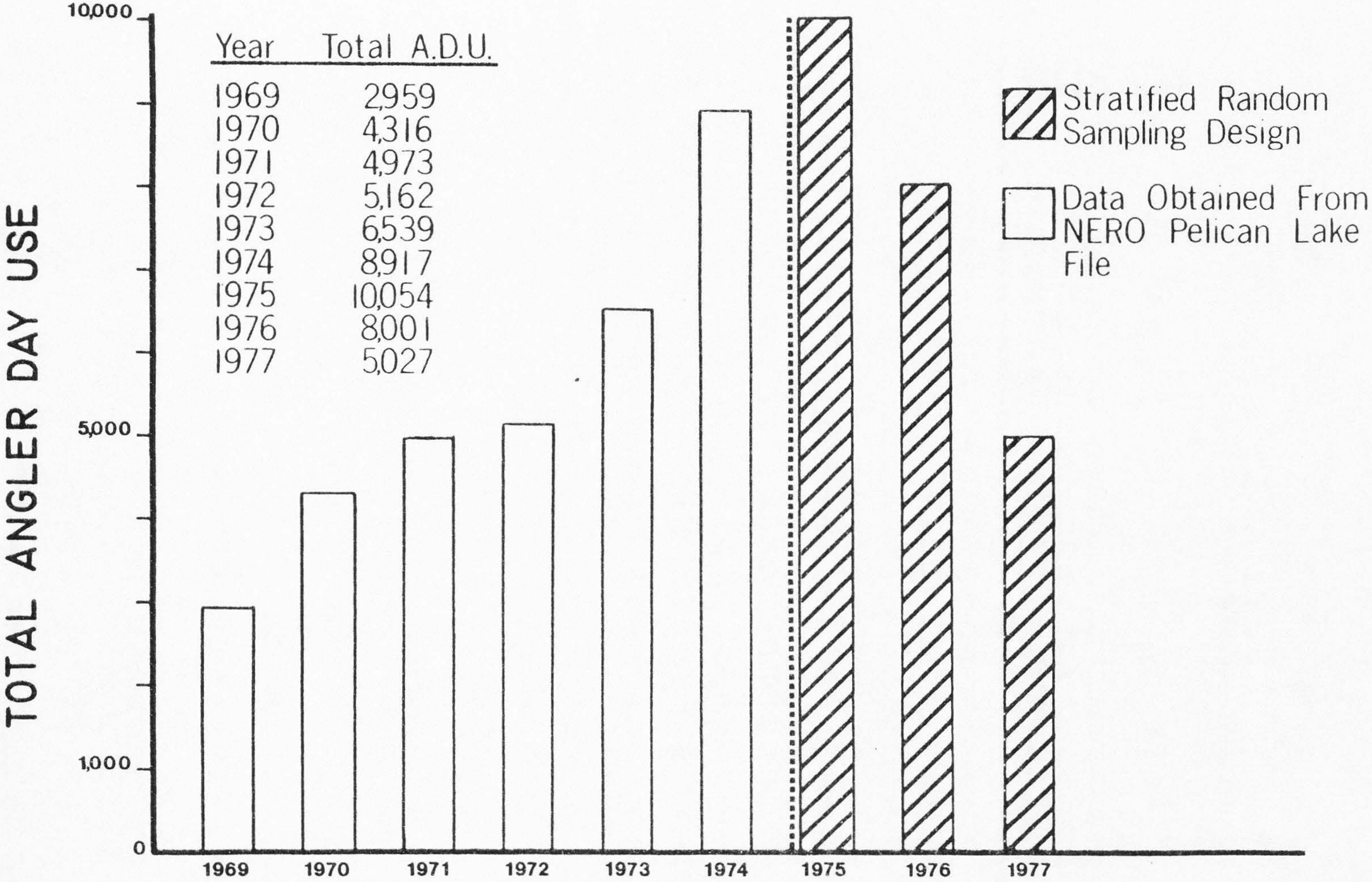


Figure 2. Trend in annual total angler day use at Pelican Lake, Uintah County, Utah. (Note: dashed line indicates initiation of 20 daily and possession bag limit.)

regulation. Results from this preliminary work were incorporated in and expanded upon in this thesis.

Objectives

At present, no campground or fish cleaning facilities exist at the lake, but a campground facility on the west end of the lake has jointly been proposed by the U. S. Bureau of Land Management and Utah DWR. This campground will undoubtedly promote more use of the lake for fishing. Maintenance of the quality fishery under increased fishing pressure and at the same time allowing optimum, sustainable yield to the angler should be the ultimate goal for the fishery management program.

The major objective of this study was to consolidate existing information and obtain baseline data on the bluegill fishery upon which to base sound management decisions that would preserve this quality fishery. The specific objectives were:

1. To provide data on the basic biology of bluegills and largemouth bass in Pelican Lake which included: age and growth (including length-weight relationships and condition factors), age composition, size and age at sexual maturity, fecundity for females and maturity index for males, location of nests, winterkill loss determined by shoreline transects after ice-out and mortality rates.

2. To determine the impact of fishing pressure on the bluegill population of Pelican Lake through a creel check which summarized data on angling pressure, the total numbers and weight of fish harvested, the age and size composition of the harvest and sex ratios in the creel.

3. To determine the mortality (initial and delayed) of bluegills caught and released by anglers.

4. To obtain information on various limnological parameters that were needed to interpret the behavior of the fish and biological data obtained.

Description of Study Area

Pelican Lake is located in the Leota-Randlett, Utah bottomlands (Latitude 40° 11' N, Longitude 109° 41' W, Township 7 South, Range 20 East, Sections 20, 21, 28 and 29) approximately 35 km southwest of Vernal, Utah and 33 km southeast of Roosevelt, Utah (Figure 1).

This natural lake lies in the Uintah Basin section of the Colorado Plateau province at an altitude of 1,463 m with a maximum and average depth of 4.88 and 2.74 m, respectively. This area is drained by the Green River and its tributaries. The lofty, east-west Uinta Mountain range can be seen to the north and the Tavaputs Plateau, or Book Cliffs to the south (Wilson 1940). The surrounding topography has been described in detail as smooth, gently sloping benches and mesas (Wilson 1940). The soil is moffat fine sandy loam, which has good drainage with unrestricted water movement within the soil. A second soil known as Winslow clay is found within the lake basin and its shores during periods of low water. The soil and rocks found in the area are derived from ancient stream deposits which were laid down during the Quaternary period of the Cenozoic era.

The area has a semiarid to arid continental climate characterized by wide daily and annual variations in air temperature and by well-defined seasons. Annual air temperatures may range from a maximum of

49 C in the summer to a minimum of -40 C in the winter. Average annual precipitation is approximately 0.178 m.

Terrestrial plants found surrounding the lake are representative of the desert shrub-sagebrush vegetative type. Cottonwood (Populus spp.), willow (Salix spp.) and tamarisk (Tamarix sp.) are well established along the floodplain of the lake. Other riparian vegetation commonly found adjacent to the lake includes sagebrush (Artemisia sp.), rabbitbrush (Chrysothamnus sp.) and curly dock (Rumex sp.) (Appendix; Table 16).

The lake is filled by the Colorado Park and Moffat Irrigation diversion canals of the Whiterocks River during the nonirrigation season, November 1 to April 30 (Dudley 1977, Randlett, Utah, Personal communication). Rooted, aquatic vegetation and filamentous algae abounds in vast areas of the lake, especially in littoral zones. The dominant species present is pondweed (Potamogeton pectinatus) while other aquatic plants present are small pondweed (P. pusillus), musk-grass (Chara sp.), coontail (Ceratophyllum spp.), water buttercup (Ranunculus sp.), water milfoil (Myriophyllum spp.) and cattail (Typha sp.) (Hotchkiss 1967). One of the more common filamentous algae present is Spirogyra spp.

Pelican Lake has been classified as a shallow eutrophic, slightly-saline lake comparable to Utah Lake in central Utah (Merritt et al. 1976). Total dissolved solids range from 625 mg/l in March to 1,150 mg/l in late September (Bessey 1977, Vernal, Utah, Personal communication; Appendix, Table 17). Total alkalinity is around 140-200 mg/l and total hardness about 260-300 mg/l (Merritt et al. 1976; this study). Available nitrogen and phosphorous concentrations analyzed by Merritt et al. (1976) were moderately low (NH_3 + NO_3 - N : 0.05 to 0.12 mg/l, PO_4 - P : 0.006 to 0.018 mg/l) in the lake indicating that at the moderate productivity observed, these species had been reduced to limiting levels.

Water temperatures may range from a minimum of 0 C in the winter months to a maximúm of 32 C in the summer months (this study). The shallow nature and absence of any substantial windbreaks plus the extensive length of the shoreline do not allow strong or extended water temperature stratifications to occur in the summer months, but a classical inverse temperature stratification occurs during the three- to four-month snow and ice cover. Complete ice cover usually occurs by mid-December and ice cover disappears during late March or early April. During this period, dissolved oxygen concentrations decline due to biotic, respiratory processes and decay of suspended and dissolved organic matter. The water quality of Pelican Lake usually begins to deteriorate in February with anoxic conditions developing near the bottom initially and proceeding upward toward the ice sheet throughout the ice-covered months. Subsequent buildup of hydrogen sulfide under these anaerobic conditions was detected in both 1977 and 1978. Concentrations reached as high as 5.0 mg/l in March 1977 (this study), levels which are lethal to fish species.

In addition to providing a fishery, the lake also provides an important staging area for migratory waterfowl during spring and fall. Numerous species of shorebirds utilize the lake during early spring on their migrating passage north to nest.

MATERIALS AND METHODS

Biological, Physical and Chemical Parameters

A description of phytoplankton and periphyton in Pelican Lake has been conducted (Merritt et al. 1976). No further effort was made in the present study to characterize the phytoplankton population.

Water level drawdown was monitored biweekly from April 1 to October 30 of 1976 and 1977, and monthly from November 1 to March 30 at the concrete outlet structure on the south side of the lake. Calculation of the amount of water in the lake was determined using an area-capacity curve map (Nielsen, Maxwell and Wangsgard Consulting Engineers, Salt Lake City, Utah).

Surface water temperatures were obtained by a Ryan, Model D, 30-day, recording thermometer from April 1 to October 30, 1977. A pocket and maximum-minimum thermometer was used in 1975 and 1976 to collect surface water temperatures. Temperature profile data were collected in June, July, August and September of 1976 and January, February and March of 1977 and 1978 at 1 m depth intervals with a Yellow Spring Instruments, thermistor thermometer. Ice and snow depths were recorded during the ice-covered months of January, February and March of 1977 and 1978 for each station.

Water quality analyses were conducted once monthly in June, July, August and September of 1976, and January, February and March of 1977 and 1978. The parameters measured included dissolved oxygen (azide modification of the Winkler method), hydrogen ion concentration (pH), total alkalinity (as $CaCO_3$), total hardness (as $CaCO_3$) and hydrogen sulfide H_2S). A Hack DR-EL engineer's chemistry field kit was utilized for water analysis. Dissolved oxygen determination in 1977 and 1978 was made in the laboratory after the samples had been fixed in the field with manganese sulfate, alkaline-iodide-azide and sulfuric acid.

Profiles of dissolved oxygen, specific conductance and temperature were determined on March 25-26, 1978, using a Yellow Spring Instruments Model 54 meter. Water samples collected were iced and transported to the Utah State Department of Health where they were analyzed for hydrogen sulfide.

Fish Biology

Collection of Fish

Intensive sampling of fish was conducted from ice-out in late March through October of 1976 and 1977. Complete ice-over of the lake from December through late March precluded sampling except for the creel check of ice fishermen.

Fish were collected by experimental gill nets varying in length from 30 to 46 m with a minimum and maximum bar mesh of 1.3 and 7.6 cm, respectively. Trammel nets, 46 m in length with an inside bar mesh of 2.5 cm and an outside bar mesh of 25 cm, were also utilized to capture fish. A deepwater trawl (4.9 m trawl width with a 3.2 cm #15 Cod End) and a purse seine (61 m long and 2.54 cm bar mesh) were utilized in April 1977 to sample midwater areas. Four bag seines measuring 46 m in length and 2 m in depth each (2.54 cm bar mesh) were spliced together to form block-off netting for the rotenone population sampling. In addition, young-of-the-year fish were captured using a 9 m bag seine with 1.0 cm bar mesh. Fyke nets (1.2 m by 1.5 m door width and 3.7 m in length) were utilized in shallow water areas to capture fish when samples from anglers' creels were unavailable.

Both largemouth bass and bluegill were measured to total, fork and standard lengths (nearest mm) and weighed (nearest 2 g). Total length (TL) was defined as the distance from the tip of the head (jaws closed) to the tip of the tail with the lobes compressed (Hile 1948). Fork length (FL) was measured from the tip of the snout to the end of the rays in the center of the caudal fin and standard length (SL) was measured from the tip of the snout to the end of the vertebral column (Carlander 1977).

Young-of-the-year bluegills captured during the rotenone samplings were preserved in 10% formalin.

Age and Growth

Scale samples from bluegills and largemouth bass were collected from April to October in 1976 and 1977. The scale method was used in determination of age and growth as described by Van Oosten (1929). Scales from both bluegills and largemouth bass were removed from an area located near the left posterior tip of the pectoral fin as suggested by Lagler (1956). Scales were placed in coin envelopes and later impressions were made on cellulose, acetate cards (7.5 cm x 12.5 cm x 0.05 mm) using a Carver Model C, hydraulic, laboratory heat press. The impressions were magnified 80 x on an Eberbach #2700 projector. Five scales from each fish were read twice for age. The ventral anterior-lateral radius was used to identify annuli due to distortion and irregularity of the scale edge at the anterior radius.

The characteristics used to identify annuli were incomplete circuli or "cutting over" and relative distance between circuli (Lagler 1956). Generally, the annuli became more difficult to distinguish as the age of the fish increased. On many bluegill scales, the first annulus was either difficult to locate or completely missing. First-year annuli may be absent or unrecognizable and young-of-the-year bluegill from a late summer spawning may grow little during autumn and winter and therefore do not form an annulus (Regier 1962). The location of the missing first annulus was estimated from scale measurements of age I and II bluegills.

The length-weight relationships for largemouth bass and bluegill were best described by the logarithmic equation (Ricker 1975; Tesch 1971):

$$\text{Log } W = b_1 \text{ Log } TL - b_0$$

where: TL = total length in millimeters,

W = total weight in grams, and

b_0, b_1 = empirical constants.

The body length-scale radius relationships for largemouth bass and bluegill were best described by a linear equation (Whitney and Carlander 1956; Regier 1962):

$$TL = b_1 \, SR + b_0$$

where: TL = total length in millimeters,

SR = scale radius x 80, and

b_0, b_1 = empirical constants.

The length-weight, body-scale regression equations were calculated and back-calculation of growth was accomplished with the computer program 'SHAD' on file at Utah State University Computer Center (Nelson 1976). Slopes of the body-scale radius and length-weight regressions were compared by the analysis of covariance (Snedecor and Cochran 1967).

The condition factor (K) was calculated by the formula (Hile 1936):

$$K_{(SL)} = \frac{W\ 10^5}{(SL)^3}$$

where: K = condition factor,

W = total weight in grams, and

SL = standard length in millimeters.

Reproduction

Fecundity

Female bluegills and largemouth bass were captured from gill nets and sampled from anglers' creels to determine fecundity during May and June of 1976. TL of each fish was measured to the nearest mm; weight was determined to the nearest 2 g. Ovaries were removed from each fish, placed in separate sampling bottles and preserved in 10% formalin.

In the laboratory, the ovaries were soaked in distilled water to remove the formalin and partly dried by blotting. Wet weights of ovaries were determined on a Fisher Model 200 tare balance after the ovarian tissue had been removed from the eggs. Fecundity was determined by the gravimetric method. A random ova sample approximating 10% total ovary weight was weighed to the nearest 0.1 g and counted. Only mature ova were counted as described by Kelley (1962) for largemouth bass and James (1946) for bluegills. Mature ova were characterized by a distinct, yellow globule which gave them a yellow, translucent appearance. Immature ova were characterized by their small size and transparent, white color. The rest of the ovary was weighed and fecundity calculated by direct proportion. The accuracy of the method was determined by total counts of all mature ova from three fish of both bluegill and largemouth bass.

Since only mature ova were counted to determine fecundity, an estimate of the proportion of the ovarian mass consisting of ovigerous lamellae and immature ova was made. All ovigerous lamellae and smaller, immature ova from ovaries of two bluegills and two largemouth bass were separated from mature ova and weighed to the nearest 0.1 g. The mean weight of immature ova and ovigerous lamellae from two fish of each species was determined. This mean weight value was deducted from the total ovary weight of each bluegill and largemouth bass from which fecundity for mature ova was estimated.

The TL-fecundity relationships for bluegills and largemouth bass were best described by the logarithmic equation (Quasim and Quyyum 1963; Bagenal 1967):

$$\text{Log } F = b_1 \text{ Log } TL - b_0$$

where: TL = total length in millimeters,

F = fecundity (mature eggs per female), and

b_0, b_1 = empirical constants.

The total weight-fecundity relationships for bluegills and largemouth bass were best described by the linear equation (Quasim and Quyyum 1963):

$$F = b_1 W + b_0$$

where: W = total weight of each fish in grams,

F = fecundity (mature eggs per female), and

b_0, b_1 = empirical constants.

The regression equations were fitted using the 'STAT PAC' programs available at Utah State University Computer Center.

Sexual maturity

Sexual maturity for male and female bluegills was determined from samples collected in May, June and July of 1976 and 1977, the period of peak spawning. Females were judged mature if ova were exuded from the vent or if large, yellow eggs were present in the ovary (James 1946). Males were considered mature if they emitted sperm when slight pressure was exerted externally on the abdomen or when the testes appeared enlarged and white (James 1946). Sexual maturity was determined both in the field and in the laboratory.

The maturity index or annual reproductive cycle was calculated for female bluegills in 1976 and 1977 and for male bluegills in 1977. Gonads (testes and ovaries) were collected from bluegills which were obtained biweekly, April through November, from gill and trammel nets and from anglers' creels. The gonads were weighed to the nearest 1 g in the field using a triple beam balance.

The maturity index was calculated by the formula:

$$MI = \frac{GW}{BW} \times 100$$

where: MI = maturity index,

GW = gonad weight,

BW = body weight, and

100 = gonad weight expressed as percent of body weight.

Fishery

Creel Census

An intensive, monthly, stratified, creel census program was conducted from March to October in 1975, 1976 and 1977, to estimate angling pressure, catch rates and total harvests. Each calendar month was segregated into four sampling strata (two weekday and two weekend strata). Scheduling included 40% of the available weekdays and 50% of the available weekends and holidays within each stratum. Each census day was subdivided in a.m. and p.m. periods of sunrise to 1300 and 1300 to sunset, respectively. Only one period was censused daily on a sampling day. Sampling dates and a.m. and p.m. periods were selected from a table of random numbers. Within each sampling period, instantaneous angler counts of shore and boat fishermen were conducted at two-hour intervals. Between count times, both shore and boat anglers were interviewed. The information collected from anglers included

(1) angler catch effort, (2) fish species composition of the harvest, (3) scales from fish species for age composition of the harvest, (4) TLs and total weights of fish species in the creel, and (5) sex ratios of fish in the creel. Priority on angler interviews was given to those fishermen who had completed fishing because data collection was then maximized.

Data collected from the creel census and instantaneous counts were expanded to monthly estimates of mean total angler hours and total harvest, stratified by weekday and weekend and shore and boat anglers (Appendix; Table 18). Statistical analysis of the data was made using the method of Neuhold and Lu (1956).

The total possible angling days per month were multiplied by the total length of the angling day in hours to obtain the total possible angling hours. Although the lake was open to fishing 24 hours per day, the length of day was defined as one-half hour prior to sunrise to one-half hour following sunset. This criteria was based on daily use patterns of anglers which indicated that most anglers fished only in daylight hours. The total number of anglers counted for the month was divided by the total number of counts to obtain the mean number of anglers per count. This value was then multiplied by the total possible angling hours in the month (Appendix; Table 18). Thus,

$$G = (F)(C)$$

where: G = mean total shore fishing hours,

F = mean number of shore anglers per count, and

C = total possible fishing hours.

The precision of the value for mean total shore fishing hours was determined by calculating the standard error of the mean from the variance of the mean number of shore fishermen per count:

$$S_F = \sqrt{\frac{S^2}{N}}$$

where: S_F = the standard error of the mean,

S^2 = the variance of the mean shore fishermen per count, and

N = number of shore counts for the period covered.

Once the standard error of the mean was calculated, the confidence interval of the fishermen per count could be estimated using a t-distribution:

$$F \pm (t.95, n-1)(S_F)$$

where: F = mean number of shore anglers per count, and

(t.95,n-1) = 95% of the "student's t" value,

and is expanded to

$$(F)(C) \pm (t.95, n-1)(S_F)(C)$$

where: (F)(C) = G = mean total shore angling hours, and

$t(.95, n-1)S_F$ = 95% of the "student's t" value.

The mean number of anglers per boat, determined from the creel check, was multiplied by the total angler hours to obtain the mean total boat angler hours (Appendix; Table 18):

$$I = (G)(F)(H)$$

where: I = mean total boat angler hours,

G = total possible fishing hours,

F = mean number of boats per count, and

H = mean anglers per boat.

The precision of the estimate was calculated by the formula:

$$S_I^2 = (I)^2 \left(\frac{S_F^2}{(F)^2} + \frac{S_H^2}{(H)^2} \pm \frac{2(S_F)(S_H)(T_{FH})^*}{FH} \right)$$

where: S_I^2 = the root mean square error of the combined mean,

I^2 = mean total boat angler hours squared,

S_F^2 = the root mean square error of the mean number of boat angler hours,

S_H^2 = the root mean square error of the mean rate of anglers per boat,

T_{FH} = coefficient between the numbers of boats and numbers of anglers per boat, and

thus, the standard error of the mean was

$$S_I = \sqrt{S_I^2}$$

where: S_I = standard error of the mean total boat angler hours.

Using the standard error of the mean, the confidence interval of the mean total boat angler hours could be estimated from the t-distribution:

$$I \pm (t.95, n-1)(S_I)$$

---

*If the correlation coefficient between the numbers of hours and numbers of fish was positive, this quantity was subtracted. If the correlation coefficient was negative, this quantity was added.

where: I = mean total boat angler hours,

$(t.95, n-1)$ = 95% of the "student's t" value, and

n = number of boat counts for the period covered.

The rate of success was determined from the creel check by interviews for the entire month by totaling the numbers of fish caught and dividing by the total hours required to catch the fish (Appendix; Table 18). This was described by the equation:

$$L = \frac{K}{J}$$

where: L = the mean rate of success,

K = the mean number of fish per angler, and

J = the mean number of hours per angler.

The precision of the estimate was calculated by the formula:

$$S_L^{\,2} = (L)^2 \left(\frac{S_K^{\,2}}{(K)^2} + \frac{S_J^{\,2}}{(J)^2} \pm \frac{2(S_K)(S_J)(T_{KJ})^*}{KJ} \right)$$

where: $S_L^{\,2}$ = the root mean square error of the combined mean,

L^2 = the mean rate of success squared,

$S_K^{\,2}$ = the variance of the mean number of fish per angler divided by the number of interviews (mean root square error for fish),

$S_J^{\,2}$ = the variance of the mean number of hours per angler divided by the number of interviews (mean root square error of hours),

T_{KJ} = correlation coefficient between the numbers of hours and numbers of fish, and

---

*Ibid.

thus, the standard error of the mean was

$$S_L = \sqrt{S_L^{\ 2}}$$

where: S_L = standard error of the mean rate of success.

The confidence interval of the mean rate of success could be estimated using the t-distribution and standard error of the mean:

$$L \pm t(.95, n-1)\ (S_L)$$

where: t(.95,n-1) = 95% of the "student's t" value.

The total harvest was calculated by multiplying the mean total angler hours by the mean rate of success (Appendix; Table 18):

$$M = (I)(L)$$

where: M = total estimated harvest,

I = the mean total angler hours, and

L = the mean rate of success.

The precision of the total harvest estimate was calculated by the following formula:

$$S_P^{\ 2} = (M)^2 \left(\frac{S_F^{\ 2}}{(I)^2} + \frac{(S_L)^2}{(L)^2} \right) \text{for the shore harvest,}$$

and,

$$S_P^{\ 2} = (M)^2 \left(\frac{S_I^{\ 2}}{(I)^2} + \frac{(S_L)^2}{(L)^2} \right) \text{for the boat harvest,}$$

where: S_P^2 = the root mean square error of the combined estimate,

S_F^2 = the variance of the mean number of shore anglers per count,

S_I^2 = the root mean square error of the combined means of boat hours,

S_L^2 = the standard error of the mean rate of success squared (combined mean root square error), and

thus, the standard error of the root mean square error of the combined estimate was

$$S_I = \sqrt{S_I^2}$$

Again, the standard error was used to calculate the confidence interval using a t-distribution:

$$M \pm (t.95, n-1)\ (S_I)$$

where: (t.95,n-1) = 95% of the "student's t" value.

The angler day use value was calculated by dividing the mean total angler hours by the mean number of hours needed to complete a fishing trip, which was determined from the creel check (Appendix; Table 18) and described by the formula:

$$O = \frac{I}{N}$$

where: O = angler day use,

I = mean total angler hours, and

N = mean number per completed angling trip.

During the creel check, both bluegill and largemouth bass were measured to TL (nearest mm) and total weight (nearest 2 g). All the fish from a creel were counted and measured whenever time allowed and fishermen cooperated. During May and June of 1976, scale samples were obtained from creeled bluegill and largemouth bass for age analysis. Estimates of the total annual mortality rate due to fishing and natural causes were determined from these aged fish by the use of Baranov's catch curve described by Ricker (1975). The log frequency was plotted against age and the slope of the line was multiplied by 2.303 which yielded the total instantaneous rate of mortality. Survival was calculated from the equation (Ricker 1975):

$$S = e^{-z}$$

where: S = the total annual survival rate,

e = a constant, 2.7182818, and

-z = the instantaneous mortality rate.

Mortality rate, the complement of survival rate, was calculated by:

$$A = 1 - S$$

where: A = the total annual mortality rate, and

S = the total annual survival rate.

Creeled bluegills were sexed by the method recommended by Brauhn (1972) and McComish (1968). Largemouth bass were sexed by internal inspection in the nonspawning season and externally by the method recommended by Parker (1971) in the spawning season. The 95% confidence interval for proportion of males and females was calculated by the formula (Simpson et al. 1960):

$$\frac{f_x}{N} \pm t(.95,n-1) \sqrt{\frac{\frac{f_x}{N} \quad \frac{1-f_x}{N}}{N}}$$

where: N = the total number of males and females observed,

f_x = the total number of males or females observed, and

t(.95,n-1) = 95% of the "student's t" value.

A statistically significant number of males or females were observed in the catch only when the confidence interval (p = 0.05) did not include the hypothetical value of 0.50, the normal Mendalian sex ratio.

Hooking Mortality

Bluegills were captured with conventional spinning tackle in June 1977 to determine the fate of caught and released fish. Fish were captured with various sizes of hooks (number 4 R, 6 R, 8 R and 10 R [R = regular shanks]) and artificial jigs (number 6). Earthworms were used for bait. Fish captured in trammel nets that were checked once every hour were used as the control. Thirty fish were caught on each of the hook sizes except 60 bluegills which were caught on hook size 8 R. In part of the experiment, the hook was removed carefully with a hook remover to minimize mortality; and in another part, deeply embedded hooks (number 8 regular shank) were left in place in 30 bluegills by cutting the line. TL (nearest mm) and total weight (nearest 2 g) were determined for each fish. Fish captured on each hook size were held in separate live cages to separate individual treatments. Initial mortality was determined during the first 24 hours and delayed mortality was followed to 72 hours. All dead fish were autopsied to determine the anatomical location of hook penetration.

Anglers were asked to complete a card questionnaire as they fished to determine the number and size of bluegills released, the size of hook(s) used, the type of terminal gear(s) used (i.e., bait, spinners, jig, fly), the method of hook removal and the total hours fished (Appendix; Figure 43).

The mean number of bluegills released per hour after capture was calculated from the card questionnaire by dividing the actual number of bluegills released by anglers by the actual angler hours. The monthly mean projected number of bluegills released by anglers was calculated by multiplying the mean number of bluegills released per hour by the mean total angler hours from the expanded monthly creel census.

By multiplying the total mortality by hook size from released fish from the June experiment by the projected number of released bluegills by hook size from the questionnaire, an estimate was made of the total number of bluegills lost after being caught and released by anglers. Since anglers did not have an opportunity to weigh fish, an estimate of the mean monthly weight loss caused by angling was determined from the monthly mean length of bluegills released converted to weight by the calculated length-weight relationship (sexes combined).

Population Sampling

Sampling of the population was conducted in August 1976, May and August 1977 and June 1978 to obtain population age structure data. Three 0.405 ha areas were encircled with block-off netting to inhibit the migration of fish in and out of the sample plot. At least one each of a cove, an open shoreline and midwater station was selected for each sampling in an attempt to sample representatives of each habitat type. Complete eradication of the population in the sample plot was attempted by the use of 5.0% emulsified rotenone at a recommended concentration of 0.5 to 1.0 mg/l (Surber 1959). Rotenone was premixed in a 30 gal (114 l) barrel and application was made with a boat bailer attached to the shaft housing of an outboard motor.

All dead fish were collected with aquaria and dip nets as they surfaced. Age groups I and older fish were measured to TLs, FLs and SLs (nearest mm) and total weight (nearest 2 g). For young-of-the-year fish, only several hundred of the thousands collected were measured to the above parameters. The remainder of the young-of-the-year fish were weighed and total numbers estimated by direct proportion. Scale samples were collected from all dead fish to determine age analysis of the sampled population.

Estimation of the natural mortality for age classes 0-I and qualitative survivorship curves were generated from the aged fish collected with rotenone. The natural mortality was estimated from catch curves in the same manner as the total annual mortality following the method of Ricker (1975) (see page 25). Since age classes 0 through I bluegills were not vulnerable to the creel, it was possible to partition them from older age classes to estimate the natural mortality.

Overwinter Mortality

The extent and magnitude of winter-killed fish were estimated by counting dead fish along shoreline transects in March and April of

1976, 1977 and 1978 following ice-out. Annual shoreline transect counts were conducted along (1) the 1.8 km east shoreline paralleling State Highway 88; (2) the north shoreline commencing at the north boat ramp parking lot and extending approximately 0.40 km eastward; and (3) the 1.6 km south shoreline extending from the south outlet canal eastward to State Highway 88.

Winter-killed fish were measured to TL only, as their deteriorated condition precluded any measurement of weight. Scale samples were obtained from a random portion of the dead fish along the shoreline to determine the age structure of this overwinter mortality.

RESULTS AND DISCUSSION

Biological, Physical and Chemical Parameters

Biological

Samplings conducted in August and October 1975 indicated a rather diverse algal community—more diverse, in fact, than other lakes in the Intermountain West (Merritt et al. 1976) (Appendix; Tables 19, 20, 21 and 22). Diatoms in bottom sediments obtained in August 1976 showed a high diversity ($\bar{d}$ = 3.0895) as did green and blue-green plankton algae (Merritt et al. 1976).

Physical

Surface water fluctuations

The rate of monthly fluctuation of the privately owned Pelican Lake was dictated largely by the agricultural demands of water users, although the large amount of surface water lent itself to considerable evaporative loss. Water drawdown commenced in mid-April to the first of May and continued until late October and November when agricultural demand declined, and the lake was filled by the Colorado Park Canal (Appendix; Figure 44).

Historically, the lake level has never dropped to the 493 ha m conservation pool. Water levels in 1977 were much lower than in 1976, due to the low amount of precipitation in 1977. The water level came 0.20 m from the outlet pipe on the concrete outlet structure in

September and October 1977, approximately 60 ha m from the conservation pool. Local farmers believed the lake was lower in 1977 than it had been for nearly 15 years.

Surface water temperatures

Water temperatures increased rapidly following ice-out, but intermittent cold periods in April 1975, June 1976 and May 1977 interrupted this trend (Appendix; Figure 45). Water temperatures peaked in late July and August and began to decline in late August. The shallow nature of the lake caused wide fluctuations in surface water temperatures which corresponded to air temperature fluctuations.

Temperature profiles

The shallow nature of this desert lake (maximum depth = 4.88 m), the absence of any substantial windbreaks and the extensive length of the shoreline do not allow strong or extended water temperature stratification. Water temperature profiles in the summer months of 1976 indicated a rather weak temperature stratification (Appendix; Table 23).

The classical inverse temperature stratification occurred in the ice-covered months of 1977 and 1978 (Appendix; Tables 24, 25, 27 and 28). Temperature profiles on March 15, 1977, displayed a rather peculiar stratification (Appendix; Table 26). At this time, colder, denser water laid immediately beneath the ice sheet, with the less dense, warmer water at the bottom. Hutchinson (1957) explained that when melt-water flows under clear ice, particularly in lakes with hard water such as that of Pelican Lake (220 to 300 mg/l $CaCO_3$ total hardness), the difference in density between the lake water and very dilute well water may permit water temperatures up to 7.5 C under the ice without disturbing the stable density gradient. Pelican Lake, on March 15, 1977, was receiving water inflow from the Colorado Park Canal.

Ice depth, snow depth

Ice depth between 1976 and 1977 did not vary considerably, but monthly increases in ice depth were noted from January to March in both years. The mean ice depth on January 8 and 9, 1977, was 0.288 m, increased to 0.387 m on February 11 and decreased to 0.270 m on March 15 (Appendix; Tables 24, 25 and 26, respectively). Mean ice depth on January 7 and 8, 1978, was 0.178 m, increased to 0.324 m on February 11 and 12 and further increased to 0.348 m on March 11 and 12 (Appendix; Tables 27, 28 and 29, respectively).

Snow depths in the winter months of 1978 were slightly greater than the same months in 1977. The mean snow depth on January 8 and 9, 1977, was 0.031 m as compared to a threefold increase to 0.089 m on February 12, but decreased to 0.012 m on March 15 (Appendix; Tables 24, 25 and 26, respectively). The mean snow depth on January 7 and 8, 1978, was 0.048 m, increased to 0.082 m on February 11 and 12 and decreased to 0.260 m on March 11 and 12, 1978 (Appendix; Tables 27, 28 and 29, respectively).

Ice and/or snow on the surface of a lake may produce changes in the limnological conditions of that lake. By interfering with gaseous exchange and photosynthesis, the cover may have a great effect on the dissolved oxygen balance. Varying depths of ice and/or snow cause a reduction of light reaching photosynthesizing, oxygen-producing, submergent vegetation. Without oxygen replenishment, respiration and consumption of oxygen caused by decomposition of organic material results in reduced oxygen levels in the water column.

Ice was typically opaque with numerous air pockets throughout the three sampling periods in 1977 and 1978. Snow was typically crisp, dry and crusted. In March of 1977 and 1978, ice was covered by 0.250 to 0.102 m of top slush. Percentage light transmission through various ice and snow depths has been determined for numerous ice conditions in Wisconsin lakes (Greenbank 1945). However, it has been difficult to generalize on the varying qualities of ice and snow and heterogenous properties of light. Percentage transmission values through mediums of ice and snow are a function of the quality, conditions and properties of each and probably are not predictable from one lake to another.

German researchers reported the light transmission through 0.025 m of clear ice to be about 84 to 87% and through 0.040 m of "Schneeis" to about 45%. Croxton et al. (1937) gave: 0.102 m, 86%; 0.152 m, 66%; and 0.346 m, 33% transmission values, respectively. Zinn and Ifft (1941) reported only one measurement through 0.117 m of ice, with a "slush cover," in which approximately 65% of the incident light penetrated. Chandler (1942) found 58% transmission through 0.400 m of ice.

Percentage transmission of light through various snow conditions has been reported for Wisconsin lakes by Greenbank (1945). German scientists recorded 13% transmission for 0.10 m of snow and 0.6% for 0.50 m of snow. Clean and fresh snow allows the greatest penetration, clean but wet snow, the next greatest and granular snow the least (Greenbank 1945).

Although no measurements of light transmission through the ice were recorded during this study, it was apparent that ice and snow depths could have contributed substantially to the deterioration of water quality during the winter months.

Chemical

Total alkalinity

Total alkalinity (as $CaCO_3$) ranged from 135 mg/l (this study) on August 23, 1976 (Appendix; Table 23) to 189 mg/l on September 8, 1976 (Appendix; Table 17). These total alkalinity values place the lake at the upper limit of alkalinity (as $CaCO_3$) values. The bicarbonate anion concentration was determined to be 231 mg/l on September 8, 1976 (Appendix; Table 17).

Total hardness

Total hardness (as $CaCO_3$) ranged from 270 mg/l on August 23, 1976, to 330 mg/l on July 27, 1976 (Appendix; Table 23). Calcium and magnesium cation concentrations were determined to be 23 and 55 mg/l, respectively (Appendix; Table 17).

Hydrogen-ion concentration (pH)

The high buffering capacity of the water, as indicated by the alkalinity, produced small fluctuations in the pH values. Hydrogen-ion values were consistently near 9.2 to 9.5 in the summer months in 1976 but decreased to as low as 7.1 under the ice in February 1977 at station F-3 (Appendix; Table 25). Hydrogen-ion concentrations were as low as 7.7 on March 25 and 26, 1978. Values of pH could be used as a rough index to conditions under the ice; pH values below 7.0 being the result of severe decomposition in low buffered waters (Greenbank 1945).

Hydrogen sulfide

The hydrogen sulfide reading on February 11, 1977, at station F-3 near the lake's southern outlet, was 0.8 mg/l; while at station F-9, located near the northwestern inlet, the hydrogen sulfide reading was much higher at 2.5 mg/l (Appendix; Table 25) (Figure 3). "Rotten egg" odor was also noted when the ice cap was broken in these areas and dissolved oxygen was absent. Hydrogen sulfide concentrations as high as 5.0 mg/l were reported on January 23, 1968, February 5, 1968 and February 14, 1968, at depths of 2.4, 1.8 and 2.1 m below the ice, respectively (Utah DWR 1968).

Hydrogen sulfide concentrations of 0.5 mg/l in January 1978 were recorded at 1.5 m below the ice for station J-5 (Appendix; Table 27) (Figure 4). Dissolved oxygen was absent at this depth, also. An additional buildup of H_2S was detected in February 1978. Station F-4, at 2.5 m below the ice, yielded a 1.0 mg/l reading; whereas, station F-5 (3.5 m below the ice) yielded a 0.4 mg/l value (Appendix; Table 28) (Figure 4). The values of hydrogen sulfide were highest of the three months on March 11 and 12, 1978. Station M-8 (3.0 m below the ice) yielded 2.5 mg/l; station M-4 (4.0 m below the ice) yielded 2.0 mg/l; and station M-3 (4.0 m below the ice) yielded 1.5 mg/l (Appendix; Table 29) (Figure 4).

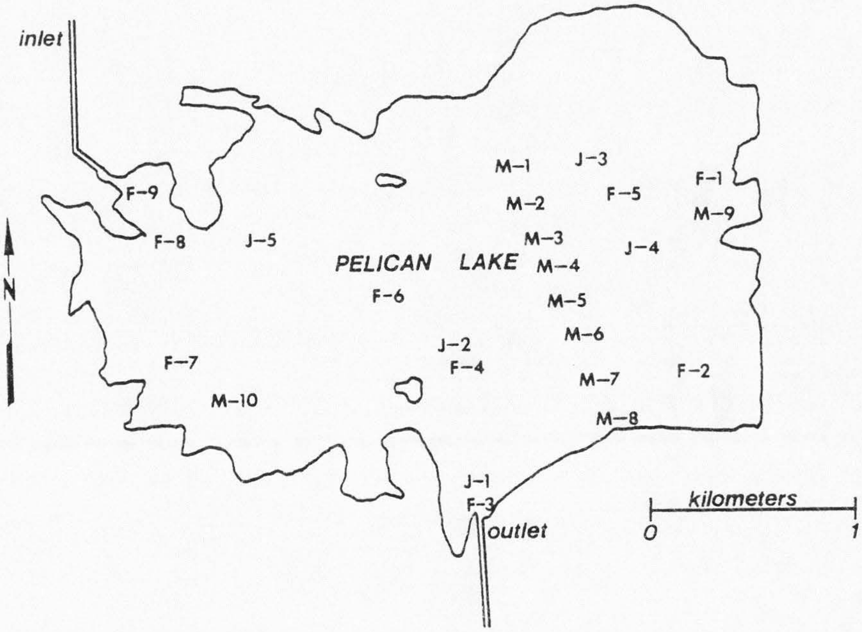


Figure 3. Relative location of winter water quality samplings, 1977, at Pelican Lake, Uintah County, Utah. (Note: J = January 8 and 9; F = February 12; M = March 15; numbers following letters indicate sampling station number.)

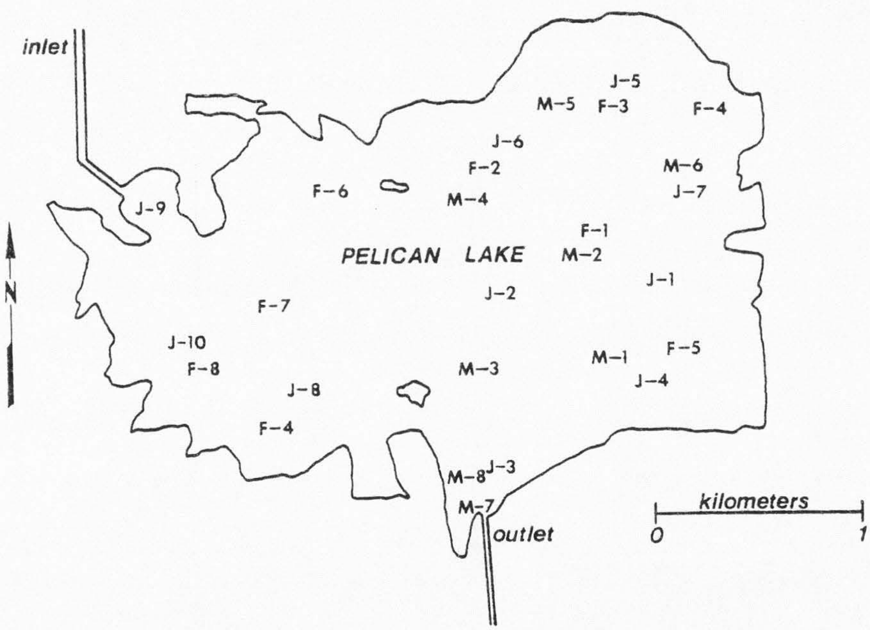


Figure 4. Relative location of winter water quality samplings, 1978, at Pelican Lake, Uintah County, Utah. (Note: J = January 7 and 8; F = February 11 and 12; M = March 11 and 12; numbers following letters indicate sampling station number.)

Ice-out water quality analyses indicated trace amounts of H_2S present (Appendix; Table 30). Hydrogen sulfide was detected in 7 of the 18 stations on March 25 and 26, 1978 (Figure 5). The greatest concentration detected was 0.044 mg/l at 2.8 m of station M-17. A noticeable concentration (0.026 mg/l) was found at 4.0 m of station M-17. The detected values of H_2S at this sampling date were found at the surface (stations M-7, M-8), midwater (stations M-3, M-10) and at the bottom depths (stations M-3, M-4, M-6, M-7, M-17), indicating no apparent large concentrations at a particular depth.

Hydrogen sulfide is highly toxic to fish populations and occurs naturally under anaerobic conditions at levels which can be unfavorable to fish production and survival (Smith et al. 1976). Acutely toxic (96-h LC 50) concentrations of hydrogen sulfide were found to vary widely among life history stages of bluegills (Smith et al. 1976). The most sensitive stage was the 35-day-old fry, which was approximately twice as sensitive as eggs and four times as sensitive as juveniles and adults (Smith et al. 1976). The LC 50 by life stage for bluegill tested in hydrogen sulfide was egg: 0.0190 mg/l (72 hours); 35-day-old fry: 0.0131 mg/l (96 hours); juveniles: 0.0473 mg/l (96 hours); and adults: 0.0448 mg/l (96 hours) (Smith et al. 1976).

Dissolved oxygen

Ice-covered, shallow, eutrophic lakes in temperate zones are frequently but unpredictably subject to oxygen deficiencies which can and do cause massive winterkills of fish. The greatest and most sudden fluctuations of dissolved oxygen occur in shallow, extremely eutrophic

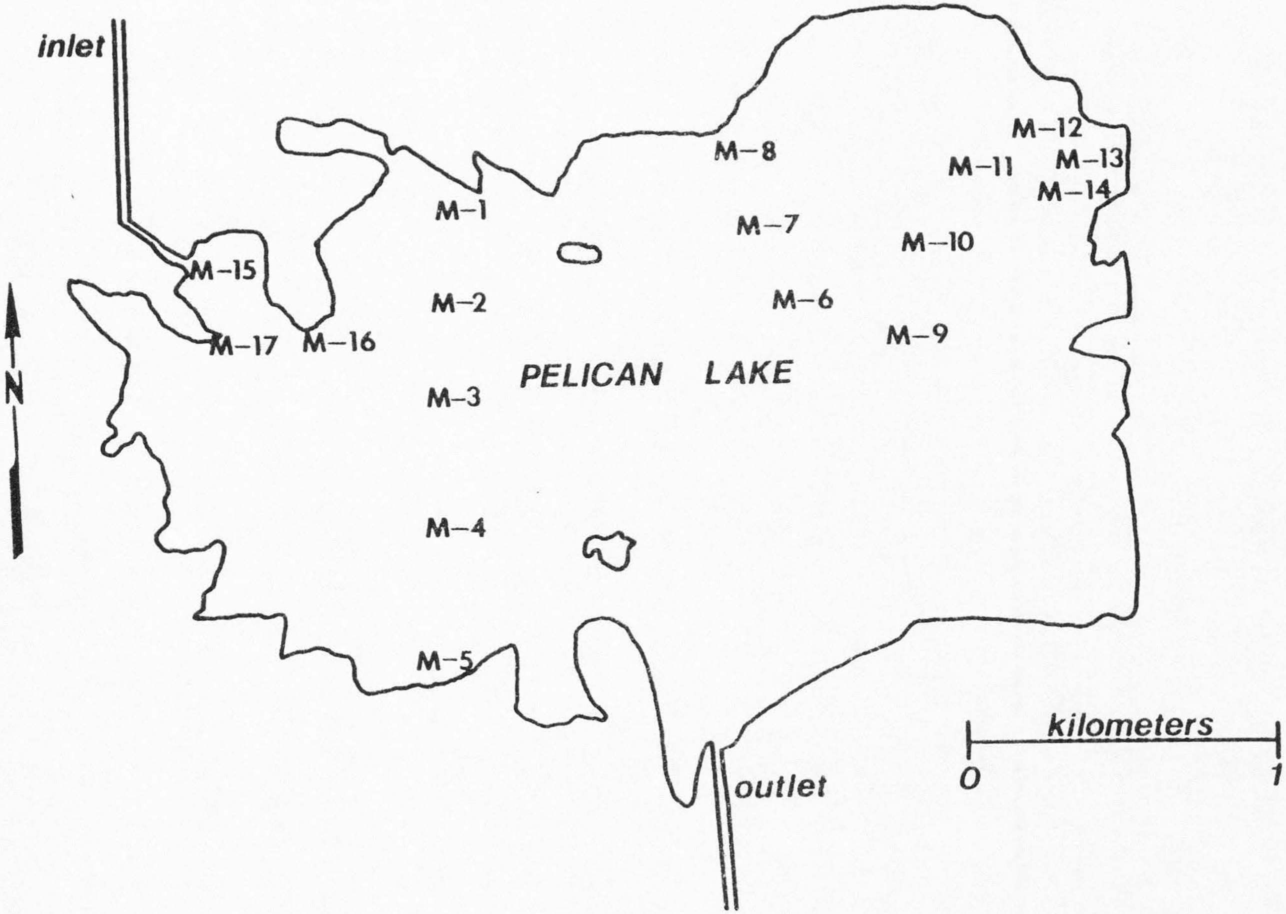


Figure 5. Relative location of water quality samplings at ice-out on March 25 and 26, 1978, at Pelican Lake, Uintah County, Utah. (Note: M = March; numbers following letters indicate sampling station number.)

lakes. The supply of oxygen for fish respiration under ice is often dependent upon the photosynthetic activity of plants, both macrophytes and phytoplankton (Greenbank 1945; Bennett 1948). However, when ice covers a lake, oxygen consumption can exceed oxygen production because ice and snow cover retard light transmission which, in turn, may stop photosynthesis. Ice cover also prevents reaeration by eliminating gaseous exchange with the atmosphere and reducing wind-produced water movements. Dissolved oxygen is further decreased by the aerobic decomposition of suspended and dissolved organic matter and respiration of aquatic organisms (Bennett 1948; Birge and Juday 1911, 1926; Zobell 1940). Concomitant with this decrease in dissolved oxygen are increases in the concentrations of toxic respiratory and decomposition products; i.e., hydrogen sulfide, ammonia and carbon dioxide. However, inadequate dissolved oxygen is considered the principal cause of winter fish mortality (Greenbank 1945; Scidmore 1957; Johnson 1965; Bennett 1948). Winterkill seldom produces complete mortality in a fish population (Moore 1942; Greenbank 1945; Moorman 1957; Bennett 1948; Johnson 1965).

Pelican Lake is a natural, shallow, eutrophic reservoir with an average depth at full capacity of 2.4 m. Investigators have perennially noted dead fish at ice-out. The lake abounds with macrophytes and algae to the extent that from late July to October the lake is "weed choked." The presence of this large vegetal biomass may have a significant influence on the dissolved oxygen regimes in the lake, particularly under the ice in winter. Water quality samplings were conducted during the ice-covered months to determine if depletion of dissolved oxygen did indeed occur in Pelican Lake. Dissolved oxygen concentrations under the ice have been suggested as an index for predicting the suitability of a lake to support fish populations (Greenbank 1945).

Water quality sampling on January 8 and 9, 1977 (Appendix; Table 24) did not reveal low dissolved oxygen levels and closely resembled readings obtained in the summer of 1976 (Appendix; Table 23). Dissolved oxygen readings during that summer indicated no significant stratification with depth and relatively high dissolved oxygen levels (Appendix; Table 23). In February, deterioration and stratification of dissolved oxygen was noted. Dissolved oxygen levels below 1.3 mg/l were found at stations F-5, F-6, F-7 and F-8 (Appendix; Table 25) (Figure 6). At the same time, however, dissolved oxygen readings immediately under the ice sheet and at 1.0 m depths were higher (Figure 6). Data collected during January and February closely agreed with that collected during earlier studies (Utah DWR 1968, 1969).

Dissolved oxygen readings on March 15, 1977 at all stations approached "normal" with the lowest dissolved oxygen reading being 6.2 mg/l immediately under the ice sheet at station M-5 (Appendix; Table 26). Inflow of water from the Colorado Park Canal and open areas along the north and south shoreline may have accounted for the increased dissolved oxygen levels. Although dissolved oxygen readings were higher in March than February in 1977, 33 days elapsed between the two sampling dates, and the ultimate degree of reduction in dissolved oxygen and increase in H_2S during that period is unknown.

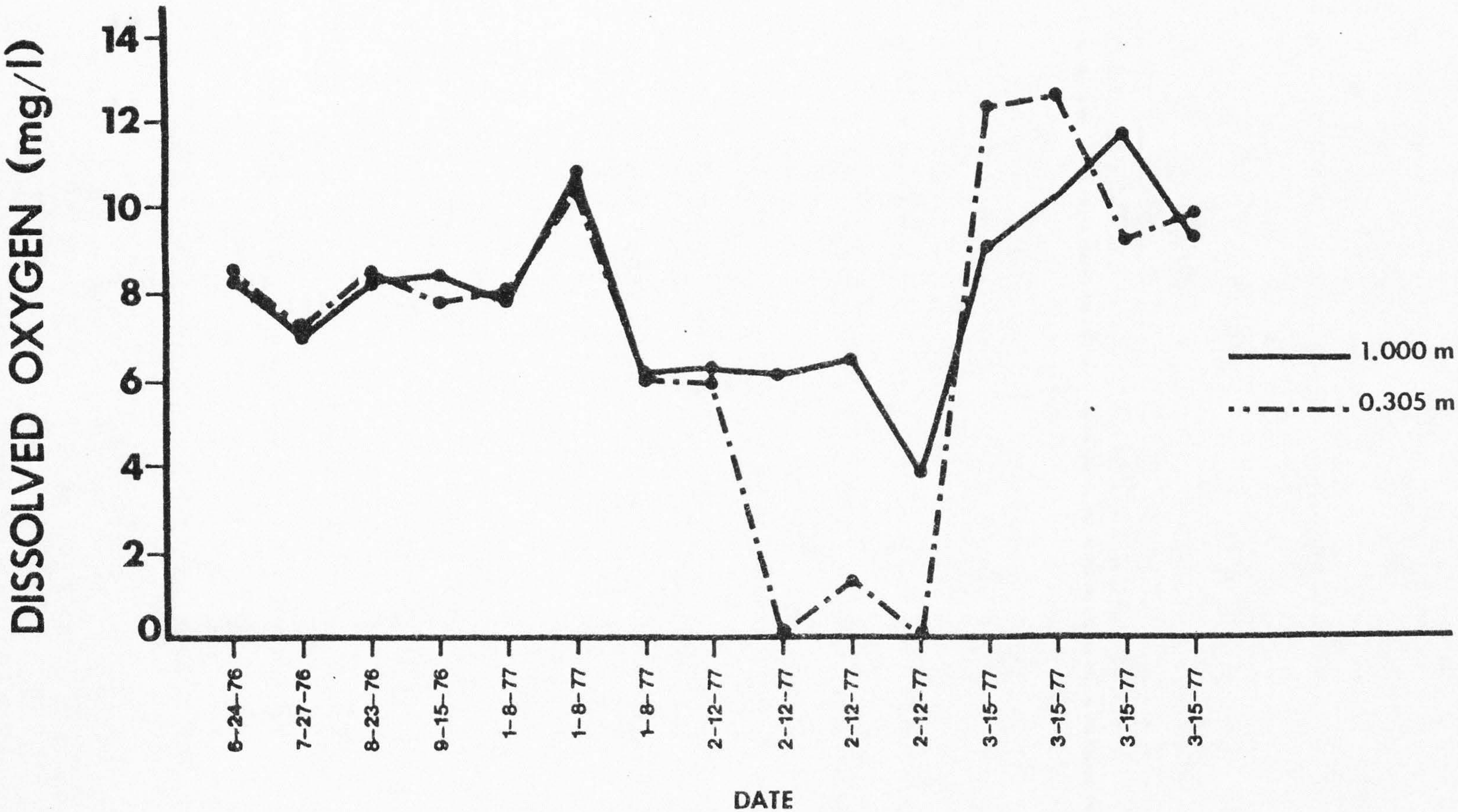


Figure 6. Monthly dissolved oxygen (mg/l) sampling at 0.305 m above the substratum and 1.000 m below the ice sheet at various sampling stations, June to September 1976 and January to March 1977, at Pelican Lake, Uintah County, Utah.

In 1978, ice and snow depths were similar to those in 1977, but the water level in January was 20% lower than that in January 1977. Deterioration and stratification of dissolved oxygen occurred on January 7 and 8 in 1978 (Appendix; Table 27). Anoxic conditions were found at 1.5 m at station J-5 and dissolved oxygen readings near the substratum at various other stations (J-1, J-7 and J-10) were well below 5.0 mg/l (Appendix; Table 27). A strong dissolved oxygen stratification occurred in February 1978. At this time, dissolved oxygen was less than 0.6 mg/l at 8 of 9 bottom stations (Appendix; Table 28), although dissolved oxygen was greater than 6.0 mg/l, 1.0 m below the ice sheet (Figure 7). Concurrently, anglers found greater success fishing in the upper part of the water column than near the bottom. This further indicated that suitable conditions for fish were present to approximately 2.0 m below the ice.

Dissolved oxygen readings on March 11 and 12, 1978, were critical below 2.0 m at all stations, but adequate amounts were present in the top 2.0 m (Appendix; Table 29). Water quality analyses at ice-out on March 25 and 26 in 1978 indicated that dissolved oxygen was still near or below critical levels at several bottom stations (Appendix; Table 30). Stratification of dissolved oxygen during the March 25 and 26 sampling was not as strong as that in the completely ice-covered months. This may have been due to reoxygenation by wind action and water inflow through the inlet canal.

Fish adapt, behaviorally and physiologically, to low oxygen levels by locating higher oxygen concentrations in the water column (Petrosky and Magnuson 1973). Although fish cannot sense a dissolved oxygen

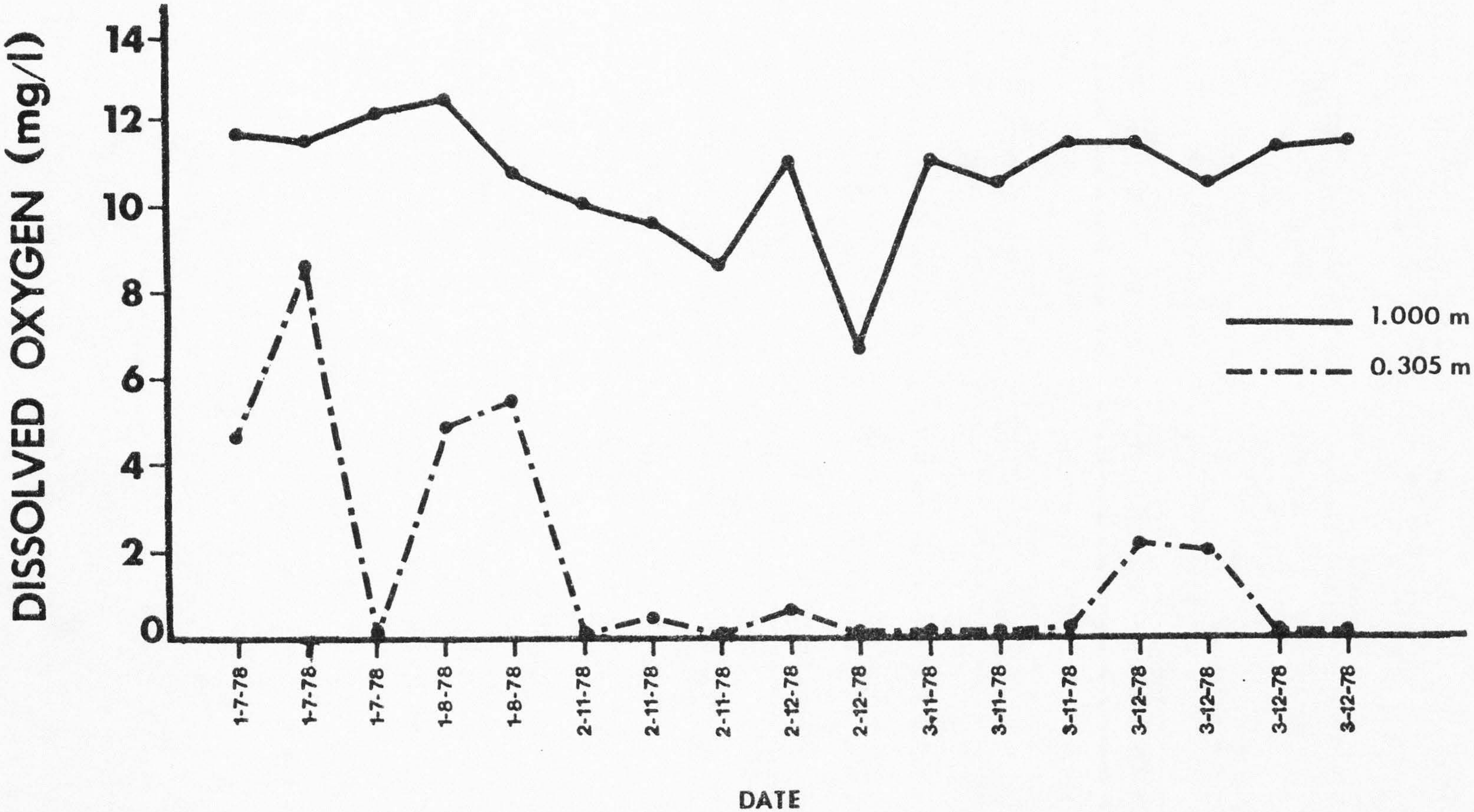


Figure 7. Monthly dissolved oxygen (mg/l) sampling at 0.305 m above the substratum and 1.000 m below the ice sheet at various sampling stations, January to March 1978, at Pelican Lake, Uintah County, Utah.

gradient, they respond initially to respiratory distress with upward movement and increased locomotive activity which facilitates their locating well oxygenated waters (Petrosky and Magnuson 1973). Dissolved oxygen tolerance thresholds for largemouth bass and bluegill have been estimated to be 0.6 mg/l (Cooper and Washburn 1949). Petrosky and Magnuson (1973) reported 0.5 mg/l as the critical low dissolved oxygen limit for the same species. In Pelican Lake, dissolved oxygen concentrations were near or below critical levels during the ice-covered months in both 1977 and 1978 at depths 2.0 m below the ice sheet to the substratum. These conditions would be conducive to fish winterkill and may explain fish mortalities reported historically.

Fish Biology

Bluegill (*Lepomis macrochirus* Rafinesque)

Age and growth

Length conversion factors. Age and growth comparisons are commonly made with various bluegill populations. However, since many investigators have reported their results using other length measurements, equations were calculated to convert TL into SL and FL. The conversion factor computed to predict SL from TL was calculated as a linear regression equation:

$$SL = 0.795TL - 0.487,$$

was significant ($F = 280,180$, $p < 0.0005$, $r = 0.99$, 272 df) (Figure 8).

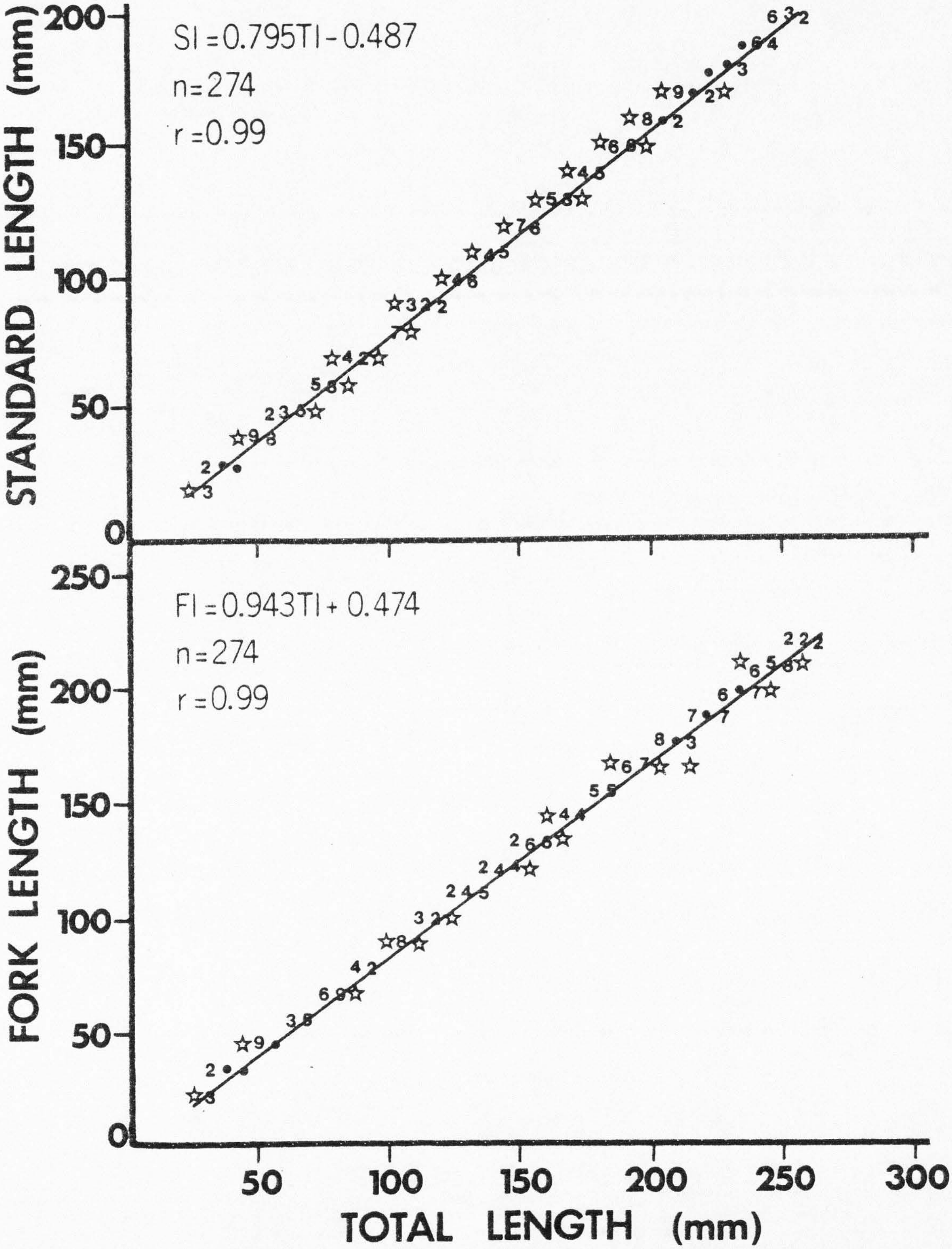


Figure 8. Regression of SL and FL compared with TL for bluegills from Pelican Lake, Uintah County, Utah, 1976 and 1977. (Note: numbers refer to overlapping points; the stars refer to 10 or more overlapping points.)

The linear regression of FL on TL was significant ($F = 288{,}195$, $p < 0.0005$, $r = 0.99$, 272 df) (Figure 8) and was described by the equation:

$$FL = 0.943TL + 0.474.$$

Length-weight relationship. The relation between length and weight,

$$\text{Log } W = 3.62 \text{ Log } TL - 5.97,$$

was significant for male bluegills ($F = 13{,}372$, $p < 0.0005$, $r = 0.97$, 737 df). The relation between length and weight,

$$\text{Log } W = 3.54 \text{ Log } TL - 5.81,$$

was also significant for female bluegills ($F = 13{,}928$, $p < 0.0005$, $r = 0.97$, 731 df), but there was no significant difference in this relation between sexes (Figure 9).

Body length-scale radius relationship. The body length-scale radius relationship was significant for both male ($F = 23{,}136$, $p < 0.0005$, $r = 0.98$, 737 df) and female ($F = 22{,}880$, $p < 0.0005$, $r = 0.98$, 731 df) bluegills, but there was no significant difference between sexes for TL-scale radius relationships (Figure 10).

Examination of young-of-the-year bluegills with the aid of a binocular microscope revealed that scales first appeared on the caudal peduncle at 12 mm TL and complete squamation (100% of fish) was attained at 19 mm TL (Appendix; Table 31). These empirical data closely compared with the y-intercept value of the TL-SR regression equations:

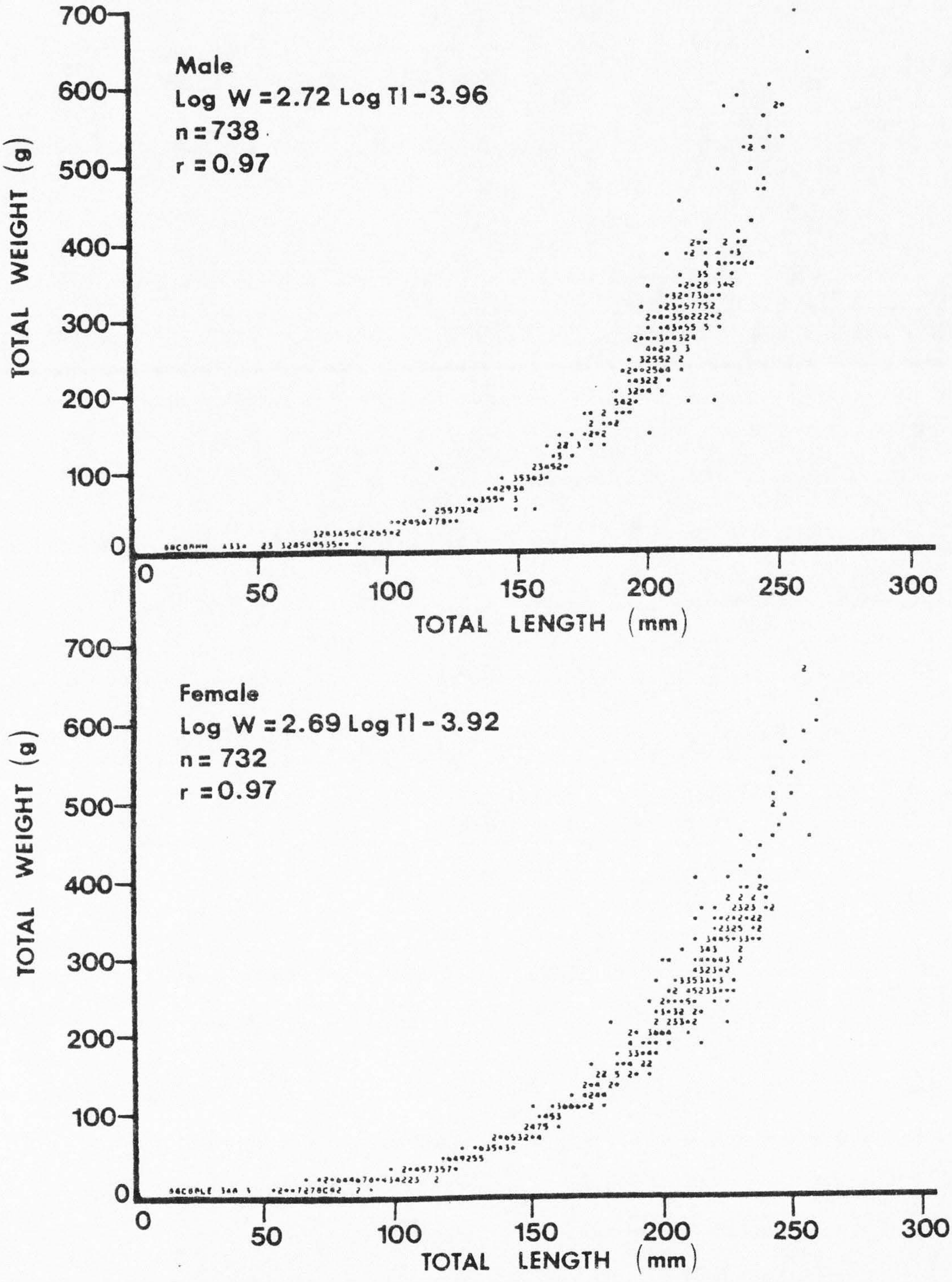


Figure 9. Length-weight relationship for male and female bluegills from Pelican Lake, Uintah County, Utah, 1976 and 1977. (Note: numbers refer to overlapping points; the letters refer to 10 or more overlapping points, A = 10, B = 11, C = 12, etc.)

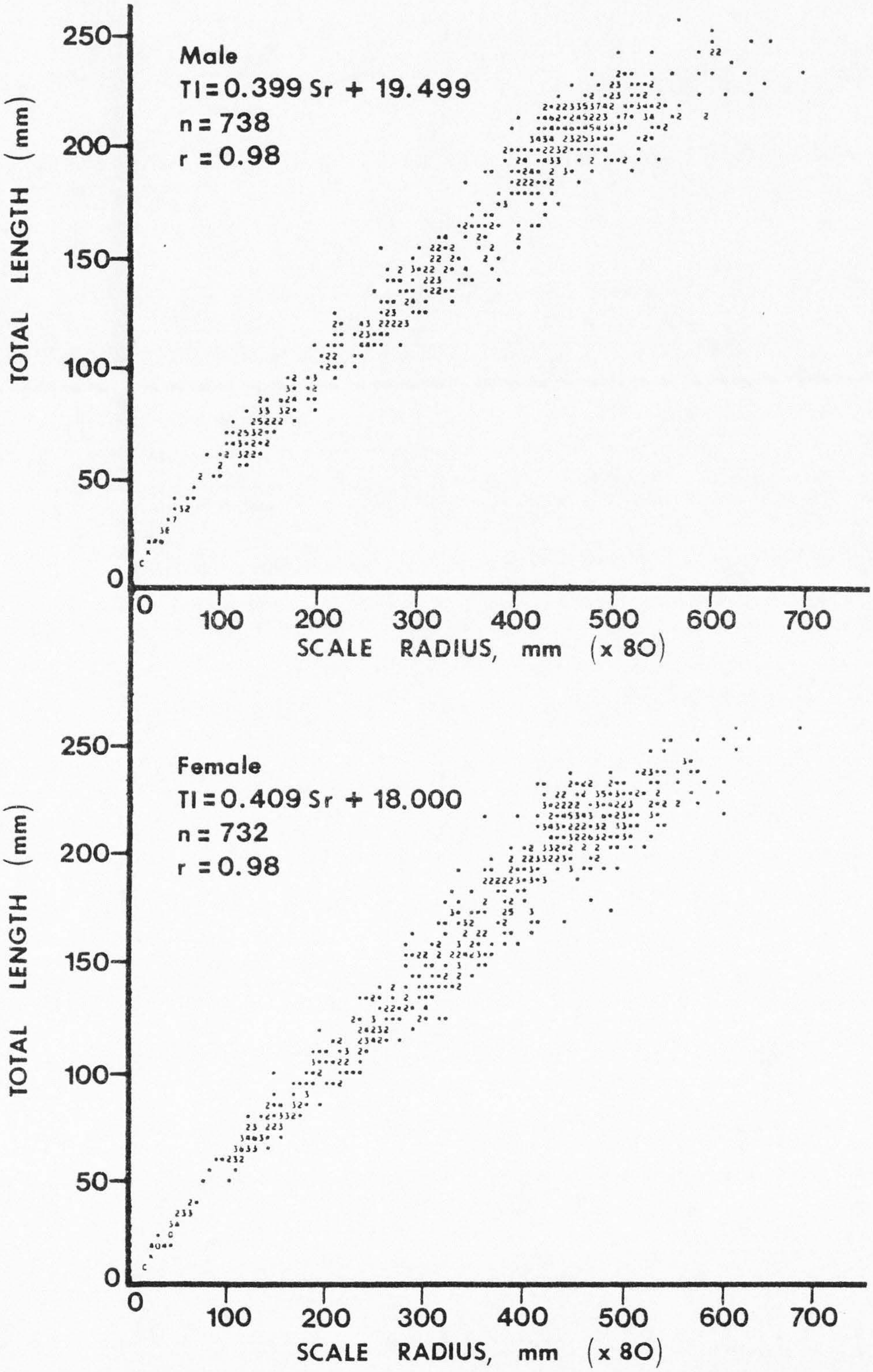


Figure 10. Relation between scale radius and total length for male and female bluegills from Pelican Lake, Uintah County, Utah, 1976 and 1977. (Note: numbers refer to overlapping points; the letters refer to 10 or more overlapping points, A = 10, B = 11, C = 12, etc.)

$$TL = 0.399\ SR + 19.499\ \text{(males)},$$

$$TL = 0.401\ SR + 17.988\ \text{(females)}.$$

Back-calculation of growth. The scale method has been validated for age and growth determination for bluegills (Regier 1962). The use of the scale method for age determination and back-calculation of growth for bluegills was considered valid by the following criteria (Tesch 1971; Everhart et al. 1975; Hile 1941; Van Oosten 1929):

1. There was an increase in the number of annuli with an increase in the length of fish.

2. Scale growth was proportional to body growth.

3. The annuli are formed once yearly and at about the same time each year.

4. Scales remained constant in number and identity throughout the life of the fish.

Mean back-calculated TLs for male bluegills from the first to eighth annulus were 55, 114, 169, 197, 214, 233, 248 and 260 mm; whereas, female bluegills grew slightly slower (Table 1). Mean back-calculated TLs for female bluegills from the first to ninth annulus were 54, 110, 163, 192, 208, 227, 243, 253 and 259 mm (Table 1). The greatest amount of growth (64%) occurred in the first three years of life, and annual growth increments decreased markedly with age after age III (Figure 11). The oldest fish observed in the study was a nine-year-old female collected from the creel in 1976; the longest was 260 mm TL; and the heaviest was 899 g total weight.

Table 1. Mean calculated total lengths at the end of each year of life for bluegills from Pelican Lake, Uintah County, Utah, 1976 and 1977.

Age Group	Number of Fish	Mean Calculated Total Length At Each Annulus (mm)								
		1	2	3	4	5	6	7	8	9
						MALES				
I	163	53.2								
		(15.4)[a]								
II	117	55.5	109.6							
		(10.6)	(22.2)							
III	155	60.2	123.7	175.7						
		(13.5)	(18.2)	(16.2)						
IV	107	54.5	111.4	165.7	199.0					
		(9.4)	(18.7)	(16.8)	(14.2)					
V	50	50.8	105.2	162.2	191.6	210.6				
		(8.0)	(16.2)	(15.7)	(14.2)	(14.1)				
VI	19	53.1	107.6	160.1	193.9	211.9	224.7			
		(8.9)	(12.0)	(12.8)	(13.2)	(13.3)	(13.3)			
VII	13	52.9	111.8	169.3	203.3	225.7	241.7	248.2		
		(6.4)	(11.2)	(16.5)	(17.4)	(18.2)	(20.3)	(21.2)		
VIII	5	52.4	108.1	165.1	202.9	225.6	241.1	246.3	260.4	
		(4.1)	(8.1)	(9.0)	(3.6)	(6.8)	(9.9)	(12.6)	(14.7)	
Average		55.0	114.2	169.5	197.0	214.0	232.9	247.9	260.4	
		(12.9)	(19.9)	(17.0)	(14.6)	(15.3)	(17.6)	(18.8)	(14.7)	
Increment		55.0	53.9	53.7	32.5	19.5	14.3	11.4	8.1	
		(12.9)	(9.6)	(9.6)	(9.7)	(5.5)	(4.3)	(3.5)	(2.6)	
Number		629	466	349	194	87	37	18	5	
						FEMALES				
I	156	53.3								
		(15.3)								
II	127	55.2	107.2							
		(10.9)	(20.9)							
III	102	58.0	116.9	170.6						
		(10.8)	(20.0)	(16.4)						
IV	92	52.3	109.8	159.9	194.6					
		(10.8)	(17.6)	(17.3)	(15.2)					
V	89	55.3	107.8	159.8	188.9	206.1				
		(10.0)	(17.5)	(16.7)	(14.8)	(24.6)				
VI	42	55.0	111.8	161.3	189.6	209.1	223.7			
		(10.6)	(26.1)	(17.3)	(15.7)	(16.5)	(17.3)			
VII	12	55.6	110.1	161.1	191.9	215.4	230.3	241.3		
		(8.8)	(17.8)	(18.1)	(14.7)	(11.3)	(10.1)	(8.9)		
VIII	5	48.7	114.3	170.5	189.2	205.3	225.1	245.3	252.4	
		(6.1)	(13.1)	(9.7)	(8.5)	(7.7)	(7.1)	(8.3)	(9.1)	
IX	1	43.8	89.2	148.1	184.6	207.8	221.1	244.6	255.4	259.1
	--	--	--	--	--	--	--	--	--	--
Average		54.6	110.5	163.5	191.7	208.7	227.3	243.1	253.0	259.1
		(12.2)	(20.1)	(17.4)	(15.2)	(21.9)	(17.3)	(14.1)	(13.5)	--
Increment		54.6	52.4	51.8	31.4	18.7	14.8	11.7	9.8	7.4
		(12.2)	(13.4)	(11.0)	(8.4)	(9.2)	(4.0)	(3.0)	(2.0)	--
Number		626	470	343	241	149	60	18	6	1

[a]Standard deviation is in parenthesis.

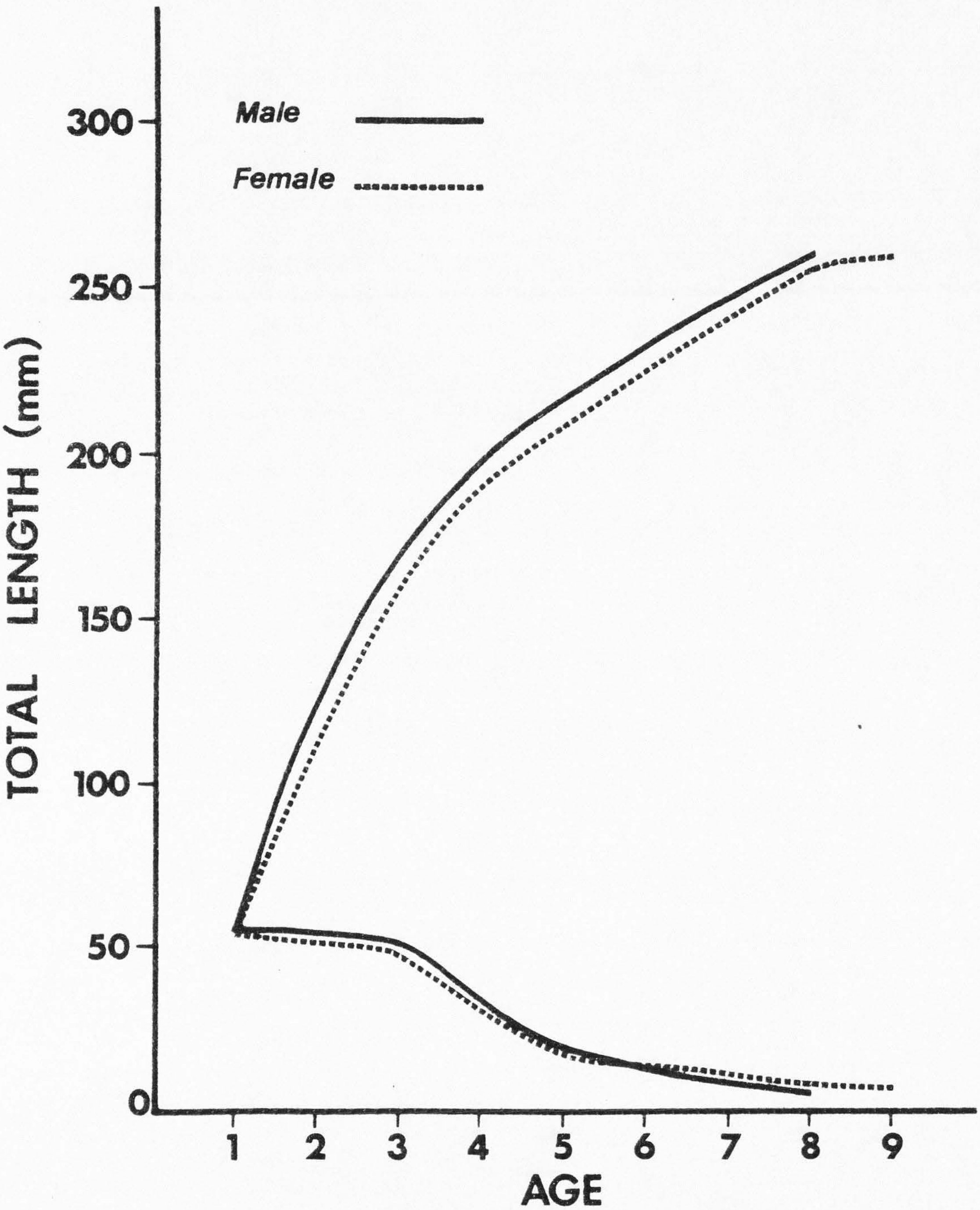


Figure 11. Growth in total length (upper curves) and annual increments of growth (lower curves) of bluegills from Pelican Lake, Uintah County, Utah, 1976 and 1977.

Many bluegills failed to deposit a first-year annulus. This phenomenon is common in young-of-the-year fish from a late summer spawning inasmuch as they grow little during autumn and winter (Regier 1962; Brown et al. 1977). Bluegills are known to spawn continually throughout the summer months (Carlander 1977; Snow et al. 1960), as long as water temperatures remain suitable (21-27 C). Male bluegills in Pelican Lake were observed guarding nests as late as the first of August in 1976 and 1977. TL frequencies of young-of-the-year bluegills captured in the August 1976 and 1977 rotenone population sampling confirmed that late summer spawning had occurred since fish as small as 10 mm TL were present (Figures 12 and 13).

The empirical TL frequency data of yearling bluegills captured in the May 12, 13 and 14 rotenone samples were utilized to validate the first annulus (Figure 14). The mean back-calculated TLs for male and female bluegills were 55 and 54 mm TL, respectively. The model class of yearlings from the May sampling was 46-48 mm TL (mean: 50 mm TL), suggesting that the empirical data closely paralleled that of the predicted values (Figure 14).

The opportunity to collect scale samples from April through October allowed precise determination of the time of annulus formation in bluegills. Formation of the annulus was in mid-May and the first of June in most bluegills. Most, if not all, bluegills had formed their yearly annulus by the first of July. Roach and Evans (1947) and Morgan (1951) reported annulus formation of bluegill in Ohio lakes, the same general latitude as Pelican Lake, to be in early May.

Growth rate of bluegills in Pelican Lake is not exceedingly rapid but is gradual in which numerous individual fish have been observed to

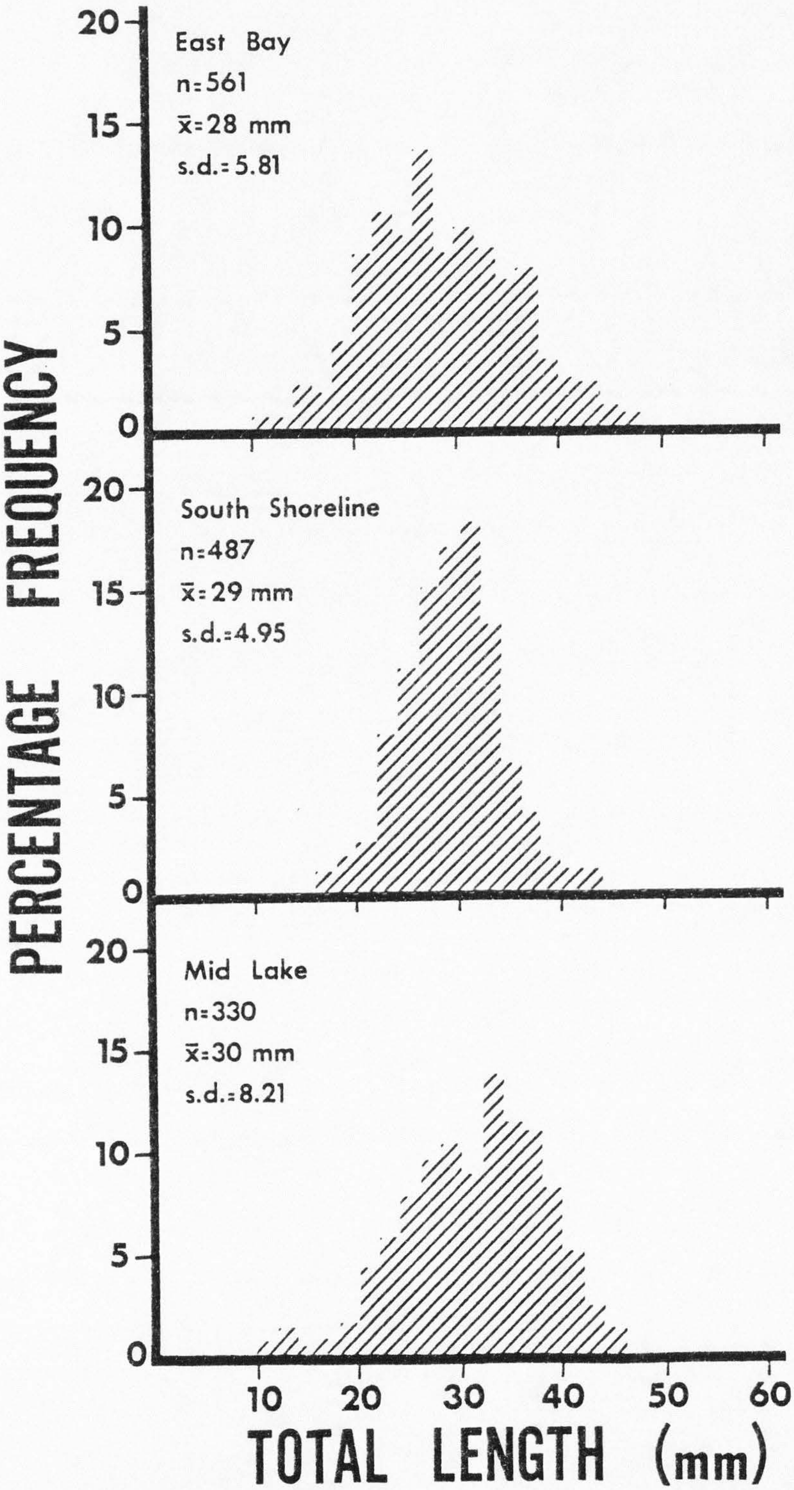


Figure 12. Length frequency of young-of-the-year bluegills captured from three 0.405 ha sites sampled with rotenone on August 24, 25 and 26, 1976, at Pelican Lake, Uintah County, Utah.

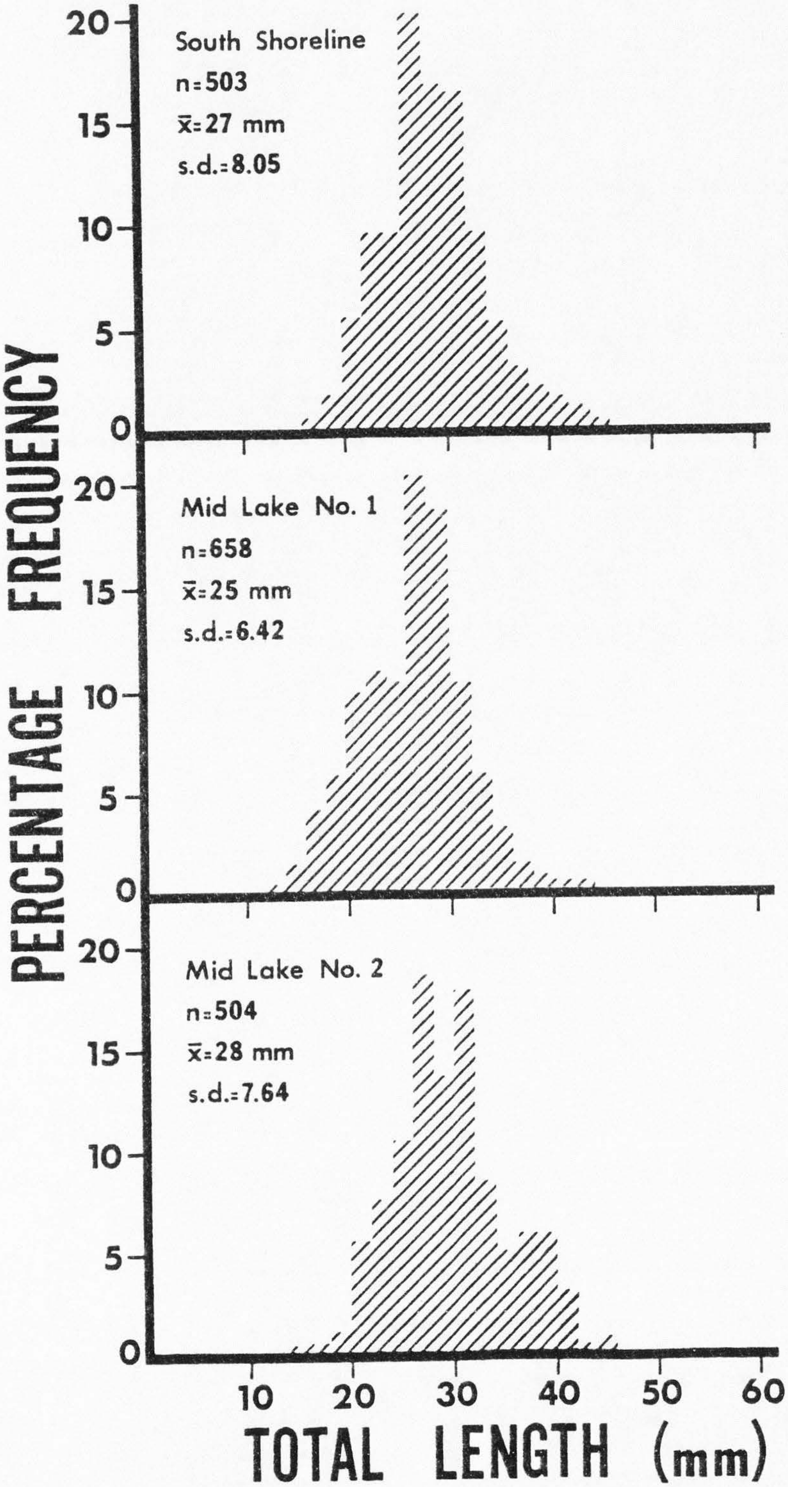


Figure 13. Length frequency of young-of-the-year bluegills captured from three 0.405 ha sites sampled with rotenone on August 29, 30 and 31, 1977, at Pelican Lake, Uintah County, Utah.

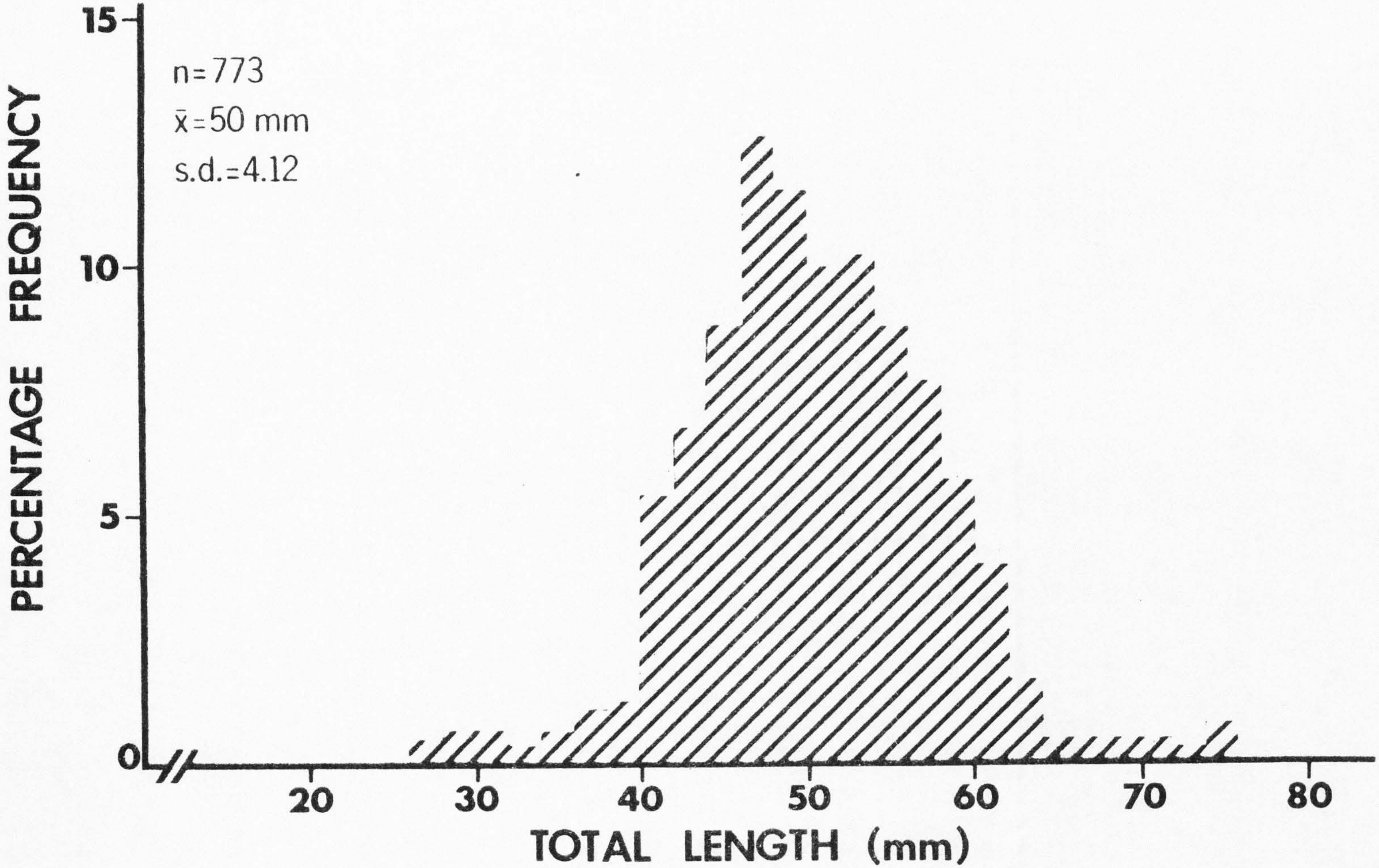


Figure 14. Length frequency of yearling bluegills captured from three 0.405 ha sites sampled with rotenone on May 11, 12 and 13, 1977, at Pelican Lake, Uintah County, Utah.

attain total weights well over 500 g and TLs over 240 mm. Comparison of bluegill growth rates in various U. S. waters (Appendix; Table 32) with those in Pelican Lake indicated that bluegills in Pelican did not suffer from natural stunting, a common management problem with this prolific species (Figure 15).

Age beyond six years was difficult to interpret because as growth of the bluegill decreased, the annuli in the lateral field became spaced closely together. The close spacing made recognition of individual annuli difficult. Accessory checks described by Regier (1962) and Coble (1970) also made age interpretation difficult. Therefore, the ages assigned to older bluegills may be in error.

The overlap of TLs between age classes was apparent in the large standard deviations (Table 1) (Appendix; Figure 46). This phenomenon probably is explained by the continuous spawning mode of the species which allows a wide TL range among young-of-the-year to occur from June to mid-September (Figures 12 and 13). Scale samples of bluegills collected from the creel in 1974 (n = 31) (Crosby 1974, Vernal, Utah, Personal communication) and 1975 (n = 103) (Mullins 1975, Vernal, Utah, Personal communication) were reread in this study for agreement with past researchers, and also to note if any changes had occurred in the age structure of angler-harvested fish in 1976 and 1977. Percentage agreement was 42% and 50% between the author and the preceding investigators for samples in 1974 and 1975, respectively. Crosby and Mullins aged bluegills consistently (63%) one year older than that interpreted in this study. Although 29% were aged by these researchers as one year less than that of this study, 12% were aged as two years greater,

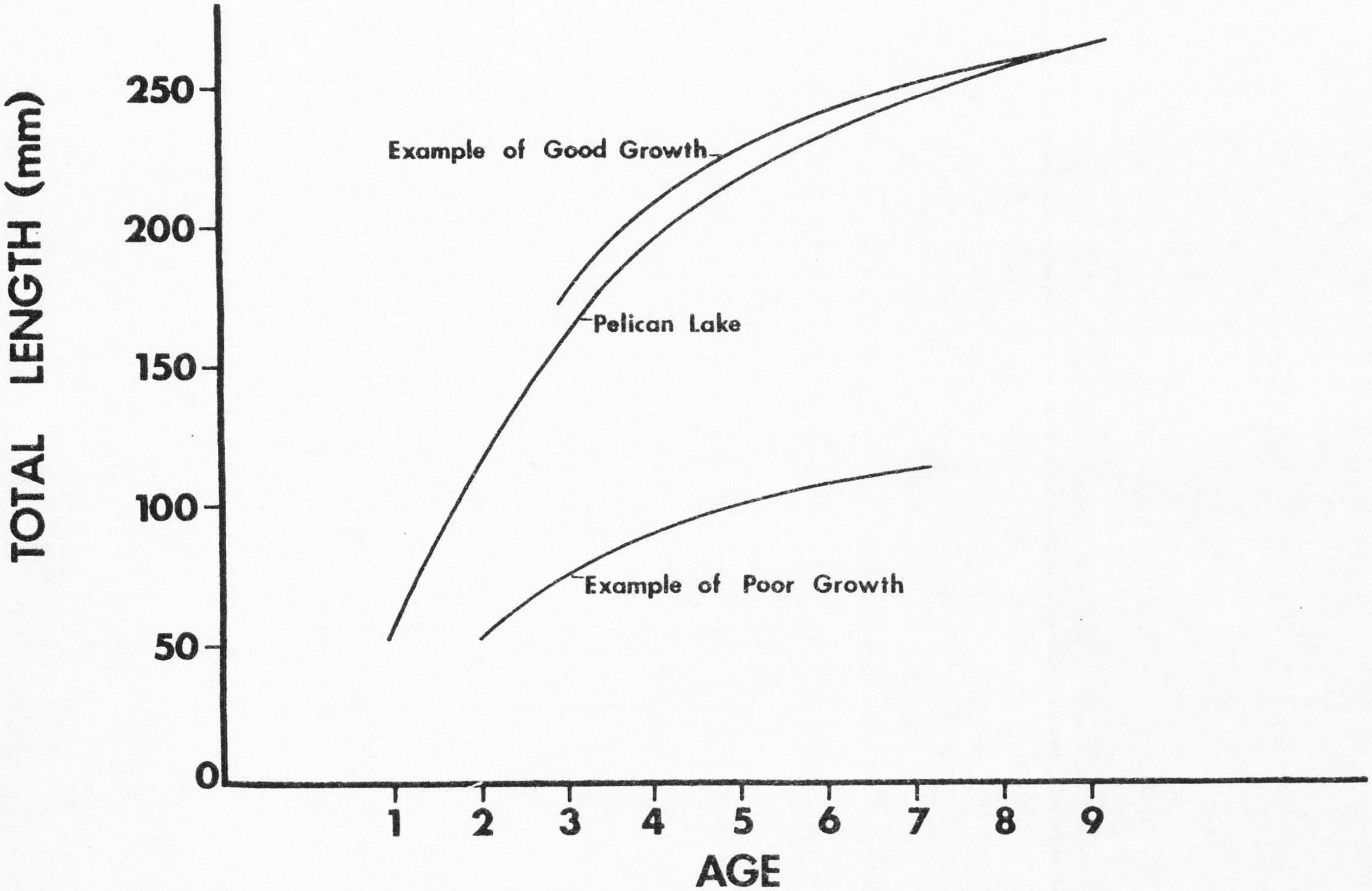


Figure 15. Absolute growth of bluegills from Pelican Lake, Uintah County, Utah, compared with two theoretical population growth rates. (Note: relative poor and good growth curves from Snow et al. 1960.)

1% as two years less and 3% as three years greater. There was no age interpretation disagreement greater than three years (Appendix; Table 33). The age composition of 1974 and 1975 bluegill compared to that of 1976 and 1977 did not indicate a significant change in age structure of the catch, although sample sizes in 1974 and 1975 were small.

Condition factor. The age specific condition factor among bluegills increased steadily from age I (3.75) to age V (6.02) but decreased slightly for age VI (5.95) (Figure 16). The aberrant condition factor values for ages V and VI are unexplainable. The condition factor for age IX (7.07, n = 1) bluegill was also less than age group VIII (7.50, n = 10).

Reproduction

Spawning. Bluegills were observed spawning from late May to mid-September in 1976 and from early June to late August in 1977. Surface water temperatures at the end of May in 1976 were approaching 22 C, but an atypical cold spell disrupted spawning (Appendix; Figure 45). Male bluegills were observed on June 10 guarding nests in dense concentrations throughout the lake. The following day when water temperatures dropped to 16.5 C (Appendix; Figure 45), bluegills could not be found occupying nests. Following the cold period, male bluegills renested until mid-September when the water temperature dropped below 21 C. Other studies have found that spawning may occur at 22-26 C or about 24 C (Carlander 1969) or when water temperatures are rising and near 27 C (Stevenson et al. 1969).

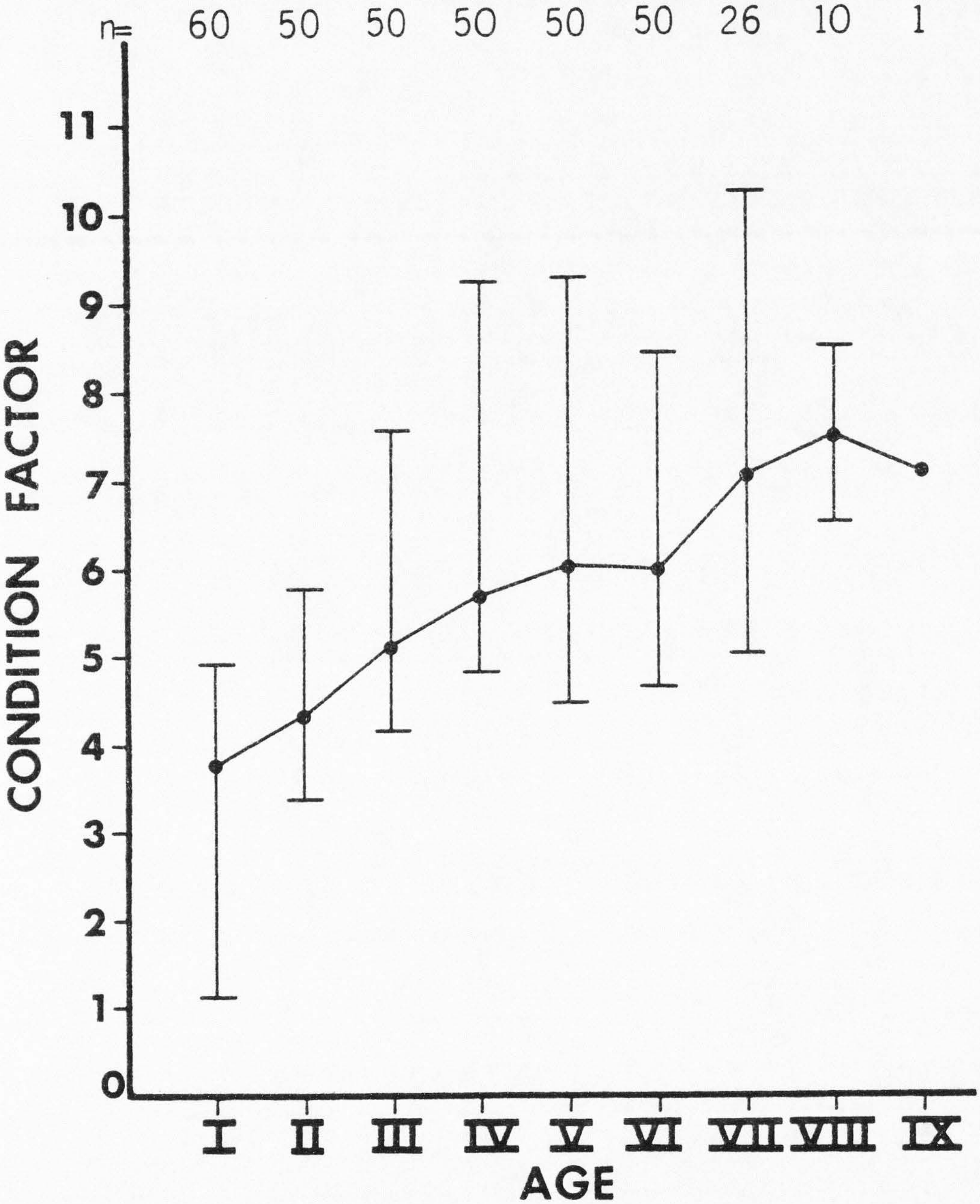


Figure 16. Age specific condition factor (standard length) for bluegills from Pelican Lake, Uintah County, Utah, 1976 and 1977. (Note: vertical lines indicate the range of values.)

Bluegill nests were easily observed in deep water because of the high water clarity. Nests were located in areas of moderate growths of submerged vegetation or near the margins of vegetation patches. Large numbers of male bluegills were observed nesting near the south shoreline and west end of the lake most of the summer months. However, remnants of nests were also found evenly scattered over the lake bottom, suggesting that there were no particular "favorite" nesting areas.

Surface water temperatures in 1977 were slightly cooler than 1976 (Appendix; Figure 45), although water levels were lower overall in 1977. A mid-May cold spell probably delayed spawning, but water temperatures were approaching 21 C on June 3 and 4, 1977 and remained within the temperature range for spawning until late August.

Bluegills as small as 10 mm TL were collected in August of 1976 and 1977, suggesting that recruitment was still occurring (Figures 12 and 13). The high maturity index values for late May and early June, along with the TL frequency data of young-of-the-year bluegills, indicated that the peak spawning period occurred in June of 1976 and 1977.

Sexual maturity. Male bluegills matured earlier than females. Males and females began to mature at age II, but males began to mature at 141-150 mm TL while females did not begin to mature until they became 151-160 mm TL (Table 2). Thirty-seven percent of the age II males were mature, as compared to 20% for age II females. Most (91%) male bluegills were mature at 171-180 mm TL; most (97%) females were mature at 181-190 mm TL. All of the age IV males were mature, as compared to age IV females which were 98% mature. The data demonstrated that both size and age had an influence on sexual maturity.

Table 2. Relation between size and age to sexual maturity for bluegills from Pelican Lake, Uintah County, Utah, 1976 and 1977.

Size TL (mm)	Age II Number of Fish	Age II Percent Mature	Age III Number of Fish	Age III Percent Mature	Age IV Number of Fish	Age IV Percent Mature	Age V Number of Fish	Age V Percent Mature	Total Number of Fish	Total Percent Mature
MALES										
101-110	8	0							8	0
111-120	6	0							6	0
121-130	6	0							6	0
131-140	7	0							7	0
141-150	10	10	2	0					12	8
151-160	9	22	12	42					21	33
161-170	14	93	9	89					23	91
171-180	11	100	5	100					16	100
181-190			25	100	6	100			31	100
191-200			24	100	21	100			45	100
201-210			9	100	25	100	25	100	59	100
211-220					2	100	13	100	15	100
Totals	71	37	86	88	54	100	38	100		
FEMALES										
101-110	6	0							6	0
111-120	6	0							6	0
121-130	3	0							3	0
131-140	5	0							5	0
141-150	8	0							8	0
151-160	11	9	4	0					15	7
161-170	13	23	9	56					21	38
171-180	9	89	14	86					23	87
181-190			21	100	9	89			30	97
191-200			18	100	20	100	1	100	38	100
201-210			12	100	25	100	22	100	59	100
211-220					4	100	19	100	23	100
Totals	61	20	78	87	58	98	42	100		

<u>Fecundity</u>. The relationships between fecundity (mature eggs) and TL, total weight and age were determined for 38 bluegills. Fecundity tended to increase with TL (Figure 17), weight and age (Figure 18), although variability within age groups was large. This was due to the wide range of fish lengths within each respective age group. Fecundity seemed to decrease beyond age V (Figure 18), although the sample sizes for age VI (n = 1) and VII (n = 1) were too small to substantiate this fact.

The TL-fecundity relationship was also significant ($F = 77.62$, $p < 0.0005$, $r = 0.82$, 36 df) and can be described by the equation:

$$\text{Log } F = 3.04 \text{ Log } TL - 2.67.$$

The total weight-fecundity relationship was also significant ($F = 69.25$, $p = < 0.0005$, $r = 0.80$, 36 df) and can be described by the equation:

$$F = 88.6\ W + 1260.$$

The greatest fecundity estimated was 46,281 mature eggs from a bluegill age V, 218 mm TL and 245 g total weight, while the lowest was 11,535 mature eggs from a bluegill age II, 153 mm TL and 72 g total weight (Appendix; Table 34). Sampling error by the gravimetric method was minimal, averaging 6.07% (Table 3). The weight estimate of immature ova and ovigerous lamellae comprised 11.7% of the total body weight for a bluegill 188 mm TL and 192 g total weight and 16.2% for a bluegill 228 mm TL and 376 g total weight.

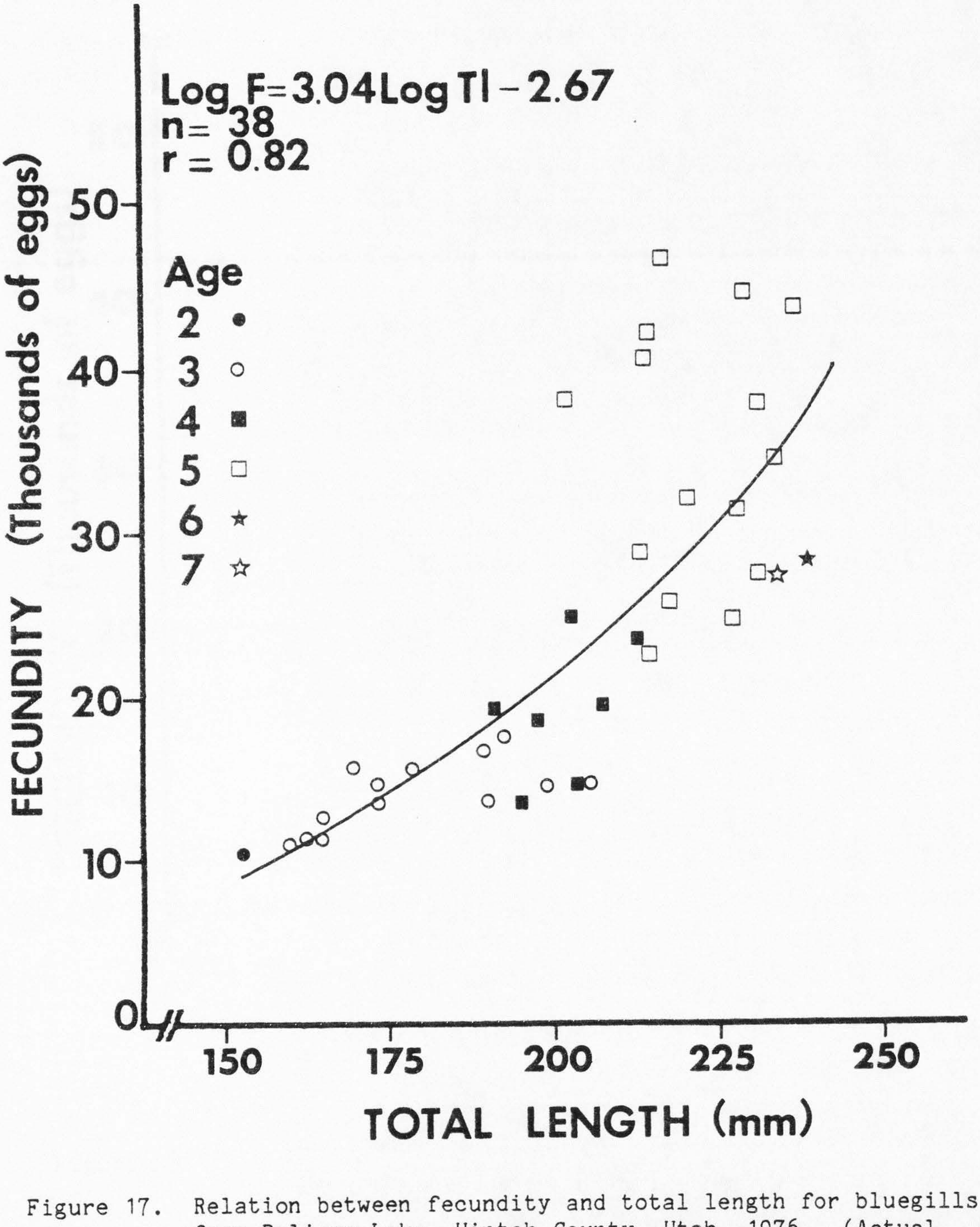


Figure 17. Relation between fecundity and total length for bluegills from Pelican Lake, Uintah County, Utah, 1976. (Actual fecundity estimates are given in Appendix; Table 34.)

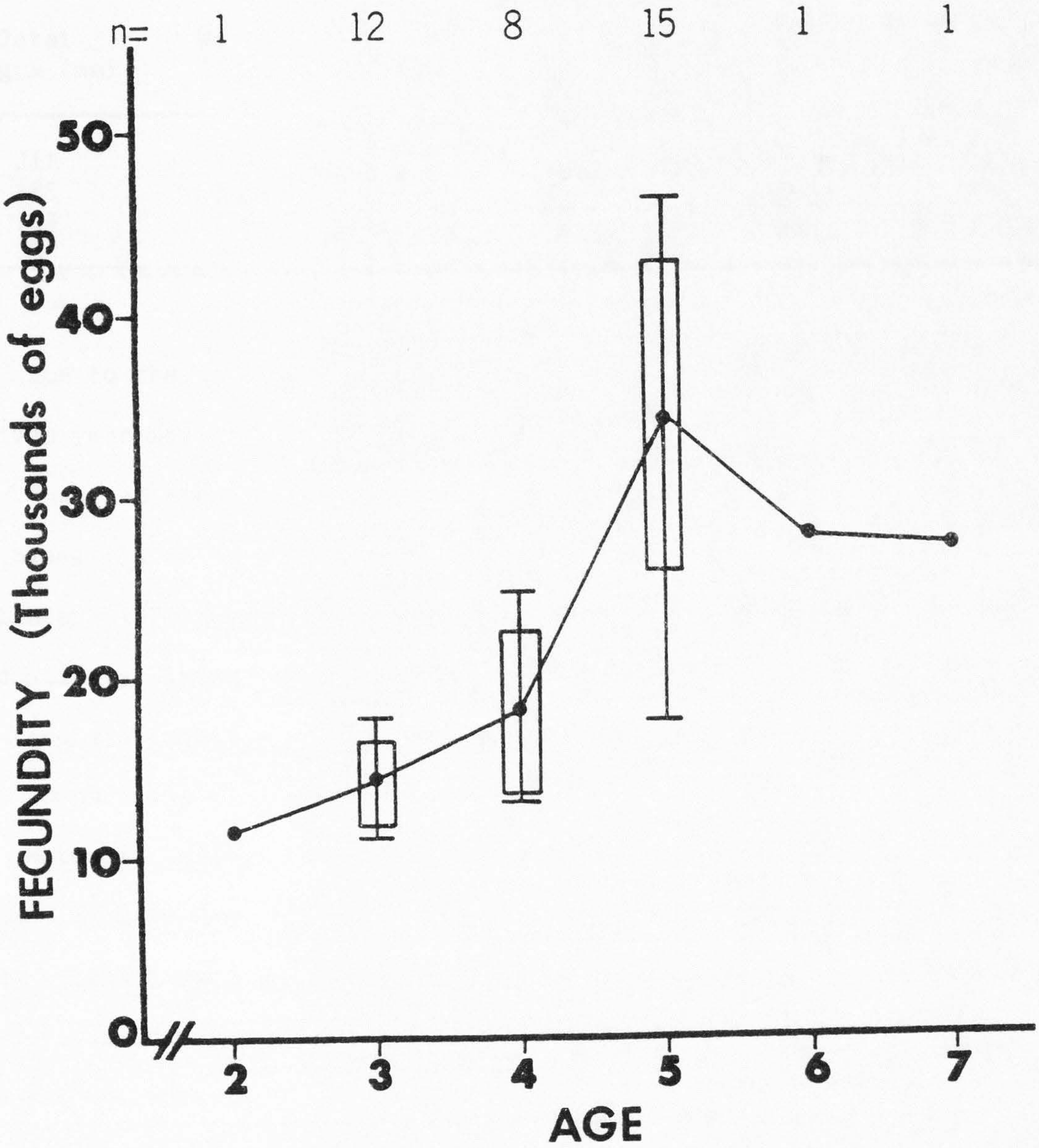


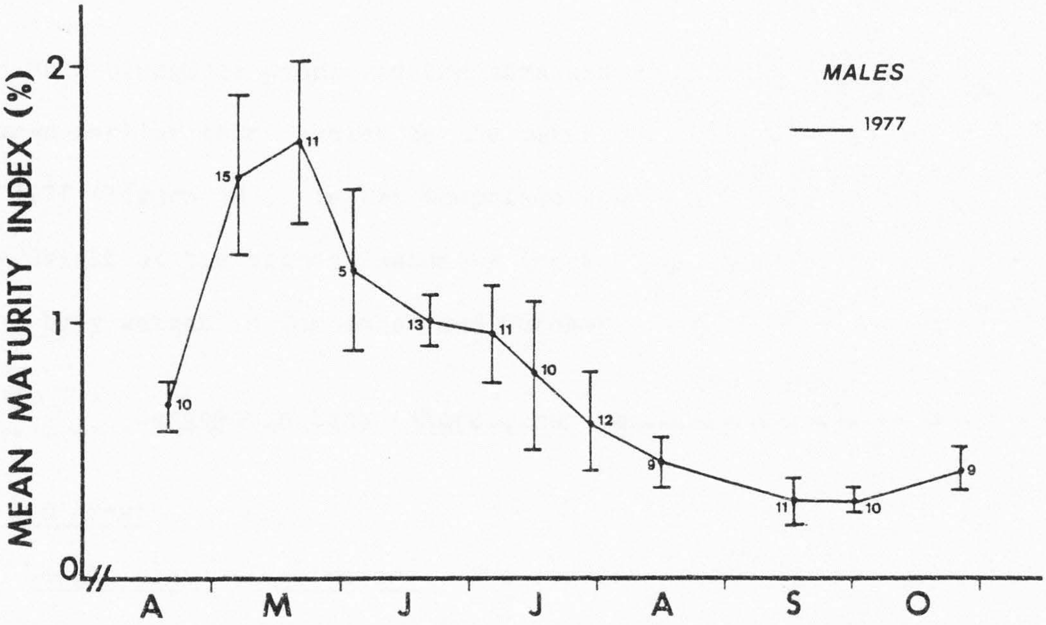
Figure 18. Age specific fecundity for bluegills from Pelican Lake, Uintah County, Utah, 1976. (Note: bars indicate one standard deviation and vertical lines show the range. Actual fecundity estimates are given in Appendix; Table 34.)

Table 3. Sampling error in estimating the fecundity of three bluegill sunfish by the gravimetric method.

Total Length (mm)	Weight (g)	Estimated No. of Eggs	Actual No. of Eggs	Percentage Error
211	400	38,078	40,401	-5.75
228	376	44,798	48,221	-7.10
163	109	11,102	11,732	-5.37

Due to the extended spawning season of this species, all eggs for a given year may not ripen at the same time. Therefore, egg counts may not be as representative of egg production. The fecundity estimates for bluegills in this study compared with the estimates reported by Carlander (1977); but differences unique to each body of water, i.e., productivity, water temperature fluctuations, length of growing season and food availability and the paucity of data on bluegill fecundity, make comparisons difficult.

Maturity index. Gonadal weight for female bluegills reached a maximum in late May in 1976 and early June in 1977 (Figure 19). Gonad weight comprised 14 and 13% of the total body weight at these two periods in 1976 and 1977, respectively. Even though gonad samples were not collected between November to April 1 of the following year, it is reasonable to conclude that gonadal weight comprised approximately 1% of the total body weight August 7 to the first of April. Morgan (1951) reported that during the spawning season the ratio of body weight to gonadal weight is about 10:1 in mature females compared to ratios 40-80:1 the rest of the year.



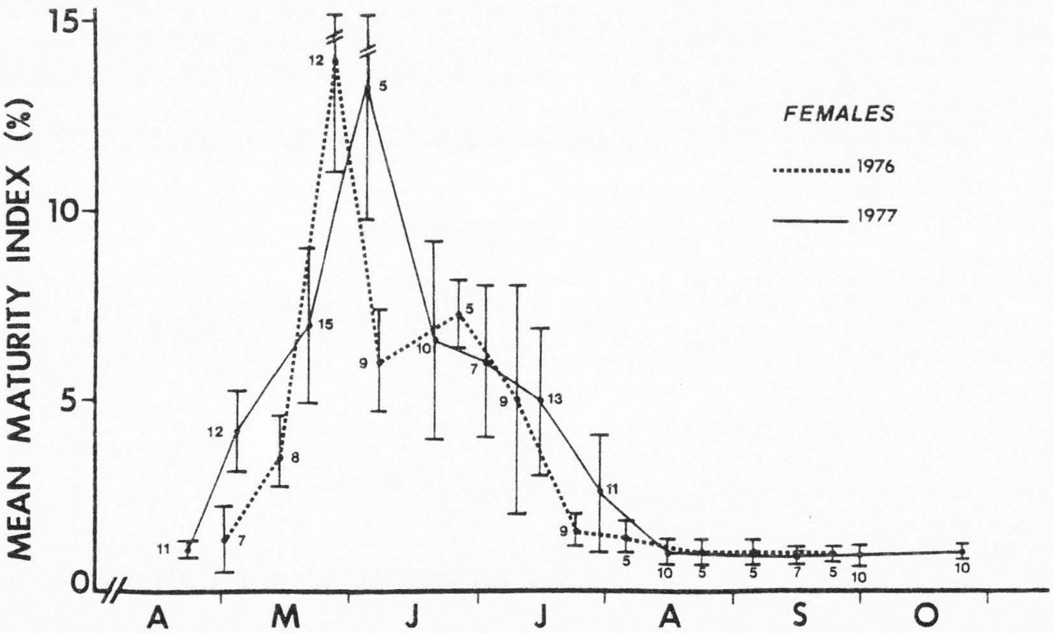


Figure 19. Changes in mean maturity index (maturity index = gonadal weight X 100 divided by total body weight) for male (1977) and female (1976 and 1977) bluegill sunfish from Pelican Lake, Uintah County, Utah. (Note: numbers beside closed circles indicate sample sizes, line connects mean values, vertical lines indicate one standard deviation.)

Male bluegills displayed the same annual pattern as females but matured earlier than females as the maturity index was highest in mid-May 1977 (Figure 19). Testes comprised approximately 1.7% of the total body weight at the highest maturity index (May) and only 0.3% of the total body weight in September and October (Figure 19).

Largemouth Bass (*Micropterus salmoides* Lacepede)

Age and growth

Length conversion factors. The conversion factor calculated to estimate SL from TL was a linear regression equation:

$$SL = 0.833\ TL - 1.980,$$

($F = 162{,}787$, $p < 0.0005$, $r = 0.99$, 373 df) (Figure 20). The linear regression of FL on TL was significant ($F = 333{,}920$, $p < 0.0005$, $r = 0.99$, 373 df) (Figure 20) and was described by the equation:

$$FL = 0.964\ TL - 0.720.$$

Length-weight relationship. The relation between length and weight,

$$\text{Log } W = 3.31 \text{ Log } TL - 5.58,$$

was significant for male largemouth bass ($F = 25{,}376$, $p < 0.0005$, $r = 0.99$, 308 df). The relation between length and weight,

$$\text{Log } W = 3.29 \text{ Log } TL - 5.54,$$

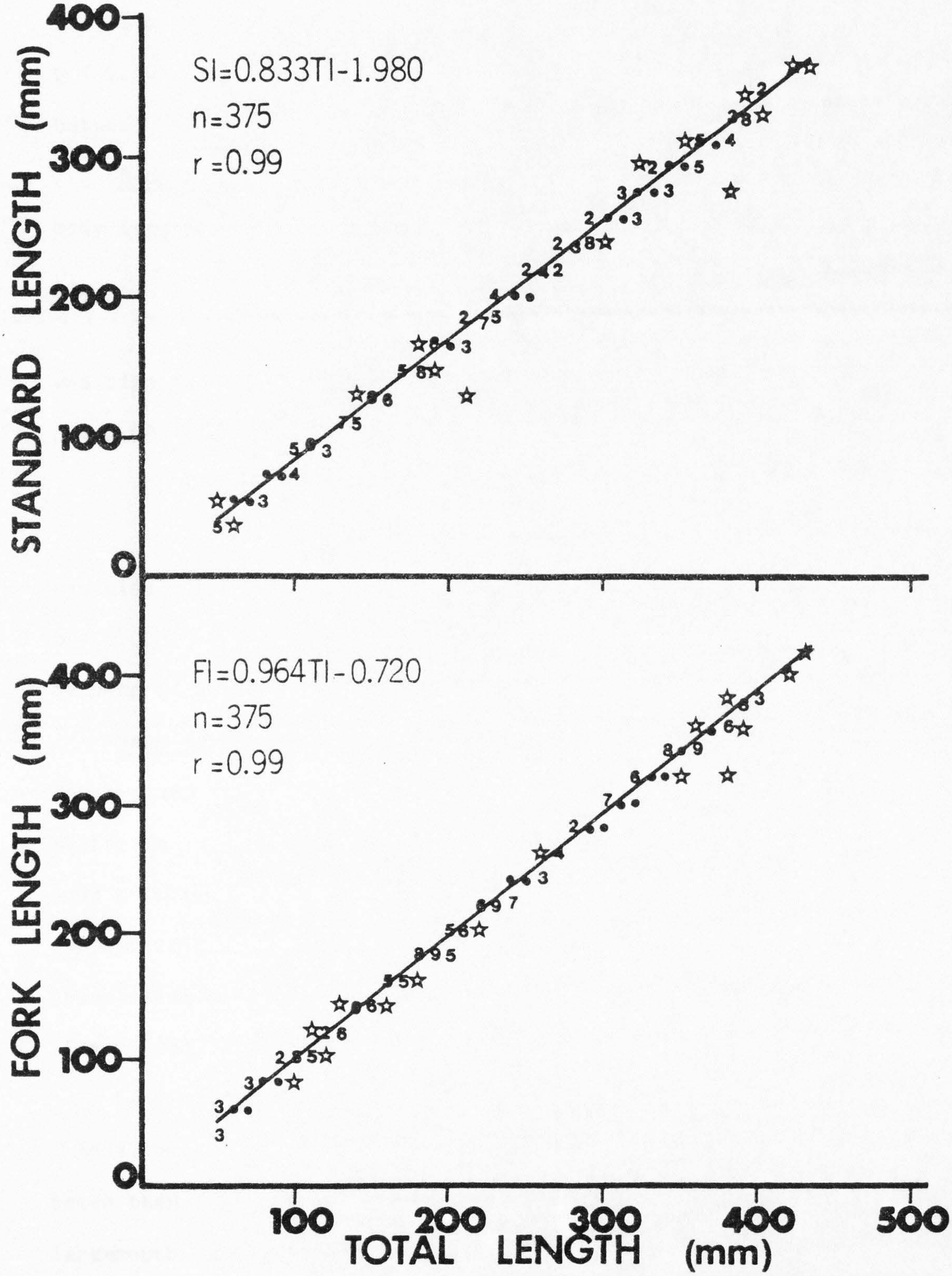


Figure 20. Regression of SL and FL compared with TL for largemouth bass from Pelican Lake, Uintah County, Utah, 1976 and 1977. (Note: numbers refer to overlapping points; the stars refer to 10 or more overlapping points.)

was also significant for female largemouth bass (F = 44,792, $p < 0.0005$, r = 0.99, 395 df), but there was no significant difference between the length-weight relationships for both sexes (Figure 21).

Body length-scale radius relationship. The relationship between body length and scale radius,

$$TL = 0.704\ SR + 20.066,$$

was significant for male largemouth bass (F = 11,808, $p < 0.0005$, r = 0.99, 308 df). The relation between body length and scale radius,

$$TL = 0.706\ SR + 20.352,$$

was also significant for female largemouth bass (F = 14,479, $p < 0.0005$, r = 0.99, 395 df), but there was no significant difference between these relationships for both sexes (Figure 22).

Back-calculation of growth. The scale method has been validated for age and growth determination for largemouth bass (Prentice and Whiteside 1974). Largemouth bass growth was the greatest in the first year of life attaining 106 mm TL and 103 mm TL for males and females, respectively (Figure 23). First-year growth of largemouth bass in 1976 was slightly greater than that of first-year growth in 1977 (Figure 24).

Females grew slightly faster than male largemouth bass from ages I to V, but one male's (age VII) growth was faster for year six and seven than that of any female. Mean back-calculated TLs for male largemouth bass from the first to seventh annulus were 103, 194, 268, 313, 346, 419 and 430 mm (Table 4). Mean back-calculated TLs for

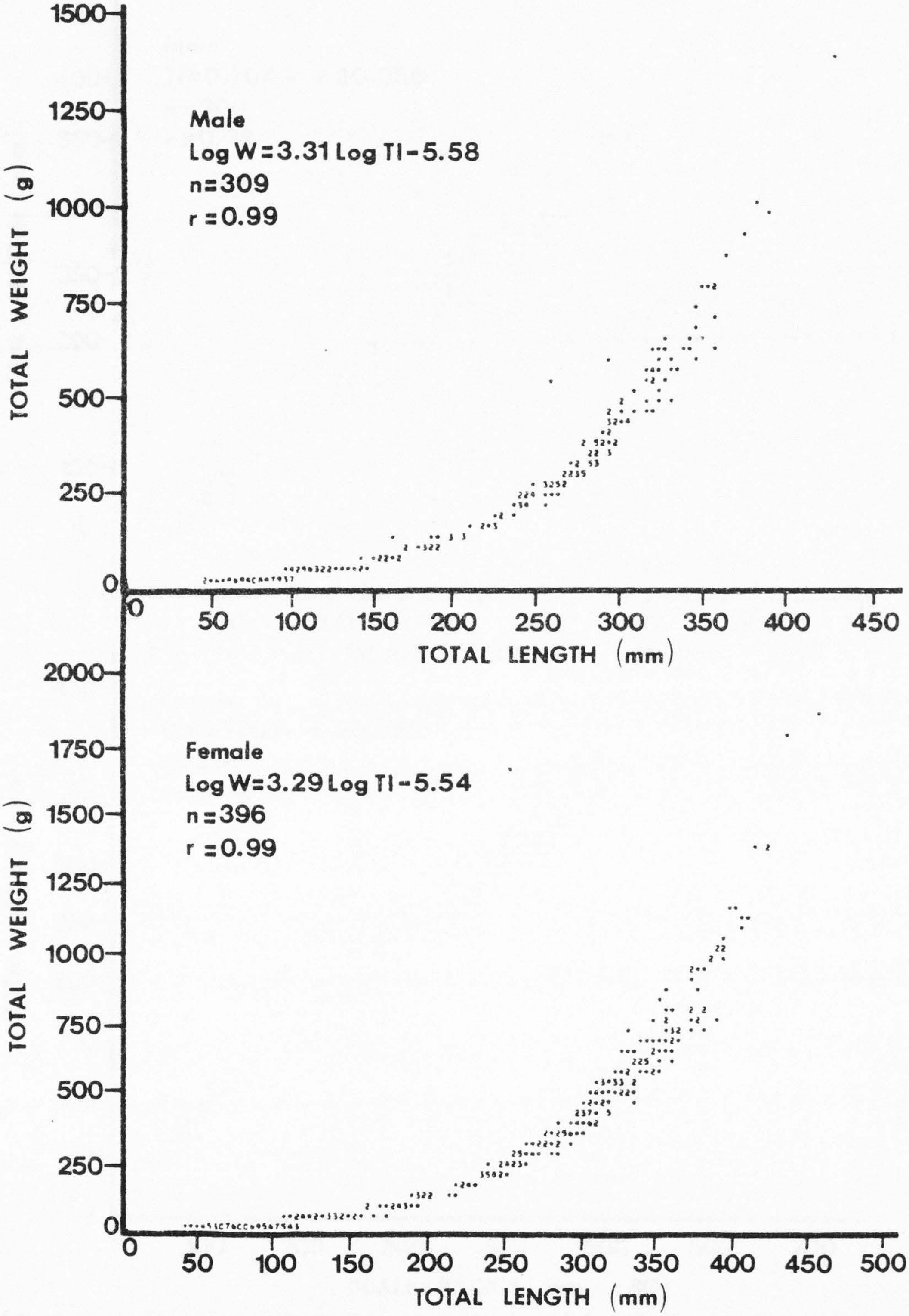


Figure 21. Length-weight relationship for male and female largemouth bass from Pelican Lake, Uintah County, Utah, 1976 and 1977. (Note: numbers refer to overlapping points; the letters refer to 10 or more overlapping points, A = 10, B = 11, C = 12, etc.)

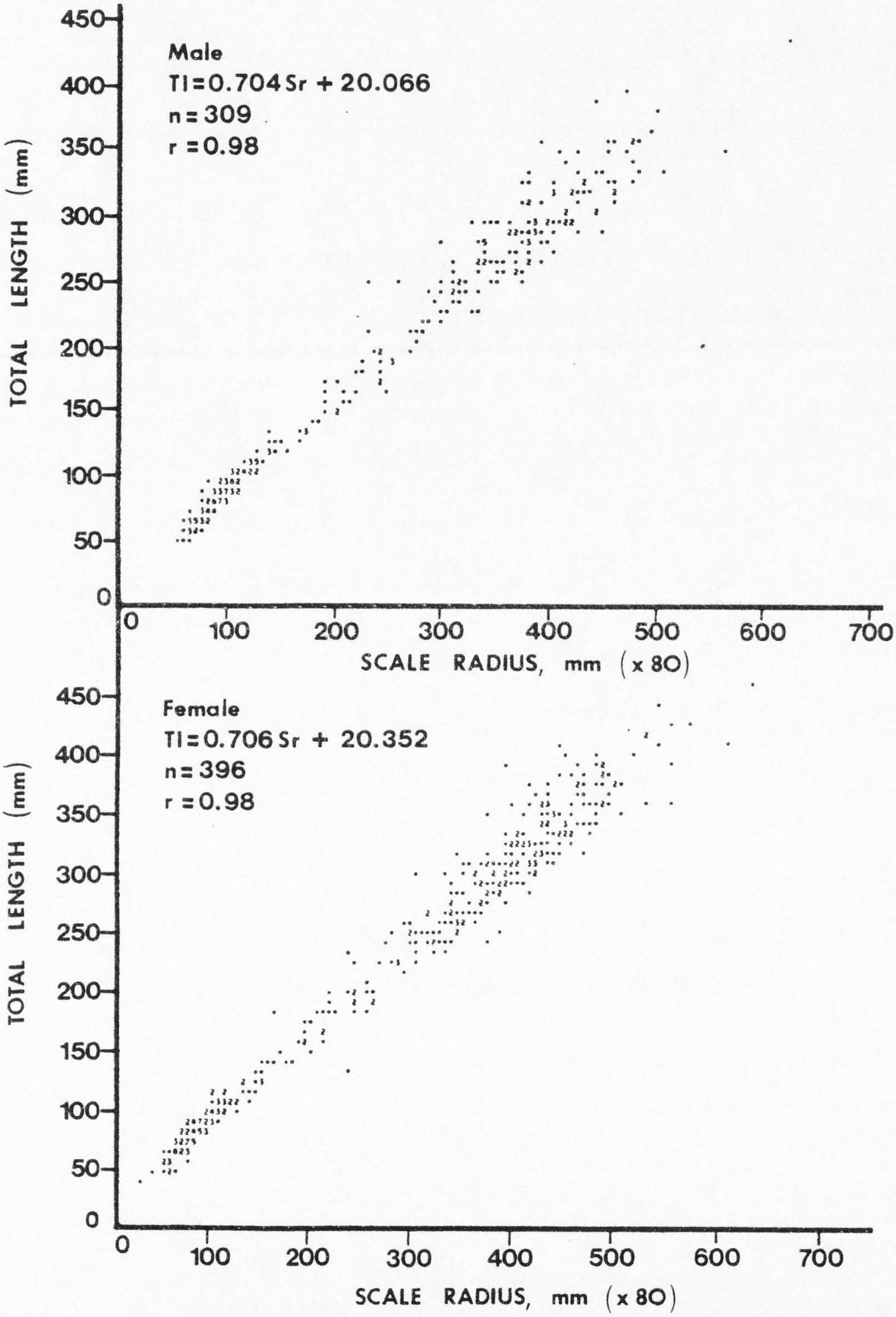


Figure 22. Relation between scale radius and total length for male and female largemouth bass from Pelican Lake, Uintah County, Utah, 1976 and 1977. (Note: numbers refer to overlapping points; the letters refer to 10 or more overlapping points, A = 10, B = 11, C = 12, etc.)

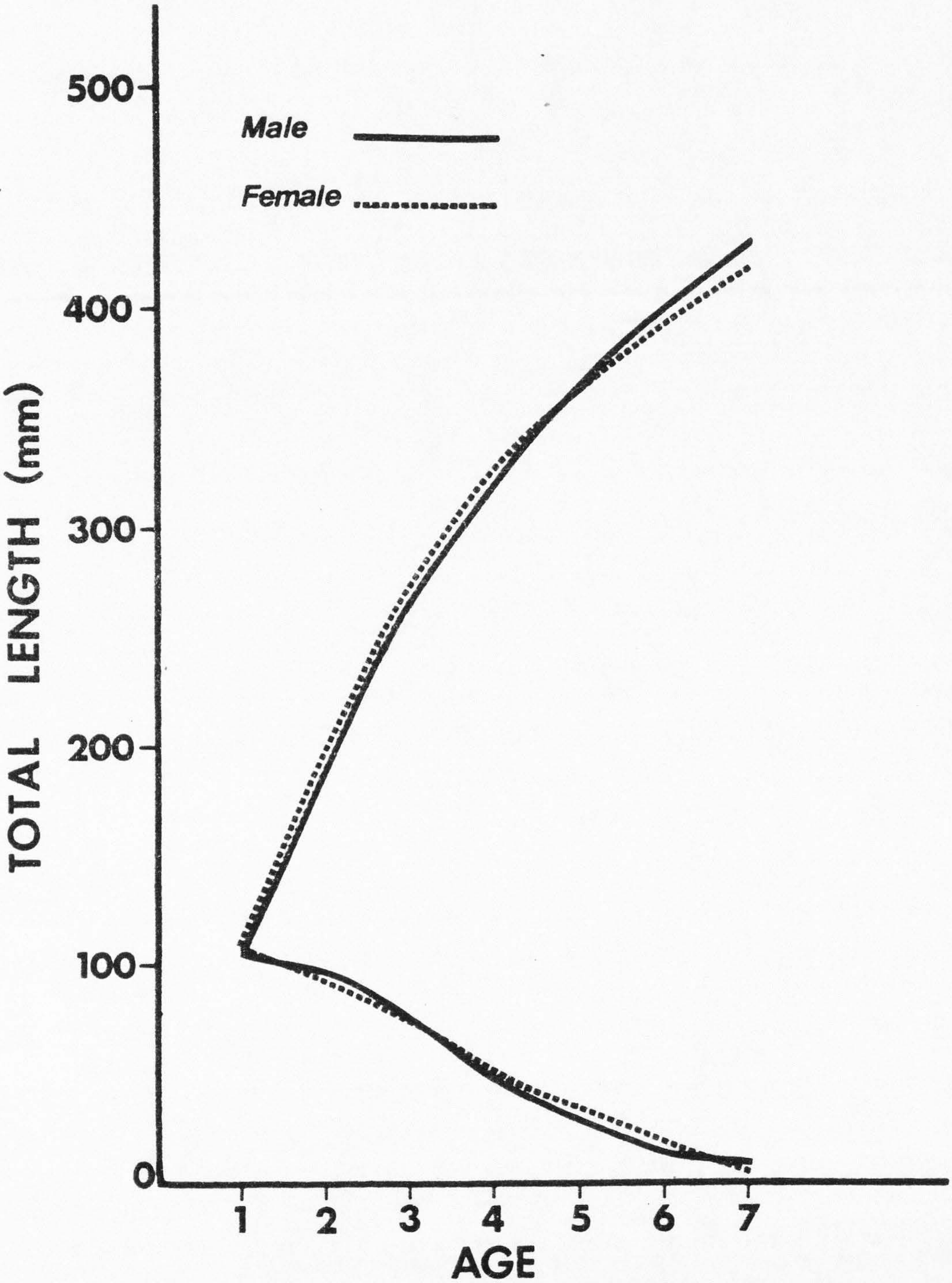


Figure 23. Growth in total length (upper curves) and annual increments of growth (lower curves) of largemouth bass from Pelican Lake, Uintah County, Utah, 1976 and 1977.

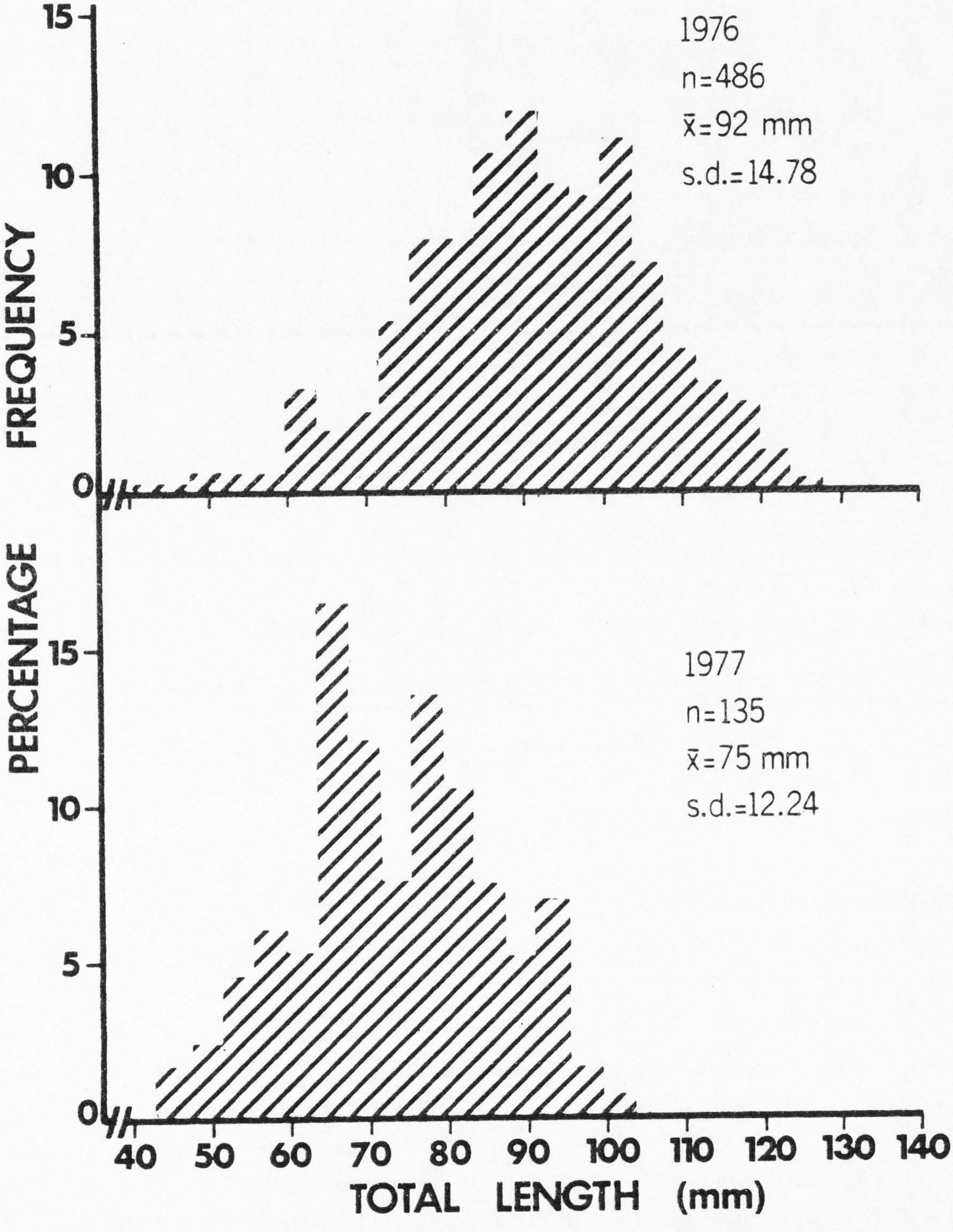


Figure 24. Length frequency of young-of-the-year largemouth bass captured from three 0.405 ha sites sampled with rotenone on August 24, 25 and 26, 1976 and August 29, 30 and 31, 1977, at Pelican Lake, Uintah County, Utah.

Table 4. Mean calculated total lengths at the end of each year of life for largemouth bass from Pelican Lake, Uintah County, Utah, 1976 and 1977.

Age Group	Number of Fish	Mean Calculated Total Length At Each Annulus (mm)						
		1	2	3	4	5	6	7
					MALES			
I	31	107.7						
		(19.7)[a]						
II	65	96.3	194.9					
		(17.1)	(35.2)					
III	50	104.4	193.7	272.9				
		(17.1)	(26.1)	(26.9)				
IV	41	107.2	190.9	265.2	314.1			
		(40.8)	(24.6)	(23.2)	(22.2)			
V	11	108.1	193.7	255.7	303.3	340.0		
		(12.4)	(16.5)	(28.6)	(32.7)	(34.7)		
VI	0	--	--	--	--	--	--	
		--	--	--	--	--	--	
VII	1	111.6	218.5	288.8	339.3	378.9	418.6	430.4
		--	--	--	--	--	--	--
Average		103.1	193.9	268.5	312.9	345.7	418.6	430.4
		(24.4)	(29.4)	(26.5)	(25.9)	(38.5)	--	--
Increment		103.1	91.6	75.3	48.6	36.7	22.5	19.0
		(24.4)	(28.2)	(17.1)	(13.2)	(7.9)	--	--
Number		199	168	103	53	12	1	1
					FEMALES			
I	36	112.6						
		(17.2)						
II	55	90.2	173.7					
		(14.0)	(29.0)					
III	88	111.9	201.5	283.2				
		(29.9)	(23.8)	(23.6)				
IV	64	105.7	195.7	267.9	319.4			
		(16.3)	(38.3)	(24.6)	(20.2)			
V	40	113.1	198.8	262.6	312.1	349.1		
		(17.2)	(25.9)	(22.9)	(24.3)	(26.2)		
VI	6	108.6	200.4	297.8	346.8	377.1	405.1	
		(21.4)	(45.2)	(29.0)	(29.1)	(27.1)	(25.4)	
VII	4	94.0	187.7	275.0	327.2	366.4	394.0	410.6
		(16.6)	(34.6)	(49.1)1	(52.0)	(54.8)	(51.1)	(52.4)
Average		106.4	193.4	274.5	318.6	353.8	400.7	410.6
		(22.7)	(31.7)	(26.1)	(24.5)	(30.1)	(35.5)	(52.4)
Increment		106.4	87.9	75.7	50.7	36.3	27.8	16.6
		(22.7)	(28.4)	(23.2)	(15.3)	(10.8)	(10.1)	(2.9)
Number		293	257	202	114	50	10	4

[a]Standard deviation is in parenthesis.

female largemouth bass were 106, 193, 275, 319, 354, 401 and 411 mm (Table 4).

Growth rate comparisons with bass from other waters in the United States indicated that largemouth bass from Pelican Lake displayed comparable first-year growth rates with lakes of about the same latitude (Appendix; Table 35). Growth in later years of life for largemouth bass from Pelican Lake compared favorably with bass from other northern latitude lakes; i.e., Wisconsin state average, although differences within each lake, i.e., productivity, food availability and length of growing season, make direct growth comparisons difficult.

Qualitative examination of largemouth bass stomach contents during the summer months revealed few, if any, bluegill had been consumed. Since bluegill growth was fairly rapid in the first three years, they may not have remained within the food preference range for bass very long. Consequently, bass growth was curtailed after their first year because they were forced to feed on less preferred food items. Also, the dense, aquatic vegetation may have reduced the efficiency of bass as predators upon smaller bluegills.

Annulus formation for the majority of largemouth bass in Pelican Lake occurred in early May. Most, if not all, had formed their yearly annulus by June 1. The largest and oldest largemouth bass observed within this study was a seven-year-old female (453 mm TL and 1,158 g total weight).

Condition factor. Age specific condition factors were calculated for largemouth bass during the 1976 and 1977 field seasons (Figure 25). Condition factor steadily increased from age I (2.28) to V (2.80) and

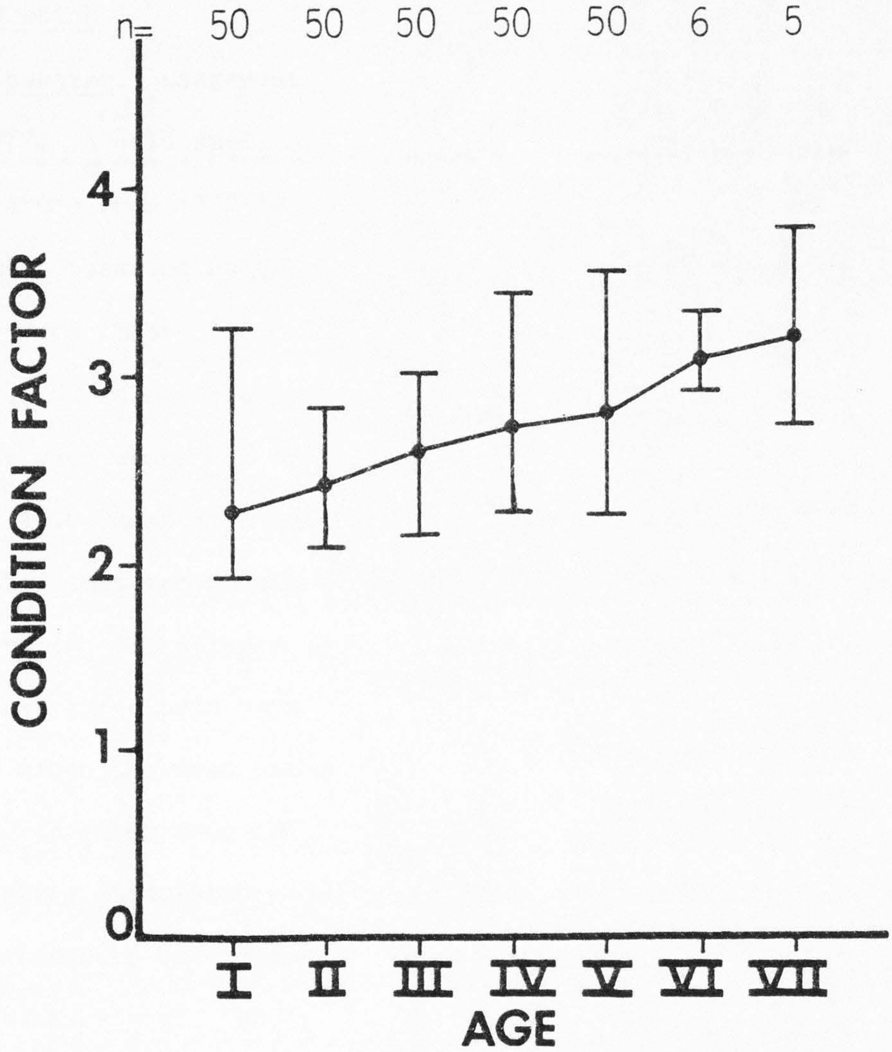


Figure 25. Age specific condition factor (standard length) for largemouth bass from Pelican Lake, Uintah County, Utah, 1976 and 1977. (Note: vertical lines indicate the range of values.)

was greater than 3.0 for age classes VI (3.10) and VII (3.21). These values compared favorably with condition factors reported by Carlander (1977).

Reproduction

Spawning. Largemouth bass nesting commenced in mid-May of 1976 and 1977. A cold spell on May 8, 1977, decreased the surface water temperature from 18 C to 9 C (Appendix; Figure 45). Largemouth bass that were observed building and guarding nests on this date were absent from these same areas the following day. Bass were not observed building or guarding nests until May 24 (16 C). This was evident when comparing the TL frequencies of young-of-the-year bass in August 1976 (mean = 92 mm TL) and 1977 (mean = 75 mm TL). This either indicated that growth was faster in 1976 or that a late spawning had occurred in 1977 (Figure 24). Kramer and Smith (1960) reported that the first largemouth bass spawning in Lake George, Minnesota was 2 to 5 days after the mean water temperature reached and remained above 15.6 C. A sharp drop in water temperature followed by a rise in water temperature stimulated repeated spawning at Lake George, Minnesota.

Largemouth bass spawning has been reported to occur at various water temperatures: above 12.8 C in Ridge Lake, Illinois (Bennett 1954), 14.4 to 23.9 C in Lake Powell, Utah (Miller and Kramer 1971), 16.7 to 17.8 C for Wisconsin waters (Carlander 1969), 17.2 to 20.0 C for Iowa waters (Harlan and Speaker 1956) and 20.0 to 24.0 C for southern waters (Swingle 1956a). Carlander (1977) provided an in-depth summary of nesting and spawning temperature requirements for largemouth bass.

Largemouth bass in Pelican Lake were observed guarding nests as late as June 29 in 1976 and July 3 in 1977. Nesting areas most commonly utilized by bass were a circular stand of cattails in the southeast corner of the lake, an isolated cove with numerous cattail stands located approximately 150 m east of the recently (1976) built south parking lot-boat ramp complex. Bass were also observed nesting along the scattered midwater stand of cattails located on the north side of the lake.

Fecundity. The relationship between fecundity (mature eggs) and TL and total weight and age was determined for 36 largemouth bass ranging in age from II to V. Fecundity tended to increase with TL (Figure 26), weight and age (Figure 27). Variability was large within age groups due to the wide range of fish lengths within each respective age group.

The TL-fecundity relationship was significant ($F = 138.20$, $p < 0.0005$, $r = 0.89$, 34 df) and was described by the equation:

$$\text{Log } F = 3.36 \text{ Log } TL - 4.24.$$

The total weight-fecundity relationship was also significant ($F = 131.36$, $p < 0.0005$, $r = 0.87$, 34 df) and was described by the equation:

$$F = 36.8 W - 1700.$$

The greatest estimated fecundity was 31,719 mature eggs from a largemouth bass age V, 388 mm TL and 763 g total weight, while the lowest was 4,810 mature eggs from a largemouth bass age II, 240 mm TL,

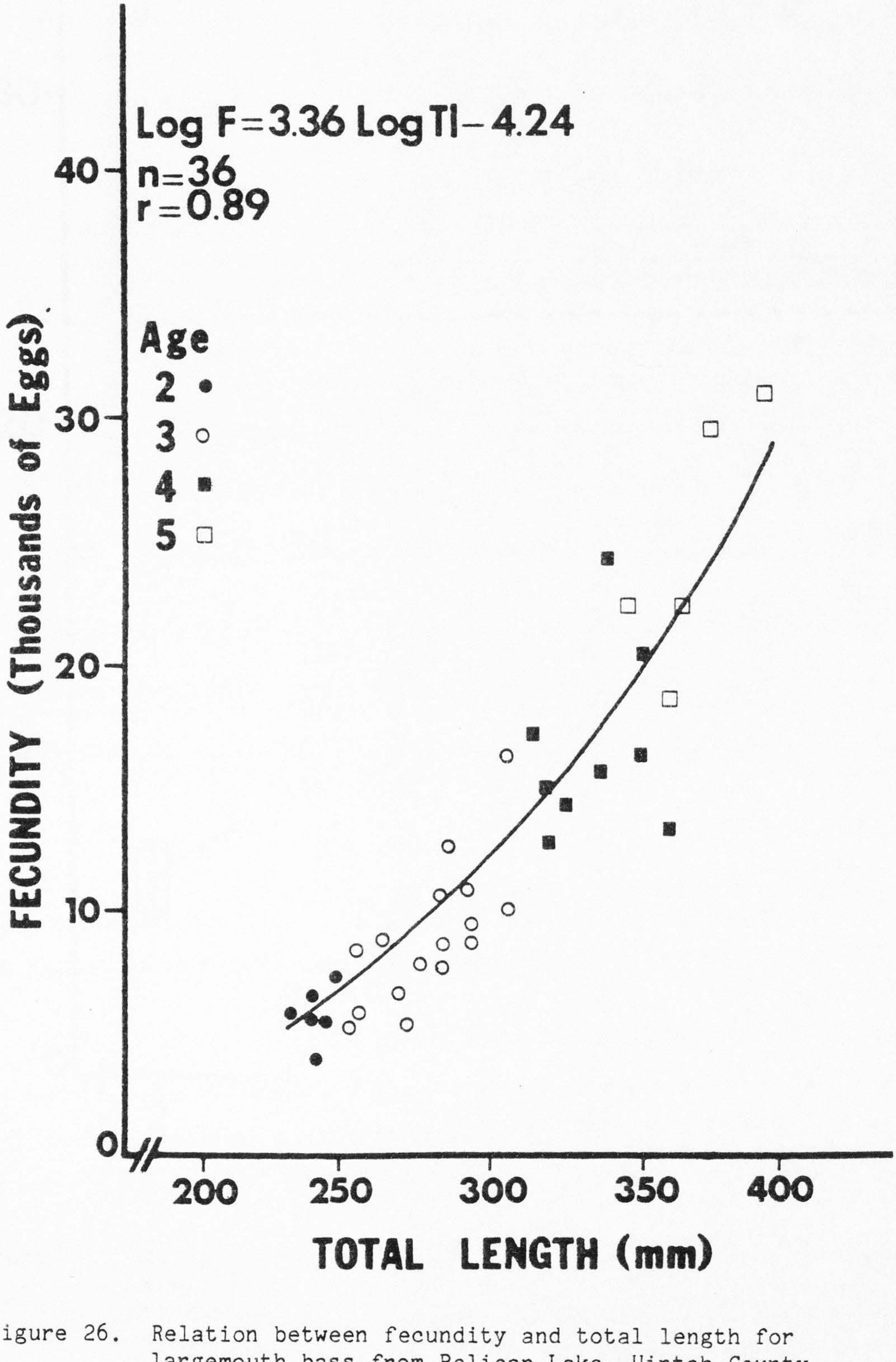


Figure 26. Relation between fecundity and total length for largemouth bass from Pelican Lake, Uintah County, Utah, 1976. (Actual fecundity estimates are given in Appendix; Table 36.)

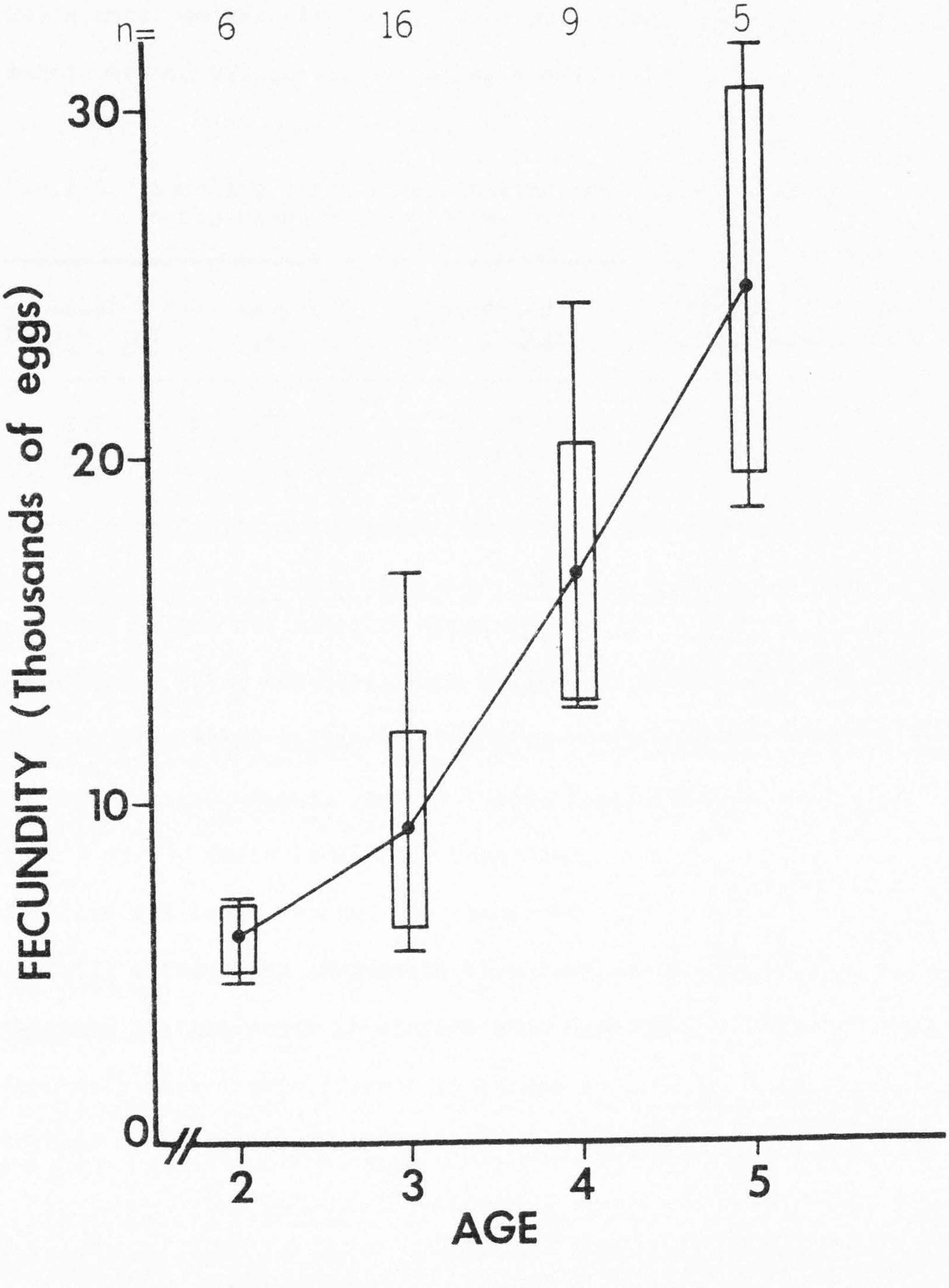


Figure 27. Age specific fecundity for largemouth bass from Pelican Lake, Uintah County, Utah, 1976. (Note: bars indicate one standard deviation and vertical lines show the range. Actual fecundity estimates are given in Appendix; Table 36.)

209 g total weight (Appendix; Table 36). Sampling error by the gravimetric method was small, averaging 4.65% (Table 5).

Table 5. Sampling error in estimating the fecundity of three largemouth bass by the gravimetric method.

Total Length (mm)	Weight (g)	Estimated No. of Eggs	Actual No. of Eggs	Percentage Error
317	400	17,056	17,871	-4.56
358	616	22,846	24,102	-5.21
241	190	6,119	6,385	-4.17

The weight estimates of immature ova and ovigerous lamellae comprised 9.8% of the total body weight for a largemouth bass 270 mm TL and 287 g total weight and 12.7% for a largemouth bass 319 mm TL and 400 g total weight. Kelley (1962) reported 20.3 $\pm$ 6.5% ($p < 0.05$) of Maine largemouth bass ovaries were composed of ovigerous lamellae and immature ova. He commented that fecundity declined after age VII, although no largemouth bass females of age greater than V were examined in this study to confirm that hypothesis. The variability in fecundity data from different locations and the nonstandardization in methods of estimating fecundity make comparisons difficult.

Fishery

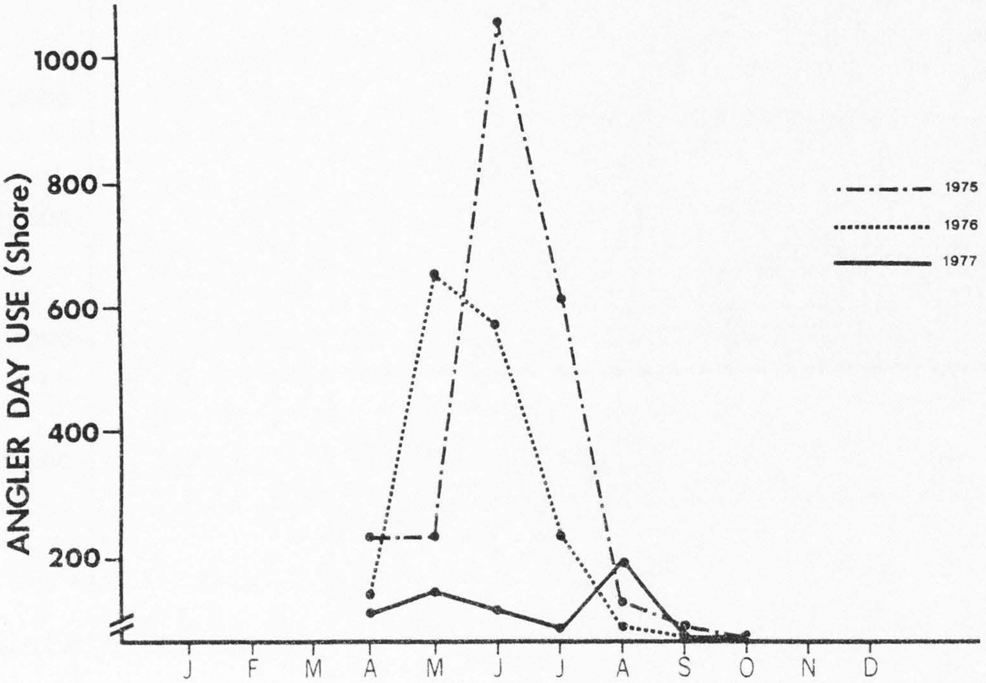
Creel Census

Angler use patterns

The creel survey was conducted from April 1 to October 30 in 1975 and 1977 and from April 1 to September 25 in 1976. Analysis of trend data for these three years indicated that cumulative angler day use declined in 1977 from 1976 (37%) and 1975 (50%) (Appendix; Table 37) (Figure 2). Increased angler use might have been anticipated due to (1) the publicity of the lake in national sporting magazines and (2) the partial completion of a joint U. S. Bureau of Land Management-Utah DWR campground-boat launching complex on the west side of the lake. A tabulation of state license plates of anglers visiting Pelican Lake was conducted during the creel check in 1975 and 1977 (Appendix; Table 38). The state of Utah provided 73 and 68% of the visitation in 1975 and 1977, respectively, followed by Colorado which provided 11 and 16% of the visitation in 1975 and 1977, respectively.

Monthly breakdown of angling use indicated that the lake was utilized heavily in May, June and July while use in April and August was significantly less (Figures 28 and 29). The majority of angling use occurred over the four-month period, April 1 to July 31, and the pattern was almost identical in each of the three years (1975: 83%; 1976: 86%; 1977: 84%). Because the general Utah fishing season does not open until the end of May or the first of June each year, waters which are open year-round to fishing, such as Pelican Lake, are subject to considerable angling use from the ice-out in early April to June 1.

Boat fishing comprised 82% of the seven-month total angler hours (30,191) in 1975, 86% of the six-month total angler hours (28,438) in 1976 and 94% of the seven-month total angler hours (19,472) in 1977 (Appendix; Table 39). Shore fishing was popular only during May and June, when water levels were at full capacity, allowing angling in the dredged canals. Shore fishing declined as the water level receded



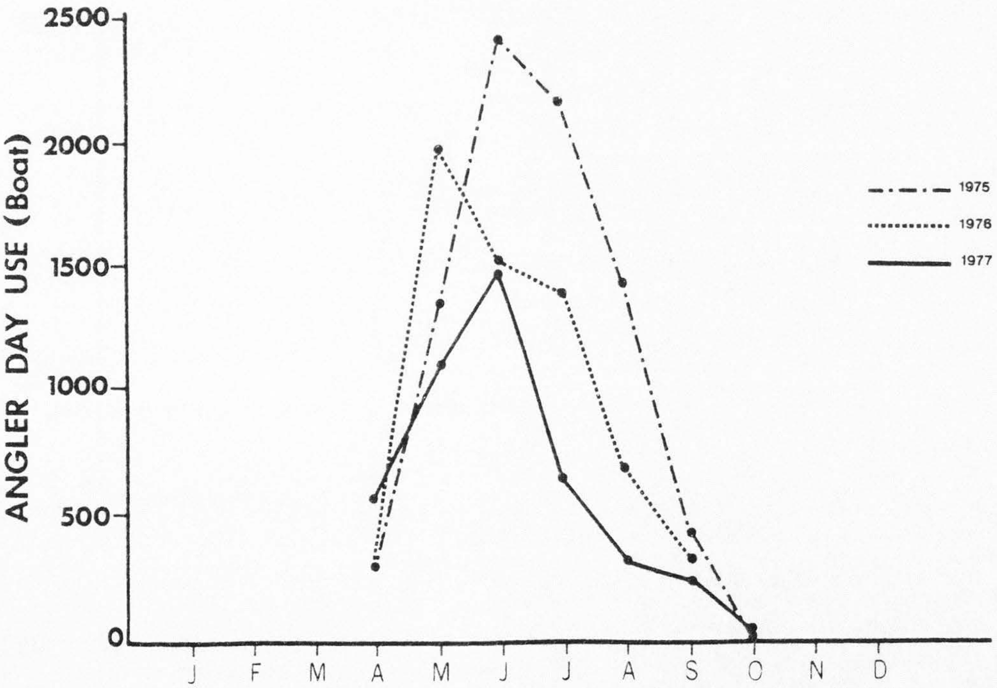
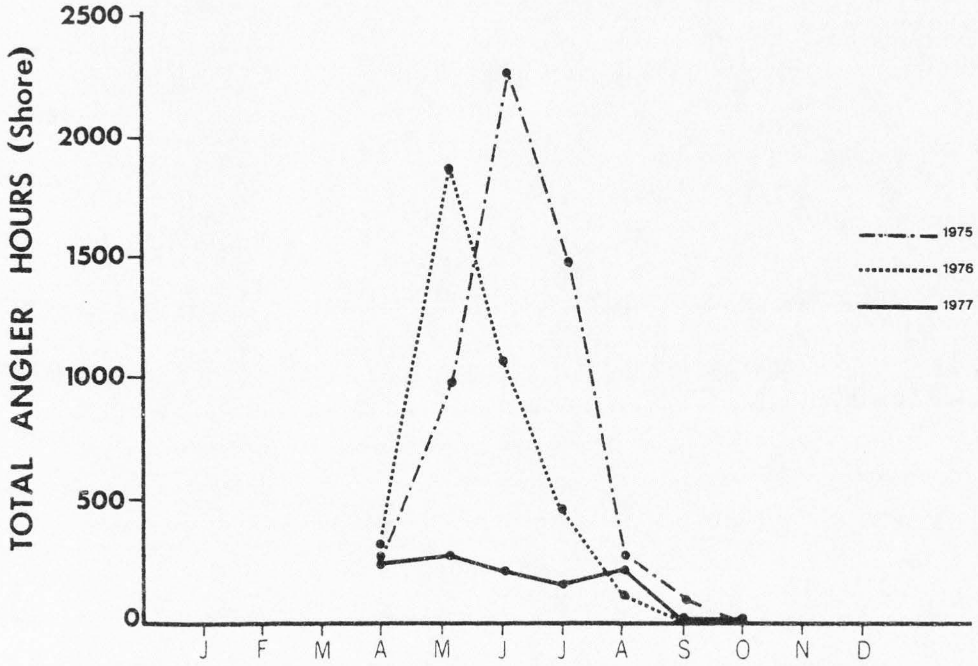


Figure 28. Monthly shore and boat angler day use for Pelican Lake, Uintah County, Utah, 1975-1977. (Note: weekdays and weekends combined. Mean values are given in Appendix; Table 37.)



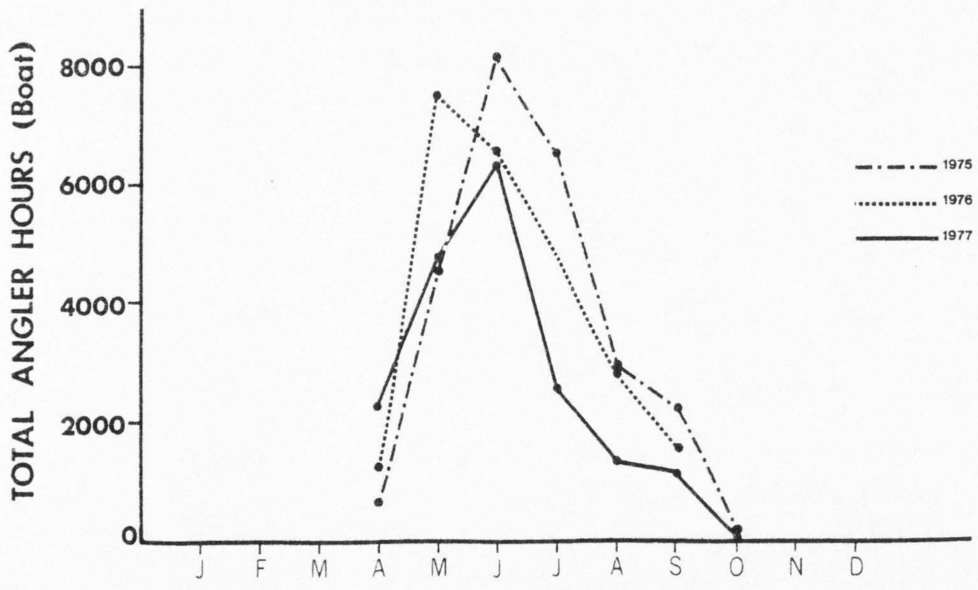


Figure 29. Mean monthly total shore and boat angler hours for Pelican Lake, Uintah County, Utah, 1975-1977. (Note: weekdays and weekends combined. Mean values and 95% confidence intervals are given in Appendix; Table 39.)

during the summer and fall months. The littoral zones and dredged canals were sites where aquatic vegetation proliferated, which further caused a decline in shore fishing.

Several reasons can be given for the decrease in boat angling during the latter summer months, but it should be noted that 1977 was marked by lower than normal water levels, in which the lake failed to reach maximum storage capacity and water levels dropped sooner than normal. This may have allowed proliferation of submerged macrophytes, possibly producing a situation undesirable for successful angling, and leading anglers to seek other waters for angling. Conditions such as these, along with no campground and fish cleaning facilities, an inaccessible boat ramp and the high unpleasant air temperatures, may be limiting factors which may be offered as plausible explanations for the decline in use of this warmwater fishery in late July, August and September.

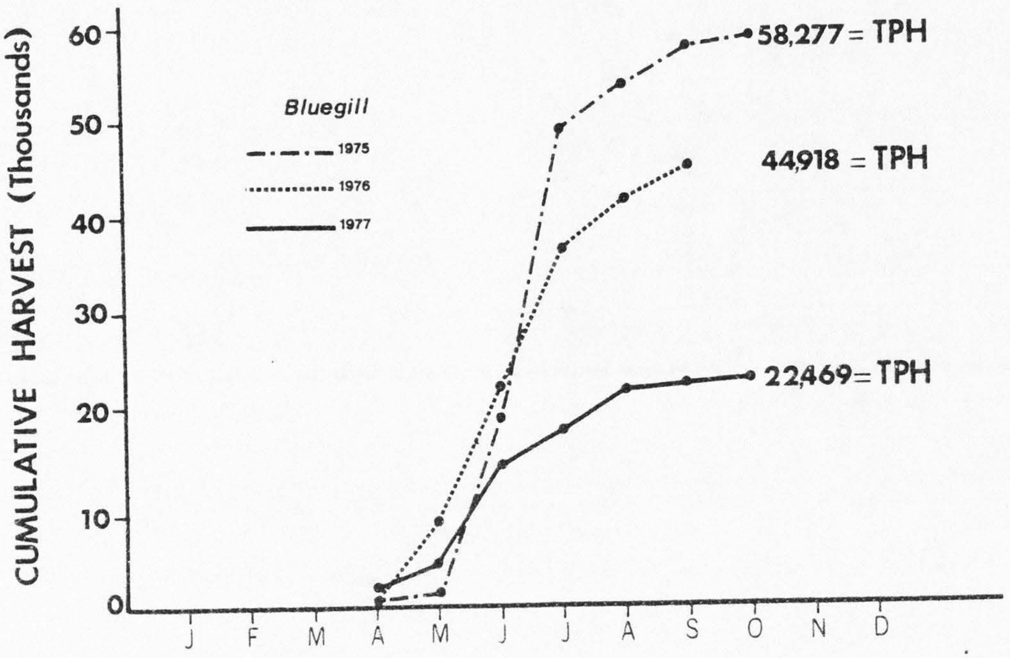
A nine-year analysis of angler use indicated that 1975 culminated a seven-year continuous increase in use (Figure 2). However, it should be pointed out that an incomplete creel census program was conducted from 1969-1974, in which angler card survey returns and conservation officer checks were utilized to estimate the annual angler day use (Utah DWR 1969-1974). It should also be noted that creel census was usually conducted from April to July. This estimate would have probably provided adequate information on angler pressure, as a majority of the annual pressure usually occurs by July. Most important of all, however, is that the sampling design was not consistent or comparable with that used in 1975, 1976 and 1977. Thus, the angler use data from 1969-1974 is not comparable with that of 1975-1977.

A significant winter fishery developed in 1978 as anglers introduced ice-fishing techniques well known in the midwestern United States. In the past, ice-fishermen were unsuccessful in catching either bluegills or largemouth bass with terminal gear commonly used in the nonice-fishing season (Shipley and Grandison 1976, Vernal, Utah, Personal communication). No attempt was made to project the total angler hours fished or total harvest for January, February or March of 1978, but data on catch effort by species were collected and will be covered later.

Angler harvest

Bluegill. Anglers harvested an estimated total of 58,277 bluegills in 1975, 44,918 in 1976 and 22,469 in 1977 (Appendix; Table 37) (Figure 30). Boat anglers harvested 91% of the total bluegills harvested in 1975, 89% in 1976 and 97% in 1977 (Appendix; Table 40). Of the boat anglers, weekend fishermen harvested 33% in 1975, 59% in 1976 and 60% in 1977 (Appendix; Table 40). Shore anglers harvested bluegills predominantly in months when water levels were high along the east causeway bordering Utah State Highway 88 and at the five dredged outlet canals located around the lake.

Monthly analyses of bluegill harvest indicated that May, June and July were peak months in 1975, 1976 and 1977 which were correlated with the months of greatest angler use (Appendix; Table 40). The annual harvested yield of bluegills was 85.58 fish/ha, (weight data not available), 66.04 fish/ha (19.385 kg/ha) and 33.03 fish/ha (9.635 kg/ha) in 1975, 1976 and 1977, respectively. McFadden (1969) estimated that the upper limit of average yield of acceptable quality sport fish from the



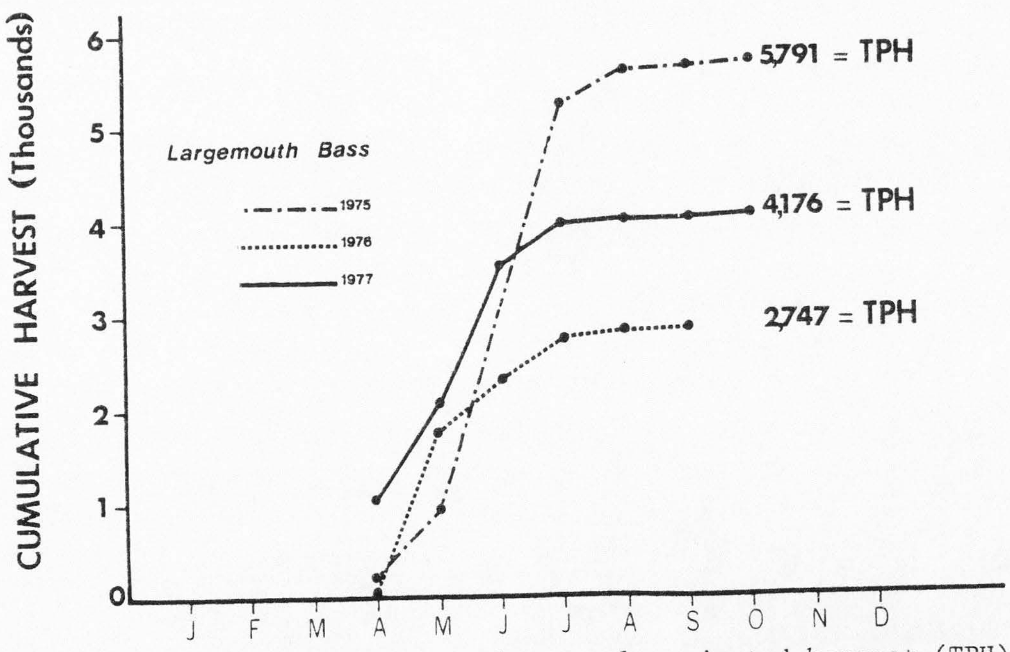


Figure 30. Mean monthly cumulative total projected harvest (TPH) for bluegills and largemouth bass from Pelican Lake, Uintah County, Utah, 1975-1977. (Note: weekdays and weekends combined; shore and boat combined. Mean values and 95% confidence intervals are given in Appendix; Table 40.)

fresh waters of the United States is around 33.600 kg/ha, although production of fish varies considerably in the diverse, natural waters of the north temperate zone.

Largemouth bass. Harvest of largemouth bass was far less than that of bluegills. Anglers harvested a total of 5,791 largemouth bass in 1975, 2,747 in 1976 and 4,176 in 1977 (Appendix; Table 37) (Figure 30). Of the total bass harvested, boat anglers harvested 78% in 1975, 76% in 1976 and 97% in 1977 (Appendix; Table 40). Largemouth bass were also caught in the deep outlet canals during months when water levels were high.

Largemouth bass were primarily taken by anglers from ice-out to mid-May; following this time, most anglers turned to the bluegill fishing. In 1975, June (2,248) and July (2,095) were the peak harvest months, while May (1,655) in 1976 yielded the greatest harvest (Appendix; Table 40). In 1977, April (1,087) and June (1,433) were the peak months of bass harvest. The annual harvested yield of largemouth bass was 8.51 fish/ha, (weight data not available), 4.04 fish/ha (1.479 kg/ha) and 6.14 fish/ha (2.946 kg/ha) for 1975, 1976 and 1977, respectively.

Catch effort

Bluegill. Catch rate has been termed an index of the biological health or abundance of a fish population (von Geldern and Tomlinson 1973). As with any fishery, wide variability between groups of anglers was detected, as anglers who had frequented the lake were far more successful than those anglers who were angling for the first time.

Anglers were interviewed as a group, so the catch rate variability among anglers of a single party was not noted.

The mean annual catch per man-hour for bluegills in 1975 (1.52) was nearly identical with 1976 (1.64) but declined in 1977 (1.13) (Appendix; Table 37). All catch rates reported in this study were for harvested fish only. Daily catch rate appeared to be influenced by the mean daily water temperature. Bluegill catch rate increased when water temperatures fell below that value. Angler success was also retarded following the cold periods in mid-June of 1976 and mid-May of 1977 when surface water temperatures fell to 14 C and 9 C, respectively (Appendix; Figure 45). Reduced feeding at lower temperatures, below 15.5 C for bluegills (Emig 1966), is a well-known phenomenon and probably explains the reduced catch rates when temperatures fell.

The mean monthly catch rate for bluegills was greatest in July 1975 (2.350) and 1976 (2.640), while June (1.60) and August (1.53) were the peak months in 1977 (Appendix; Table 41) (Figure 31). Similar patterns were demonstrated in each of the three years as water temperatures warmed which probably influenced the activity of bluegills and success of anglers. Fall water temperature cooling brought the decline in the angler success rate (Figure 31).

Although the annual catch rate declined in 1977 from the previous two years, it was apparent from personal observation and comments from anglers that the faster than normal growth of submerged macrophytes in 1977 made locating fishing "holes" difficult. Anglers complained that macrophytes were a nuisance because they became entangled in outboard motors and made navigation difficult.

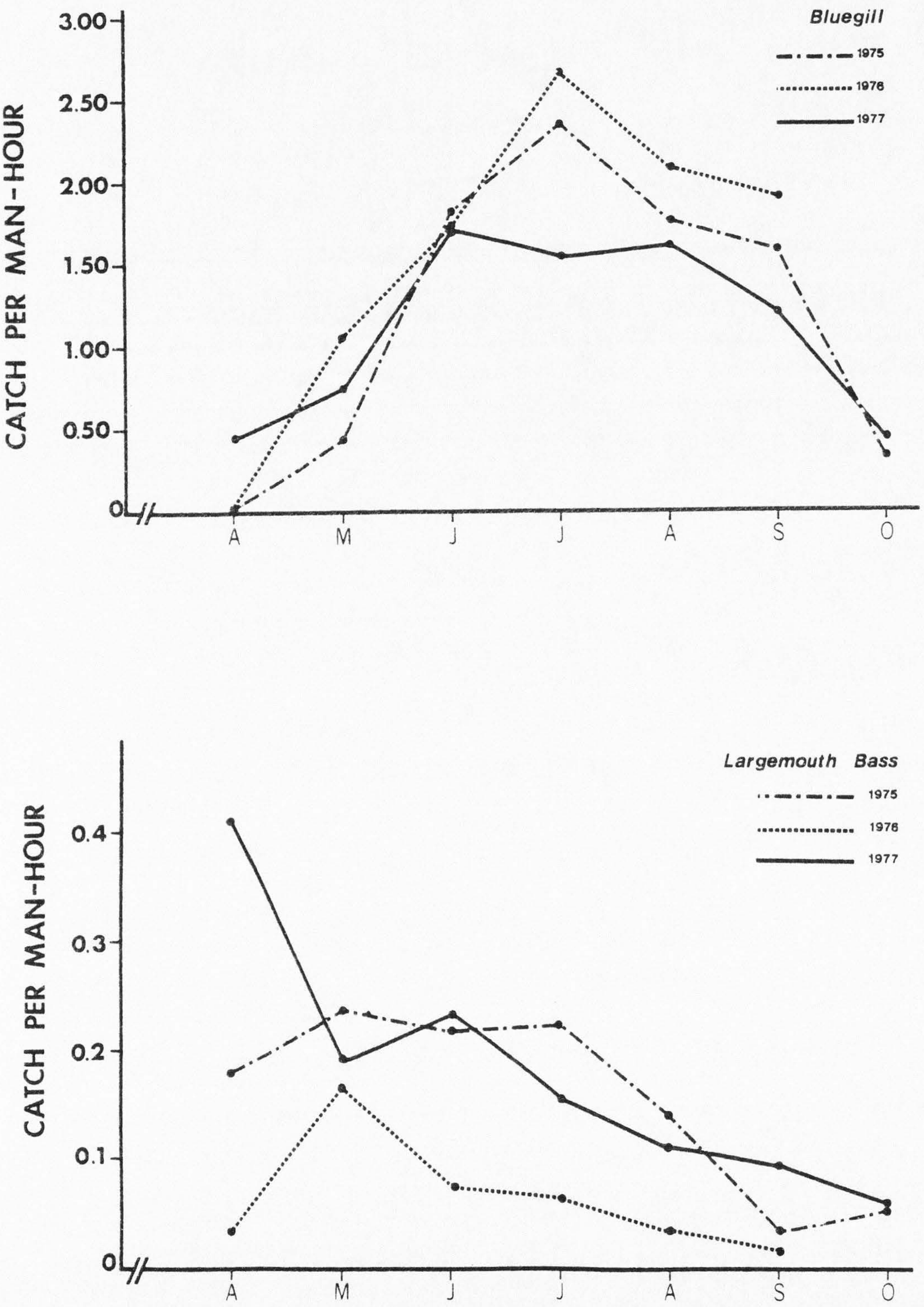


Figure 31. Mean monthly catch per angler hour for bluegills and largemouth bass from Pelican Lake, Uintah County, Utah, 1975-1977. (Note: weekdays and weekends combined; shore and boat combined. Mean values and 95% confidence intervals are given in Appendix; Table 41.)

Annual bluegill catch effort data for 1970 through 1973 were markedly lower than that of 1975 through 1977 (Table 6). Mean annual catch rates (fish/hr) for bluegills were 1.02: shore, 1:00: boat (1970); 0.54: shore, 0.58: boat (1971); 0.90: shore, 0.54: boat (1972); and 1.27: shore, 0.09: boat (1973) (Table 6). Creel census estimates of ice-fishing catch rates (fish/hr) for bluegills in 1978 ranged from 2.670 in January to 0.539 in March, while the month of February yielded a 2.250 catch rate (Table 7).

Largemouth bass. Mean annual catch rates (fish/hr) for bass fluctuated from 0.204 in 1975 to 0.094 in 1976 to 0.213 in 1977 (Appendix; Table 37). Largemouth bass catch rates in 1976 were noticeably lower in every month than of the other years (Figure 31). The fluctuating rates in these three years may suggest a stronger year class in 1972 and 1974 than in 1973. It is common for largemouth bass to exhibit year-class strengths (Kramer and Smith 1962).

Largemouth bass catch rate was highest in April, May and June and declined as the summer months progressed. The increased preponderance of bluegills in the anglers' creels commencing in mid- to late May suggested that anglers were fishing for the more vulnerable bluegills. Many anglers commented that they were exclusively fishing for bluegills and caught largemouth bass only unintentionally, yet total hours fished by anglers were tallied for both bluegills and largemouth bass in this study. This was done to consistently analyze catch rate data which had been collected in the same manner in 1975. Rates of success for individual species in a multi- or, in this case, bi-specific fishery, are somewhat difficult to determine precisely. Most anglers fish for

Table 6. Mean monthly catch per effort (fish/hour) for bluegills and largemouth bass harvested from Pelican Lake, Uintah County, Utah, 1970-1973.

Year	Month	Bluegills		Largemouth Bass	
		Shore	Boat	Shore	Boat
1970	April	0.00	--	1.09(11.0)[a]	--(0.0)
	May	1.63	2.56	0.36(52.3)	0.36(19.5)
	June	0.91	0.43	1.17(107.5)	1.08(41.5)
	July	1.04	0.64	1.22(82.5)	1.04(17.3)
	August	0.50	1.00	1.55(22.0)	0.54(35.0)
	Mean	1.02	1.00	1.06(275.3)	0.78(113.3)
1971	March	0.00	0.00	0.58(12.0)	0.71(48.0)
	April	0.00	0.06	0.47(48.8)	0.55(113.0)
	May	0.34	0.68	0.60(129.5)	0.75(228.3)
	June	1.46	1.30	0.64(31.5)	0.78(63.0)
	July	0.77	1.76	1.01(126.5)	0.59(17.0)
	Mean	0.54	0.58	0.73(348.3)	0.70(469.3)
1972	March	0.00	0.16	0.54(22.3)	0.53(102.3)
	April	0.12	0.20	0.98(49.0)	0.78(90.0)
	May	1.44	1.17	0.56(129.5)	0.74(115.8)
	June	0.77	0.47	0.84(84.5)	0.88(77.0)
	Mean	0.90	0.54	0.71(285.3)	0.72(385.1)
1973	April	0.00	0.09	0.66(74.5)	1.49(221.5)
	May	1.41	0.10	0.54(61.0)	1.49(74.0)
	June	2.89	--	0.33(9.0)	--
	July	3.89	--	0.30(27.0)	--
	Mean	1.27	0.09	0.54(171.5)	1.49(295.5)

[a]Total angler hours interviewed is in parenthesis.

Table 7. Winter creel census for Pelican Lake, Uintah County, Utah, January, February and March 1978.[a]

Month	Number of Anglers Interviewed	Number of Angler Hours Interviewed	Number of Bluegills Caught	Number of Largemouth Bass Caught	Catch Effort[b]	
					Bluegill	Largemouth Bass
January						
Weekday	0	0.0	0	0	0.000	0.000
Weekend	6	30.0	80	0	2.670	0.000
February						
Weekday	17	87.0	166	5	1.908	0.057
Weekend	95	255.5	605	44	2.363	0.172
March						
Weekday	0	0.0	0	0	0.000	0.000
Weekend	28	148.5	80	1	0.539	0.007
Totals	146	521.0	931	50	1.787	0.096

[a]Angler interviews conducted by Chad Crosby, regional fishery manager, and John Dickerson, conservation officer, Utah DWR, Vernal, Utah.

[b]Refers to catch per man-hour.

one given species. As in this case, a bass may be caught unintentionally on terminal gear preferred by bluegills, although the angler is primarily fishing for bluegills.

Annual largemouth bass catch rates in 1975 through 1977 decreased from catch rate data of 1970 through 1973. Catch rates (fish/hr) were noticeably higher in earlier years: 1.06: shore, 0.78: boat (1970); 0.73: shore, 0.70: boat (1971); 0.71: shore, 0.72: boat (1972); and 0.54: shore, 1.49: boat (1973) (Table 6). Creel census estimates of ice-fishing catch rates for largemouth bass in 1978 ranged from 0.143 in February to 0.007 fish per hour in March (Table 7).

Sex ratios

Bluegill. A total of 3,155 bluegills in 1976 and 2,779 bluegills in 1977 were sampled from creels. Significant sex differences ($p = 0.05$) were noted in creeled fish in various months (Table 8). Male bluegills were predominantly found in anglers' creels in 11 of 13 months in 1976 and 1977. Significant sex differences were noted in 6 of those 13 months (Table 8). Differences between sexes of fish in the creel were most notable during the nesting and spawning months of May, June and July. The greatest difference was in June 1977 when 89% of creeled fish were male bluegills, suggesting that males were more vulnerable to anglers at this time. A favorite angling technique was fishing over nests when the high water clarity allowed anglers to see fish guarding the nests.

Largemouth bass. A total of 266 bass in 1976 and 968 bass in 1977 were examined from creels. Significant differences in sex ($p = 0.05$) were noted in three months in 1976 and only one month in 1977

Table 8. Monthly sex ratios of angler harvested bluegills and largemouth bass from Pelican Lake, Uintah County, Utah, in 1976 and 1977 (± 95% confidence interval).

		Bluegills			Largemouth Bass		
Year	Month	Number of Fish	Percent Males	Percent Females	Number of Fish	Percent Males	Percent Females
1976	April	1	100	0	11	9±19*	90±19*
	May	182	69±7*	31±7*	111	41±9	58±9
	June	855	58±3*	42±3*	58	35±12*	65±12*
	July	1,293	54±3*	46±3*	74	72±10*	28±10*
	August	491	53±4	47±4	14	50±29	50±29
	September	333	54±5	46±5	8	38±39	62±39
1977	April	175	60±7*	40±7	168	44±8	56±8
	May	394	51±5	49±5	86	51±11	49±11
	June	1,686	89±2*	11±2*	81	55±14	45±14
	July	94	49±10	56±10	599	56±4*	44±4*
	August	162	49±7	51±7	18	50±25	50±25
	September	260	57±6*	43±6*	15	47±28	53±28
	October	8	100	0	1	0	100

*Significant at p = .05.

(Table 8). The greatest difference occurred in April of 1976 when 90% (n = 11) of the catch was composed of females. However, no apparent trend could be established, as a significant number of males composed the catch in July 1976 and July 1977 (Table 8).

Age composition of harvest

Bluegill. A total of 391 bluegills were obtained from creels in May and June of 1976 and analyzed for age. The age composition of the harvest ranged from II- to VIII-year-old bluegills, although II and III year olds were less vulnerable to capture at that time. The catch sample included 5 age II, 98 age III, 123 age IV, 109 age V, 40 age VI, 12 age VII and 4 age VIII bluegills (Figure 32).

A catch curve was generated from the above information and the total annual mortality rate (A) estimated by comparing the number of individuals of successive ages in the catch (Figure 33). Since ages II and III were less vulnerable to the catch, determination of the slope of the line was made for ages IV through VIII. The slope of the line for ages IV through VIII was calculated to be 0.393. Conversion to natural logarithms by multiplying the slope, 0.393, by 2.303 yielded the total annual instantaneous mortality rate (z), 0.905. Thus,

$$S = e^{-z} \text{ (Ricker 1975)}$$

$$S = 2.7182818^{-0.905}$$

$$S = 0.405$$

$$A = 1 - S$$

$$A = 1 - 0.405$$

and,

$$A = 0.595.$$

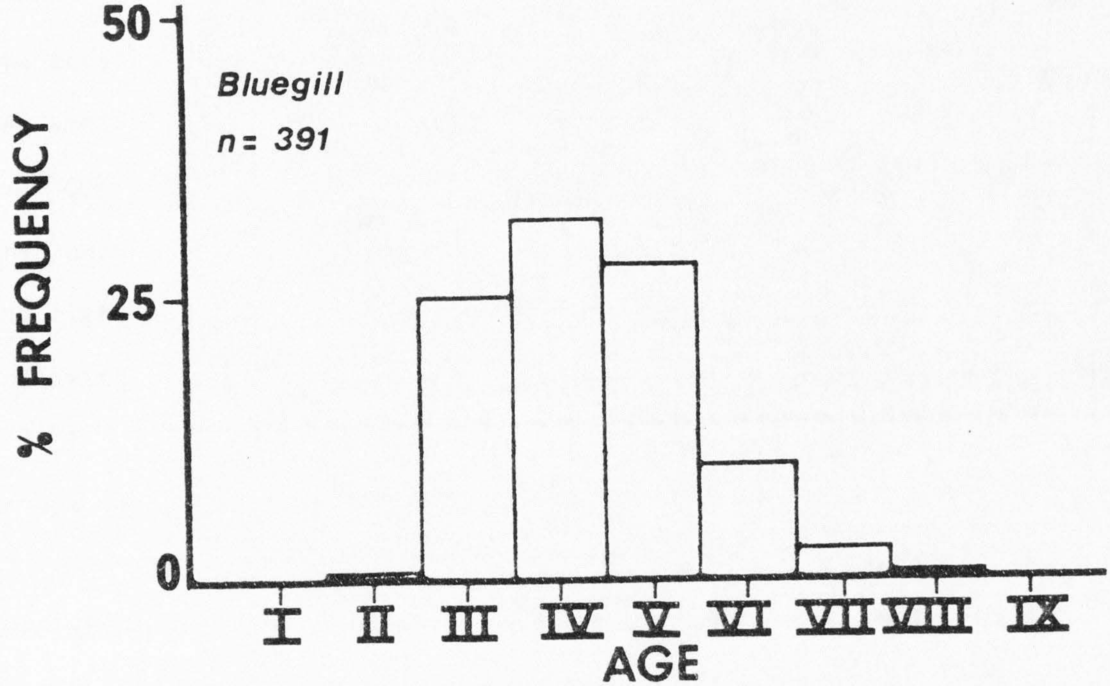


Figure 32. Age composition of bluegills harvested by anglers from Pelican Lake, Uintah County, Utah, May and June 1976.

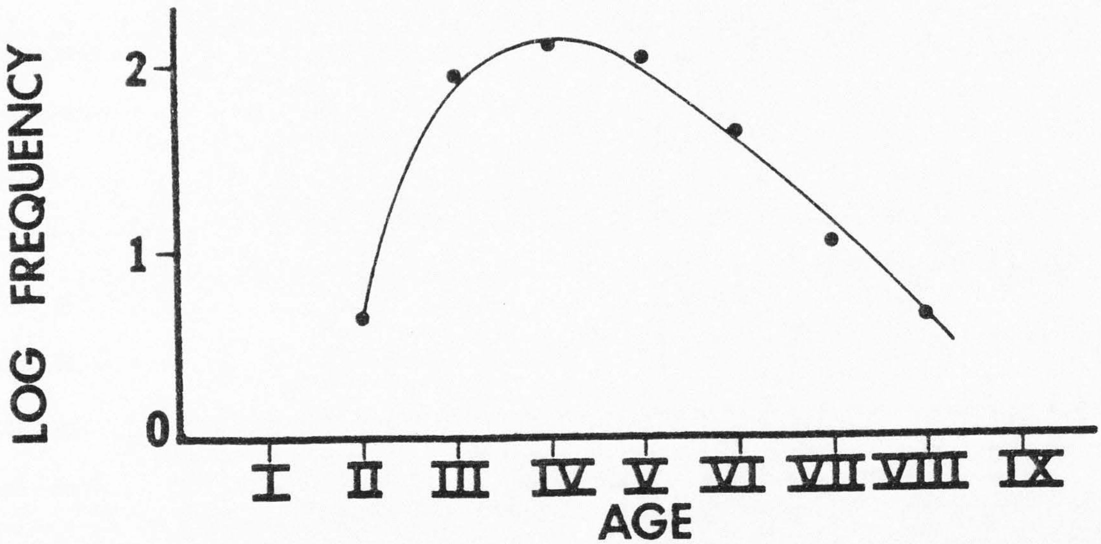


Figure 33. Catch curve for bluegills that were harvested from Pelican Lake, Uintah County, Utah, May and June 1976. (Note: the line was fitted by inspection.)

The total annual mortality rate due to both fishing and natural causes was estimated to be 59.5%.

Qualitatively, the catch curve can be interpreted as a survivorship curve which is both age-specific and time-specific. The flatter the right limb of the curve, the greater the survival under the following conditions (Ricker 1975):

1. The survival rate is uniform with age, over the range of age groups in question.

2. Since survival rate is the complement of mortality rate, and the latter is compounded of fishing and natural mortality, this will usually mean that each of these, individually, is uniform.

3. There has been no change with mortality rate with time.

4. The sample is taken randomly from the age-groups involved.

5. The age-groups in question were equal in numbers at the time each was being recruited to the fishery.

Age composition data of the catch prior to 1976 were unavailable to analyze trends in total annual mortality.

Largemouth bass. A total of 168 largemouth bass were obtained from creels in May and June of 1976 and analyzed for age. The age composition of the harvest was composed of II- to VII-year-old bass, although II year olds were less vulnerable to capture. The catch included 22 age II, 102 age III, 28 age IV, 14 age V and 1 each of age VI and age VII bass (Figure 34).

A catch curve was also generated from the above data and the total annual mortality rate (A) estimated (Figure 35). The total instantaneous mortality rate (z) was calculated as 1.26. Thus,

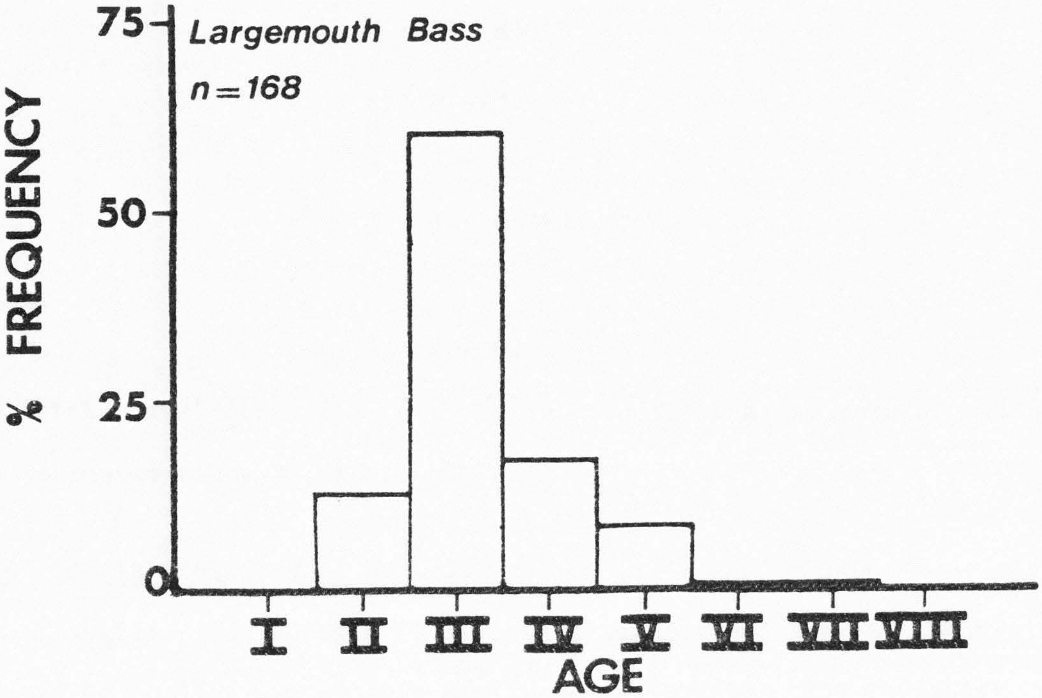


Figure 34. Age composition of largemouth bass harvested by anglers from Pelican Lake, Uintah County, Utah, May and June 1976.

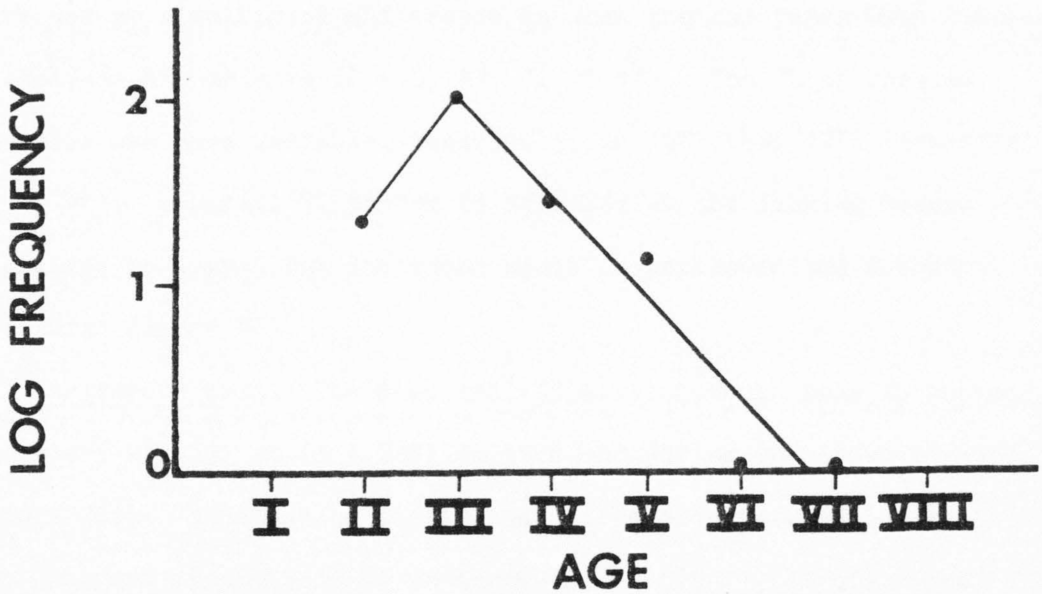


Figure 35. Catch curve for largemouth bass that were harvested from Pelican Lake, Uintah County, Utah, May and June 1976. (Note: the line was fitted by inspection.)

$$S = 2.7182818^{-1.26}$$

$$S = 0.284$$

$$A = 1 - S$$

$$A = 1 - 0.284$$

and,

$$A = 0.716.$$

The total annual mortality rate due to both fishing and natural causes was estimated to be 71.6%.

Total length frequency of harvest

Bluegill. The monthly TL of both bluegills and largemouth bass creeled by anglers was closely monitored in 1976 and 1977 (Appendix; Table 42). The mean individual bluegill TL harvested by anglers in 1976 was 212 mm (n = 1,446) and 214 mm (n = 1,127) in 1977 (Figure 36). There was no significant difference between the two years when compared by analysis of variance (F = 0.144, 1, 11 df). The TL of creeled bluegills was more variable, seasonally, in 1977 than 1976 (Appendix; Figure 47). Bluegill TL tended to decrease as the fishing season progressed to August but increased again in September and October (Appendix; Figure 47).

Largemouth bass. The mean individual largemouth bass TL harvested by anglers was 291 mm (n = 248) in 1976 and 307 mm (n = 400) in 1977 (Figure 36). There was no significant difference between the two years when compared by analysis of variance (F = 0.029, 1, 11 df). The monthly individual TL of creeled bass in 1976 was nearly identical to that in 1977, although bass creeled in 1977 were larger in all months except September and October (Appendix; Figure 48).

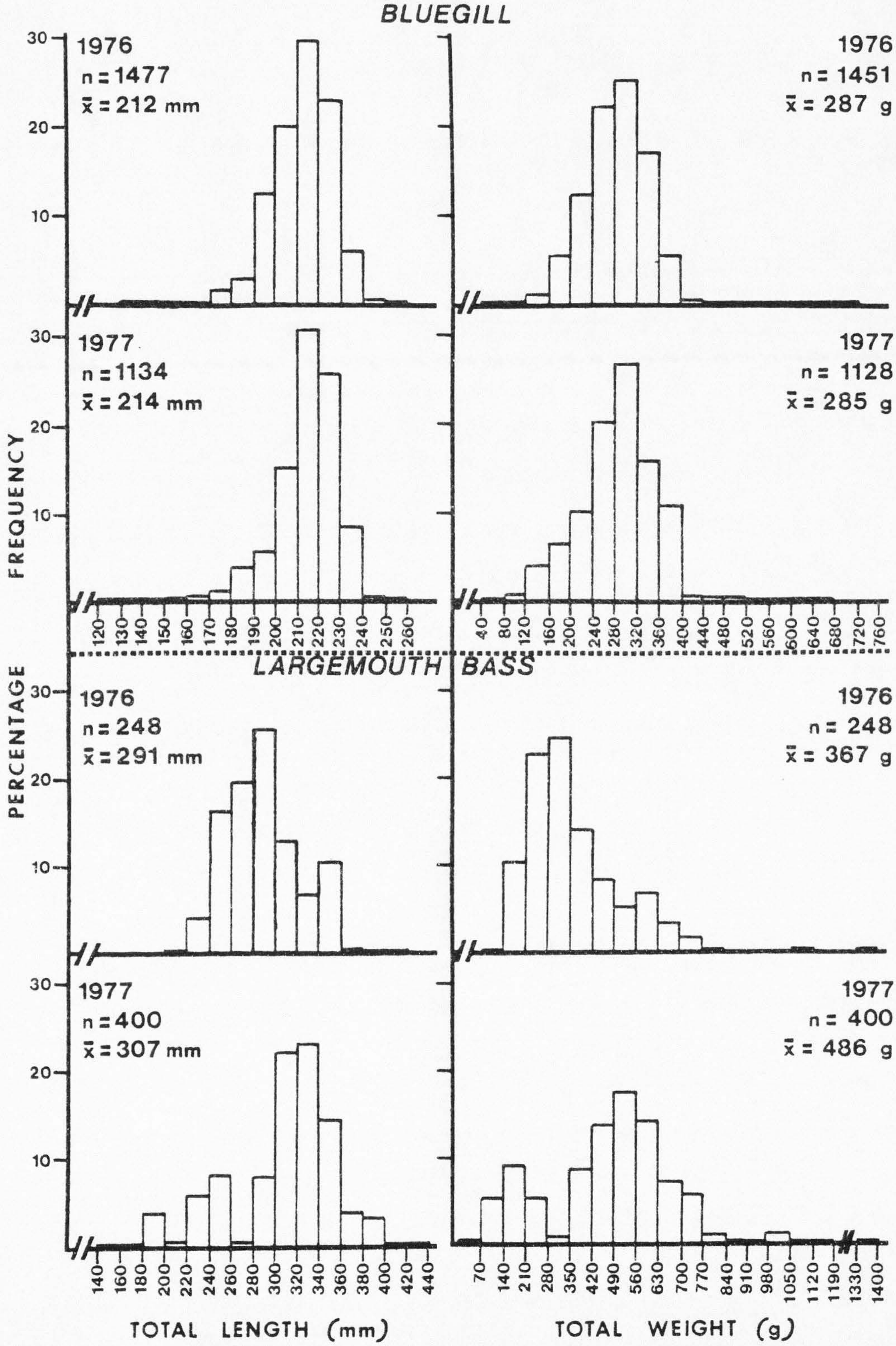


Figure 36. Length and weight frequency composition of creeled bluegills and largemouth bass from Pelican Lake, Uintah County, Utah, for April to September 1976 and April to October 1977.

Weight frequency of harvest

Bluegill. Total weights of creeled fish were recorded for 1976 and 1977 (Appendix; Table 42). The mean individual bluegill total weight harvested by anglers in 1976 was 287 g (n = 1,446) and 285 g (n = 1,127) in 1977 (Figure 36). There was no significant difference between the two years when compared by analysis of variance (F = 0.100, 1, 11 df). The same seasonal trend noticed for TL of creeled bluegills was also noted for the weight of creeled bluegills (Appendix; Figure 47). Mean individual total weight of bluegills harvested was more variable by month in 1977 than 1976 and steadily decreased from May to August 1977, only to increase in September and October.

Largemouth bass. The mean individual largemouth bass total weight harvested by anglers in 1976 was 367 g (n = 248) and 486 g (n = 400) in 1977 (Figure 36). There was a significant difference between the two years when compared by analysis of variance ($F = 4.250$, $p < 0.10$, 1, 11 df). The seasonal trend in mean individual total weight of creeled bass was almost continuous in 1976, although bass creeled in 1977 were larger in all months except September and October (Appendix; Figure 48), the same as was noted for TL.

Hooking Mortality

Information was needed to determine the total fishing mortality of bluegills, since the creel census only provided information on fish harvested and not fish lost due to mortality by anglers. Although numerous studies on hooking mortality have been done on salmonids, data on the fate of released centrarchids are not available except for largemouth bass caught in tournaments (Holbrook 1975). During the 1976 and 1977 creel checks, anglers reported releasing numerous smaller bluegills and selecting larger bluegills for the creel. This practice resulted because experienced anglers were aware of the large bluegills in the lake and the 20 bluegill bag limit.

Creel census surveys conducted in 1969 through 1973 indicated that anglers released 25, 59, 49, 33 and 10% of the total bluegill caught during respective years (Utah DWR 1969-1973). In addition, anglers were selective, releasing smaller bluegills (Wilson 1972, Vernal, Utah, Personal communication).

In the June hooking mortality experiment, bluegills were easily caught on baited hooks, but some difficulty was encountered in catching fish on jigs. During the experiment on hooking mortality, anglers could actually observe the fish due to the high water clarity and could fish for a particular bluegill. Most of the fish that were caught during the experiment were males on or near spawning beds.

There were no significant differences in the mean TL or mean total weight of fish caught in the experiment on different hook sizes (Appendix; Table 43). Bluegills caught in the June experiment were noticeably larger than those caught and released by anglers during the summer of 1977 (Table 9; Appendix; Table 43). A total of 60 bluegills were caught on 8 R hooks as the first 30 fish escaped from the holding net in the initial treatment.

Immediate mortality (within the first 24 hours of capture) was greatest for a size 8 R (10%) followed by 4 R, 6 R and 10 R (7%) hooks (Table 10). Immediate mortality for number 6 jigs, plus the separate

Table 9. Sizes of bluegills released by anglers during the summer of 1977 at Pelican Lake, Uintah County, Utah, based on angler card questionnaires.

Size of Fish Total Length (mm)	Mean Total Weight (g)[a]	Number of Fish Released	Percentage of Total
89–102	16	66	16.7
103–114	24	44	11.2
115–127	36	40	10.3
128–140	52	39	9.9
141–152	72	35	9.0
153–165	96	27	7.0
166–178	126	36	9.3
179–191	164	44	11.2
192–203	206	60	15.4
Totals	--	391	100.0

[a]Mean weight of bluegills within each total length size class converted to weight by calculated length-weight relationship (Log W = 3.54 Log TL − 5.81).

Table 10. Mortality of bluegills hooked on different sizes of hooks baited with earthworms and artificial jigs at Pelican Lake, Uintah County, Utah, June 1977.

Hook Size	Number of Fish	Immediate[a] No.	Immediate[a] %	Delayed[b] No.	Delayed[b] %	Total No.	Total %
Hook removed[c]							
4 R	30	2	7	2(0)[e]	7(0)[e]	2	7
6 R	30	2	7	3(1)	10(3)	3	10
8 R	60	6	10	11(5)	18(8)	11	18
10 R	30	2	7	3(1)	10(3)	3	10
Hook in place[f]							
8 R	30	0	0	0	0	0	0
Jig with No. 6 hook	30	0	0	0	0	0	0
Control	30	0	0	0	0	0	0

[a]Mortality within 24 hours of capture.

[b]Mortality within 72 hours of capture.

[c]Hook removed carefully with hook remover to minimize damage to fish.

[d]Shank of hook: R = regular (IX).

[e]Numbers within parentheses indicate the number and percentage of bluegill mortality greater than 24 hours to 72 hours after capture.

[f]Hook allowed to remain in place by cutting the line.

treatment of hook size 8 R (hook deeply embedded and left in place), was negligible (Table 10). Delayed mortality (within the first 72 hours of capture) was greatest in size 8 R (18%) followed by 6 R and 10 R (10%) (Table 10) (Figure 37). Of the 19 bluegill mortalities during the experiment, 12 (63%) died within the first 24 hours after capture. The total mortality by hook size was 4 R (7%), 6 R (10%), 8 R (18%) and 10 R (10%) (Table 10). All of the 30 control fish caught in the trammel nets survived. Bluegills hooked in the esophagus and gill/gill arch area suffered the greatest mortality (Appendix; Table 44). Of the 19 bluegills that died during the experiment, 12 (63%) were hooked in the esophagus and 7 (37%) in the gill/gill arch area (Appendix; Table 44). Autopsies of those bluegills hooked in the esophagus revealed punctured pericardial cavities and blood clots. Bluegills caught on number 4 R and 6 R hooks and number 6 jigs were most often hooked in the jaw or roof of the mouth. This suggests that the rather terminal mouth of the bluegill precludes their swallowing larger hooks as often as the smaller number 8 R and 10 R hooks.

The water temperature profile at the location of the live cages on June 2, 1977 (1100 hour) was:

Depth	Temperature
0.0 m	23 C
1.0 m	22 C
2.0 m	20 C
3.0 m	19 C
3.5 m	18 C

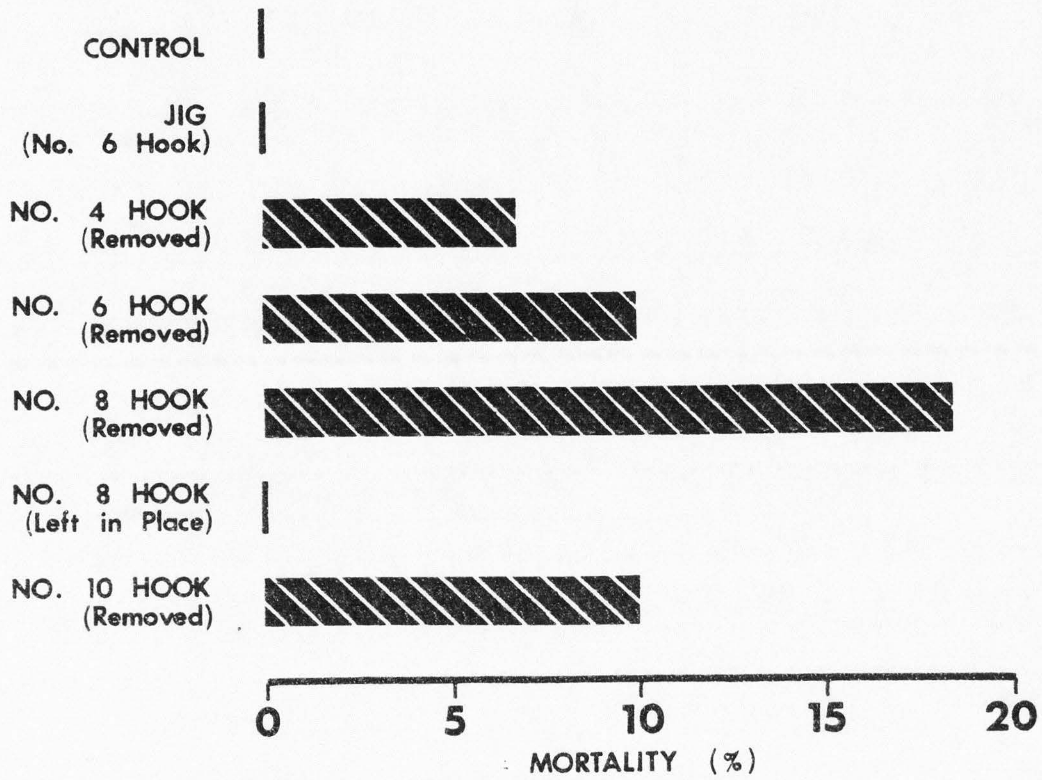


Figure 37. Delayed hooking mortality (72 hours) of bluegills captured on regular shank hooks from Pelican Lake, Uintah County, Utah, at 21 C. (Note: the sample size was 30 fish for each treatment, except for 60 fish caught on number [No.] 8 hooks that were removed from the fish.)

Anglers returned 80% of the card questionnaires over a five-month period. Data computation from 64 angler questionnaires from June through October 1977 revealed 40% of anglers used a hook remover, 42% did not use a hook remover at all and 19% cut the fishing line allowing the hook to remain in place (Appendix; Figure 49). Because the June hooking mortality experiment indicated negligible mortality for released fish when the hook was allowed to remain by cutting the leader, data from anglers who released fish by this method were not considered in the total mortality estimates. Terminal gear used by anglers was 58% bait, 24% jig, 10% spinner and 8% fly (Appendix; Figure 50). The hook sizes used by anglers in the five-month period were 45% number 6 R, 20% number 4 R, 19% number 8 R, 9% number 12 R and 6% number 10 R (Appendix; Figure 51). Because data on number 12 hooks were not collected during the June hooking mortality experiment, the use of number 12 R and 10 R hook sizes, as reported on angler card questionnaires, was combined to determine the total mortality estimates.

Anglers were not necessarily selective for fish size when releasing bluegills in the five-month period (Table 9). Anglers released a total of 391 bluegills in the five-month period with TL classes 89-102 mm (16.7%), 192-203 mm (15.4%) and 179-191 mm (11.2%) comprising the greatest number of released fish (Table 9).

Monthly analyses of the bluegill release rate indicated that anglers released a fish for every 3.5 hours of angling (0.280 fish per angler hour) (Appendix; Table 45). The mean rate of released fish in August (0.415) was greater than other months. The mean TL and total weight (Appendix; Table 42) of creeled bluegills were also lowest in August which probably suggested anglers caught more small bluegills during August and thus released more of them than in other months when larger bluegills could be caught.

The estimated loss of bluegills by the catch and release fishery may be somewhat conservative, as the card questionnaires were not utilized during the months of April and May, although these months comprised only 20% (4,533) of the total estimated annual bluegill harvest (22,469) (Appendix; Table 46). Estimates of the total number of bluegills released during these two months were made by substituting the five-month mean number of bluegills released per hour. This substitution was probably not too unrealistic since the variability in release rate between months was not large (Appendix; Table 45).

Anglers released an estimated 5,158 bluegills in 1977. Of those released, an estimated 565 (11%) were lost due to hooking mortality (Appendix; Table 46). The total estimated weight loss due to angler released bluegills in 1977 was 55.712 kg. The loss was 2.5% of the estimated annual harvest (22,469) and 1.0% of the estimated total harvested weight (6,403.665 kg).

The following conditions had to apply if the total estimates of hooking mortality of released bluegills were to be considered valid:

1. The experimental procedures closely resembled that used by the typical Pelican Lake bluegill angler; i.e., the method of hook removal.

2. The total mortality by hook size estimated in the experiment closely resembled that of the total mortality by hook size used by anglers releasing bluegills.

3. Anglers completing the questionnaire were representative of the total bluegill angler clientele.

4. Anglers could distinguish between hook sizes and terminal gear types.

5. Anglers reported data correctly; i.e., actual numbers and sizes of bluegills released.

Anglers were often hesitant and reluctant to report actual data because of a fear of prosecution by conservation officers. Anglers were aware that some bluegill mortality would occur, irregardless of how careful they were in removing hooks, and feared being cited for wasting game fish. Most questionnaires were returned to a pickup box since it was difficult to intercept them upon completion of angling. For this reason, it was difficult to insure that data had been reported correctly on the questionnaires by the angler(s).

Population Sampling

Standing crop estimation

A total of five individual population samplings were conducted September 1975 through June 1978. Shoreline sites were all located on the south side of the lake (Figure 38), but midwater sites were not replicated from one sampling to the next. This was because water levels were variable, and the depth of midwater sites was limited to approximately 3.0 m, the depth of the largest block-off net.

Bluegill and largemouth bass standing crop population estimates for each site are given in Table 11. The estimated total bluegill standing crop was 34.040 kg/ha in August 1976 (Table 12), 20.144 kg/ha in May 1977 (Table 13) and 52.517 kg/ha in August 1977 (Table 14).

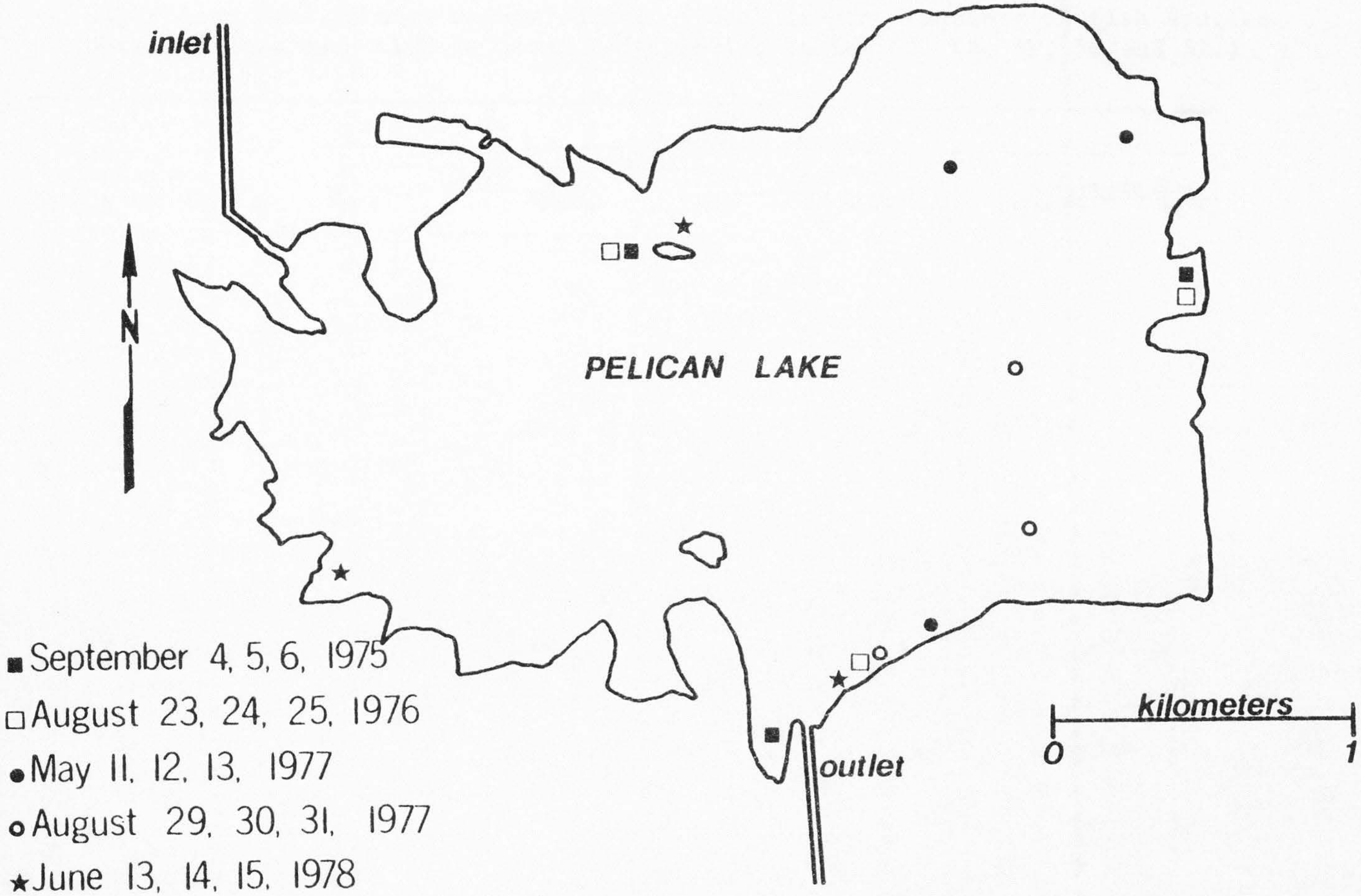


Figure 38. Location of population sites sampled with rotenone, September 1975, August 1976, May 1977, August 1977 and June 1978, at Pelican Lake, Uintah County, Utah.

Table 11. Standing crop estimates for bluegills and largemouth bass based on rotenone population samplings, September 1975, August 1976, May 1977, August 1977 and June 1978, at Pelican Lake, Uintah County, Utah. (Total length frequency of fish species obtained from each site is given in Appendix; Tables 47, 48, 49, 50 and 51.)

Sampling Date and Plot Description[a]	Standing Crop Estimate: Bluegills Fish/ha y-o-y[b]	Bluegills Fish/ha Adults[c]	Bluegills kg/ha y-o-y[b]	Bluegills kg/ha Adults[c]	Largemouth Bass Fish/ha	Largemouth Bass kg/ha
September 1975						
East Bay	1,213	138	0.415	9.717	30	3.997
South Bay	808	133	0.383	16.359	12	0.064
Midlake	625	195	0.284	26.241	15	0.104
August 1976						
East	20,128	153	9.857	8.326	22	2.316
South Shoreline	45,651	4,033	20.630	38.138	813	13.522
Midlake	29,465	148	10.120	15.381	5	0.059
May 1977						
South Shoreline	--[d]	244	--[d]	0.351	22	13.684
Midlake Number 1	--	331	--	5.043	20	8.030
Midlake Number 2	--	2,635	--	60.058	109	11.256
August 1977						
South Shoreline	7,146	403	2.072	45.621	67	1.156
Midlake Number 1	2,890	119	1.336	15.652	128	4.130
Midlake Number 2	15,119	590	6.054	87.164	203	5.993
June 1978						
South Shoreline	--[d]	20	--[d]	3.920	17	7.138
Midlake	--	247	--	76.876	5	1.529
West Cove[e]	--	53	--	13.156	35	9.019

[a]Refer to Figure 38 for relative location of rotenone sampling plots.

[b]y-o-y refers to young-of-the-year bluegills from 0 to 50 mm total length.

[c]Refers to bluegill greater than 50 mm total length.

[d]Dash refers to no young-of-the-year because spawning had not yet commenced.

[e]West Cove plot approximated 1.012 ha.

Table 12. Population age structure for bluegills and largemouth bass collected from three 0.405 ha sites sampled with rotenone on August 24, 25 and 26, 1976, at Pelican Lake, Uintah County, Utah.[a]

Bluegills

Age	Number of Fish	Percentage Number	Total Weight (kg)	Percentage Weight
0	38,561	95.9	16.633	40.2
I	1,623	4.0	14.021	33.9
II	11	< 0.1	1.258	3.0
III	12	< 0.1	2.776	6.7
IV	10	< 0.1	2.844	6.9
V	10	< 0.1	3.145	7.6
VI	2	< 0.1	0.651	1.7
VII	0	--	--	--
VIII	0	--	--	--
Totals	40,229	100.0	41.328	100.0

Largemouth Bass

Age	Number of Fish	Percentage Number	Total Weight (kg)	Percentage Weight
0	321	94.7	3.740	58.1
I	16	4.7	1.014	15.8
II	0	--	--	--
III	2	0.6	0.855	13.3
IV	0	--	--	--
V	1	--	0.855	12.8
VI	0	--	--	--
VII	0	--	--	--
Totals	340	100.0	6.434	100.0

[a]The results of the three 0.405 ha sampling sites were combined and divided by three to obtain an average estimate. This was done for both bluegills and largemouth bass.

Table 13. Population age structure for bluegills and largemouth bass collected from three 0.405 ha sites sampled with rotenone on May 11, 12 and 13, 1977, at Pelican Lake, Uintah County, Utah.[a]

Bluegills

Age	Number of Fish	Percentage Number	Total Weight (kg)	Percentage Weight
0	0	--	--	--
I	1,111	85.5	1.746	7.1
II	107	8.2	4.016	16.4
III	29	2.2	4.566	18.7
IV	25	1.9	5.637	23.0
V	19	1.5	5.428	22.2
VI	8	0.6	2.648	10.8
VII	1	< 0.1	0.416	1.8
VIII	0	--	--	--
Totals	1,300	100.0	24.457	100.0

Largemouth Bass

Age	Number of Fish	Percentage Number	Total Weight (kg)	Percentage Weight
0	0	--	--	--
I	20	32.8	0.377	2.7
II	20	32.8	1.201	9.0
III	6	9.8	2.638	19.8
IV	12	19.7	6.644	49.9
V	3	4.9	2.488	18.6
VI	0	--	--	--
VII	0	--	--	--
Totals	61	100.0	13.348	100.0

[a]The results of the three 0.405 ha sampling sites were combined and divided by three to obtain an average estimate. This was done for both bluegills and largemouth bass.

Table 14. Population age structure for bluegills and largemouth bass collected from three 0.405 ha sites sampled with rotenone on August 29, 30 and 31, 1977, at Pelican Lake, Uintah County, Utah.[a]

Bluegills

Age	Number of Fish	Percentage Number	Total Weight (kg)	Percentage Weight
0	10,194	95.9	3.831	6.0
I	177	1.6	5.701	8.9
II	97	0.9	9.249	14.5
III	72	0.7	17.139	26.9
IV	61	0.6	17.801	27.9
V	28	0.3	8.998	14.1
VI	3	< 0.1	1.041	1.7
VII	0	--	--	--
VIII	0	--	--	--
Totals	10,632	100.0	63.760	100.0

Largemouth Bass

Age	Number of Fish	Percentage Number	Total Weight (kg)	Percentage Weight
0	134	83.2	0.579	12.7
I	15	9.3	1.038	22.7
II	9	5.7	1.214	26.6
III	2	1.2	1.039	22.7
IV	1	0.6	0.700	15.3
V	0	--	--	--
VI	0	--	--	--
VII	0	--	--	--
Totals	161	100.0	4.570	100.0

[a]The results of the three 0.405 ha sampling sites were combined and divided by three to obtain an average estimate. This was done for both bluegills and largemouth bass.

The June 1978 sampling yielded 32.900 kg/ha (Table 15). The standing crop estimate in September 1975 of 43.079 kg/ha (Table 11) was not exactly comparable, since a total estimate of young-of-the-year bluegills was not made.

It was apparent that, although angling activity was nearly terminated by the time of the August sampling, a considerable weight loss of bluegills occurred between the fall sampling and spring sampling. The August to May-June sampling weight loss was 40% from August 1976 to May 1977, and 37% from August 1977 to June 1978. Natural mortality such as predation by piscivorous birds in the fall, bass predation or winterkill are some factors which may have eliminated a considerable number of fish. Negative production over the period (Chapman 1971) and behavioral patterns of fish associated with vegetation and water temperatures in the two sampling periods may certainly have contributed variation to the estimates.

Reported bluegill standing crops vary from 5.04 kg/ha in Louisiana backwater lakes (Lambou 1959) to 839.51 kg/ha in Kentucky farm ponds (Turner 1960). The standing crop may vary considerably from year to year as exemplified in Ridge Lake, Illinois, where it ranged from 216.66 kg/ha in 1947 to 65.35 kg/ha in 1953 (Bennett 1954). Muskellunge Lake, Indiana in 1942 yielded 3,117 fish/ha but declined to 1,431 fish/ha in 1943 (Ricker 1945).

The estimated total largemouth bass standing crop in September 1975 was 3.431 kg/ha (Table 11). The estimate for August 1976 was 5.299 kg/ha (Table 12); May 1977 was 10.994 kg/ha (Table 13); August 1977 was 3.760 kg/ha (Table 14); and June 1978 was 5.895 kg/ha

Table 15. Population age structure for bluegills and largemouth bass collected from three 0.405 ha sites sampled with rotenone on June 13, 14 and 15, 1978, at Pelican Lake, Uintah County, Utah.[a]

Bluegills

Age	Number of Fish	Percentage Number	Total Weight (kg)	Percentage Weight
0	0	--	--	--
I	8	5.0	0.056	0.1
II	5	3.1	0.317	0.8
III	17	10.6	2.195	5.5
IV	38	23.5	8.711	21.8
V	70	43.5	20.312	50.9
VI	23	14.3	8.352	20.9
VII	0	--	--	--
VIII	0	--	--	--
Totals	161	100.0	39.943	100.0

Largemouth Bass

Age	Number of Fish	Percentage Number	Total Weight (kg)	Percentage Weight
0	0	--	--	--
I	0	--	--	--
II	28	63.6	2.959	25.7
III	5	11.4	1.509	13.1
IV	5	11.4	2.841	24.7
V	6	13.6	4.197	36.5
VI	0	--	--	--
VII	0	--	--	--
Totals	44	100.0	11.506	100.0

[a]The results of the three 0.405 ha sampling sites and one cove site, approximating 1.012 ha, were combined and divided by three to obtain an average estimate. This was done for both bluegills and largemouth bass.

(Table 15). The trend is inverse to that noted for bluegills. The spring sampling yielded a 107% greater standing crop of bass in 1977 than the previous years' August sampling. The June 1978 standing crop was 57% greater than the August 1977 standing crop estimate.

The average standing crop of largemouth bass in North America lakes has been reported by Bennett (1962) as 16.92 kg/ha. In lakes and reservoirs in the northern states, standing crops of largemouth bass have been reported to range from 6.84 kg/ha to 50.33 kg/ha and 4.60 fish/ha to 66.69 fish/ha (Newburg 1975).

It was apparent from the numerous samplings that fathead minnows composed only a small percentage of the total fish population. Fathead minnows were common in the east bay site in September 1975 (n = 262) and August 1976 (n = 249). Only eight fathead minnows were captured along the south shoreline in August 1976, and one was captured in this same site in May 1977.

No attempt was made to assess the efficiency of the rotenone application within the target area. However, an error estimate on bluegill numbers that did not surface was conducted in the August 1976 east bay site. The dense, rooted, aquatic vegetation which abounds in Pelican Lake probably entrapped many struggling fish preventing them from coming to the surface. Investigators, wading four abreast and two arm lengths apart from each other, walked transects throughout the total 0.405 ha area (mean depth = 0.762 m) and counted all dead fish. Results of this error estimate indicated that 38% of the total 8,302 bluegills did not surface and were entangled in the rooted, aquatic vegetation and algae. The percentage recovery was probably lower in deeper midwater and shoreline sites where dense, rooted, aquatic vegetation was located at all water depths. Because of the inherent variation associated with recovery of fish killed with rotenone, standing crop estimates in this study should be viewed with some caution.

Environmental factors that influenced the surfacing of fish killed by rotenone, i.e., water temperatures, total alkalinity, rooted aquatic vegetation, were reported by Parker (1970). Parker noted that rotenone-killed bluegills surface at a considerably slower rate at temperatures below 17 C. He also reported that practically all rotenone-killed bluegills could be expected to surface within one week when water temperatures were above 16 C in depths to at least 3.0 m, and in waters lacking abundant, rooted, aquatic plants. Surface water temperatures during the Pelican Lake population samplings were:

Date	Temperature
August 1976	27 C
May 1977	18 C
August 1976	23 C
June 1978	20 C

Parker further demonstrated that 95 to 100% of the centrarchids killed surfaced in one day at 27 C, two days at 22 C, three days at 17 C and five days at 15 C. Krumholz (1950) reported that 96% of largemouth bass surfaced in 2.5 days, 91% in two days and 62% in one day at 20 C. Bartoo (1977) reported surfacing rates of yellow perch killed with rotenone in Washington were 15.5% in one day and 17.5% in four days at 10.5 C.

Henley (1967), utilizing SCUBA observations along a series of bottom transect lines, evaluated the number and weight of fish that do not float to the surface. His results indicated that 91% of the fishes that remained on the bottom were young-of-the-year fish. He found that sunfishes (bluegill and longear sunfish, L. megalotis Rafinesque) displayed the highest recovery rate (95.5%), and largemouth bass had the second highest recovery rate (84.1%). Sunfish were the most abundant species recovered and largemouth bass the fourth most abundant. Henley also reported that the percentage of fish that sank to the bottom on the first day was dependent upon the technique used by the investigator. Higher rotenone concentrations applied quickly usually resulted in a greater total loss of fish; i.e., lower percentage of recovery (Henley 1967).

Year-class strength

Wide variation in year-class strength and recruitment of young-of-the-year fish (dominant year classes) are characteristic of unbalanced bluegill populations (Anderson 1973). The mean estimated standing crop of young-of-the-year bluegill in this study was quite variable. For example, August 1976 estimates of young-of-the-year bluegills (31,748 fish/ha) were 3.8 times greater than the mean standing crop of young-of-the-year bluegills in August 1977 (8,385 fish/ha) (Table 11). The lowest young-of-the-year standing crop estimate in August 1976 (east bay: 20,128 fish/ha) was greater than the highest standing crop estimate of young-of-the-year bluegill in August 1977 (midlake number 2: 15,119 fish/ha) (Table 11).

Year-class strength of bluegills has been associated with the abundance of bass fingerlings, and first-year growth of bass has been positively related to the abundance of bluegill fry (Elrod 1971). Toetz (1966) reported that numerical strength of a year class of bluegill was probably established before metamorphosis from larva to juvenile. Factors that affect the survival of bluegill larva were the characteristic of the ova, fertility, hatching and the events marking the "critical period" when the larva switch from endogenous to exogenous nutrition (Toetz 1966).

Similar year-class variability was observed with the largemouth bass population in Pelican Lake. The mean estimated standing crop of young-of-the-year largemouth bass in August 1976 (264 fish/ha) was 2.4 times greater than the mean standing crop of young-of-the-year largemouth bass in August 1977 (110 fish/ha) (Tables 12 and 14). In the spring of 1977, Pelican Lake failed to reach full storage capacity because of the low amounts of precipitation in the fall of 1976 and winter of 1977. Lake water levels rapidly receded in the spring of 1977 because of the great water demand by agricultural users. The rapidly receding water levels may have destroyed bass nests and eventually could have been responsible for the decreased numbers of young-of-the-year bass in 1977.

Various factors have been examined for their effect on the formation of largemouth bass year classes. Bennett et al. (1969), Mraz et al. (1961) and Jenkins and Hall (1953) have reported that carrying capacity, predation and other environmental influences are the determining factors influencing the strength of individual year classes.

Year-class strength was believed to be set between time of egg deposition and two weeks after hatching in Lake George, Minnesota (Kramer and Smith 1962). In Lake George, year-class strength was related to wind velocity and water temperature during incubation incubation (Kramer and Smith 1962). The relative rank of year-class strength did not change after the first two weeks, and brood size and fingerling abundance maintained the same relative rank in all years.

Age composition

Survivorship curves of aged bluegills from three of the rotenone population samplings were generated to note annual trends in population age structure (Figure 39). The survivorship curves of Pelican Lake bluegills indicate a high rate of mortality between young-of-the-year and age II bluegills. Anderson (1973) indicated that survivorship curves of balanced populations demonstrated high rates of mortality in young fish while unbalanced populations demonstrated low mortality in young fish and high mortality for age II and older fish. The bluegill survivorship curves (Figure 39) indicate that bluegills in Pelican Lake of ages II to V demonstrated low mortality rates with a noticeable increase in mortality between age V and VI. This is exhibited by a preponderance of age V bluegills (28%) in the creel and subsequent low number (10%) of age VI bluegills in the harvest. Sampling bias also must not be ruled out as a possible explanation for the low numbers of age VI and older fish in the rotenone samplings.

The mortality of young-of-the-year bluegill captured in the August 1976 rotenone sampling to age I bluegill captured in the May 1977 rotenone sampling was determined from a catch curve. The total

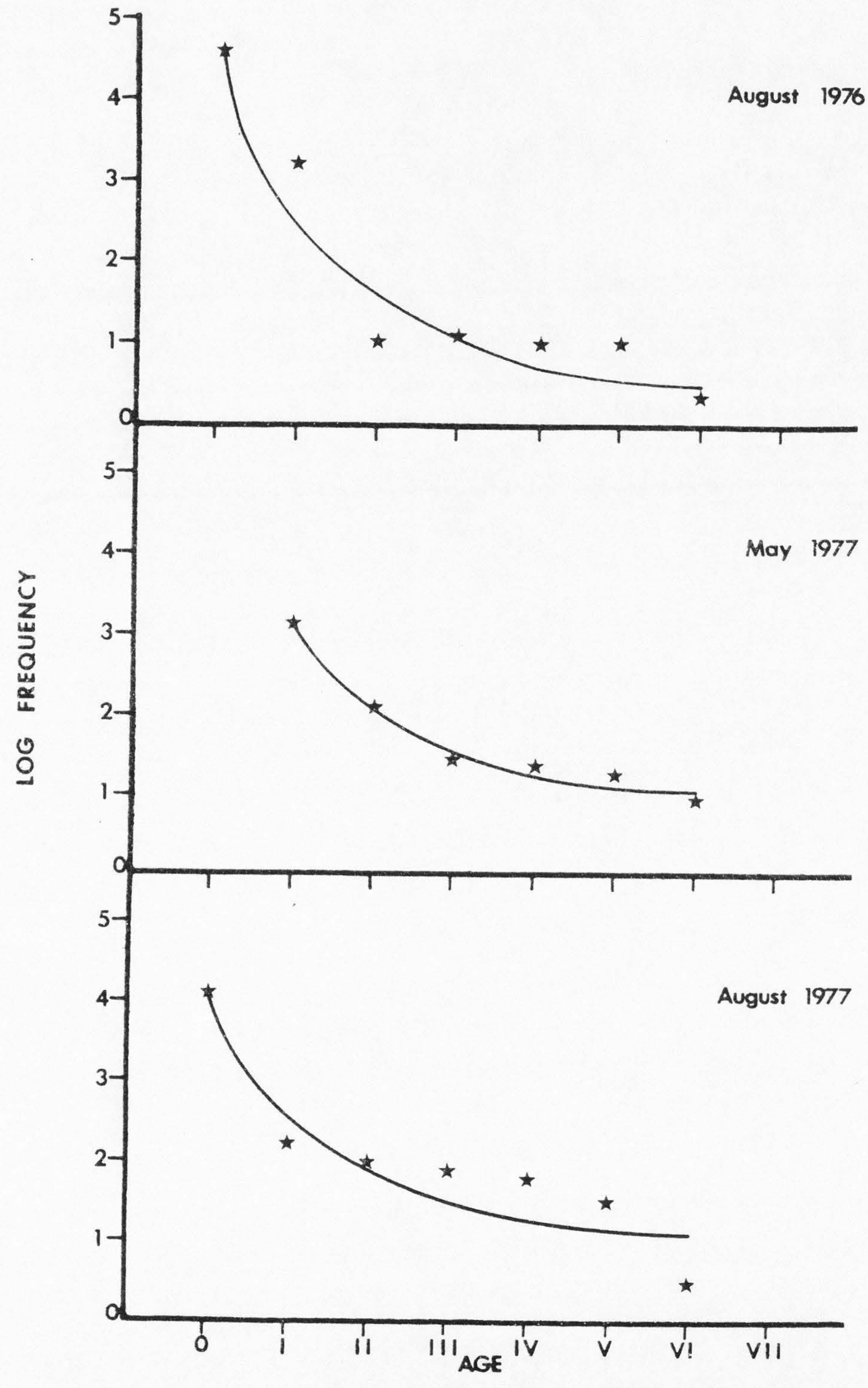


Figure 39. Population survivorship curves from aged bluegills captured with rotenone in August 1976, May 1977 and August 1977. (Note: the survivorship curves were fitted by inspection.)

instantaneous mortality rate was 1.76 between the two samplings. The total mortality rate was then, 98.3%. The standing crop of young-of-the-year bluegill in August 1976 was estimated to be 31,748 fish/ha but was reduced to 915 fish/ha in May 1977, suggesting that predation by piscivorous birds, fish predators and/or winterkill contributed to the large decline in standing crop.

Balance in fish populations is an important concept in warmwater fisheries management. Balanced populations have been defined by Swingle (1950) as populations that have the capacity to produce a satisfactory sustainable yield of fish of suitable size in proportion to the productive capacity of the water. Balance, in this context, may be taken to mean a satisfactory relationship between a fish population and its food supply. Satisfactory is judged according to the values of society; namely, fishermen and management objectives.

If management objectives for a species or a lake include a reasonable sustained yield of fish of suitable size, and yield is dependent upon the productive capacity of the water rather than put-and-take stocking or artificial feeding, then the concept of balance must be part of the biological basis of management (Anderson 1973). Various information and research have been provided on the characteristics and dynamics of balanced and unbalanced bluegill populations (Swingle 1950, 1956b; Bennett 1970; Anderson 1973, 1975b, 1976).

Balanced vs. unbalanced populations have been characterized as follows (Anderson 1973; Bennett 1970):

1. Balanced bluegill populations are characterized by good growth rates of intermediate large fish; unbalanced bluegill populations exhibit poor growth of adults.

2. Balanced bluegill populations are characterized by a high, relatively stable recruitment of young bluegills; unbalanced bluegill populations exhibit variation in year-class strength and recruitment of young fish producing dominant year classes.

3. Older fish are represented well in balanced populations; whereas, unbalanced populations are dominated by many young fish, and few older fish survive beyond age IV.

4. Fish in a balanced population must produce an optimum sustained yield in the fishery (Anderson 1975b).

5. Fish in a balanced population must contain a combination of species including at least one piscivorous species.

Comparisons of bluegill survivorship curves from Pelican Lake with two theoretical bluegill populations (one balanced and one unbalanced) and real populations from two Indiana lakes (Gerking 1953, 1954, 1962) indicate that the population age structure of Pelican Lake bluegills resembles that of a balanced population (Figure 40). Bluegills age IV+ are well represented in the theoretical balanced population and in both populations at Gordy Lake, Indiana and Pelican Lake. Bluegills of these same ages are not well represented in the Wyland Lake, Indiana population (Figure 40). Longevity is longer in balanced populations (Anderson 1973).

Survivorship curves of bluegills in Wyland Lake were similar to that for the theoretical, unbalanced, pond population (Figure 40), while the survivorship curve of Gordy Lake closely exhibited that of the theoretical, balanced, pond population (Figure 40). Pelican Lake bluegills, ages IV through VII, demonstrated a higher survival rate

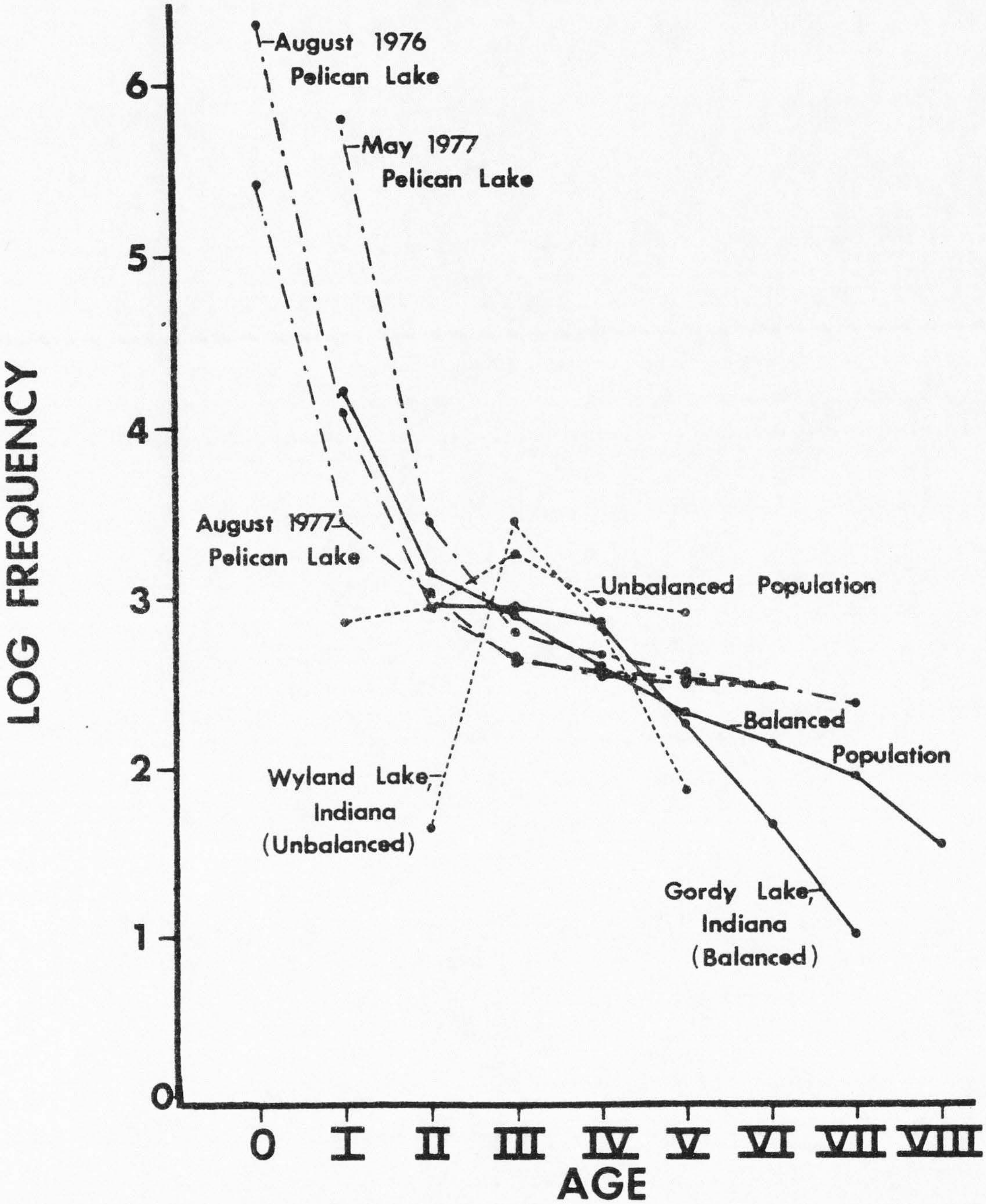


Figure 40. Comparison of bluegill log frequency, survivorship curves per 100 kg of biomass from Pelican Lake, Uintah County, Utah, with two Indiana lakes and two theoretical populations. (Note: Indiana lake data from Gerking 1953, 1954 and 1962; theoretical data from Anderson 1973.)

than bluegills of the same age in Gordy Lake, Indiana. A dominant year-class of age III bluegill was followed by a weak year class in Wyland Lake; whereas, no wide variation in year-class strength was apparent in Gordy Lake. Although standing crop estimates of young-of-the-year bluegills were variable in this study, variation in bluegill year classes at Pelican Lake was not as extreme as those noted for the unbalanced Wyland Lake population.

Overwinter Mortality

Winterkill has been previously mentioned as a controlling factor especially affecting overwinter survival of young-of-the-year bluegills. Winterkills were substantiated by shoreline transect counts of dead fish in 1976 and 1977. Winter-killed fish totaled 1,460 bluegills and four largemouth bass in April 1976. One channel catfish was recovered in the transect counts of 1976. The five-day, post ice-out, shoreline survey in March and April 1977 totaled 813 bluegills. No largemouth bass or other fish species were observed at this time. No open water counts were attempted due to windy weather conditions following ice-out and subsequent turnover of the lake causing murky water conditions. SCUBA was not used to estimate mortality under the ice because of poor visibility in the water.

Ninety-six percent of the total winter-killed bluegills were found along the east causeway shoreline in 1977. A strong easterly wind at ice-out piled unprooted, aquatic vegetation and dead fish along the shoreline. Numerous "stressed" fish were observed at ice-out swimming lethargically at the water's surface. Badly deteriorated dead fish were observed along the shorelines and suggested that mortality occurred beneath the ice prior to ice-out. Scale samples from 50 and 68 bluegills in 1976 and 1977, respectively, were read to determine the age composition of dead fish along the shorelines. The mean age of winter-killed bluegills found in the shoreline transects was 5.45 years in 1975 (Utah DWR 1975), 4.96 years in 1976 and 6.13 years in 1977 (Figure 41). Age classes V, VI and VII composed 80.5% of the sampled mortality (Figure 41). The mean TL of winter-killed bluegills was 218 mm in 1977 (Figure 42) and 211 mm in 1976.

Bluegills less than 140 mm TL were not observed in the transect counts, although laborious attempts were made to locate yearlings and I year olds in the windrowed vegetation. The shoreline transects seemed to indicate that the winterkill selectively reduced the numbers of larger fish. However, spring rotenone samplings indicated that numbers of younger fish were also being reduced from the population during the fall and winter. This observed loss of young-of-the-year and juvenile fish during the fall and winter may have been partially due to predation. The midwinter deterioration of water quality may have forced these smaller fish from the dense, aquatic vegetation near the substratum into midwater areas, enhancing predation by bass and/or bluegill. The fate of the carcasses of these smaller bluegills which which were apparently killed during the winter is a mystery. However, investigators using SCUBA during ice-out on April 4, 1979, observed numerous dead, yearling bluegills entangled in the vegetation and on the substratum (Crosby and Schmidt 1979, Vernal, Utah, Personal communication). These investigators roughly estimated the yearling

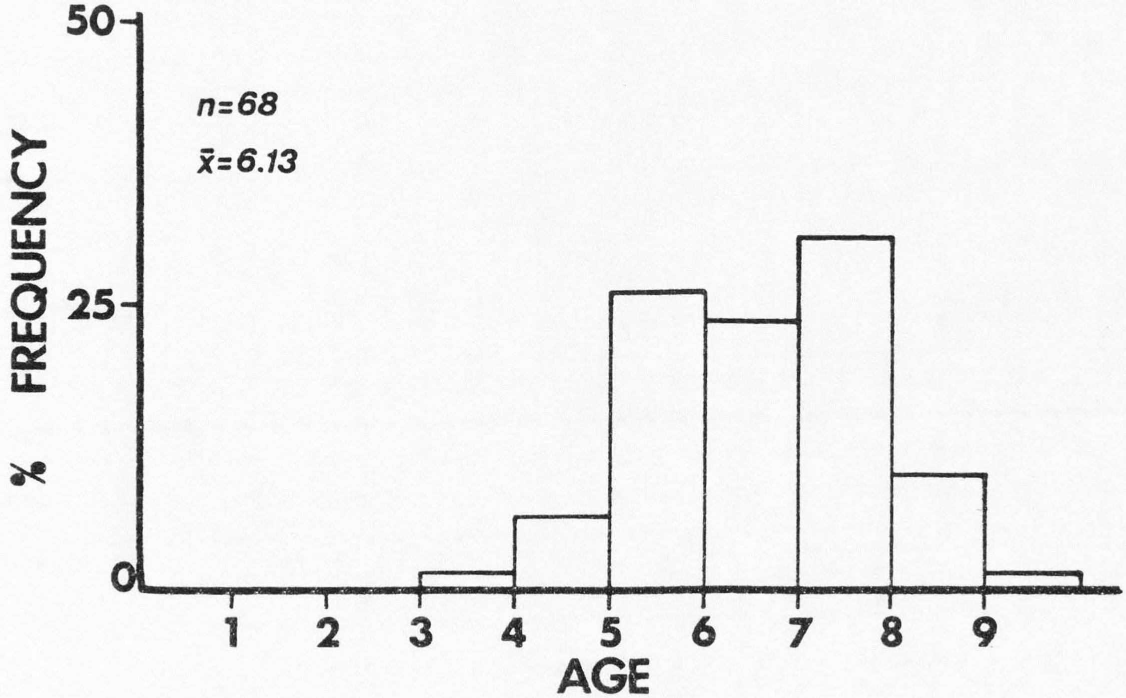


Figure 41. Age composition of winter-killed bluegills from shoreline transects at Pelican Lake, Uintah County, Utah, March 27 to April 2, 1977.

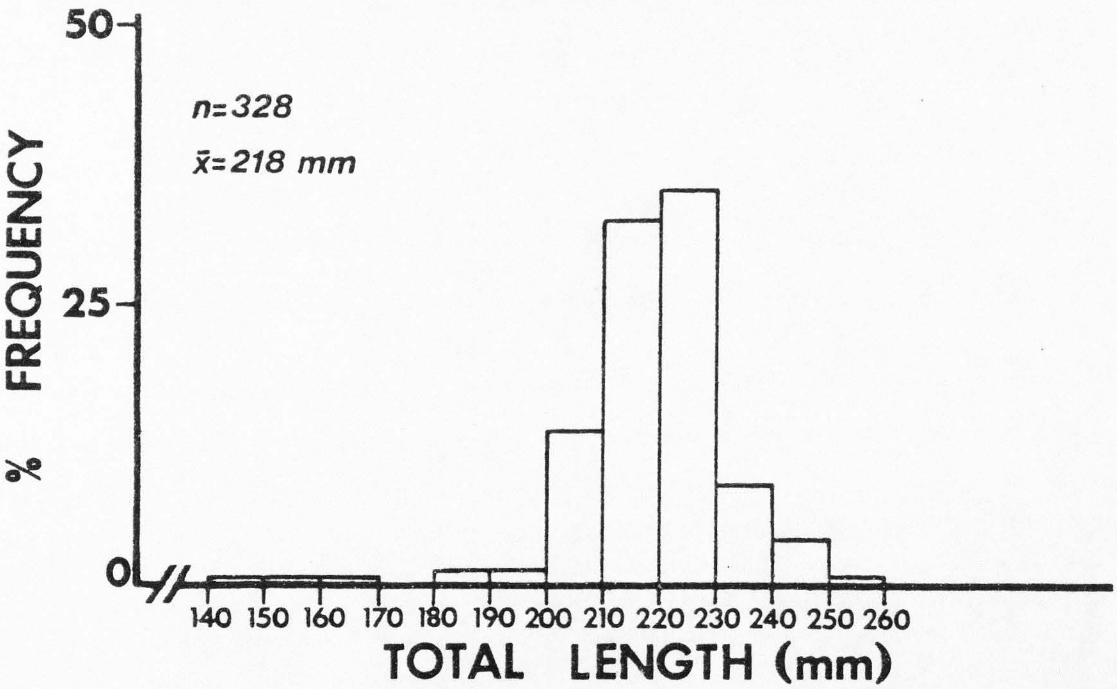


Figure 42. Total length of winter-killed bluegills from shoreline transects at Pelican Lake, Uintah County, Utah, March 27 to April 2, 1977.

bluegill mortality to be 1/5 m^2. These recent observations may explain why yearling and age II bluegills are not found among the dead fish in the post ice-out, shoreline transect counts.

The empirical data on winterkill at Pelican Lake were substantiated by quantitative and qualitative observations made during this study. As mentioned previously, the causative factor of the winterkill was undoubtedly poor water quality under the ice during the winter months. Reduced dissolved oxygen and elevated hydrogen sulfide were the most important limiting factors.

MANAGEMENT CONSIDERATIONS

Bluegill

The overall goal of the fishery management program at Pelican Lake is the maintenance of the quality, bluegill fishery. An exact index of fishing quality is impossible to achieve because quality and personal gratification are influenced by intangible factors such as aesthetics and environmental quality. Fishing quality means different things to different people. An angler's values may change as the individual evolves through the stages of novice, expert and philosophical angler (Anderson 1975b). One individual's values may depend on angling location or the fish species, while another's may depend on the size and numbers of fish caught, fighting ability, palatability or other characteristics of a fish species.

Quantitative methods to evaluate fish and fishing quality have been developed. Weithman and Anderson (1978) used angler values for catch quality, fish quality, harvest quality and trip quality to develop an index of overall fishing quality. Anderson (1976) believes that the best bluegill fishing occurs when 40 to 80% of the bluegills caught by angling are of quality size (6.0 in: 152 mm or larger). If less than 40% of the bluegills caught are larger than 6.0 in, bluegills are probably too abundant for that water. Clark and Lackey (1974) have graphically illustrated the general relationships between quantity and quality of angler days on the basis of cumulative knowledge from various studies. The relation is inverse—the quality of an angler day decreases as the quantity of angler days increases. Each of the above authors points out that the definition of quality differs among anglers, among fish communities and among different bodies of water. The management strategies of each must also differ.

Sustained quality fishing is necessary if we are to approach optimum sustainable economic and social benefits (Anderson 1975b). Anglers must realize that maximum sustainable yield (quantity) and optimum catch (quality or sport fishing) cannot be achieved at the same time. If anglers fishing for bluegills at Pelican Lake consider catching large numbers of fish more important than quality-sized fish, then the current bag limit is not needed since it was enacted to preserve larger and older fish from being exploited faster than they could be recruited to those ages and sizes. The fishery in this case would probably never be overexploited, but numerous smaller bluegills and fewer larger bluegills would be caught. With this type of management, anglers could harvest the maximum sustained yield. However, the fishermen at Pelican Lake accept the concept of retaining and harvesting only quality-sized fish, while at the same time having a restricted bag limit. Zern (1971) points out that there can be no quality fishing without quality anglers; the sport needs individuals who are aware of angling courtesy, the tradition for sportsmanship and the love of the sport of angling rather than merely catching fish.

Regarding Pelican Lake, the term quality-sized bluegill has been used loosely. For the purpose of this discussion, a working definition of a quality-sized fish was suggested to be fish reaching a length and/or weight equal to or greater than the mean TL (213 mm) and mean total weight (286 g) of bluegill creeled during 1976 and 1977. Of course, this is only an arbitrary definition of a quality-sized bluegill. For Pelican Lake, a quality-sized bluegill may actually be larger than that defined above. So, it may be necessary to adjust the definition of a quality-sized bluegill for management purposes. The number of creeled, quality-sized bluegill did not decrease during the period of this study. Although age composition of creeled bluegill was determined only in 1976, it is believed that there were no substantial changes in age composition of creeled bluegills in 1977.

Although no statistically significant changes were noted in the parameters discussed above, there may have been biological changes which were too subtle to detect over this short-term study. For this reason, making long-term predictions about the fishery would be difficult. Also, the lack of documented data on size and age composition of the bluegill harvest in Pelican Lake prior to 1976 does not allow speculation on whether the bluegill population has decreased in size or age because of overharvest. The hypothesis that bluegills would decline in numbers and size because of the increase in angling pressure could not actually be tested since angler use declined in both years of this study from the peak year of use in 1975. This downward trend in angler use was unexplainable, especially since the lake received national publicity and notoriety as an excellent fishery.

This study indicates that the bluegill population in Pelican Lake is in balance as defined by Anderson (1973, 1975b) and graphically demonstrated by Gerking (1953, 1954, 1962) and does not exhibit characteristics of being overfished. Although it has traditionally been contended that bluegills could not be overharvested, this theory did not hold at Binder Lake, Missouri where overexploitation occurred. More than 60% of the annual harvest of bluegills was caught during a few weeks in May, and bluegill harvest declined by 75% (Anderson 1976). Johnson and Anderson (1974) suggest that bluegill populations in Missouri ponds may be balanced when numbers of intermediate and adult bluegill have a size distribution of 75% of 75-100 mm TL (3.0-5.9 in) and 25% of > 150 mm TL (6.0 in). The fishery manager should be aware to the dangers and effects of overexploitation. The effects of overexploitation have been assessed by such qualitative indices as (Gulland 1971):

1. A decrease in the age composition of fish harvested.
2. A decrease in the size of fish harvested.
3. A decrease in the catch per unit of effort of fish harvested.
4. An increase in the total mortality.

Because of the possibility that bluegill may become overharvested at Pelican Lake in the future, there is a need for some level of continual monitoring to evaluate annual catch figures. Any of the above indices could also be used to determine if future overexploitation of the bluegill fishery occurs.

Historically, angling regulations, particularly creel limits, have been determined arbitrarily with little biological justification to support them. The enactment of the 20 daily bag and possession limit in 1975 was to avoid overfishing this sport fishery known for its large numbers of quality-sized bluegills. The rationale for the 20 limit was probably a consumptive rather than a biological regulation to prevent waste and encourage fishing for sport (quality) rather than meat for the table (quantity).

The socioeconomic effect of the bag limit enacted in 1975 was difficult to assess. Anglers had been accustomed to no restriction on bluegills before 1975. A departure from this regulation and a bag limit may have eliminated those anglers that considered catching as many bluegills as possible (quantity) an important fishing value. Anglers from the population centers of Utah along the Wasatch Mountains (Ogden south to Provo, Utah) and nonresident anglers may have been adversely influenced by this regulation. The reduced bag limit, coupled with the long distance (approximately 350 miles round trip to Salt Lake City, Utah) and increased cost of gasoline, may have caused many potential Pelican Lake anglers to fish elsewhere. In fact, this may account for the decline in angler use after 1975. Most anglers who fished Pelican Lake in 1976 and 1977 were local residents who came to the lake after working hours (this study).

Because of the unchanged age and size composition of the catch with the angling pressures recorded during 1976 and 1977, the bag limit could be either increased or removed completely. This may not be totally justified since the impacts of this action are not known. Relaxing the current bag limit may encourage an increase in angler use. If increased angler use is too great, overexploitation causing a decrease in the size and/or age of bluegills creeled would foster the deterioration of the quality fishery. However, with monitoring suggested above, this situation could possibly be detected in time by adjusting regulations accordingly.

An argument might be posed that the removal of the current bag limit would allow anglers to harvest bluegills that are eliminated by the winterkill. Investigating the extent of winterkill in the past (before 1967) was conducted empirically along shoreline transects. There was no evidence to suggest that overwinter mortality was less in years of unrestrictive harvest than in years when harvest was restrictive. If the current bag limit were removed, the severity of the following year's winterkill would probably not be reduced and, furthermore, could not be predicted. The reason for this is that it is difficult to predict winterkill severity because of year-to-year variability in conditions such as water fluctuation, snow depth, ice cover and angling use. For example, although water levels and vegetal growth in the summer and fall of 1977 and dissolved oxygen levels during the winter of 1978 were more conducive to a larger winterkill in 1978 than in 1977, the numbers of winter-killed bluegills were practically the same in both years. This may suggest that there are so many factors involved that winterill prediction cannot be made based on any one factor, particularly bag limits which may be less important than physical factors. This may suggest that the annual winterkill is governed by density independent factors. Lack of depth, in and of itself, could not be used to predict if winterkill would occur in South Dakota lakes (Schneberger 1970). However, winterkill is less likely to occur in South Dakota lakes over 5 m in depth. Smith (1941) and Hubbs and Eschmeyer (1938) have recommended raising the level of a lake and thus enlarging the initial supply of oxygen as a means of preventing winterkill. However, Schneberger doubted that the additional amount of water could furnish enough oxygen to meet the demands of decaying, organic materials.

The annual winterkill at Pelican Lake is caused by (1) the shallow conditions (2.4 m maximum depth at conservation pool) which promote prolific vegetal growth in the summer and fall, (2) climatological factors which promote ice formation most winters and (3) physical and chemical factors that alter the water quality beneath the ice. The onset of ice and snow on the lake prohibits surface aeration of lake water. Dissolved oxygen is further reduced because ice and snow on the lake inhibits light transmission to photosynthesizing macrophytes and phytoplankton and oxygen production cannot supply the demand by decomposing organic matter. Anoxic conditions frequently occurred near the bottom. Under these anoxic conditions, toxic gases, such as H_2S and other by-products of anaerobic decomposition, were produced. Concentrations of H_2S reached as high as 5.0 mg/l in March 1977, levels which are lethal to fish species. These conditions may have caused modifications in fish behavior and movement beneath the ice. Fish may have responded to these conditions by moving upward in the water column in an attempt to locate higher oxygen concentrations. Poor water quality during ice cover in both years of this study was severe enough to have caused fish mortality.

Bluegill populations in small lakes which support a bluegill-largemouth bass fishery frequently become imbalanced because of the high reproductive potential of bluegills. This is especially true if angler harvest is nil as it was at Pelican Lake during the 13 years prior to 1967. However, the bluegill population in Pelican Lake remained "healthy" throughout this time. What factors kept the bluegill population in check? Studies have suggested that predation by largemouth bass may serve this purpose (Tarrant 1960; Lewis et al. 1962; Mraz et al. 1961; MacKay 1960); other studies disagree (Bennett et al. 1969; Beard 1971). The dense, aquatic vegetation in Pelican Lake would certainly have decreased the efficiency of the bass as a predator, and the control of bluegill numbers before 1967 probably cannot be attributed solely to the bass.

Winterkill may have been the most important controlling factor. Winterkill has been found not only to reduce fish numbers but also reduce competition among survivors (Scidmore 1957) and improve fish growth rates. For example, bluegill growth in Batteese Lake, Michigan increased 36% following a winterkill (Beckman 1948). Winterkill may have contributed to the moderately fast growth rates typical of Pelican Lake bluegills (Figure 15) by reducing the annual production of the population to the appropriate carrying capacity of the lake. Winterkill has probably been the dominant, compensatory, mortality factor promoting a balanced population in Pelican Lake through the years and because of physical conditions in the lake and climatological conditions in the area, can probably be relied upon to continue functioning as a subtle management "tool."

Several management options might be considered to insure continuation of quality bluegill fishing at Pelican Lake. These are:

1. Adjustment of the bag limit. At the present level of angling use, consideration should be given to remove the current bag and possession limit. There is actually no biological rationale for a bag

limit because the reasoning is usually made on a sociological basis. At the present time, overharvest and/or quality depreciation of bluegill are not probable. If the bag limit is removed and bluegill overharvest occurs, the bag limit can be adjusted accordingly based on monitoring suggested indices. If the quality size of bluegills decreases, the bag limit may have to be decreased during periods when Pelican Lake receives the heaviest angling use and increased during periods of low angling use. For example, Pelican Lake receives 80 to 90% (this study) of the annual angling use between April 1 and July 31. Anglers have a high incentive to fish Pelican Lake during this period because few other Utah waters are open to legal fishing. Anglers may have less incentive to fish Pelican Lake in the spring if the bag limit is reduced during this period. In fact, this regulation may redistribute or decrease the annual angling pressure on Pelican Lake. The general opening of the trout fishing season in early June may relieve some of the angling pressure on this lake. When the angling use subsides in late June and early July, the bag limit may then be increased.

2. Implementation of a <u>length regulation</u> in conjunction <u>with terminal gear restrictions</u>. Because the loss of bluegills caught and released by anglers amounted to only 1% of the total weight harvested in 1977, at this time a terminal gear restriction on creeled bluegills should not be established, nor should a length restriction on creeled bluegills be initiated. However, if angling use increases and creeled bluegill size decreases, enactment of a length restriction may be necessary to protect smaller bluegill in the population. This regulation may allow more fish to reach quality size and provide an

equitable distribution of larger bluegill to anglers. Data are not readily available on the effects of length regulations on Lepomis spp. populations. However, the obvious result of a length restriction on creeled bluegills is that more fish would be returned to the lake. When this occurs, hooking mortality would undoubtedly increase as a result of hooking and "playing," handling and/or method of release. Such a regulation would force anglers to release all sublegal fish regardless of hook location. The enactment of a gear restriction in conjunction with a length restriction is important to reduce mortality of released bluegills. Based on observations made in this study, fish mortality depended on terminal gear utilized by anglers. Numbers 4, 6 and number 6 regular shank jig hooks caused the least mortality of released bluegills. If hooking mortality becomes a problem and/or a length restriction is enacted, it is recommended that the proclamation allow the use of only number 4, 6 and number 6 regular shank jig hooks. The method of hook removal is also important to the survival of released fish. Data from this study revealed that a large percentage of anglers at Pelican Lake either removed the hook without the aid of a hook remover (42%) or with the aid of a hook remover (40%). Few anglers actually cut the leader allowing the hook to remain in place (19%). A regulation calling for mandatory leader-cutting would inconvenience and impose an economic hardship on the angler. Realistically, abidance by and implementation of such a regulation would depend on the sportsmanship of the angler because it could not be easily enforced. In addition, the benefit to the fishery would be negligible. For these reasons, a regulation calling for cutting the leader and allowing the hook to remain in released bluegills should not be seriously considered as a management "tool." If angling use increases and bluegill size decreases, a further consideration might be to restrict terminal gear used by anglers exclusively to artificial lures. Fish appear to be more difficult to catch on artificial lures, such as jigs, rather than natural bait; i.e., earthworms, meal and wax worms, grasshoppers, etc. (this study). This regulation may be utilized in lieu of the bag or size limit and may provide a more equitable distribution of larger-sized bluegills to anglers.

3. Acquisition of additional water storage. Future consideration should be given to the acquisition of additional water storage from the Ouray Park Irrigation Company in conjunction with the present 493 ha m conservation pool. The increased agricultural crop production in recent years near Pelican Lake has increased the demand for water. Extended periods of drought, as recorded in 1977, concomitant with prolonged ice and snow cover, could completely eliminate this fishery in one year by winterkill. However, the lake has not completely winter-killed in 23 years.

4. Continuation of biological assessment of the state of the fishery. It is important that data from this study be utilized as baseline information to compare with future trends in the bluegill fishery. Since it is vital to assess whether the bluegill fishery stocks in Pelican Lake are affected by an increase in angling use, the following additional data need be collected:

a. A creel census similar to the stratified random design used in this study should be conducted at least on a biennial basis, but preferably annually, between April 1 to July 31. Data in this study indicated that sufficient trend data could be obtained in these four months. It is important to utilize a standardized creel census format in order to consistently compare trends from year to year. Since a significant winter fishery has developed, a creel census should also be conducted to estimate the total use and harvest of fish at this time. At least four weekend sampling dates and either an a.m. or p.m. period per date should be sampled at random on a monthly basis when ice fishing is occurring. At least four counts per a.m. or p.m. period should be made daily during this period.

b. Data on TLs, total weights and age composition of fish from the harvest should be monitored annually and compared with this study to note changes in size, age structure and total annual mortality.

c. An attempt should be made to identify and eliminate factors other than winterkill which cause mortality and therefore reduce the standing crop of young-of-the-year and other smaller bluegills. Some procedures would include: monthly midwater SCUBA analysis to note mortality under the ice and at ice-out; monthly stomach analysis of both largemouth bass and bluegills, particularly during the ice-covered months; stomach analysis from a random sampling of piscivorous birds, i.e., seagulls and terns, at ice-out in March to note depredation of small bluegills dying at this time.

Largemouth Bass

The concept of quality fishing in Pelican Lake has been discussed as the overall management goal of this study. The quality of bass fishing is reflected in the size of the fish available to the angler. A philosophy developed by Anderson (1975a) is that one large fish contributes more to the personal gratification and memories, and therefore to fishing quality, than does an equal weight of small fish. Also, the numbers of anglers and fishery scientists who recognize the value of a catch-and-release philosophy for bass are increasing. The largemouth bass is an important component of the quality of the lake's fishery. However, the overall quality of the fishery may be decreased if largemouth bass are overharvested.

Largemouth bass appear to be subject to a greater rate of exploitation than panfish (Hulse and Miller 1958; MacKay 1960; Anderson 1975a, 1976); whereas, other studies have shown that largemouth bass are less affected by fishing than most other species (Bennett 1972). Overexploitation of a largemouth bass fishery was evidenced in Onized Lake, Illinois from 1938 to 1941 (Bennett 1945). However, overfishing in Onized Lake was the result of an intensity of angling far greater than that observed in most waters. The effect of overfishing on the largemouth bass population was (1) a decrease in yield of bass to the anglers' creel from 1938 to 1941; (2) the mean weight per bass was less in 1941 than 1938; (3) the catch rate declined from 1.162 to 0.531 fish per hour (all species); and (4) the age composition of the catch declined in the three years indicating that overharvest tended to remove the larger and older fish (Bennett 1945). Other changes might also occur. Reduced predation could allow the forage species (bluegills) to become overabundant and stunted. Under these conditions, fish production could be reduced and sport fishing may deteriorate; but more importantly, it could reduce quality in the fishery.

Regulations governing the harvest of largemouth bass are probably the most widely used tool in bass management. Regulations can be broadly categorized as restrictions on (1) season of harvest, (2) number of fish creeled and (3) size of fish creeled. An evaluation of each regulation provides some indication of their utility. Although bass overharvest is a problem in many areas, it is possible that restricted seasons could be utilized to alleviate overharvest if applied at the proper time. Closures at times of high vulnerability to angling could reduce the harvest significantly (Redmond 1974). Saila (1957) concluded that it is not necessary to close seasons to maintain an adequate bass brood stock. Closures during the winter are probably designed for this purpose, but the effect of this restriction on harvest is negligible because bass are essentially invulnerable to sport fishing during cold weather (Redmond 1974). No evidence was found that year-round fishing from 1952 to 1956 had affected the annual crop of bass in TVA reservoirs (Hulse and Miller 1958). Regulating the angling season apparently has little value in reducing bass harvest.

Creel limits are designed to stabilize the catch and to prevent overexploitation during the period when the species are most vulnerable (Saila 1957). Saila, however, found that a reduction of the creel limit in Rhode Island from six to four bass reduced the catch by only

4%, and the number of fishermen catching their limit increased only 6%. The fact that most anglers do not catch a daily limit of bass was clearly demonstrated by Redmond (1974). At Little Dixie Lake, Missouri, only 0.2% of 4,591 anglers caught the limit of 10 bass during the first four days of fishing; 59% caught no bass at all. Thus, if the creel limit had been reduced to four fish, only 10% of the bass caught over the four-day period would have been saved or redistributed. A reduced creel limit would assure a more equitable distribution of bass but probably would not reduce the harvest significantly unless a high proportion of the bass learned to avoid lures.

Management for bass, particularly in waters receiving very heavy pressure, can be done by establishing limits on size. A thorough knowledge of the population structure, recruitment, mortality rates, growth rates and angling pressure is necessary before size limit restrictions can be assigned (Anderson 1974). The objectives of restrictions on size limits are (Keith 1978):

1. Increasing the fishermen's effectiveness (catch rate).
2. Increasing the quality of fishing.
3. Prevent the harvest of predator fishes before they become effective in controlling forage fishes.

Historically, the most common premise on which size limits have been based is that each fish should be allowed to reproduce at least once. This is probably valid for bass because of their low reproductive potential and high vulnerability to fishing. When present in such numbers that forage becomes scarce, bass are quite vulnerable to artificial lures (Bennett 1974). Without a minimum length restriction, an overabundant population of bass may become a stunted one with very few individuals reaching desirable sizes. A minimum size limit can be deemed successful if growth rate is not seriously retarded and natural mortality is unchanged (Hackney 1974). To be continually successful as a management "tool," size limits might have to be removed, increased or decreased as the situation warrants (Anderson 1974).

Another value of length limits in recreational fisheries is that they do not prevent the catching--only the keeping. Fish caught and released still contribute to the quality of fishing (Anderson 1976). Although a large number of bass are released under length restrictions, the extent of mortality is probably negligible or minimal. Gustaveson (1978) indicated that handling largemouth bass after being captured by angling was more stressful than the damage incurred by the hook and being played by anglers.

Attempts to prevent largemouth bass overharvest in small, northwest Missouri lakes led to the implementation of 12-in (305 mm) length limits in October 1968. Numerous studies on various lakes in Missouri have evaluated the effectiveness of this restriction. Results indicated that the restriction led to a stockpiling of bass under the length limit (Rasmussen and Michaelson 1974). This produced an unsatisfactory situation because bass growth rates were low. However, the length limit was beneficial in improving bluegill growth, survival and harvest. The greatest advantage of the length limit was that it provided a large number of sublegal bass (< 12 in [305 mm]) strictly for catch and release. Anglers appeared to accept this situation as desirable.

Manipulation of bass populations through regulations on size of fish has resulted in better angling in numerous cases. Results were similar in Jo Shelby Lake (12-in [305 mm] length limit), Sterling Price Lake (12-in [305 mm] length limit), Henry Sever Lake (12-in [305 mm] length limit) and Ella Ewing Lake (15-in [381 mm] length limit). The stockpiling of bass immediately under the size limit occurred, bluegill harvest, growth and survival increased and bass harvest in numbers increased (Hickman and Congdon 1974). The 15-in (381 mm) length limit in Ella Ewing Lake produced larger bass than before the size limit was implemented. As a result, increased predation on the forage base (bluegills) depleted the forage and slow bass growth rates resulted (Keith 1978).

The effects of a 12-in (305 mm) length limit on largemouth bass in Deer Ridge and Wakonda, Missouri (Farabee 1974), and a 14-in (356 mm) length limit in Binder Lake, Missouri (Hoey and Redmond 1974) were documented with results comparable to those previously discussed. Interestingly, Wakonda Lake was similar to Pelican Lake because larger bluegills (7 in [178 mm]) were consistently available to anglers in three years of growth before the initiation of the length limit; but length structure of largemouth bass in Binder Lake revealed only 3.2% were legal size (14 in [356 mm]).

The most current proposed and perhaps most promising management regulations designed to curtail largemouth bass overharvest come from the study of Phillips Lake, Missouri, a 15 ha private impoundment (Johnson and Anderson 1974). In 1974, a new regulation was applied to protect the size range of bass from 12-15 in (305-381 mm) in length.

A 12-in (305 mm) length limit was in effect several years prior to 1974. The new regulation called for releasing bass 12, 13 and 14 in (305, 330 and 356 mm) long, yet allowed harvesting the surplus of bass in the small size group and the large quality-sized group. Anderson believed that although bass less than 12 in (305 mm) could be legally harvested, anglers would release most of these bass because many bass anglers today have a self-imposed length limit of about 12 in (305 mm). This management strategy has been recommended for use in cases where there is a relatively high number and total weight of bass but few of quality size, or where the initial stock in a new pond or lake have spawned and most are a quality size (about two years). According to Anderson's research, the optimum population structure for the best sustained bass and bluegill fishing quality exists when 40-60% of the bass 8 in (203 mm) and above are longer than 12 in (305 mm). This length is considered to be a minimum size acceptable to most anglers. At the same time, 10-25% of the stock number should be longer than 15 in (381 mm) (Anderson 1976).

The intent of this regulation is (Johnson and Anderson 1974):

1. To allow harvest of a surplus of suitable size bass of age I and II.

2. To protect bass through age III and IV.

3. To increase the number of bass of age V and older or 15 in (381 mm) long and longer in the harvest.

4. To retain a balanced bluegill population.

The rationale of the regulation is to protect important predators for 20-25% of their life span when their potential annual weight gain is high rather than to protect them when annual weight gains are relatively low. It is important to protect bass larger than 12 in (305 mm) since bass of this size and larger have the best potential for growth and utilize the larger, available food such as 3-4-in (76-102 mm) bluegills.

As a result of this innovative management approach, the structure of the bass population in Phillips Lake improved in only two years from one which contained less than 10% quality-sized bass to a population with about 50% quality-sized bass. The percentage of quality-sized bass has ranged from 40-60% for the last three years, and the proportion of quality-sized bluegills in the catch has remained high for 10 years. Anderson reported that this 12-15-in (305-381 mm) length restriction has promoted the catch and release of quality-sized bass and has been well received by the anglers. Recently, the length limit restriction was changed to protect bass 13-17 in (330-432 mm) long. This regulation was also accepted by more than two thirds of the bass anglers.

The condition of the Pelican Lake bass population was evaluated using a number of indices. It is difficult to say whether the population has been overharvested. Catch rates indicate that overharvest has possibly occurred. The largemouth bass annual catch rates at Pelican Lake in the years 1970 to 1973 (0.988, 0.713, 0.716 and 1.141 fish/hr, respectively) were greater than those catch rates from 1975 to 1977 (0.204, 0.094 and 0.213 fish/hr, respectively). However, catch rates in 1970 to 1973 were computed from data collected primarily between March and June, while catch rates for 1975 to 1977 were computed from data collected from April to October. Bass catch rates from July to October in this study were significantly lower than from April to July. Because catch rates were not computed for July to October in 1970 to 1973, this probably inflated the annual catch rate estimates compared to annual catch rates in 1975 to 1977. Furthermore, success rates in 1970 to 1973 were determined by obtaining only the hours fished solely for bluegill and hours fished solely for largemouth bass. Success rates from this study (1975 to 1977) were determined by obtaining total hours fished regardless of the fish species anglers pursued. The decrease in bass catch rates in 1975 to 1977 from the early 1970s may be explained by differences in computing catch rates in the two periods. Although angling pressure was lower in 1977 than 1976, the catch rate for bass increased almost 2.3 times in 1977 from 1976, suggesting possibly better or more experienced bass anglers in 1977. Another possible explanation is that a strong year class of bass may have been produced three years prior to 1977.

Yearly trends in length frequency data are a common index for determining whether a population is being overharvested. If a downward trend is noticed, overharvest may be the cause. Largemouth bass harvested in 1977 from Pelican Lake were larger in both length and weight than those harvested in 1976 (Figure 36). Length and weight frequency data of harvested bass prior to 1976 and after 1977 are not available. Consequently, the possibility of overharvest and/or the presence of a strong year class cannot be assessed.

Annual trends in age composition are also utilized as an index for determining overharvest. A decrease in the number of older bass in the population may be caused by overharvest. The length and weight composition (Figure 36) and age composition (Figure 34) of bass in the creel indicate few bass survive beyond age V (0.6% in age VI and VII). Age class III bass composed 61% of the total fish that were harvested in 1976 at Pelican Lake. The calculated total annual mortality was 71.6% for bass in 1976. Although the components of this total mortality (natural and fishing) are unknown, this value is higher than the mortality recommended by Graham (1974) for the maximum annual harvest rate. If a given harvest rate, i.e., 40%, is found to provide the most desirable bass populations, it makes little difference in management on the time required to reach the harvest quota. He believed that it is vital to keep the mortality below 40%.

Age and length frequency composition data indicate that Pelican Lake lacks older (age IV+) bass in the population. Gill and trammel nets captured several large bass (> 350 mm TL). However, these fish were not aged. This may indicate that bass are present but are difficult for anglers to catch. Largemouth bass exceeding 1.13 kg (2.5 lbs) in total weight are known to be difficult to catch (Bennett 1974). A 30-year study of Ridge Lake, Illinois revealed that bass were capable of learning through experience (Bennett 1974). He emphasized that a small number of bass which survived the first several years of life were very difficult to catch. Therefore, it is unrealistic to state that all of the larger bass in any lake have been caught by fishermen. During four "spot" rotenone treatments of Pelican Lake, too few bass older than age IV were captured to estimate the number of older bass in the population (Tables 12-15). These above data suggest that either

(1) older bass are present but difficult to catch and, therefore, may not appear in the creel because angling is selective; (2) the sites sampled with rotenone were not representative of habitat for older bass; or (3) the number of larger and older bass in the population at Pelican Lake is either small or nil.

Several management options might be considered to promote a quality, largemouth bass fishery at Pelican Lake. These are:

1. Stocking fingerling bass. Year-class strength seemed to be apparent at Pelican Lake since 1976 yielded an average of 264 young-of-the-year bass/ha; whereas, 110 young-of-the-year bass/ha were captured in 1977. Research indicates that in most waters stocking fingerling bass would merely be replacing other bass fingerlings that would have been produced naturally and would not bring about any significant improvement in fishing (Spencer 1978). Studies on Lake Jordan, Alabama revealed an average of 583 young-of-the-year bass/ha were produced naturally in 1972 (Spencer 1978). Although Lake Jordan has not been artificially stocked during the past 20 years, natural reproduction has been adequate enough to maintain the bass fishery stocks. The conclusion from the Lake Jordan study was that when conditions are suitable, bass can do the stocking each year through natural reproduction much better than artificial stocking and at no additional cost to the state agency. Therefore, augmenting the bass population by stocking fingerling bass as a management "tool" is not recommended at this time for Pelican Lake because recruitment appears to be adequate.

2. Implementation of a season restriction and adjustment of the bag limit. Results from studies previously mentioned indicate that regulating the angling season apparently has little effect on the total bass harvested. In addition, a reduced bag limit does not necessarily reduce the bass harvest but only assures a more equitable distribution of bass to anglers. For these reasons, a season restriction to regulate bass harvest is not recommended at this time. Also, the daily bag limit of 10 bass should be retained.

3. Implementation of a length regulation. The establishment of minimum size limits on bass has lead to negative and positive effects on the fishery. The negative effects have been a stockpiling of bass immediately under the size limit and availability of fewer legal bass to the angler. The beneficial effects of a size limit have (1) increased bluegill growth, survival and harvest; and (2) increased the number of sublegal bass for catch-and-release fishing. A new size regulation to protect 12-15-in (305-381 mm) bass has been effective in increasing the number of larger and older bass. This management strategy is recommended where there is a relatively high number and total weight of bass but few of quality size. The largemouth bass population at Pelican Lake appears to lack older (age IV+) bass. If the decision is made to manage largemouth bass in Pelican Lake as a quality fishery, then the number of age IV and older bass should be increased in the harvest. Preliminary data from Johnson and Anderson (1974) would suggest that application of their 12-15-in (305-381 mm) size limit to the bass fishery at Pelican Lake would protect age III largemouth bass and increase or cause a buildup of older age groups

in the fishery. However, additional data need to be collected in future years before population trends can be recognized. Only when sufficient data have been obtained should consideration be given to such a length limit of 12-15 in (305-381 mm) or other size regulations.

4. Continuation of biological assessment of the state of the fishery. Because only two years of data are available, the following additional data need to be collected: total harvest, catch rate and age composition along with harvest rates (fishing mortality). These data should be utilized to compare trends on an annual basis to ascertain whether the bass population has indeed experienced over-harvest by angling resulting in fewer, older bass in the fishery from the early 1970s.

It must be stressed that if and when regulations are imposed that they be initiated with sound, biological data to substantiate the particular regulation and not whim as has been the practice in the past. Furthermore, the public should be properly informed and educated as to the intent of the regulation(s).

SUMMARY AND CONCLUSIONS

Pelican Lake, located in southwestern Uintah County, supports a rather unique, quality, warmwater, bluegill fishery along with largemouth bass. This shallow, productive, 680 ha, desert lake produces consistently larger bluegills to the angler than other typical bluegill fisheries where fish would average 210 mm in TL and 300 g in total weight. A steady increase in angler use promoted concern for the overexploitation of the large-sized bluegills and resulted in the promulgation of a 20-per-day bag limit on bluegills in 1975, the only Utah water that has a limit on bluegill.

Specific project objectives conducted were the collection of baseline data to ascertain the extent of angling recreation in the form of a stratified creel census to determine total harvest, age and size composition of the harvest and species specific catch rates. Other investigations included collection of life history biology data on bluegill and largemouth bass such as age and growth, reproductive potential and sexual maturity. Measurement of limnological conditions during ice-covered winter months, shoreline transect assessment of winter-killed fish and prewinter and postwinter, spot population sampling to determine relative abundance, age structure and mortality rates of fish species and estimates of bluegills dying due to angler catch and release in 1977 rounded out the investigations on Pelican Lake.

A seven-year continuous increase in angler use on the lake of 10,054 A.D.U. was culminated in 1975. Although two nationally published magazine articles were subsequently released in 1976 and 1977, angler use decreased in 1976 (8,001 A.D.U.) and again in 1977 (5,027 A.D.U.). The greatest seasonal use occurred from ice-out in April to July 31, when rooted, aquatic vegetation proliferated as water drawdown proceeded and as air temperatures soared to unpleasant levels. Boat fishing comprised 82, 86 and 94% of the total annual angler hours in 1975, 1976 and 1977, respectively.

The total estimated harvest of bluegills was 58,277, 44,918 and 22,469 in 1975, 1976 and 1977, respectively. Mean annual bluegill catch rates in 1975, 1976 and 1977 were 1.520, 1.640 and 1.130 fish/hr, respectively. Bluegill harvest peaked in May, June and July of the three years sampled. The total estimated harvest of largemouth bass was 5,791, 2,747 and 4,176 in 1975, 1976 and 1977, respectively. Mean annual largemouth bass catch rates in 1975, 1976 and 1977 were 0.204, 0.094 and 0.213 fish/hr, respectively. Largemouth bass harvest usually peaked in April and May. Bluegill population dynamics did not appear to differ from year to year. Age and size composition of angler harvested bluegills indicated no statistically significant change between 1976 and 1977. The mean annual TL of angler harvested bluegills in 1976 and 1977 was 210 and 212 mm, respectively; the mean annual total weight of harvested bluegills was 287 and 285 g, respectively. Largemouth bass harvested in 1977 were significantly greater in weight than the harvest of 1976. Bluegill age classes IV and V (59%) and largemouth bass age class III (61%) composed the majority of the angler harvested fish in 1976 and 1977. The total annual mortality determined from scale analysis of harvested fish was 59.9% for bluegills and 71.6% for largemouth bass. A significant number of male bluegills (88%) was harvested by anglers in June 1977, the time of peak nesting activity.

Anglers caught and released an estimated 5,158 bluegills in 1977, which was 23% of the total annual estimated angler bluegill harvest. Of the 5,158 released, 565 (11%) were estimated to be lost to hooking mortality. This loss was estimated at 2.5 and 1.0% of the total numbers and total weight harvested, respectively. Of the six various hook sizes, number 8 regular shank hooks caused the highest total mortality (18%); the lowest mortality (0%) was with number 6 regular shank jig hooks and where the leader was cut and the hook allowed to remain (0%). Higher mortality of worm-hooked fish was attributed largely to anatomical location of hooking. Of the total (19) bluegill mortalities, 63% were hooked in the esophagus and 37% in the gill/gill arch.

Male and female bluegill growth rates were not significantly different but were considered good growths compared to bluegill growth rates in numerous other U. S. waters. Growth of largemouth bass was greatest in the first year of life but declined in following years. Bass growth in Pelican Lake was assessed as being average when compared with bass growth rates of other waters of comparable latitude and growing season.

Male bluegills matured earlier in life than females. Males and females began to mature at age II, but males began to mature at 141-150 mm TL while females did not begin to mature until they became

151-160 mm TL. Female bluegills examined for fecundity produced from 11,102 (age III) to 46,281 (age V) mature ova. Largemouth bass produced from 4,810 (age II) to 31,719 (age V) mature ova. Spawning for bluegills peaked in early June in 1976 and mid-June in 1977, although spawning occurred continually from the first of June to the first of September in both years. Largemouth bass spawned in late May in 1976 and early June in 1977.

Postwinter population sampling in May 1977 indicated the estimated bluegill standing crop weight was 40% less than the August 1976 prewinter standing crop weight estimate. A similar weight loss (37%) was noted from August 1977 to June 1978. An extensive overwinter mortality of young-of-the-year bluegill was observed in both years. Young-of-the-year bluegill suffered a 98% overwinter mortality. Winter mortalities may be responsible for preventing overcrowding by small bluegill which is typical of most bluegill populations in northern latitudes. Largemouth bass standing crop weight estimates were greater in the postwinter sampling than the prewinter sampling, the complete inverse of the bluegill standing crop.

The mean estimated standing crop of young-of-the-year bluegill in August 1976 (31,748 fish/ha) was 3.8 times greater than the mean standing crop of young-of-the-year bluegills in August 1977 (8,385 fish/ha). The mean estimated standing crop of young-of-the-year largemouth bass in August 1976 (264 fish/ha) was 2.4 times greater than the mean standing crop of young-of-the-year largemouth bass in August 1977 (110 fish/ha).

Survivorship curves of bluegills from Pelican Lake, compared with numerous balanced and unbalanced bluegill populations, indicated that the Pelican Lake bluegill population was characteristic of a balanced population. Bluegills in Pelican Lake exhibit good growth rates of intermediate and large fish. Relatively stable recruitment and older fish are well represented in the population. The high rate of mortality in young fish and longevity of life in the Pelican Lake bluegill population are additional evidence of a balanced population.

Midwinter water quality analyses in 1977 and 1978 indicated an inverse stratification and depletion of dissolved oxygen. Anoxic conditions in mid-February and mid-March were noted from 2.0 m below the ice sheet to the substratum of this 4.8 m maximum deep lake. Hydrogen sulfide concentrations attained under these anaerobic conditions were well above acute toxicity levels reported by Smith et al. (1976). Concentrations of H_2S were also noted at ice-out in March 1978. Water levels in 1977 were lower than in 1976, and snow depth on the lake was slightly greater in 1978 than in 1977. Although physical and climatological conditions in 1978 seemed more critical than those in 1977, i.e., lower prewinter water levels, far more rooted aquatic vegetation and greater snow depths on the ice cap during 1978, the shoreline transect counts of winterkilled bluegills in 1978 were no greater than the 1977 counts. Transect counts of dead fish along the shorelines conducted at ice-out revealed that only harvestable-sized bluegills and few bass died during the overwinter period. The mean age of winter-killed bluegills found in the shoreline transects was 5.45 years in 1975, 4.96 years in 1976 and 6.13 years in 1977. These post ice-out shoreline transects indicated that the winterkill was selective for older and larger bluegills. Postwinter population sampling indicated that the overwinter mortality was indiscriminate of age but highly selective for bluegill and not largemouth bass. The overwinter mortality, which occurs annually, may be a subtle management "tool" in thinning bluegill populations which, traditionally and biologically, exhibit high reproductive potentials. This winterkill appears to be a phenomenon unique to this population that may allow intraspecific competition among surviving bluegills to be minimized and improve growth rates.

At the present level of angling use, the 20 daily bag limit on bluegills could be removed, but appropriate restrictions should be applied if angling pressure becomes excessive. The fishery manager should be aware of the dangers of overexploitation. The dangers are (1) a decrease in the age composition of the harvest; (2) a decrease in the size of fish harvested; (3) a decrease in the catch per unit of effort; and (4) an increase in total mortality. No terminal gear restrictions on catching bluegills or size-length restrictions on keeping bluegills are recommended at this time. No adjustments in the current daily bag limit of 10 largemouth bass or additional season or size limits need be enacted at this time. However, the concept of protecting bass of 305-381 mm TL (12-15 in) may have promise in maintaining a quality bass fishery. This management "tool" may increase the numbers of larger, older bass in the population. The purchase of additional water storage from the Ouray Park Irrigation Company in conjunction with the present 493 ha m conservation pool should be considered.

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APPENDIX

Table 16. Riparian vegetation from the shoreline of Pelican Lake, Uintah County, Utah.

Genus	Species	Common Name
Alopecurus		Foxtail
Artemisia	tridentata	Big sagebrush
Asclepias		Milkweed
Atriplex		Saltbush
Chrysothamnus		Rabbitbrush
Cichorium	intybus	Common chicory
Cleome	lutea	Yellow spiderflower
Distichlis	stricta	Saltgrass
Grinderlia		Gumweed
Gutierrezia		Snakeweed
Helianthus	nuttallii	Sunflower
Kochia		Summer cypress
Lepidium		Pepperweed
Lupinus		Lupine
Medicago	sativa	Alfalfa
Melilotus	alba	White sweetclover
Melilotus	officinalis	Yellow sweetclover
Monarda		Beebalm
Oenothera	caespitosa	Tufted evening primrose
Opuntia		Pricklypear
Populus		Cottonwood
Rumex		Curly dock
Salix		Willow
Salsola	kali	Russian thistle
Sarcobatus	vermiculatus	Black greasewood
Scirpus		Bulrush
Sesuvium	verrucosum	Seapurslane
Sonchus	asper	Sowthistle
Sphaeralcea		Globemallow
Tamarix		Tamarisk
Tetradymia		Horsebrush
Tragopogon	dubius	Yellow salsify
Typha		Cattail
Xanthium	strumarium	Cocklebur

Table 17. Water quality analyses of Pelican Lake, Uintah County, Utah, September 8, 1976.[a]

Parameter	Concentration	Parameter	Concentration
Total Alkalinity ($CaCO_3$)	189.00 mg/l	Phosphate (dissolved ortho)	0.03 mg/l
Bicarbonate	231.00 mg/l	Potassium (dissolved)	4.60 mg/l
Baron (dissolved)	300.00 mg/l	Silica (dissolved)	8.90 mg/l
Calcium (dissolved)	23.00 mg/l	Sodium (dissolved)	100.00 mg/l
Chloride (dissolved)	45.00 mg/l	Sulfate (dissolved)	270.00 mg/l
Fluoride (dissolved)	0.50 mg/l	Specific conductance	963.00 [b]
Hardness (noncarbonate)	94.00 mg/l	Water temperature (C)	21.00
Total Hardness ($CaCO_3$)	280.00 mg/l	Hydrogen Ion (pH) concentration	9.30
Magnesium (dissolved)	55.00 mg/l		
Nitrite and nitrate as nitrogen dissolved	0.03 mg/l		
Phosphate (ortho dissolved as phosphorus)	0.01 mg/l		

Cations	Concentration	Anions	Concentration
Calcium (dissolved)	23.00 mg/l	Bicarbonate	231.00 mg/l
Magnesium (dissolved)	55.00 mg/l	Chloride (dissolved)	45.00 mg/l
Potassium (dissolved)	4.60 mg/l	Fluoride (dissolved)	0.50 mg/l
Sodium (dissolved)	100.00 mg/l	Sulfate (dissolved)	270.00 mg/l
		Nitrite and nitrate as nitrogen dissolved	0.03 mg/l

[a] Data collected by Bob Bessey, fishery biologist, Bureau of Land Management, Vernal, Utah; data analyzed by U. S. Department of the Interior, Geological Survey, Central Laboratory, Denver, Colorado.

[b] Units are in micromhos/cm.

Table 18. An example of the method utilized to project the monthly mean total angler hours, mean total harvest and angler day use from instantaneous angler counts and creel interviews. (Note: June 1977 values were used as an example.)

	A	B	C	D	E	F	G	H
	Total Possible Angling Days Per Month	Length of Angling Day (Hours)	Total Hours Angling	Number of Counts	Total Anglers Counted	Mean Anglers Per Count	Total Angler Hours	Mean Anglers Per Boat
Bluegill								
Weekday shore	22	15	330	40	13	0.32	105.60	--
Weekday boat	22	15	330	40	93	2.32	765.60	3.00
Weekend shore	8	15	120	16	12	0.75	90.00	--
Weekend boat	8	15	120	16	193	12.06	1,447.20	2.77

	I	J	K	L	M	N	O
	Mean Total Angler Hours	Total Angler Hours Interviewed	Total Fish Checked	Mean Fish Per Hour	Mean Total Harvest	Mean Hours Per Completed Trip	Angler Day Use
Weekday shore	105.60	7.00	10	1.43	151	2.33	45.32
Weekday boat	2,296.80	370.50	525	1.42	3,261	3.70	620.76
Weekend shore	90.00	17.00	45	2.65	239	1.32	68.18
Weekend boat	4,008.70	520.00	883	1.70	6,815	4.63	865.81

1. (A)(B) = C
2. E/D = F
3. (C)(F) = G
4. (G)(H) = I
5. K/J = L
6. (I)(L) = M
7. I/N = 0

Table 19. Diatom composition collected in the bottom sediments[a] at Pelican Lake, Uintah County, Utah, August 6, 1975.[b]

Species	% Relative Density
Achnanthes clevei	present
Amphora ovalis	3
Amphora veneta	13
Cocconeis placentula var. lineata	2
Cymbella ventricosa	7
Denticula elegans	1
Epithemia sorex	4
Epithemia turgida	6
Fragilaria vaucheriae	4
Gyrosigma acuminatum	1
Hantzschia amphioxys	4
Navicula capitata	2
Navicula cryptocephala	13
Navicula cryptocephala var. veneta	1
Navicula halophila	1
Navicula pupula	1
Navicula radiosa	1
Navicula rhynchocephala	7
Navicula secreta	1
Navicula tripunctata	1
Navicula viridula	present
Neidium iridis	3
Nitzschia linearis	1
Nitzschia palea	4
Nitzschia sigmoidea	1
Pinnularia borralis	1
Pinnularia lata	1
Rhopalodia gibba	2
Rhopalodia gibberula	1
Stephanodiscus astrea var. minutula	2
Surirella ovalis	2
Synedra ulna	11
Tabellaria floculosa	1

[a]Bottom sediments sampled near the west end of the lake.

[b]Sampling and analyses conducted by the Erying Research Institute, Provo, Utah.

Table 20. Phytoplankton analysis for nondiatom algae and percentage relative density for diatom community for Pelican Lake, Uintah County, Utah, August 6 and October 21, 1975.[a]

Sampling Date	Species	% Relative Density
August 6, 1975 West end of lake	Oscillatoria agardhii	Rare
	Oscillatoria limosa	Common
	Pediastrum duplex	Rare-common
	Staurastrum anatinum	Rare
	Diatoms:	
	Achnanthes minutissima	37.5
	Amphora coffaeiformis	12.5
	Navicula cryptocephala var. veneta	37.5
	Nitzschia dissipata	12.5
October 21, 1975 Irrigation canal near entrance into lake	Anabena flos-aquae	Common
	Closterium acerosum	Rare
	Closterium moniliforme	Rare
	Evastrum sp.	Rare
	Gomphosphaeria aponia	Rare
	Merismopedia tenuissima	Common-abundant
	Mougeotia genuflexa	Common
	Mougeotia parvula	Common
	Oscillatoria amphibia	Common
	Oscillatoria limosa	Common
	Oscillatoria sp.	Abundant
	Oscillatoria tenuis	Common
	Pandorina morum	Rare
	Pediastrum duplex	Common
	Phacus sp.	Rare
	Raphidium spiralis	Common
	Rhizoclonium hieroglyphicum	Abundant
	Scenedesmus bijuga	Rare
	Scenedesmus quadricauda	Rare
	Sphaerocystis schroeteri	Rare
	Spirogyra neglecta	Common
	Spirogyra porticalis	Common
	Spirulina major	Common
	Staurastrum polymorphum	Rare

[a]Sampling and analysis conducted by the Erying Research Institute, Provo, Utah.

Table 21. Percentage relative density for periphyton diatom community[a] for Pelican Lake, Uintah County, Utah, October 21, 1975.[b]

Species	% Relative Density
Achnanthes minutissima	9.7
Amphora veneta	1.4
Cocconeis placentula var. *lineata*	50.0
Cyclotella meneghiniana	0.7
Cymbella incerta	13.8
Navicula cryptocephala var. *veneta*	1.4
Nitzschia palea	8.3
Rhoicosphenia curvata	0.7
Synedra pulchella var. *lacerata*	2.8
Synedra tabulata	4.1
Synedra ulna var. *longissima*	0.7

[a]Diatoms sampled near the irrigation canal inlet.

[b]Sampling and analyses conducted by the Erying Research Institute, Provo, Utah.

Table 22. Percentage relative density for phytoplankton diatom community[a] for Pelican Lake, Uintah County, Utah, October 21, 1975.[b]

Species	% Relative Density
Diatoms:	
Achnanthes lanceolata	0.7
Achnanthes minutissima	5.0
Amphora veneta	7.9
Amphipleura lindheimeri	0.7
Asterionella formosa	35.0
Cocconeis placentula var. lineata	16.4
Cyclotella meneghiniana	2.9
Cymbella affinis	0.7
Cymbella aspera	0.7
Cymbella ventricosa	0.7
Epithemia argus	0.7
Eunotia perpusilla	0.7
Gomphonema parvulum	0.7
Nitzschia acicularis	7.1
Nitzschia amphibia	2.1
Nitzschia dissipata	0.7
Nitzschia palea	0.7
Rhopalodia gibba	0.7
Surirella ovata	0.7
Synedra pulchella var. lacerata	1.4
Synedra tabulata	0.7
Synedra ulna	11.4
Tabellaria floculosa	2.1

[a]Diatoms sampled near the irrigational canal inlet.

[b]Sampling and analyses conducted by the Erying Research Institute, Provo, Utah.

Table 23. Water quality analyses at various sampling stations at Pelican Lake, Uintah County, Utah, 1976.

Sampling Date; Time of Day	Sampling Depth (m)	Dissolved Oxygen (mg/1)	Total Alkalinity as $CaCO_3$ (mg/1)	Total Hardness as $CaCO_3$ (mg/1)	pH	Temperature Profile (C)
June 24; 1100	0.0	7.6	160	280	9.2	19.0
	1.0	8.1				19.0
	2.0	8.1				19.0
	3.0	8.2				18.5
	4.0	8.2	140	285	9.3	18.5
	5.0	8.0				18.5
July 27; 1300	0.0	7.6	155	330	9.2	25.5
	1.0	7.2				24.5
	2.0	7.0				24.5
	3.0	7.2				24.5
	4.0	6.0	140	310	9.2	24.5
August 23; 1100	0.0	7.6	135	270	9.2	22.0
	1.0	7.9				21.0
	2.0	8.2				20.5
	3.0	8.2				20.5
	4.0	7.9	140	280	9.5	20.5
September 15; 1115	0.0	8.1	155	290	9.1	21.0
	1.0	8.2				20.0
	2.0	7.9				19.5
	3.0	7.9				19.0
	4.0	7.6	150	285	9.3	19.0

Table 24. Water quality analyses at various sampling stations at Pelican Lake, Uintah County, Utah, January 8 and 9, 1977. (Note: refer to Figure 3 for relative location of sampling stations.)

Sampling Station	Sampling Depth (m)	Dissolved Oxygen (mg/l)	pH	Hydrogen Sulfide (mg/l)	Temperature Profile (C)	Snow Depth (m)	Ice Depth (m)
J-1	1.0	7.8	8.9	0.0	4.0	0.025	0.290
J-2	0.0	7.9	9.2	0.0	0.0	0.032	0.240
	1.0	8.2			4.0		
	2.0	7.8			4.0		
	2.8	8.0	9.3	0.0	4.0		
J-3	0.0	10.7	8.7	0.0	0.0	0.031	0.290
	1.0	10.6			3.5		
	2.0	10.4			4.0		
	3.0	10.6	9.0	0.0	4.0		
J-4	0.0	12.0	9.0	0.0	0.0	0.032	0.300
	1.0	11.1			4.0		
	2.0	10.2			4.0		
	3.0	10.0	9.1	0.0	4.5		
J-5	0.0	7.2	9.2	0.0	0.0	0.033	0.320
	1.0	6.6	9.2	0.0	3.0		
	2.0	6.6	9.3	0.0	4.5		
	3.0	6.4	9.4	0.0	4.5		

Table 25. Water quality analyses at various sampling stations at Pelican Lake, Uintah County, Utah, February 11, 1977. (Note: refer to Figure 3 for relative location of sampling stations.)

Sampling Station	Sampling Depth (m)	Dissolved Oxygen (mg/l)	pH	Hydrogen Sulfide (mg/l)	Temperature Profile (C)	Snow Depth (m)	Ice Depth (m)
F-1	0.0	6.3	9.4	0.0	0.0	0.091	0.418
	1.0	6.7	9.3	0.0	2.5		
	2.0	5.4	9.2	0.0	3.5		
	3.0	3.2	9.3	0.0	4.5		
F-2	0.0	7.0		0.0		0.092	0.364
	1.0	6.2					
	2.0	6.0					
	2.8	6.0		0.0			
F-3	1.0	0.0	7.1	0.8		0.086	0.351
F-4	0.0	6.6		0.0		0.090	0.393
	1.0	5.9					
	2.0	4.6					
	3.0	3.1		0.0			
F-5	0.0	4.4		0.0	0.0	0.097	0.430
	1.0	5.8			2.5		
	2.0	2.6			3.5		
	2.8	1.0	9.3	0.0	5.0		
F-6	0.0	5.6		0.0		0.091	0.419
	1.0	6.6					
	2.0	4.4					
	3.0	1.3		0.0			
F-7	0.0			0.0	0.0	0.088	0.400
	1.0				3.0		
	2.0				4.0		
	3.0				4.5		
F-8	0.0	4.8		0.0	0.0	0.088	0.410
	1.0	4.0			3.0		
	2.0	3.1			4.0		
	2.5	0.6		0.0	4.5		
F-9	1.0	0.0	7.3	2.5	2.0	0.082	0.301

Table 26. Water quality analyses at various sampling stations at Pelican Lake, Uintah County, Utah, March 15, 1977. (Note: refer to Figure 3 for relative location of sampling stations.)

Sampling Station	Sampling Depth (m)	Dissolved Oxygen (mg/l)	pH	Hydrogen Sulfide (mg/l)	Temperature Profile (C)	Snow Depth (m)	Ice Depth (m)
M-1	0.0	9.4	8.6	0.0	6.0	0.010	0.263
	1.0	9.8			6.5		
	2.0	9.4			7.0		
	3.0	10.0			7.0		
	4.0	9.6	9.5	0.0	7.0		
M-2	0.0	10.2			6.5	0.015	0.264
	1.0	10.9			7.0		
	2.0	9.9			7.0		
	3.0	8.5			7.0		
	3.8	8.2		0.0	7.0		
M-3	0.0	9.6			6.0	0.013	0.271
	1.0	9.2			6.5		
	2.0	8.6			7.0		
	3.0	12.2	9.7	0.0	7.0		
M-4	0.0	8.8			5.0	0.012	0.248
	1.0	10.1			6.0		
	2.0	10.8			6.0		
	2.5	14.0		0.0	6.5		
M-5	0.0	6.2	8.3		4.5	0.013	0.247
	1.0	10.1			6.0		
	2.0	12.1			7.0		
	2.5	12.5	9.6	0.0	7.0		
M-6	0.0	10.2				0.011	0.248
	1.0	9.8					
	2.0	12.0					
	2.8	12.0					
M-7	0.0					0.013	0.319
	1.8	11.8		0.0			
M-8	0.0					0.010	0.292
	1.0	9.9	8.8		5.0		
M-9	0.0	8.1		0.0		0.013	0.281
	1.0	8.7					
	2.0	9.8					
	3.0	9.4		0.0			
M-10	0.0	8.9				0.010	0.263
	1.0	8.8					
	2.0	10.2					
	3.0	9.8					

Table 27. Water quality analyses at various sampling stations at Pelican Lake, Uintah County, Utah, January 7 and 8, 1978. (Note: refer to Figure 4 for relative location of sampling stations.)

Sampling Station	Sampling Depth (m)	Dissolved Oxygen (mg/l)	pH	Hydrogen Sulfide (mg/l)	Temperature Profile (C)	Snow Depth (m)	Ice Depth (m)
J-1	0.0	11.7			0.5	0.044	0.189
	1.0	10.6			3.0		
	2.0	6.5			5.0		
	2.5	4.7		0.0	5.0		
J-2	0.0	11.4			0.3	0.044	0.191
	1.0	11.0			3.0		
	2.0	9.0			4.0		
	3.0	8.5		0.0	4.5		
J-3	0.0	11.9				0.044	0.152
	1.0	10.7					
	2.0	5.3		0.0			
J-4	0.0	12.0				0.044	0.190
	1.0	10.8					
	2.0	9.4					
	2.5	6.2		0.0			
J-5	0.0	10.1				0.044	0.165
	1.0	9.3					
	1.5	0.0		0.5			
J-6	0.0					0.044	0.152
	1.0	12.8					
	1.5	8.9		0.0			
J-7	0.0	10.7			0.5	0.051	0.197
	1.0				3.0		
	2.0	9.4			4.0		
	2.5	4.8		0.0	4.5		
J-8	0.0				0.0	0.038	0.203
	1.0	10.6			2.0		
	2.0	9.8			2.5		
	3.0	9.0		0.0	4.0		
J-9	0.0					0.064	0.159
	1.0	8.4					
	2.0	9.1		0.0			
J-10	0.0	9.8				0.064	0.178
	1.0	10.7					
	2.0	7.3					
	3.0	4.4		0.0			

Table 28. Water quality analyses at various sampling stations at Pelican Lake, Uintah County, Utah, February 11 and 12, 1978. (Note: refer to Figure 4 for relative location of sampling stations.)

Sampling Station	Sampling Depth (m)	Dissolved Oxygen (mg/l)	pH	Hydrogen Sulfide (mg/l)	Temperature Profile (C)	Snow Depth (m)	Ice Depth (m)
F-1	0.0	11.0	8.7	0.0	0.0	0.064	0.349
	1.0	8.6			1.0		
	2.0	2.5			4.0		
	3.0	1.0			5.0		
	4.0	0.6	8.9	0.0	5.0		
F-2	0.0	10.2	8.9	0.0	0.0	0.076	0.419
	1.0	7.0			1.0		
	2.0	0.5	8.8	0.0	4.0		
F-3	0.0	9.7				0.051	0.318
	1.0	7.8					
	2.0	1.6	8.7	0.0			
F-4	0.0	8.5	8.7		0.0	0.057	0.203
	1.0	6.9			1.0		
	2.5	0.0	8.5	1.0	4.5		
F-5	0.0	10.2	8.8		0.0	0.070	0.330
	1.0	9.2			1.0		
	2.0	1.0			4.5		
	3.5	0.0	8.5	0.4	5.0		
F-6	0.0	10.6			0.0	0.089	0.337
	1.0	10.0			1.5		
	2.0	5.0			4.0		
	3.0	1.1			5.0		
	4.0	0.0	8.7	0.1	5.0		
F-7	0.0	11.1	8.9	0.0		0.191	0.292
	1.5	8.9					
	2.5	0.8					
	3.5	0.0	8.8	0.0			
F-8	0.0	11.3	8.6		0.0	0.038	0.343
	1.0	11.3			1.0		
	2.0	1.0			4.5		
	3.0	0.0	8.2	0.2	5.0		
F-9	0.0	10.3	8.9	0.0	0.0	0.102	0.330
	1.0	9.4			1.0		
	2.0	6.7			4.5		
	3.0	0.4			5.0		
	4.0	0.0	8.8	0.0	5.0		

Table 29. Water quality analyses at various sampling stations at Pelican Lake, Uintah County, Utah, March 11 and 12, 1978. (Note: refer to Figure 4 for relative location of sampling stations.)

Sampling Station	Sampling Depth (m)	Dissolved Oxygen (mg/l)	pH	Hydrogen Sulfide (mg/l)	Temperature Profile (C)	Snow Depth (m)	Ice Depth (m)
M-1	0.0	10.6	8.2	0.0		0.044	0.330
	1.0	11.0					
	2.0	9.1					
	3.0	0.4					
	4.0	0.0	8.6	0.5			
M-2	0.0	10.6	8.6	0.0		0.019	0.368
	1.0	10.5					
	2.0	7.6					
	3.0	0.2					
	4.0	0.0	8.4	0.5			
M-3	0.0	10.6		0.0	1.0	0.013	0.331
	1.0	10.4			2.0		
	2.0	5.3			3.0		
	3.0	0.9			3.5		
	4.0	0.0		1.5	5.0		
M-4	0.0	11.8	8.6	0.0	0.0	0.025	0.394
	1.0	11.5			1.0		
	2.0	5.0			2.5		
	3.0	0.0			4.0		
	4.0	0.0	8.6	2.0	5.0		
M-5	0.0	13.5		0.0		0.030	0.381
	1.0	11.5					
	2.0	1.9		0.0			
M-6	0.0				0.0	0.025	0.318
	1.0	11.0		0.0	1.0		
	2.0	6.2			2.0		
	3.0	0.2		0.0	3.5		
M-7	0.0	12.0	8.5	0.0		0.028	0.330
	1.5	11.9					
	2.5	2.1	8.5	0.0			
M-8	0.0					0.025	0.332
	1.0	10.8					
	2.0	6.7					
	3.0	0.0		2.5			

Table 30. Water quality analyses at various sampling stations at Pelican Lake, Uintah County, Utah, during ice-out, March 25 and 26, 1978. (Note: refer to Figure 5 for relative location of sampling stations.)

Sampling Station	Sampling Depth (m)	Dissolved Oxygen (mg/l)	H_2S (mg/l)	pH	Temperature Profile (C)	Specific Conductivity (micromhos/cm)
M-1	0.0	8.1	0.000	7.9	8.8	332
	1.0	7.5	0.000	7.9	7.0	321
M-2	0.0	6.6	0.000	7.9	8.5	342
	1.6	6.0	0.000	8.0	6.1	340
	3.2	3.6	0.000	8.1	7.0	393
M-3	0.0	1.2	0.000	7.9	8.0	328
	2.5	2.4	0.002	7.9	6.9	418
	4.9	0.9	0.003	7.9	6.8	452
M-4	0.0	6.2	0.000	8.6	7.9	341
	2.3	2.7	0.000	8.5	6.9	420
	4.5	1.6	0.003	8.5	6.9	431
M-5	0.0	4.8	0.000	8.9	10.0	442
	1.0	4.7	0.000	8.7	8.6	430
M-6	0.0	7.1	0.000	8.2	5.3	250
	1.5	5.1	0.000	8.2	6.5	348
	3.0	0.9	0.010	8.1	7.0	405
M-7	0.0	7.0	0.014	7.8	6.0	258
	1.4	3.9	0.000	7.9	6.5	340
	2.8	0.6	0.044	8.0	7.0	430
M-8	0.0	6.9	0.020	7.9	6.0	262
	1.0	7.0	0.000	7.9	6.5	271
	1.8	4.8	0.000	7.9	7.0	382
M-9	1.3	--	0.000	--	--	--
M-10	0.0	6.9	0.000	7.8	5.2	249
	1.9	4.7	0.003	7.8	6.0	355
	3.9	0.2	0.000	7.9	8.6	710
M-11	0.0	7.1	0.000	7.7	7.2	282
	1.5	5.5	0.000	7.7	5.6	331
	3.0	2.4	0.000	7.7	6.9	472
M-12	0.0	7.5	0.000	7.9	6.9	281
	1.1	7.3	0.000	7.9	7.0	281
M-13	0.0	7.2	0.000	7.8	7.1	285
	0.9	7.4	0.000	7.8	7.0	282
	2.0	4.4	0.000	7.9	7.0	350
M-14	0.0	2.0	0.000	7.9	7.2	290
	1.5	7.2	0.000	7.8	7.0	289
M-15	0.0	9.5	0.000	8.1	11.0	352
	1.1	10.1	0.000	8.2	10.0	331
M-16	0.0	6.3	0.000	7.9	10.1	385
	1.0	5.9	0.000	8.0	8.0	360
M-17	0.0	5.8	0.000	7.7	10.2	380
	2.0	4.7	0.000	7.8	7.1	363
	4.0	0.5	0.026	7.8	7.1	421
M-18	0.0	5.4	0.000	7.9	9.0	391
	1.8	3.9	0.000	7.8	7.1	410
	3.7	0.7	0.000	7.8	6.1	424

Table 31. Relation of complete squamation to total length for young-of-the-year bluegills from Pelican Lake, Uintah County, Utah, August 1976.

Total Length (mm)	Number of Fish	Percentage of Fish Completely with Scalation
9	1	0
10	1	0
11	1	0
12	5	0
13	8	0
14	11	18
15	18	22
16	21	43
17	17	61
18	15	94
19	14	100
20	12	100
21	12	100
22	11	100
23	12	100
24	12	100
25	10	100
26	16	100
27	13	100
28	15	100
29	9	100
30	12	100

Table 32. A comparison of mean back-calculated total lengths at the end of each year of life for bluegills from various United States waters with Pelican Lake, Uintah County, Utah.

Water State[a]	Number of Fish	Calculated Total Length at Each Annulus (mm) 1	2	3	4	5	6	7	8	9	10
Duck Harbor, PA	107	25	51	81	114	147	175	193	185	198	
Cowan's Gap Lake, PA	92	46	71	99	130	175	206	229			
Battesse Lake, MI	195	37	84	130	172	203	228				
State Average, MN	2,248	49	86	124	155	180	198	211	218	231	244
Buckeye Lake, OH	300	41	74	104	132	152	180	188	196	213	
State Average, OH	1,000	41	91	130	152	173	190	193	216		
Best Lake, OH		49	132	168	193						
Muskellunge Lake, IN		49	99	153	179	195	206				
State Average (56 lakes) IN		40	80	128	174	198	217	246	238		
Onized Lake, IL	329	49	117	165	185						
Ridge Lake, IL											
stable water levels	326	51	119	146	161	169					
drawdown	112	48	137	170	188						
State Average, IL	9,059	81	117	145	168	188	213				
Ahquabi Lake, IA	635	49	94	119	142	160					
W. Okoboji Lake, IA	228	40	88	137	170	189	210	230			
Clear Lake, IA	166	61	107	142	157	198	208				
State Average, OH, IN, IL, IA		51	98	134	158	171	190	205	226	226	
State Average, TN, KY		63	108	138	158	182					
Woods Lake, TN	190	81	130								
Lake of the Ozarks, MO	1,372	43	94	132	155	175					
Bull Shoals Lake, AR	124	49	84	102	122	150					
Lake Eucha, OK	1,209	56	102	140	170	190					
OK Lakes											
slowest		38	76	109	137	163					
fastest		157	196	213	239	259					
59 clear waters		81	127	155	178	196					
State Average, AR, OK		75	122	150	170	190	185				
State Average, DE		102	147	175	193	213	226				
Potomac River, MD		56	104	122	147						
Snowden Pond, MD	465	38	74	109	150						
Lookout Shoals Lake, NC	84	69	97	122	142	152	170	198			
Tillery Lake, NC	75	69	102	137	160	175					
Lake Lure, NC	33	58	97	130	173						
State Average, TX, GA		49	85	114	144	163	190				
Pelican Lake, UT[b]	1,255	55	112	167	194	212	230	245	255	260	

[a]K. D. Carlander, Handbook of freshwater fishery biology, Vol. II (Ames: Iowa State University Press, 1977), pp. 94-100.

[b]This study.

Table 33. Comparative age analysis from scales of bluegills, Pelican Lake, Uintah County, Utah, September 1974 and June, July and August 1975.

Species	Year Collected	Total Number of Fish	Percentage Agreement	Percentage Disagreement					
				+3[c]	+2[b]	+1[a]	−1[d]	−2[e]	−3[f]
Bluegill	1974	31	42	0	10	42	6	0	0
	1975	103	50	3	2	21	23	1	0

[a]Refers to fish age interpreted in 1974 and 1975 as three years greater than that interpreted by Burdick in 1978.

[b]Refers to fish age interpreted in 1974 and 1975 as two years greater than that interpreted by Burdick in 1978.

[c]Refers to fish age interpreted in 1974 and 1975 as one year greater than that interpreted by Burdick in 1978.

[d]Refers to fish age interpreted in 1974 and 1975 as one year less than that interpreted by Burdick in 1978.

[e]Refers to fish age interpreted in 1974 and 1975 as two years less than that interpreted by Burdick in 1978.

[f]Refers to fish age interpreted in 1974 and 1975 as three years less than that interpreted by Burdick in 1978.

Table 34. Calculated fecundity for 38 bluegills from Pelican Lake, Uintah County, Utah, 1976.

Date Collected	Total Length (mm)	Total Weight (g)	Age	Fecundity
May 27	153	72	II	11,535
May 14	164	104	III	11,495
May 14	174	147	III	14,973
May 14	208	252	III	14,924
May 27	160	106	III	11,226
May 27	163	109	III	11,102
May 27	166	119	III	12,856
May 27	170	124	III	15,830
May 27	174	142	III	13,335
May 27	179	158	III	15,311
May 27	188	192	III	16,783
May 27	190	200	III	17,974
May 27	199	223	III	14,122
May 14	205	264	IV	14,993
May 27	188	197	IV	11,183
May 27	189	177	IV	13,670
May 27	197	204	IV	18,051
May 27	203	240	IV	24,980
May 27	207	303	IV	19,410
May 27	213	184	IV	22,947
May 29	194	164	IV	13,177
May 14	216	315	V	17,691
May 23	226	345	V	31,245
May 27	211	400	V	38,078
May 27	214	285	V	40,675
May 27	214	365	V	42,081
May 27	218	345	V	46,281
May 27	221	340	V	32,642
May 27	228	376	V	44,798
May 21	234	330	V	43,312
June 8	213	309	V	28,718
June 8	219	280	V	25,610
June 8	226	364	V	24,326
June 8	227	365	V	27,071
June 8	233	380	V	34,484
June 8	238	366	V	37,446
May 27	235	407	VI	27,915
May 29	230	318	VII	27,132

Table 35. A comparison of mean back-calculated total lengths at the end of each year of life for largemouth bass from various United States waters with Pelican Lake, Uintah County, Utah.

Water State[a]	Number of Fish	Calculated Total Length at Each Annulus (mm)									
		1	2	3	4	5	6	7	8	9	10
State Average, WI	618	84	188	267	318	356	384	414	442	460	475
Murphy Flowage, WI		130	208	259	340	373	391	427			
Gavins Point Lake, SD		140	209	277	337	383	424				
Wintergreen Lake, MI		112	229	302	343	381	396	409			
Reinings Lake, PA	38	84	196	274	328	366	434	486	508		
State Average, MT	449	56	130	190	236	272	320	358	378		
Fern Ridge Lake, OR		81	237	312	361	396					
Havasu Lake, CA	72	127	264	368	445						
Millerton Lake, CA		112	213	307	373	467	480	488			
State Average, CA, CO, NM		131	245	325	389	451	459	447	446	489	
St. Mary's Lake, OH		89	170	236	279	330	373	411	447	486	500
State Average, OH		89	178	257	318	368	409	450	480	503	
Red Haw Lake, IA	291	98	170	246	316	391	439	472	484		
Horseshoe Lake, IL	37	99	179	261	326	375	428	458	496		
Sportsman's Lake, IL	144	97	206	290	338	378	421	498	495		
Onized Lake, IL	81	86	269	356	419	472					
Lake of Ozarks, MO		135	208	284	335	363	421	470	500	508	
Bull Shores Lake, AR	1,075	176	297	377	427	457	492	519	524		
Kentucky Lake, KY	33	109	213	300	371	437					
Norris Lake, TN	1,589	175	315	373	409	445	490	528			
Back Bay, VA	378	130	274	358	404	452	503	541	554		
Badin Lake, NC	75	130	246	361	429	465	500	493			
Lookout Shoals Lake, NC	70	132	244	312	366	406	439	465	472	490	
Spavinaw Lake, OK	94	150	277	356	429	486	523	546	561	577	
Hiwassee Lake, OK	123	124	226	325	371	457	490	531			
Auburn Lake, AL											
males	89	202	322	408	460	499	543				
females	97	213	325	408	460	503	541	559	587	602	
Ferndale, TX	109	155	234	318	391	450	483	528			
Pelican Lake, UT[b]	492	105	193	272	316	350	403	418			

[a]K. D. Carlander, Handbook of freshwater fishery biology, Vol. II (Ames: Iowa State University Press, 1977), pp. 228-244.

[b]This study.

Table 36. Calculated fecundity for 36 largemouth bass from Pelican Lake, Uintah County, Utah, 1976.

Date Collected	Total Length (mm)	Total Weight (g)	Age	Fecundity
May 14	240	209	II	4,810
May 23	238	186	II	6,923
May 23	244	197	II	5,579
June 5	234	186	II	5,602
June 5	245	172	II	7,233
June 12	241	190	II	6,119
May 14	253	239	III	5,657
May 14	270	287	III	6,236
May 14	288	358	III	10,558
May 14	296	365	III	8,892
May 23	258	251	III	5,862
May 23	284	338	III	8,713
May 23	284	366	III	10,562
May 23	305	428	III	16,548
May 27	278	320	III	7,909
May 29	260	228	III	9,810
May 29	258	254	III	8,812
May 29	305	366	III	10,012
May 31	284	308	III	8,326
May 31	292	342	III	9,485
June 5	275	292	III	5,790
June 5	286	272	III	12,612
May 14	335	538	IV	15,781
May 27	319	412	IV	14,987
May 29	317	400	IV	17,056
May 29	325	495	IV	14,366
May 29	347	628	IV	20,461
May 31	319	400	IV	12,511
June 5	346	576	IV	16,522
June 7	358	679	IV	13,314
June 9	332	480	IV	24,462
May 25	351	560	V	18,442
May 29	341	608	V	22,314
May 29	358	616	V	22,846
May 29	374	758	V	29,130
June 5	388	763	V	31,719

Table 37. Monthly creel census comparison, Pelican Lake, Uintah County, Utah, in 1975-77. (Note: weekday and weekend and shore and boat angler data combined.)

Month	Mean Catch Per Man-Hour						Mean Estimated Projected Harvest						Angler Day Use		
	Largemouth Bass			Bluegill			Largemouth Bass			Bluegill					
	1975	1976	1977	1975	1976	1977	1975	1976	1977	1975	1976	1977	1975	1976	1977
April	0.180	0.037	0.410	0.026	0.011	0.438	155	66	1,087	24	19	628	542	486	680
May	0.236	0.164	0.193	0.423	1.160	0.731	785	1,655	933	1,301	9,186	3,905	1,543	2,616	1,225
June	0.219	0.073	0.224	1.770	1.720	1.600	2,248	575	1,433	18,327	13,390	10,471	3,478	2,105	1,601
July	0.221	0.066	0.153	2.350	2.640	1.490	2,095	307	461	28,918	13,242	3,920	2,820	1,654	732
August	0.140	0.034	0..118	1.750	2.110	1.530	430	102	147	5,905	6,032	2,112	1,087	767	560
September	0.034	0.012	0.096	1.610	1.830	1.240	68	42	110	3,731	3,049	1,396	554	373	215
October	0.053	--	0.058	0.368	--	0.464	10	--	5	71	--	37	30	--	14
Totals	0.204	0.094	0.213	1.520	1.640	1.130	5,791	2,747	4,176	58,277	44,918	22,469	10,054	8,001	5,027

Table 38. Comparison of angler visitation at Pelican Lake, Uintah County, Utah, by state license plates, 1975 and 1977.

State	1975		1977	
	No.	%	No.	%
Arizona	2	< 1	7	3
California	16	4	9	4
Colorado	60	11	38	16
Illinois	4	1	2	1
Indiana	5	1	1	< 1
Kansas	1	< 1	0	--
Kentucky	2	< 1	0	--
Michigan	1	< 1	0	--
Mississippi	0	--	1	< 1
Missouri	0	--	4	2
Montana	1	< 1	0	--
Nebraska	2	< 1	0	--
Nevada	0	--	1	< 1
North Carolina	0	--	2	1
Ohio	1	< 1	1	< 1
Oklahoma	3	1	0	1
Oregon	0	--	1	< 1
Tennessee	1	< 1	0	--
Texas	1	< 1	0	--
Utah	387	73	160	68
Washington	1	< 1	4	2
Wisconsin	8	2	0	--
Wyoming	31	6	6	2
Totals	527	100	237	100

Table 39. Total angler hours stratified by weekday and weekend and shore and boat angler by month for 1976 and 1977 for Pelican Lake, Uintah County, Utah.

		Total Angler Hours				
		Weekday		Weekend		
Year	Month	Shore	Boat	Shore	Boat	Totals
1976	April	158±138[a]	161±102	168±119	1,126±658	1,613±953
	May	455±211	1,392±570	1,437±417	6,095±2,134	9,379±3,256
	June	498±279	3,277±1,418	600±331	3,297±1,253	7,672±3,111
	July	297±183	2,813±1,181	186±113	1,917±893	5,213±2,067
	August	37±28	1,025±441	95±53	1,788±804	2,944±1,261
	September	0	117±71	0	1,500±712	1,617±731
1977	April	35±21	635±248	244±124	1,658±738	2,572±1,043
	May	48±39	1,348±467	214±106	3,432±1,444	5,042±1,868
	June	107±84	2,302±636	90±75	4,006±1,482	6,505±2,057
	July	48±36	1,297±678	100±79	1,212±452	2,657±1,111
	August	64±48	613±193	115±75	696±270	1,488±489
	September	0	329±188	0	799±349	1,128±505
	October	0	0	0	80±71	80±69

[a]95% confidence interval.

Table 40. Total number of bluegills and largemouth bass harvested by weekday and weekend and shore and boat anglers by month for 1976 and 1977, Pelican Lake, Uintah County, Utah.

		Bluegills				
		Total Harvest				
		Weekday		Weekend		
Year	Month	Shore	Boat	Shore	Boat	Totals
1976	April	0	0	0	19±12[a]	19±12
	May	780±438	264±98	2,254±1,179	5,888±2,280	9,186±3,862
	June	862±518	6,750±2,916	569±304	5,209±2,119	13,390±5,716
	July	151±88	7,483±3,166	106±63	5,502±2,319	13,242±5,413
	August	0	1,742±932	0	4,290±2,101	6,032±2,877
	September	0	199±121	0	2,850±1,425	3,049±1,498
1977	April	0	455±182	154±100	19±10	805±231
	May	0	1,698±923	0	2,207±1,329	3,905±1,989
	June	153±94	3,269±1,049	239±165	6,810±2,669	10,471±3,664
	July	0	1,946±793	84±61	1,890±889	3,920±1,581
	August	109±86	882±356	0	1,121±487	2,112±851
	September	0	456±272	0	940±397	1,396±577
	October	0	0	0	37	37

Table 40 (continued)

		Largemouth Bass				
		Total Harvest				
		Weekday		Weekend		
Year	Month	Shore	Boat	Shore	Boat	Totals
1976	April	0	0	9±7[a]	57±43	66±46
	May	162±87	359±171	299±165	835±317	1,655±704
	June	40±25	193±75	105±56	237±105	575±239
	July	23±12	87±36	19±11	178±73	307±119
	August	0	39±21	15±11	48±22	102±22
	September	0	2±1	0	40±23	42±22
1977	April	0	262±74	33±20	792±246	1,087±299
	May	6±4	164±68	5±4	758±378	933±402
	June	0	548±218	32±30	853±350	1,433±511
	July	13±11	285±127	29±20	136±70	463±196
	August	28±14	29±15	0	90±23	147±42
	September	0	7±5	0	103±50	110±49
	October	0	0	0	5	5

[a]95% confidence interval.

Table 41. Monthly catch per effort for bluegills and largemouth bass harvested by weekday and weekend and shore and boat anglers for 1976 and 1977 from Pelican Lake, Uintah County, Utah.

		Bluegills				
		Catch/Effort (fish/hour)				
		Weekday		Weekend		
Year	Month	Shore	Boat	Shore	Boat	Totals
1976	April	0.00 (25.00)[b]	0.00 (73.00)	0.00 (19.50)	0.02±0.01[a] (236.00)	0.02±0.01 (353.50)
	May	1.71±0.96 (42.00)	1.90±0.70 (225.00)	1.57±0.82 (279.00)	0.97±0.37 (1,593.00)	1.16±0.37 (2,139.00)
	June	1.73±1.04 (37.50)	2.06±0.89 (663.50)	0.95±0.51 (125.50)	1.58±0.64 (869.50)	1.72±0.67 (1,696.00)
	July	0.51±0.30 (25.50)	2.66±1.13 (479.00)	0.57±0.34 (38.50)	2.87±1.21 (545.50)	2.64±1.02 (1,088.50)
	August	0.00 (4.00)	1.70±0.91 (185.00)	0.00 (15.00)	2.40±1.22 (407.50)	2.17±1.01 (611.50)
	September	0.00 (0.00)	1.70±1.03 (135.50)	0.00 (0.00)	1.90±0.95 (261.00)	1.83±0.91 (396.50)
1977	April	0.00 (2.50)	0.72±0.29 (305.50)	0.63±0.41 (73.00)	1.18±0.06 (306.50)	0.44±0.20 (687.50)
	May	0.00 (8.50)	1.26±0.61 (220.50)	0.00 (46.00)	0.64±0.27 (868.50)	0.73±0.29 (3,128.00)
	June	1.43±0.88 (7.00)	1.42±0.24 (370.50)	2.65±0.18 (17.00)	1.70±0.22 (520.00)	1.60±0.15 (914.50)
	July	0.00 (7.50)	1.50±0.56 (282.00)	0.84±0.61 (51.00)	1.58±0.40 (632.25)	1.49±0.38 (972.75)
	August	1.68±1.33 (23.25)	1.44±0.36 (125.50)	0.00 (2.00)	1.61±0.38 (162.50)	1.54±0.34 (313.25)
	September	0.00 (0.00)	1.38±0.36 (89.50)	0.00 (0.00)	1.18±0.23 (201.50)	1.24±0.19 (291.00)
	October	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.46 (17.25)	0.46 (17.25)

Table 41 (continued)

		Largemouth Bass				
		Catch/Effort (fish/hour)				
		Weekday		Weekend		
Year	Month	Shore	Boat	Shore	Boat	Totals
1976	April	0.00	0.00	0.05±0.04[a]	0.05±0.04	0.05±0.03
		(25.00)[b]	(73.00)	(19.50)	(236.00)	(353.50)
	May	0.36±0.19	0.26±0.12	0.21±0.12	0.14±0.05	0.16±0.07
		(42.00)	(225.00)	(279.00)	(1,593.00)	(2,139.00)
	June	0.08±0.05	0.06±0.02	0.18±0.09	0.07±0.03	0.08±0.03
		(37.50)	(663.50)	(125.50)	(869.50)	(1,696.00)
	July	0.08±0.04	0.03±0.01	0.10±0.06	0.09±0.04	0.07±0.03
		(25.50)	(479.00)	(38.50)	(545.50)	(1,088.50)
	August	0.00	0.04±0.02	0.16±0.12	0.03±0.01	0.03±0.01
		(4.00)	(185.00)	(15.00)	(407.50)	(611.50)
	September	0.00	0.02±0.01	0.00	0.03±0.01	0.02±0.01
		(0.00)	(135.50)	(0.00)	(261.00)	(396.50)
1977	April	0.00	0.41±0.12	0.14±0.08	0.48±0.15	0.42±0.16
		(2.50)	(305.50)	(73.00)	(306.50)	(687.50)
	May	0.12±0.09	0.12±0.05	0.02±0.01	0.22±0.06	0.19±0.06
		(8.50)	(220.50)	(46.00)	(868.50)	(3,128.00)
	June	0.00	0.24±0.07	0.35±0.32	0.21±0.04	0.22±0.06
		(7.00)	(370.50)	(17.00)	(520.00)	(914.50)
	July	0.27±0.10	0.22±0.14	0.29±0.21	0.11±0.05	0.15±0.07
		(7.50)	(282.00)	(51.00)	(632.25)	(972.75)
	August	0.43±0.21	0.05±0.02	0.00	0.13±0.04	0.12±0.04
		(23.25)	(125.50)	(2.00)	(162.50)	(313.25)
	September	0.00	0.02±0.01	0.00	0.13±0.03	0.10±0.02
		(0.00)	(89.50)	(0.00)	(201.50)	(291.00)
	October	0.00	0.00	0.00	0.06	0.06
		(0.00)	(0.00)	(0.00)	(17.25)	(17.25)

[a] 95% confidence interval.

[b] Total number of angler hours sampled is in parenthesis.

Table 42. Total lengths and total weights of bluegills and largemouth bass from creeled fish from Pelican Lake, Uintah County, Utah, 1976 and 1977.

Year Month	Total Length (mm)		Total Weight (g)	
	Bluegills	Largemouth Bass	Bluegills	Largemouth Bass
1976				
April	222 (1)[a]	306 (14)	325 (1)	445 (14)
May	210 (202)	291 (111)	292 (202)	370 (111)
June	211 (201)	290 (58)	300 (201)	355 (58)
July	212 (378)	291 (43)	298 (378)	342 (43)
August	210 (416)	290 (14)	272 (416)	386 (14)
September	215 (248)	288 (8)	283 (248)	374 (8)
October	-- --	-- --	-- --	-- --
1977				
April	228 (110)	323 (148)	331 (110)	559 (148)
May	219 (135)	317 (69)	326 (135)	522 (69)
June	216 (218)	298 (49)	297 (218)	419 (49)
July	211 (306)	291 (94)	266 (306)	420 (94)
August	203 (162)	325 (18)	244 (162)	593 (18)
September	213 (188)	241 (21)	282 (188)	243 (21)
October	214 (8)	235 (1)	287 (8)	191 (1)

[a]Sample size is in parenthesis.

Table 43. Mean total length and total weights of bluegills captured by angling with baited hooks at different sizes and jigs at Pelican Lake, Uintah County, Utah, June 1977.

Hook Size	Number of Fish	Total Length[a] (mm)	Total Weight[a] (g)
Hook removed			
4 R[b]	30	208 (23.9)	263 (91.6)
6 R	30	215 (52.5)	281 (101.6)
8 R	60	217 (9.4)	320 (43.5)
10 R	30	219 (13.9)	313 (57.0)
Hook in place			
8 R	30	213 (14.6)	290 (71.7)
No. 6 Jig	30	219 (9.0)	308 (46.6)
Control[c]	30	215 (16.7)	321 (76.5)

[a]One standard deviation in parenthesis.

[b]R : regular shank hook (1 X).

[c]Fish captured by trammel net and removed within one hour.

Table 44. Mortality of bluegills hooked on different sizes of hooks[a] in relation to anatomical location of hooking at Pelican Lake, Uintah County, Utah, June 1977.

Hooking Location	Number of Mortalities By Size of Hook[b]					Total Mortality By Hooking Location	
	4 R	6 R	8 R	10 R	Jig	No.	%
Esophagus	2	2	7	1	0	12	63
Gill/gill arch	0	1	4	2	0	7	37
Isthmus/tongue	0	0	0	0	0	0	0
Roof of mouth	0	0	0	0	0	0	0
Eye	0	0	0	0	0	0	0
Jaw	0	0	0	0	0	0	0

[a]Number of bluegills captured by hook was 30 except for 8 R hooks which was 60 fish.

[b]See Table 10 for explanation.

Table 45. Estimated number of bluegills released by anglers by month at Pelican Lake, Uintah County, Utah, 1977.

Month	Actual Bluegills Released[a]	Actual Angler Hours[a]	Mean Number Bluegills Released Per Hour	Projected Number Total Angler Hours[b]	Projected Mean Number of Bluegills Released
April	--	--	0.280[c]	2,572	720
May	--	--	0.280[c]	5,042	1,412
June	90	446	0.201	6,505	1,308
July	141	495	0.285	2,657	757
August	90	236	0.415	1,488	619
September	58	201	0.288	1,128	324
October	4	18	0.222	80	18
Totals	391	1,396	0.280	19,472	5,158

[a]Determined from 64 card questionnaire returns.

[b]Determined from projected creel census.

[c]Card questionnaire returns not utilized; June through October release rate mean (0.280) substituted for April and May to calculate projected mean number of bluegills released.

Table 46. Estimated losses of bluegills that were caught and released by anglers by month at Pelican Lake, Uintah County, Utah, 1977.

Month	Projected Mean Number of Bluegills Released By Hook Size[a]					Total Mortality By Hook Size[b]					Projected Total Mortality of Released Bluegills	Mean Weight of Fish (kg)[c]	Estimated Weight of Fish Lost (kg)
	4 R	6 R	8 R	10 R	Jig	4 R	6 R	8 R	10 R	Jig			
April	146	326	135	113	0	10	33	24	11	0	78	0.089[d]	6.942
May	287	640	265	220	0	20	64	48	22	0	154	0.089[d]	13.706
June	265	593	246	204	0	19	59	44	20	0	142	0.131	18.602
July	154	343	142	118	0	11	23	26	12	0	83	0.106	8.798
August	126	280	116	97	0	9	28	21	10	0	68	0.075	5.100
September	66	147	61	51	0	5	15	11	5	0	36	0.054	2.160
October	4	8	3	3	0	1	1	1	1	0	4	0.101	0.404
Totals	--	--	--	--	--	--	--	--	--	--	565	--	55.712

[a]Number of bluegills released by anglers determined from 64 card questionnaires for June through October (see Figure 43).

[b]Total mortality of bluegills caught on different sizes of hooks and released (see Table 10).

[c]Mean weight of fish determined from mean length of released bluegills converted to weight by calculated length-weight relationship (Log W = 3.54 Log TL - 5.81).

[d]April and May mean weight of fish calculated from June through October percentage of total number of bluegills released weighted for each total length class.

Table 47. Total length frequency of fish species obtained from three sites sampled with rotenone, September 4, 5 and 6, 1975, at Pelican Lake, Uintah County, Utah.

Bluegills
(East Bay Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency	
				Numbers	Weight
21-30	345	0.2	76.0	63.1	1.9
31-40	68	0.4	27.0	12.4	0.6
41-50	78	0.8	65.0	14.2	1.6
51-60	0	--	--	--	--
61-70	7	5.4	38.0	1.3	0.9
71-80	12	9.1	109.0	2.2	2.7
81-90	4	11.0	44.0	0.7	1.1
91-100	5	16.0	16.0	0.9	0.4
101-110	0	--	--	--	--
111-120	4	33.8	135.0	0.7	3.3
121-130	3	44.7	134.0	0.5	3.3
131-140	1	57.0	57.0	0.2	1.4
141-150	2	75.5	151.0	0.4	3.7
151-160	4	87.5	350.0	0.7	8.5
161-170	2	103.0	206.0	0.4	5.0
171-180	2	151.0	302.0	0.4	7.4
181-190	1	152.0	152.0	0.2	3.7
191-200	4	193.3	773.0	0.7	18.8
201-210	2	257.5	515.0	0.4	12.6
211-220	2	320.0	640.0	0.4	15.6
221-230	1	312.0	312.0	0.2	7.6
Totals	547	--	4,102.0	100.0	100.0

Largemouth Bass
(East Bay Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency	
				Numbers	Weight
41-50	1	2.0	2.0	8.3	0.1
51-60	3	2.0	6.0	25.0	0.4
61-70	2	4.5	9.0	16.7	0.6
71-80	0	--	--	--	--

Table 47 (continued)

Largemouth Bass
(East Bay Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	Weight
81-90	1	7.0	7.0	8.3	0.4
91-210	0	--	--	--	--
211-220	1	145.0	145.0	8.3	8.9
221-250	0	--	--	--	--
251-260	1	228.0	228.0	8.3	14.1
261-290	0	--	--	--	--
291-300	2	343.0	686.0	16.7	42.4
301-340	0	--	--	--	--
341-350	1	535.0	535.0	8.3	33.1
Totals	12	--	1,618.0	100.0	100.0

Fathead Minnows
(East Bay Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	Weight
41-50	52	--	--	19.8	--
51-60	197	--	--	75.2	--
61-70	13	--	--	5.0	--
Totals	262	--	262.0	100.0	--

Bluegills
(South Bay Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	Weight
21-30	77	0.3	20.0	20.2	0.3
31-40	211	0.4	95.0	55.4	1.4
41-50	39	1.2	40.0	10.2	0.6

Table 47 (continued)

Bluegills
(South Bay Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
51-60	1	4.0	4.0	0.3	< 0.1
61-70	6	6.8	41.0	1.3	0.5
71-80	2	9.5	19.0	0.5	0.3
81-90	2	13.0	26.0	0.5	0.4
91-110	0	--	--	--	--
111-120	2	38.5	77.0	0.5	1.1
121-130	7	41.6	291.0	1.8	4.3
131-140	3	58.7	176.0	0.8	2.6
141-150	1	76.0	76.0	0.3	1.1
151-160	2	95.0	190.0	0.5	2.8
161-170	6	111.0	666.0	1.6	9.8
171-180	3	146.0	438.0	0.8	6.5
181-190	2	162.0	324.0	0.5	4.8
191-200	8	180.5	1,444.0	2.1	21.3
201-210	5	273.4	1,367.0	1.3	20.2
211-220	4	292.3	1,169.0	1.0	17.2
221-230	1	321.0	321.0	0.3	4.7
Totals	382	--	6,784.0	100.0	100.0

Largemouth Bass
(South Bay Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
31-40	1	3.0	3.0	20.0	11.5
41-50	0	--	--	--	--
51-60	1	4.0	4.0	20.0	15.4
61-70	2	5.5	11.0	40.0	42.3
71-80	1	8.0	8.0	20.0	30.8
Totals	5	--	26.0	100.0	100.0

Table 47 (continued)

Fathead Minnows
(South Bay Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency	
				Numbers	Weight
31-40	2	--	--	10.5	--
41-50	13	--	--	68.4	--
51-60	4	--	--	21.1	--
61-70	0	--	--	--	--
Totals	19	--	18.0	100.0	100.0

Green Sunfish
(South Bay Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency	
				Numbers	Weight
71-80	1	10.0	10.0	16.7	12.5
81-90	3	37.0	37.0	50.0	46.3
91-100	2	33.0	33.0	33.3	41.2
Totals	6	--	80.0	100.0	100.0

Bluegills
(Midlake Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency	
				Numbers	Weight
21-30	113	0.2	24.0	34.0	0.2
31-40	100	0.5	50.0	30.1	0.5
41-50	40	1.0	41.0	12.0	0.4
51-60	2	6.0	12.0	0.6	0.1
61-70	2	7.5	15.0	0.6	0.1
71-90	0	--	--	--	--
91-100	1	20.0	20.0	0.3	0.2
101-110	2	22.5	45.0	0.6	0.4

Table 47 (continued)

Bluegills
(Midlake Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency	
				Numbers	Weight
111-120	4	39.3	157.0	1.2	1.5
121-130	3	53.0	159.0	0.9	1.5
131-140	4	59.8	239.0	1.3	2.2
141-150	9	75.1	676.0	2.7	6.3
151-160	5	91.4	457.0	1.5	4.4
161-170	15	111.9	1,679.0	4.5	15.6
171-180	5	134.2	671.0	1.5	6.2
181-190	7	169.1	1,184.0	2.1	11.0
191-200	4	205.5	822.0	1.3	7.6
201-210	7	253.6	1,773.0	2.1	16.5
211-220	6	299.0	1,794.0	1.8	16.7
221-230	3	306.3	919.0	0.9	8.6
Totals	332	—	10,739.0	100.0	100.0

Largemouth Bass
(Midlake Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency	
				Numbers	Weight
51-60	2	3.5	7.0	33.3	16.7
61-70	0	—	—	—	—
71-80	3	7.7	23.0	50.0	54.8
81-90	1	12.0	12.0	16.7	28.5
Totals	6	—	42.0	100.0	100.0

Table 48. Total length frequency of fish species obtained from three sites sampled with rotenone, August 23, 24 and 25, 1976, at Pelican Lake, Uintah County, Utah.

Bluegills
(East Bay Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
11-20	823	0.1	82.3	10.0	1.1
21-30	3,874	0.3	1,096.3	47.2	14.9
31-40	2,945	0.8	2,208.8	35.9	30.0
41-50	507	1.2	603.3	6.2	8.2
51-60	10	2.8	27.7	0.1	0.4
61-70	15	5.1	76.1	0.2	1.0
71-80	12	6.6	79.2	0.1	1.1
81-90	3	11.3	33.8	< 0.1	0.5
91-100	3	14.2	42.7	< 0.1	0.6
101-110	2	23.9	47.8	< 0.1	0.6
111-120	3	28.0	84.0	< 0.1	1.1
121-130	1	46.0	46.0	< 0.1	0.6
131-140	0	--	--	--	--
141-150	0	--	--	--	--
151-160	1	81.5	81.5	< 0.1	1.1
161-170	1	112.0	112.0	< 0.1	1.5
171-180	1	122.0	122.0	< 0.1	1.7
181-190	1	154.0	154.0	< 0.1	2.1
191-200	1	190.0	190.0	< 0.1	2.6
201-210	2	267.0	534.0	< 0.1	7.3
211-220	3	265.0	796.0	< 0.1	10.8
221-230	3	315.0	944.0	< 0.1	12.8
Totals	8,211	--	7,361.5	100.0	100.0

Largemouth Bass
(East Bay Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
61-70	1	3.0	3.0	11.1	0.3
71-80	0	--	--	--	--
81-90	2	8.1	16.3	22.2	1.7

Table 48 (continued)

Largemouth Bass
(East Bay Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
91-100	1	10.5	10.5	11.1	1.1
101-110	1	13.3	13.3	11.1	1.4
111-120	2	19.6	39.3	22.2	4.2
121-290	0	--	--	--	--
291-300	1	357.0	357.0	11.1	38.1
301-310	0	--	--	--	--
311-320	1	498.0	498.0	11.1	53.1
Totals	9	--	937.4	100.0	100.0

Fathead Minnows
(East Bay Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
31-40	7	0.8	5.6	2.8	1.3
41-50	68	1.1	74.8	27.3	16.9
51-60	153	2.0	306.0	61.5	69.0
61-70	21	2.7	56.7	8.4	12.8
Totals	249	--	443.1	100.0	100.0

Bluegills
(South Shoreline Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
11-20	1,145	0.1	115.0	3.3	0.4
21-30	20,144	0.3	5,702.0	58.5	18.8
31-40	10,644	0.8	7,983.0	30.9	26.4
41-50	876	1.2	1,042.0	2.5	3.4

Table 48 (continued)

Bluegills
(South Shoreline Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
51-60	69	3.5	242.0	0.2	0.8
61-70	666	5.6	3,699.0	1.9	12.2
71-80	468	7.7	3,598.0	1.4	11.9
81-90	277	12.5	3,462.0	0.8	11.4
91-100	120	15.9	1,913.0	0.3	6.3
101-110	10	23.7	237.0	< 0.1	0.8
111-120	8	32.5	260.0	< 0.1	0.9
121-130	3	41.0	123.0	< 0.1	0.4
131-140	0	--	--	--	--
141-150	2	63.0	126.0	< 0.1	0.4
151-160	1	109.0	109.0	< 0.1	0.4
161-170	0	--	--	--	--
171-180	2	123.5	247.0	< 0.1	0.8
181-190	0	--	--	--	--
191-200	2	227.0	454.0	< 0.1	1.5
201-210	3	213.3	640.0	< 0.1	2.1
211-220	1	325.0	325.0	< 0.1	1.1
Totals	34,441	--	30,277.4	100.0	100.0

Largemouth Bass
(South Shoreline Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
41-50	2	0.8	1.6	0.6	< 0.1
51-60	4	1.3	5.2	1.2	< 0.1
61-70	11	2.0	22.0	3.3	0.4
71-80	49	6.1	298.9	14.9	5.5
81-90	82	8.4	688.8	24.9	12.6
91-100	90	14.1	1,269.0	27.9	23.2
101-110	57	17.2	980.4	17.3	17.9
111-120	14	22.3	312.2	4.2	5.7
121-130	6	33.8	202.8	1.8	3.7
131-140	2	37.3	74.6	0.6	1.4

Table 48 (continued)

Largemouth Bass
(South Shoreline Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	Weight
141-150	5	44.4	222.0	1.5	4.0
151-160	0	--	--	--	--
161-170	2	88.0	176.0	0.6	3.2
171-180	0	--	--	--	--
181-190	2	92.0	184.0	0.6	3.4
191-200	2	105.0	210.0	0.6	3.8
201-350	0	--	--	--	--
351-360	1	826.0	826.0	0.3	15.1
Totals	329	--	5,472.5	100.0	100.0

Fathead Minnows
(South Shoreline Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	Weight
41-50	1	--	--	12.5	--
51-60	3	--	--	37.5	--
61-70	4	--	--	50.0	--
Totals	8	--	14.0	100.0	

Bluegills
(Midlake Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	Weight
1-50	11,929	0.3	4,125.5	99.5	39.8
51-60	1	3.4	3.4	< 0.1	< 0.1
61-70	19	5.5	105.5	< 0.1	1.0
71-80	9	7.7	69.2	< 0.1	< 0.1

Table 48 (continued)

Bluegills
(Midlake Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
81-90	7	12.5	87.4	< 0.1	< 0.1
91-100	0	--	--	--	--
101-110	1	26.0	26.0	< 0.1	< 0.1
111-140	0	--	--	--	--
141-150	1	62.0	62.0	< 0.1	< 0.1
151-160	1	90.0	90.0	< 0.1	< 0.1
161-170	0	--	--	--	--
171-180	1	138.0	138.0	< 0.1	1.3
181-190	2	169.0	338.0	< 0.1	3.2
191-200	1	196.0	196.0	< 0.1	1.9
201-210	4	259.0	1,036.0	< 0.1	10.0
211-220	5	290.8	1,454.0	< 0.1	14.0
221-230	8	327.6	2,621.0	< 0.1	25.3
Totals	11,989	--	10,352.5	100.0	100.0

Largemouth Bass
(Midlake Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
81-90	1	8.0	8.0	50.0	33.3
91-100	0	--	--	--	--
101-110	1	16.0	16.0	50.0	67.7
Totals	2	--	24.0	100.0	100.0

Table 49. Total length frequency of fish species obtained from three sites sampled with rotenone, May 11, 12 and 13, 1977, at Pelican Lake, Uintah County, Utah.

Bluegills
(South Shoreline Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
31-40	29	0.8	21.8	29.3	15.4
41-50	52	1.2	62.4	52.5	44.0
51-60	15	1.9	28.7	15.2	20.2
61-70	1	4.0	4.0	1.0	2.8
71-80	1	7.0	7.0	1.0	4.9
81-90	0	--	--	--	--
91-100	1	18.0	18.0	1.0	12.7
Totals	99	--	141.9	100.0	100.0

Largemouth Bass
(South Shoreline Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
311-320	1	428.0	428.0	11.1	7.7
321-330	4	521.5	2,086.0	44.4	37.7
331-340	1	558.0	558.0	11.1	10.1
341-350	1	654.0	654.0	11.1	11.8
351-360	0	--	--	--	--
361-370	1	848.0	848.0	11.1	15.3
371-380	0	--	--	--	--
381-390	1	966.0	966.0	11.1	17.4
Totals	9	--	5,540.0	100.0	100.0

Table 49 (continued)

Fathead Minnows
(South Shoreline Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency	
				Numbers	Weight
21-30	1	--	--	100.0	100.0
Totals	1	--	--	100.0	100.0

Bluegills
(Midlake Number 1 Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency	
				Numbers	Weight
21-30	3	0.3	0.9	2.3	< 0.1
31-40	29	0.8	22.0	21.6	1.1
41-50	44	1.2	53.0	32.8	2.6
51-60	18	1.9	34.0	13.4	1.7
61-70	3	3.3	10.0	2.3	0.5
71-80	16	7.3	116.0	11.9	5.7
81-90	10	11.4	114.0	7.5	5.6
91-100	2	16.0	32.0	1.5	1.6
101-110	2	20.0	40.0	1.5	1.9
111-120	2	33.0	66.0	1.5	3.2
121-160	0	--	--	--	--
161-170	1	114.0	114.0	0.7	5.5
171-210	0	--	--	--	--
211-220	1	340.0	340.0	0.7	16.7
221-230	2	342.0	684.0	1.5	33.5
231-240	1	416.0	416.0	0.7	20.4
Totals	134	--	2,041.9	100.0	100.0

Table 49 (continued)

Largemouth Bass
(Midlake Number 1 Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency	
				Numbers	Weight
101-110	1	21.0	21.0	12.5	0.6
111-160	0	--	--	--	--
161-170	1	62.0	62.0	12.5	2.0
171-300	0	--	--	--	--
301-310	3	425.0	1,276.0	37.5	39.2
311-320	0	--	--	--	--
321-330	1	562.0	562.0	12.5	17.3
331-350	0	--	--	--	--
351-360	2	665.0	1,330.0	25.0	40.9
Totals	8	--	3,251.0	100.0	100.0

Bluegills
(Midlake Number 2 Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency	
				Numbers	Weight
21-30	10	0.3	3.0	0.9	< 0.1
31-40	239	0.8	179.0	22.4	0.8
41-50	405	1.2	486.0	38.0	2.2
51-60	134	1.9	255.0	12.6	1.1
61-70	31	3.3	102.0	2.9	0.4
71-80	43	7.3	314.0	4.0	1.4
81-90	33	11.5	380.0	3.1	1.7
91-100	24	16.0	384.0	2.2	1.7
101-110	18	21.5	386.0	1.7	1.7
111-120	14	30.3	424.0	1.3	1.9
121-130	10	37.0	370.0	0.9	1.7
131-140	4	49.0	196.0	0.4	0.8
141-150	12	59.0	708.0	1.1	3.2
151-160	7	78.9	552.0	0.7	2.5
161-170	6	102.3	614.0	0.6	2.8
171-180	6	122.3	734.0	0.6	3.3
181-190	12	155.6	1,867.0	1.1	8.4
191-200	19	186.7	3,547.0	1.8	15.9
201-210	14	228.5	3,199.0	1.3	14.4

Table 49 (continued)

Bluegills
(Midlake Number 2 Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency	
				Numbers	Weight
211-220	13	260.4	3,385.0	1.2	15.2
221-230	11	314.3	3,457.0	1.0	15.5
231-240	2	365.5	731.0	0.2	3.2
Totals	1,067	--	22,273.0	100.0	100.0

Largemouth Bass
(Midlake Number 2 Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency	
				Numbers	Weight
91-100	1	12.0	12.0	2.3	0.3
101-110	6	14.0	84.0	13.5	1.8
111-120	6	16.8	101.0	13.5	2.2
121-130	5	23.0	115.0	11.4	2.5
131-140	5	30.2	151.0	11.4	3.3
141-150	4	37.5	150.0	9.0	3.3
151-160	5	51.4	257.0	11.4	5.6
161-170	0	--	--	--	--
171-180	1	26.0	26.0	2.3	0.6
181-190	1	86.0	86.0	2.3	1.9
191-200	1	98.0	98.0	2.3	2.2
201-210	1	125.0	125.0	2.3	2.7
211-220	2	175.0	350.0	4.5	7.7
221-230	1	142.0	142.0	2.3	3.1
231-290	0	--	--	--	--
291-300	1	364.0	364.0	2.3	8.0
301-310	0	--	--	--	--
311-320	1	552.0	552.0	2.3	12.1
321-330	0	--	--	--	--
331-340	1	572.0	572.0	2.3	12.6
341-350	1	652.0	652.0	2.3	14.3
351-360	1	720.0	720.0	2.3	15.8
Totals	44	--	4,557.0	100.0	100.0

Table 50. Total length frequency of fish species obtained from three sites sampled with rotenone, August 29, 30 and 31, 1977, at Pelican Lake, Uintah County, Utah.

Bluegills
(South Shoreline Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
1-50	2,893	0.3	838.2	94.7	4.3
51-60	2	2.5	5.0	< 0.1	< 0.1
61-70	3	6.3	19.0	< 0.1	< 0.1
71-80	9	7.8	70.0	0.3	0.4
81-90	10	11.4	114.0	0.3	0.6
91-100	5	16.4	82.0	0.2	0.4
101-110	8	22.3	178.0	0.3	0.9
111-120	20	29.7	594.0	0.7	3.1
121-130	22	43.1	948.0	0.7	4.9
131-140	15	56.5	847.0	0.5	4.4
141-150	6	74.8	449.0	0.2	2.3
151-160	8	94.3	754.0	0.3	3.9
161-170	4	121.0	484.0	0.1	2.5
171-180	1	164.0	164.0	< 0.1	0.9
181-190	3	167.0	501.0	< 0.1	2.6
191-200	6	217.5	1,305.0	0.2	6.8
201-210	14	271.7	3,804.0	0.5	19.7
211-220	20	298.5	5,969.0	0.7	31.0
221-230	6	297.3	1,784.0	0.2	9.3
231-240	1	364.0	364.0	< 0.1	1.9
Totals	3,056	--	19,273.2	100.0	100.0

Largemouth Bass
(South Shoreline Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
61-70	3	3.3	10.0	11.1	2.1
71-80	7	5.3	37.0	25.9	7.9
81-90	10	7.0	70.0	37.1	15.0
91-100	3	7.7	23.0	11.1	4.9
101-140	0	--	--	--	--

Table 50 (continued)

Largemouth Bass
(South Shoreline Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
141-150	1	37.0	37.0	3.7	7.9
151-160	1	40.0	40.0	3.7	8.5
161-200	0	--	--	--	--
201-210	1	121.0	121.0	3.7	25.9
211-220	1	130.0	130.0	3.7	27.8
Totals	27	--	468.0	100.0	100.0

Bluegills
(Midlake Number 1 Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
1-50	1,170	0.4	540.5	96.0	7.9
51-110	0	--	--	--	--
111-120	1	30.0	30.0	< 0.1	0.4
121-130	5	43.4	217.0	0.4	3.2
131-140	4	54.8	219.0	0.3	3.2
141-150	11	67.9	747.0	0.9	10.9
151-160	9	85.0	765.0	0.7	11.1
161-170	3	101.3	304.0	0.2	4.4
171-180	1	120.0	120.0	< 0.1	1.7
181-200	0	--	--	--	--
201-210	3	220.0	660.0	0.2	9.6
211-220	8	285.0	2,282.0	0.6	33.2
221-230	3	331.0	993.0	0.2	14.4
Totals	1,218	--	6,877.5	100.0	100.0

Table 50 (continued)

Largemouth Bass
(Midlake Number 1 Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
51-60	3	1.7	5.0	5.9	0.3
61-70	12	3.3	39.0	23.5	2.3
71-80	9	4.8	43.0	17.6	2.4
81-90	7	7.4	52.0	11.8	3.1
91-100	4	9.8	39.0	7.8	2.3
101-110	1	10.0	10.0	2.0	0.6
110-150	0	--	--	--	--
151-160	1	42.0	42.0	2.0	2.5
161-170	3	61.7	185.0	5.9	11.1
171-180	2	71.0	142.0	3.9	8.5
181-190	2	80.0	160.0	3.9	9.6
191-200	3	98.0	294.0	5.9	17.6
201-210	2	110.0	220.0	3.9	13.2
211-220	2	125.0	250.0	3.9	14.9
221-250	0	--	--	--	--
251-260	1	194.0	194.0	2.0	11.6
Totals	52	--	1,675.0	100.0	100.0

Bluegills
(Midlake Number 2 Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
1-50	6,121	0.4	2,448.8	96.2	6.5
51-60	1	2.0	2.0	< 0.1	< 0.1
61-70	11	3.5	39.0	0.2	0.1
71-80	17	5.6	96.0	0.3	0.3
81-90	11	7.4	81.0	0.2	0.2
91-100	2	16.0	32.0	< 0.1	< 0.1
101-110	1	26.0	26.0	< 0.1	< 0.1
111-120	10	33.1	331.0	0.2	0.9
121-130	10	43.4	434.0	0.2	1.2
131-140	15	58.1	872.0	0.2	2.3
141-150	14	68.1	953.0	0.2	2.5

Table 50 (continued)

Bluegills
(Midlake Number 2 Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
151-160	24	91.0	2,183.0	0.4	5.8
161-170	14	110.4	1,546.0	0.2	4.1
171-180	8	156.9	1,255.0	0.1	3.3
181-190	7	191.5	1,149.0	0.1	3.1
191-200	7	227.4	1,592.0	0.1	4.2
201-210	26	264.1	6,868.0	0.4	18.3
211-220	50	285.3	14,263.0	0.8	37.9
221-230	10	304.4	3,044.0	0.2	8.1
231-240	1	390.0	390.0	< 0.1	1.0
Totals	6,360	--	37,604.8	100.0	100.0

Largemouth Bass
(Midlake Number 2 Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
41-50	3	0.8	2.5	3.8	0.1
51-60	13	1.2	16.0	15.9	0.7
61-70	22	1.9	42.0	26.8	1.7
71-80	19	3.1	60.0	23.2	2.5
81-90	11	5.6	62.0	13.4	2.6
91-100	7	9.7	68.0	8.5	2.8
101-150	0	--	--	--	--
151-160	1	60.0	60.0	1.2	2.5
161-170	1	78.0	78.0	1.2	3.2
171-200	0	--	--	--	--
201-210	1	109.0	109.0	1.2	4.5
211-240	0	--	--	--	--
241-250	1	190.0	190.0	1.2	7.8
251-320	0	--	--	--	--
321-330	2	519.5	1,039.0	2.4	42.8
331-370	0	--	--	--	--
371-380	1	700.0	700.0	1.2	28.8
Totals	82	--	2,426.5	100.0	100.0

Table 51. Total length frequency of fish species obtained from three sites sampled with rotenone, June 13, 14 and 15, 1978, at Pelican Lake, Uintah County, Utah.

Bluegills
(South Shoreline Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
51-60	2	1.5	3.0	25.0	0.2
61-170	0	--	--	--	--
171-180	1	180.0	180.0	12.5	11.3
181-190	0	--	--	--	--
191-200	1	212.0	212.0	12.5	13.4
201-210	0	--	--	--	--
211-220	3	283.3	850.0	37.5	53.5
221-230	1	343.0	343.0	12.5	21.6
Totals	8	--	1,587.0	100.0	100.0

Largemouth Bass
(South Shoreline Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
201-210	1	116.0	116.0	14.2	4.0
211-220	1	124.0	124.0	14.2	4.3
221-240	0	--	--	--	--
241-250	1	224.0	224.0	14.2	7.8
251-290	0	--	--	--	--
291-300	1	308.0	308.0	14.2	10.7
351-360	1	308.0	308.0	14.2	20.8
361-380	0	--	--	--	--
381-390	1	773.0	773.0	14.2	26.7
391-400	1	745.0	745.0	14.2	25.8
Totals	7	--	2,598.0	100.0	100.0

Table 51 (continued)

Bluegills
(Midlake Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency	
				Numbers	Weight
121-130	1	51.0	51.0	1.0	0.2
131-140	1	66.0	66.0		
141-150	0	--	--	--	--
151-160	2	92.5	185.0	2.0	0.6
161-170	1	122.0	122.0	1.0	0.4
171-180	4	152.8	611.0	4.0	2.0
181-190	6	208.8	1,252.0	6.0	4.0
191-200	2	212.0	424.0	2.0	1.4
201-210	14	313.4	4,387.0	14.0	14.1
211-220	35	326.5	11,429.0	35.0	36.7
221-230	32	369.7	11,831.0	32.0	38.0
231-240	2	383.0	766.0	2.0	2.5
Totals	100	--	31,124.0	100.0	100.0

Largemouth Bass
(Midlake Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency	
				Numbers	Weight
221-230	1	57.0	57.0	50.0	9.2
231-330	0	--	--	--	--
331-340	1	562.0	562.0	50.0	90.8
Totals	2	--	619.0	100.0	100.0

Bluegills
(West Cove Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency	
				Numbers	Weight
41-50	2	3.0	6.0	3.8	< 0.1
51-80	0	--	--	--	--

Table 51 (continued)

Bluegills
(West Cove Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
81-90	4	12.2	49.0	7.5	< 0.1
91-110	0	--	--	--	--
111-120	1	41.0	41.0	1.9	0.3
121-130	0	--	--	--	--
131-140	1	70.0	70.0	1.9	0.5
141-160	0	--	--	--	--
161-170	1	128.0	128.0	1.9	1.0
171-180	1	155.0	155.0	1.9	1.2
181-190	3	197.3	592.0	5.7	4.4
191-200	4	210.8	843.0	7.5	6.3
201-210	8	288.0	2,304.0	15.1	17.3
211-220	17	315.7	5,366.0	33.9	40.3
221-230	10	334.1	3,341.0	17.0	25.1
231-240	1	419.0	419.0	1.9	3.1
Totals	54	--	13,314.0	100.0	100.0

Largemouth Bass
(West Cove Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
191-200	4	99.2	397.0	11.4	4.3
201-210	4	124.0	496.0	11.4	5.4
211-220	5	148.8	744.0	14.3	8.2
221-230	7	171.1	1,198.0	20.0	13.1
231-240	4	183.2	733.0	11.4	8.0
241-260	0	--	--	--	--
261-270	1	280.0	280.0	2.9	3.1
271-280	2	295.5	591.0	5.7	6.5
281-300	0	--	--	--	--
301-310	1	330.0	330.0	2.9	3.6
311-320	0	--	--	--	--
321-330	1	501.0	501.0	2.9	5.5
331-340	2	608.5	1,217.0	5.7	13.3

Table 51 (continued)

Largemouth Bass
(West Cove Site)

Total Length (mm)	Number of Fish	Mean Weight (g)	Total Weight (g)	% Relative Frequency Numbers	% Relative Frequency Weight
341-350	1	561.0	561.0	2.9	6.1
351-360	2	677.0	1,354.0	5.7	14.8
361-370	1	725.0	725.0	2.9	7.9
Totals	35	--	9,127.0	100.0	100.0

UTAH DIVISION OF WILDLIFE RESOURCES
AND
UTAH COOPERATIVE FISHERY RESEARCH UNIT
PELICAN LAKE SURVEY

Fishermen: Information is being collected on the number and size of bluegill sunfish you release while fishing at Pelican Lake, along with the type of terminal gear, and method of hook removal. Please, complete this form as you fish. Pencils have been provided along with this survey form. Hopefully, this will not be much of an inconvenience for you while you fish, as the valuable information obtained will benefit the fishermen and provide biologists pertinent data on better ways to manage the fishery at Pelican Lake. Thank-you for your cooperation and time.

1) Method of hook removal:
   a. Cutting leader, thus allowing hook to remain____________________
   b. Use of hook remover, i.e. pliers, specialized hook remover____________
   ____
   c. Removal of hook - - without any tools________________________
   Tally the number of fish you released by each of the above methods.

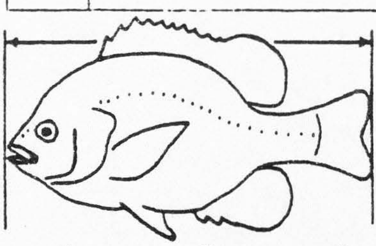
2) Type of terminal gear used:
   a. Jig____________________ c. Spinner____________________
   b. Bait, earth worms__________ d. Fly________________________
   e. Other (please, be specific)____________________
   Indicate which type of gear you used by an "X". If you used more than one type of terminal gear, indicate by number (1,2,3, etc.) which type you utilized the most, timewise.

3) Size of hook used:
   a. #4________ b. #6________ c. #8__________ d. #10________ e. #12 ________
   Other (Please specify)______________________________________
   Do not know________________________
   If you utilized more than one hook size, indicate by number (1, 2, 3, etc.) which hook size you utilized most of the time.

(Over)

4) Measurement of released fish. Directions: Before releasing bluegill back to the water, place the snout of the fish on the 0" mark and measure to the tip of the tail fin (see diagram for correct procedure). Measure the fish to the nearest ½" and keep a running tally of the fish you release in the table provided by length groupings.

		Total
3½"-4"		
4"-4½"		
4½"-5"		
5"-5½"		
5½"-6"		
6"-6½"		
6½"-7"		
7"-7½"		
7½"-8"		



Measure the bluegill from arrow to arrow. Use the edge of the form so as not to dirty the form.

5) Please, return this questionnaire form to the distribution box after completion of fishing.

6) Total hours angled____________
   No. of anglers in party____________

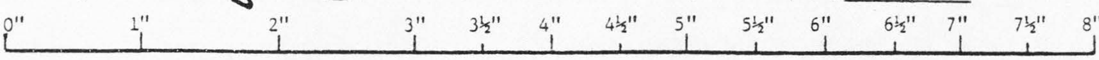


Figure 43. Card questionnaire utilized by anglers at Pelican Lake, Uintah County, Utah, 1977, to determine the numbers and sizes of bluegills released while fishing.

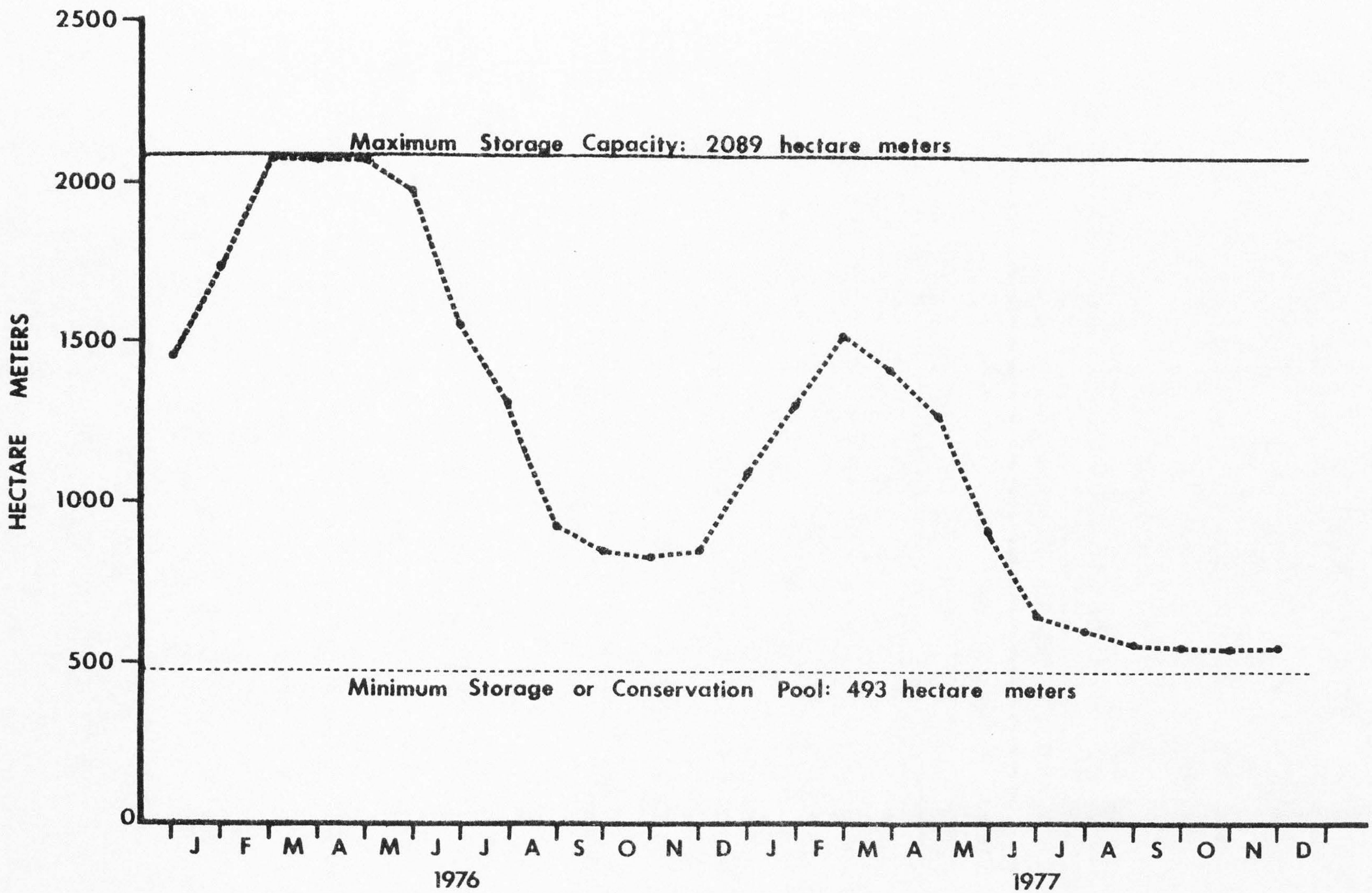


Figure 44. Monthly water storage capacity in ha m of Pelican Lake, Uintah County, Utah, January 1976 to December 1977.

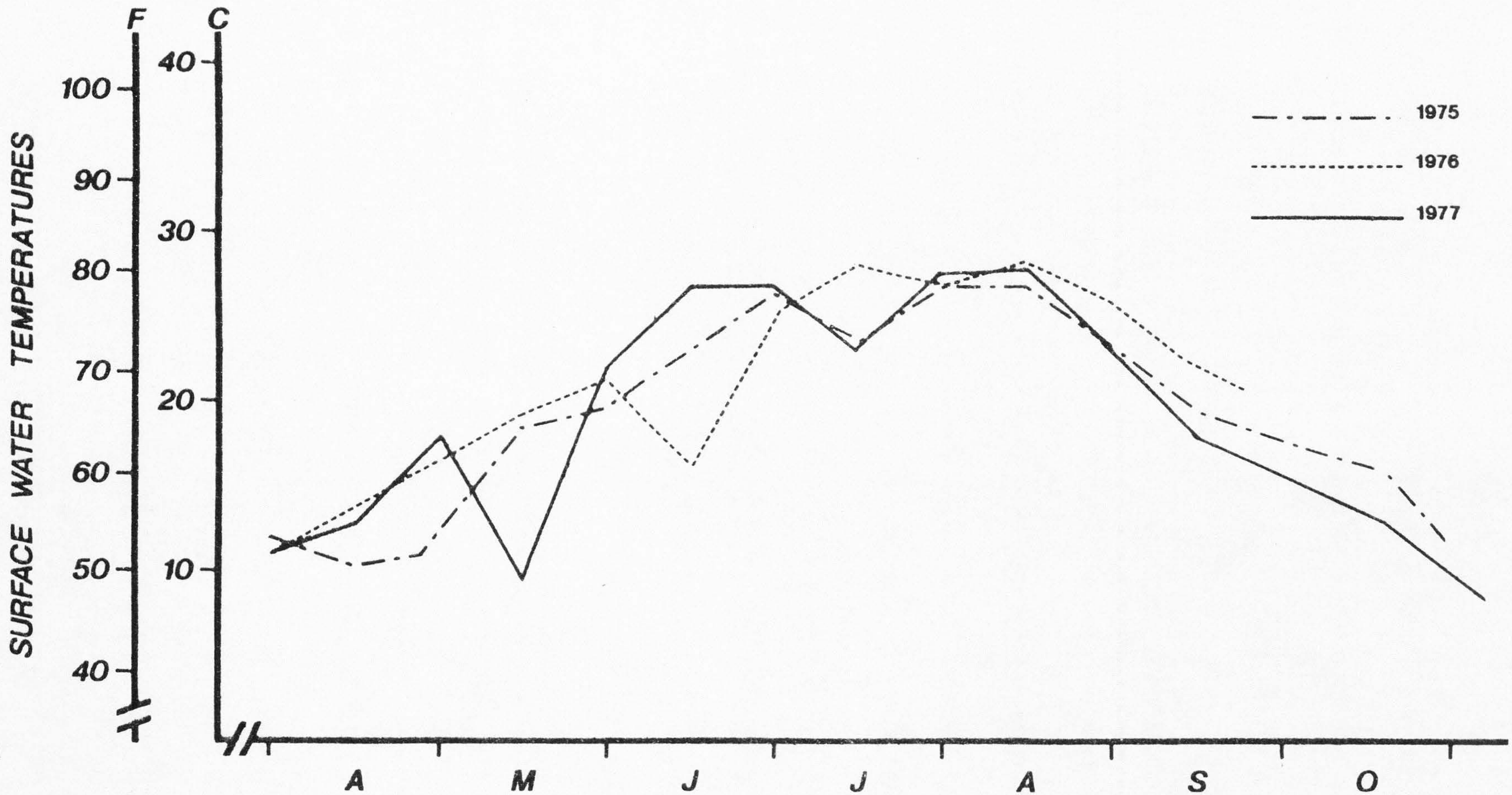


Figure 45. Surface water temperatures for Pelican Lake, Uintah County, Utah, April through October 1975, 1976 and 1977. (Note: the daily surface water temperature was the mean daily maximum and minimum temperature.)

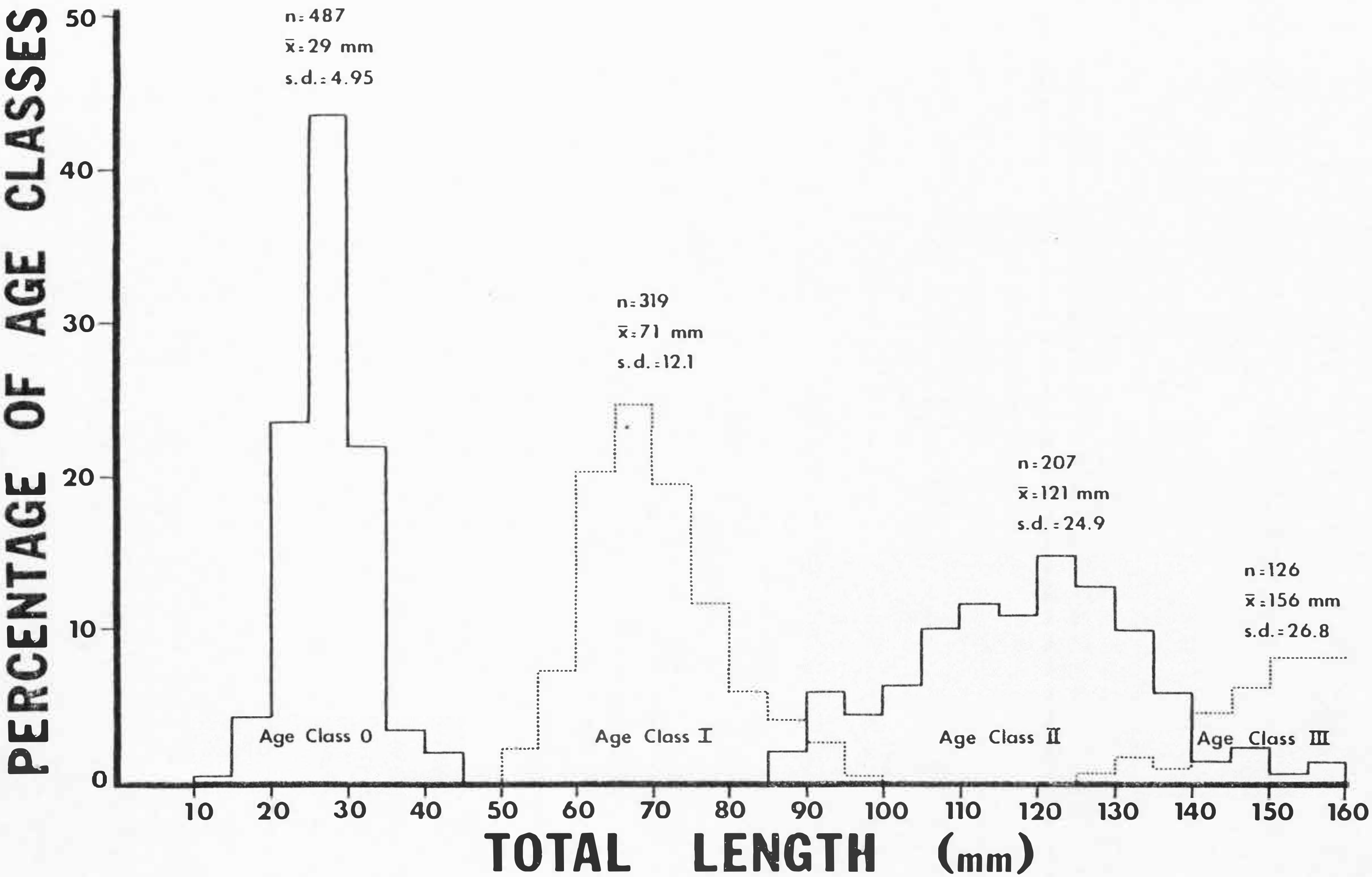
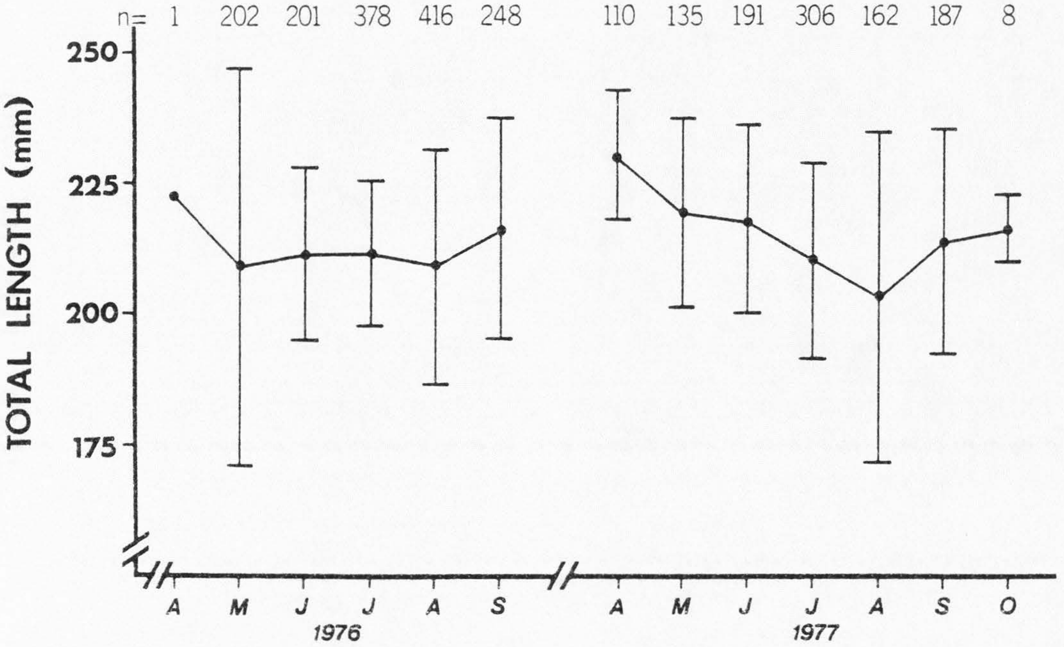


Figure 46. Age and length structure of bluegills from three 0.405 ha sites sampled with rotenone on August 24, 25 and 26, 1976, at Pelican Lake, Uintah County, Utah.



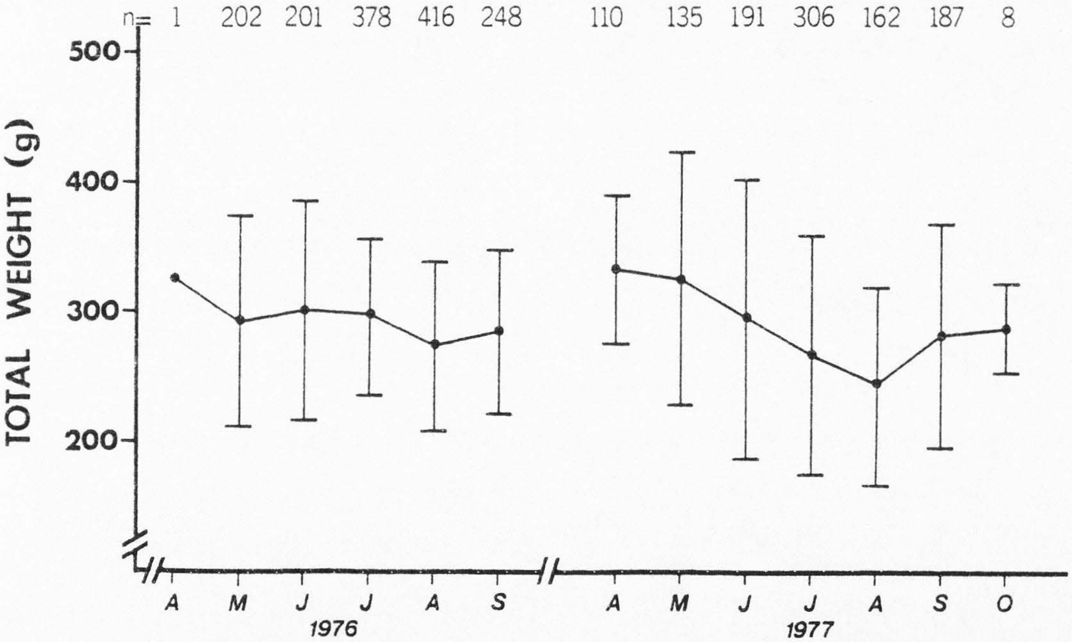


Figure 47. Mean monthly total length and total weight of angler harvested bluegills from Pelican Lake, Uintah County, Utah, 1976 and 1977. (Note: vertical lines indicate one standard deviation. Actual mean values are given in Appendix; Table 42.)

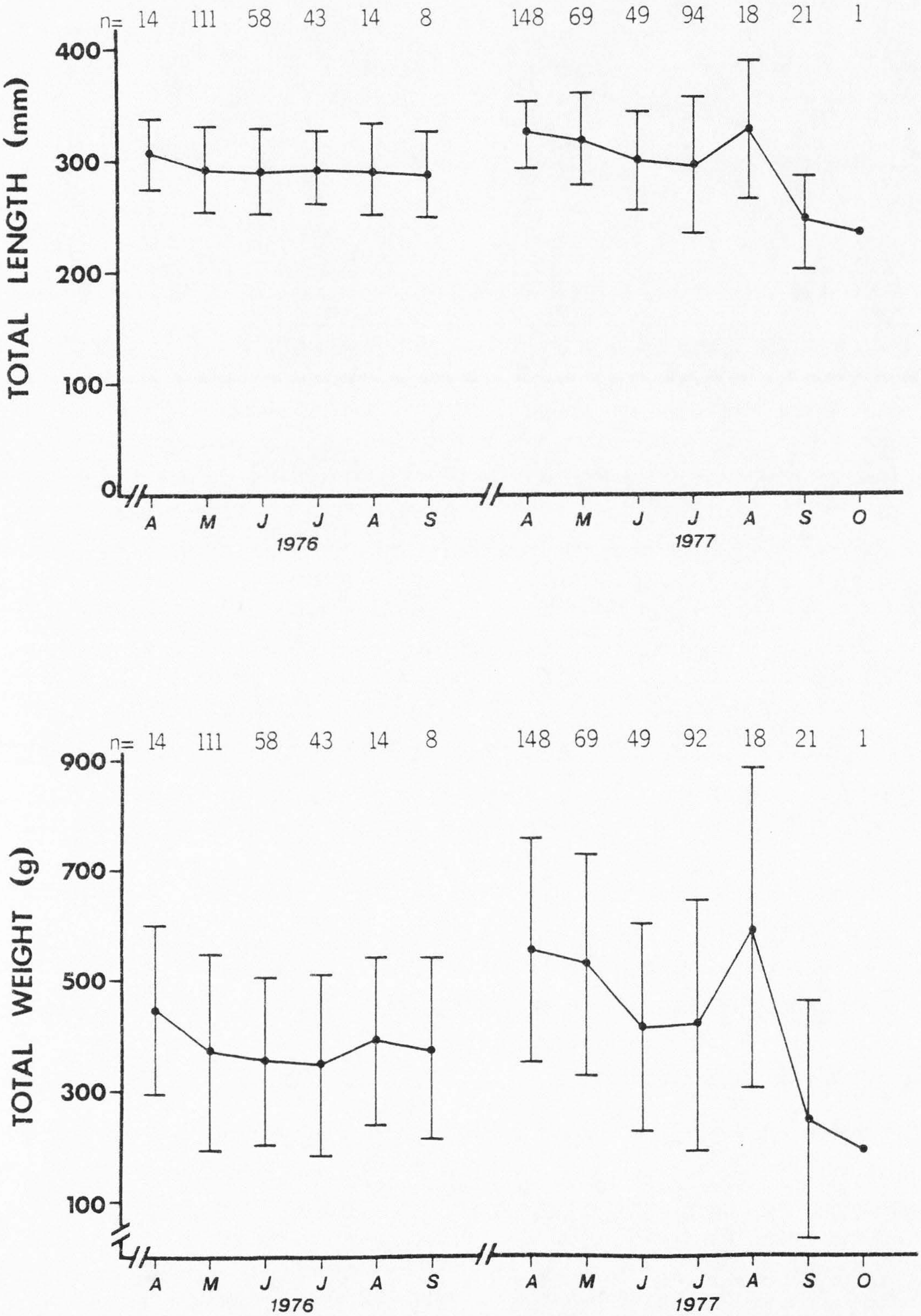


Figure 48. Mean monthly total length and total weight of angler harvested largemouth bass from Pelican Lake, Uintah County, Utah, 1976 and 1977. (Note: vertical lines indicate one standard deviation. Actual mean values are given in Appendix; Table 42.)

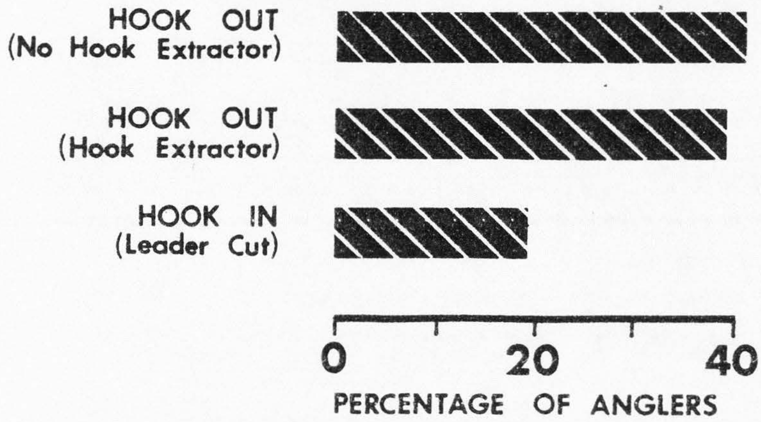


Figure 49. Fish handling procedures used by 211 anglers while bluegill fishing at Pelican Lake, Uintah County, Utah, summer 1977.

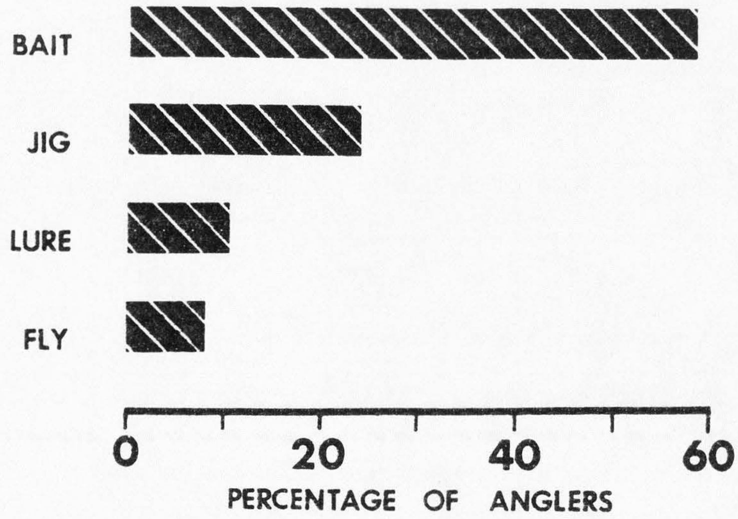


Figure 50. Terminal gear used by 211 anglers for bluegills at Pelican Lake, Uintah County, Utah, summer 1977.

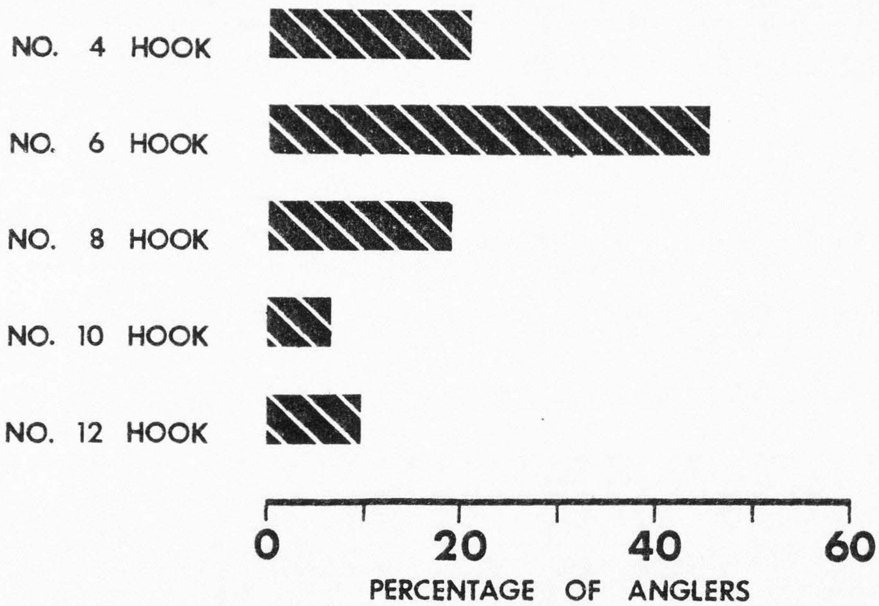


Figure 51. Hook sizes used by 211 anglers for bluegills at Pelican Lake, Uintah County, Utah, summer 1977.

VITA

Bob D. Burdick

Candidate for the Degree of

Master of Science

Thesis: Biology, Reproductive Potential and the Impact of Fishing Pressure on the Bluegill Fishery of Pelican Lake, Uintah County, Utah.

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