AN ABSTRACT OF THE THESIS OF

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Title: AGE, GROWTH, AND MANAGEMENT OF CHANNEL CATFISH, *ICTALURUS PUNCTATUS* (RAFINESQUE), IN OREGON

Abstract approved: Redacted for privacy

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The age and growth of channel catfish, *Ictalurus punctatus* (Rafinesque), in the Snake River was investigated to provide a basis for future management when hydroelectric development in the middle section of the river is completed.

The need for information concerning the channel catfish arose when plans for the Brownlee Dam were activated in 1955. Studies of the channel catfish in the Snake River since their introduction by the state of Idaho in 1939, 1940 and 1941, had not been previously made.

Channel catfish from five to 33 inches in length were captured in seines, traps, trotlines and on conventional angling tackle for the study. Samples from anglers' creels were also utilized in determination of age and growth.

Two separate samples were taken from the Snake River, one from that area which was inundated in 1958 by the Brownlee Reservoir, and the other from Brownlee Reservoir

in 1962, for the purpose of making comparisons in growth from the two dissimilar ecological environments.

An analysis of 530 channel catfish from the Snake River and 164 channel catfish from the Brownlee Reservoir indicates growth is considerably slower in the impoundment than in the normal channel of the river. A regression coefficient of 3.3320 was found in a calculation of length-weight relationships among the Snake River fish. Wide differences in mean weight occur between the Brownlee and Snake River channel catfish in the six- to nine-inch group, the Snake River fish being the larger.

Methods were developed to prepare pectoral spine cross sections for comparative examination and study. Significant differences occurred in the mean weight of fish from the Snake River and Brownlee Reservoir in age II, III, and IV groups, the Snake River fish being the heavier. The magnitude of the difference between the mean weights of each age was determined. In every age group, the mean length and weight of channel catfish in the Snake River exceeded mean length and weight of fish from Brownlee Reservoir. The formation of annuli on channel catfish spines was believed to occur from about the first of May to the middle of June in the Snake River.

Migration data were collected from traps operated by the Oregon Fish Commission and the Idaho Department of Fish and Game in the main canyon of the Snake River, and by the Idaho Power Company at the newly constructed Brownlee Dam.

The movement of channel catfish was measured among 44 recovered tagged individuals in the Snake River. Of 22 which showed movement of at least a mile from the point of trapping and tagging, half moved upstream while the other half moved downstream. The mean distance traveled upstream was one-half the distance traveled downstream, a ratio of movement reported in other studies.

The impoundment of Snake River water at the Brownlee Dam in 1958 caused sharp differences in the temperature regime in the river below. Delays of 30 to 50 days were recorded for temperatures to reach and persist at 70° F. or above, a level known to be required for the successful reproduction of channel catfish.

Prior to the construction of Brownlee Dam, about 75 percent of the sport catch on the Snake River were channel catfish, while four years later, only five percent of the catch from the impoundment was channel catfish. The catch per angler ratio for channel catfish is eight times higher in the Snake River outside the influence of Brownlee Dam.

AGE, GROWTH, AND MANAGEMENT OF CHANNEL CATFISH, *ICTALURUS PUNCTATUS* (RAFINESQUE), IN OREGON

by

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Carl E. Bond, Associate Professor of Fish and Game Management, encouraged the preparation of this thesis with helpful ideas, criticisms and direct editing.

An original interest in the channel catfish was provided by Dr. John Rayner, then chief of the Fishery Division of the Oregon State Game Commission, who expressed a need for information on the species.

Dr. Lyle Calvin, Professor of Statistics, gave valuable advice in the preparation of descriptive data.

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I. INTRODUCTION

A. Purpose and scope

The purpose of this study was to provide information concerning the life requirements of the channel catfish and its utilization in the sport fishery, which might form a basis for future management in Oregon when hydroelectric development of the Columbia and Snake Rivers is completed.

In its native Mississippi River system, the general life history of the channel catfish, *Ictalurus punctatus* (Rafinesque), is well known, but west of the Rocky Mountains little information is available. The channel catfish was introduced in the Snake River near the turn of the century, and later in 1939, 1940, and 1941. Since the channel catfish abounds in the larger rivers of strong currents of the Mississippi drainage, its establishment in a similar ecological situation in the Snake River is not surprising.

A sport fishery for the channel catfish developed rapidly in northeastern Oregon about 1948, when catches of large catfish from the Snake River became common. Sportsmen of the area have enjoyed this fishery at many points along the Snake River from the Oregon-Idaho line near the town of Adrian, Oregon to Lewiston, Idaho, a distance of about 150 miles.

A threat to the burgeoning fishery on the Oregon and Idaho sides of the Snake River came in 1955 when construction began on the Brownlee Dam. Prior to that time, the Oregon Game Commission had been conducting general field surveys to determine the condition of existing channel catfish populations as a first step in the regulation and management of a valuable sport fish.

The influence of hydroelectric dams on a species of game fish is seen as a result of a changing flow pattern, the inundation of spawning and food production areas, thermal differences within the reservoir, and the loss of a suitable environment for many miles upstream. An altered migration route blocked from below and confused from above by a long, deep reservoir could have damaging results on the channel catfish and its ability to maintain suitable numbers in the Snake River. The same factors militating against anadromous salmonids in the upper Snake River could also affect the movement, growth and behavior of channel catfish. Drastic physical change in the areas where channel catfish were established is a point of grave concern to fishery biologists in Idaho and Oregon.

The inevitable construction of hydroelectric dams on the main stem of the Columbia and Snake Rivers presented the need for a study of the channel catfish and for the determination of the effect of an encroaching civilization upon its environment.

B. Description of study area

The general area involved in this study includes the Snake River from Adrian on the Oregon-Idaho border, downstream to its confluence with the Columbia River, a distance of about 190 miles. Incidental records of the catch and migration of channel catfish are also included from the mouth of the Snake River downstream on the Columbia River to Bonneville Dam.

Specifically, the area of greatest concern is the portion of the Snake River from Adrian to Homestead, a distance of approximately 100 miles. The Brownlee and Oxbow Dams are located within the area (Figure 1).

Before Brownlee Reservoir was built, the Snake River in the area from Adrian to Huntington was characterized by wide, swift, smooth water flowing through flat farm land and arid rolling hills covered with sagebrush (Figure 2). Below Huntington the river entered a steeper canyon where basalt outcropping was evident, and the river width and gradient varied, producing rapids with spectacular hydraulic jumps and whitewater. The canyon became noticeably steeper in the vicinity of Brownlee and at about 25 miles beyond, it plunges into Hell's Canyon, 5,550 feet deep (Figure 2).

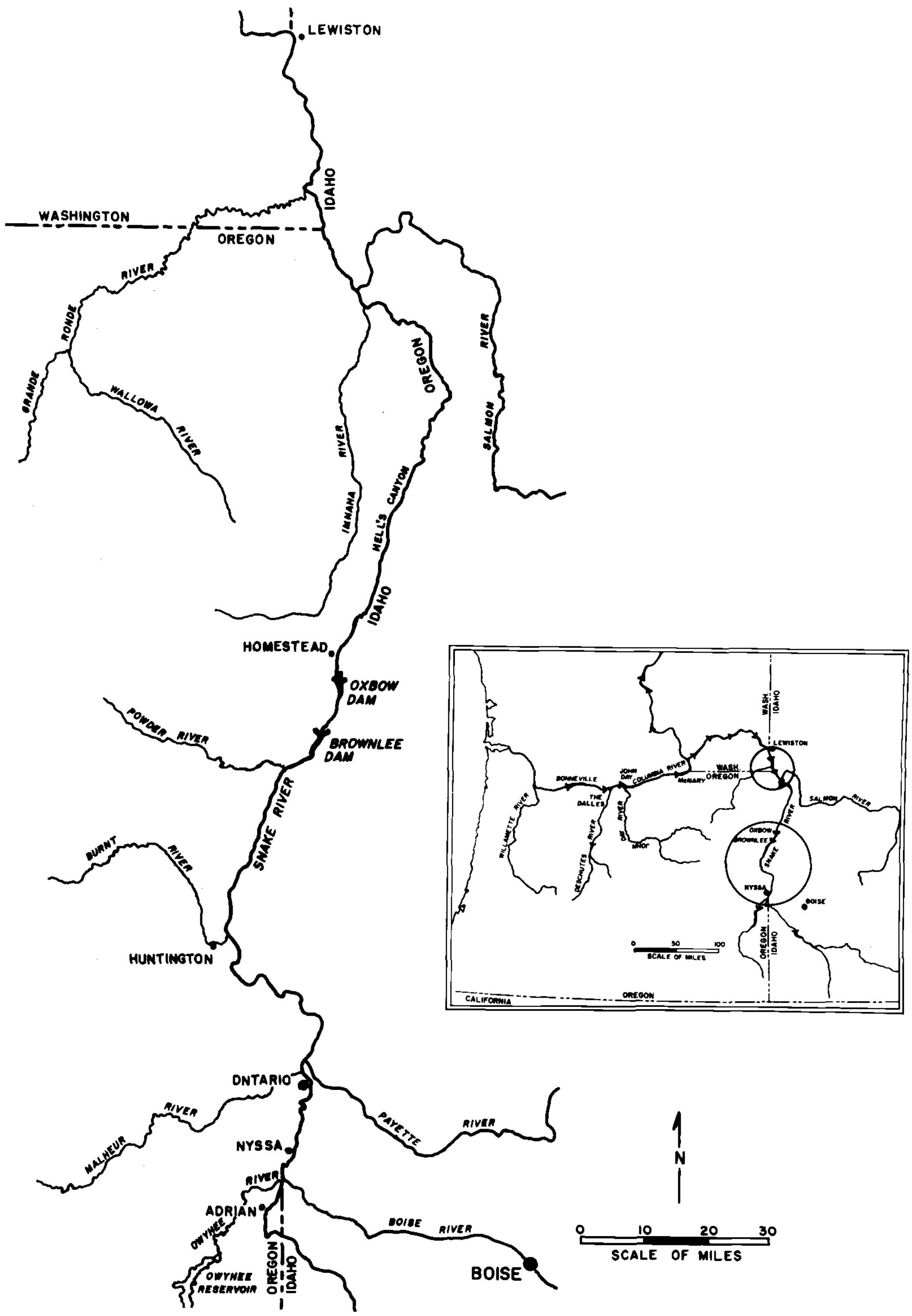
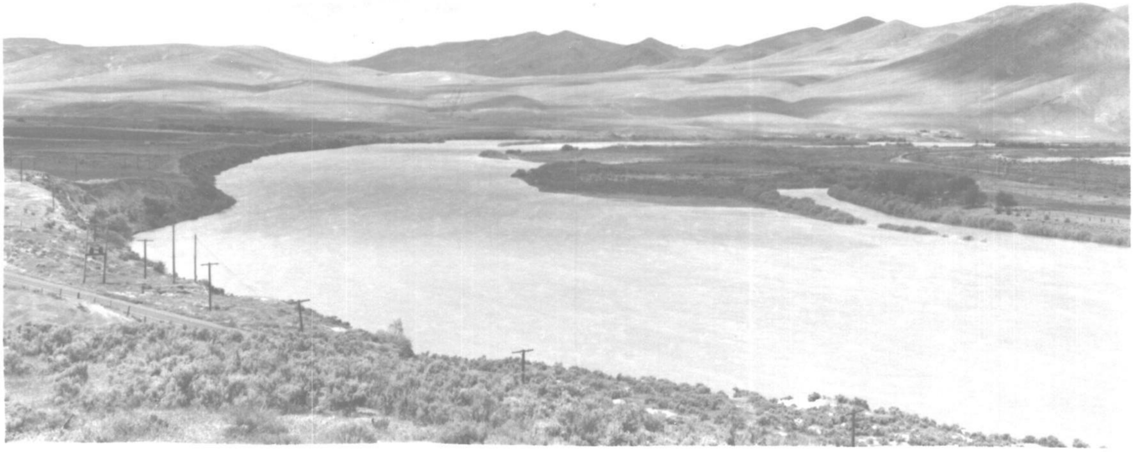


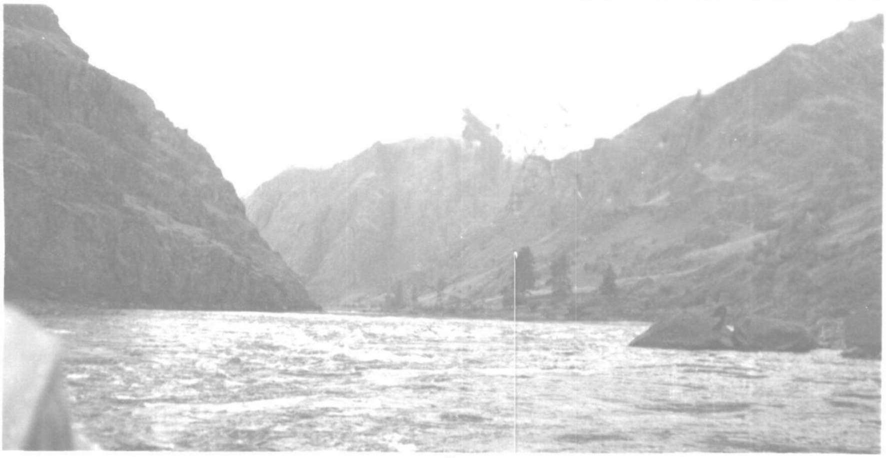
Figure 1

MAP OF STUDY AREA



A. Farewell Bend (Oregon State Highway Commission photo)

B. Brownlee area



C. Hell's Canyon

Figure 2

AN ILLUSTRATION OF PHYSICAL DIFFERENCES IN THE MIDDLE SNAKE RIVER AREA

C. Taxonomy and description of the channel catfish

The channel catfish, *Ictalurus punctatus* (Rafinesque), is a member of the family Ictaluridae, characterized by a smooth scaleless body, the presence of an adipose fin, and stout spines in the dorsal and pectoral fins. It is closely related to the blue catfish, *Ictalurus furcatus* (Le Sueur), the white catfish, *Ictalurus catus* (Linnaeus), and the flathead catfish, *Pilodictis olivaris* (Rafinesque).

In 1818 Constantine Rafinesque (24, p. 355) named the channel catfish of the Ohio River *Silurus punctatus*. The next year Le Sueur (15, p. 152) recorded the same fish from the Wabash and Mississippi Rivers as *Pimelodus caudafurcatus*. In 1820 Rafinesque provided eight names as variations of *Pimelodus maculatus* for the same fish from the Ohio River. From 1820 to 1862, the channel catfish was given nine other names in the usual taxonomic sequence historically associated with the more common species.

In the field, the catfishes are recognized by their general size, coloration, and by the number of rays in the anal fin. The channel catfish has 24 to 29 anal rays, including rudiments, while the blue catfish has 32 to 35 anal rays. The flathead catfish has only 12 to 16. In the Snake River, the channel catfish is usually distinguished from the less common flathead catfish by the deeply forked tail and the slender caudal peduncle area of the channel catfish. The flathead catfish has a full, gently rounded tail, and usually less than half the number of anal rays. The white catfish does not occur in the Snake River.

The channel catfish has a rather slender compressed body and a deeply forked caudal fin. Barbels are in arrangements of two pairs below and one nasal pair above the mouth. The color is usually a light olive on the back, slightly lighter on the sides and more or less covered with small circular spots of a bluish color (Figure 3). The older fish appear to be darker than the younger ones, and the spots are often obscured on breeding adults. The eyes are situated in the dorsal half of the head. The upper jaw is slightly longer than the lower jaw. The air bladder consists of two chambers arranged side by side.

Since anal ray counts overlap in the white and channel catfish, other criteria have been developed for separating the two species. The physical characteristics of channel catfish which set it apart from its close relative, the white catfish, are the ten soft rays which follow the pectoral spine. In the white catfish, nine rays always follow the pectoral spine. Another obvious distinction involves a break in the bony ridge between the head and the dorsal spine of the white catfish, while none appears in the channel catfish. White catfish rarely occur over ten pounds in weight, while channel catfish have been

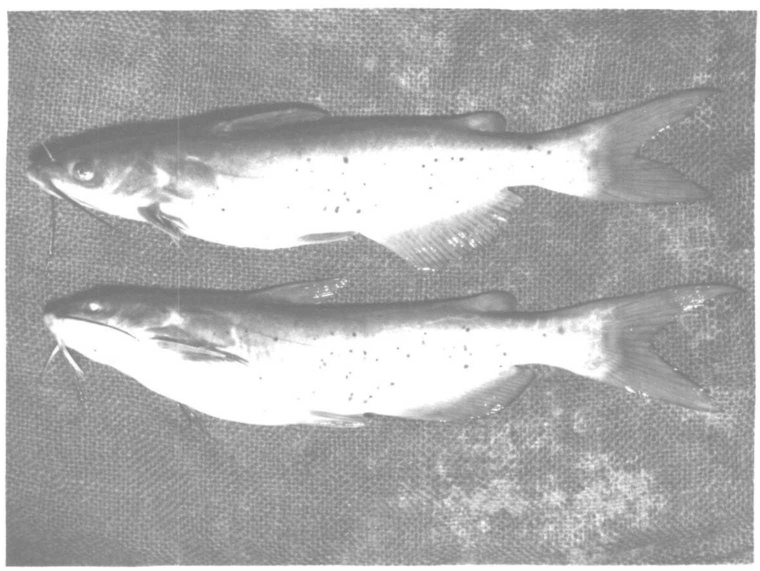


Figure 3

CHARACTERISTIC SPOTTING AND CONFORMATION
OF SMALL CHANNEL CATFISH

taken up to 57 pounds below the Santee-Cooper Reservoir dam in South Carolina (31, p. 10).

D. History and distribution of the channel catfish

The channel catfish is generally distributed throughout the Mississippi River drainage. It prefers large streams with strong currents, and has been identified as far north as the St. Croix and Ottertail Rivers in Minnesota (8, p. 172), and southward through the southern Mississippi states. The channel catfish is not native to rivers west of the Rocky Mountains.

The channel catfish is found from the prairie provinces of Canada north to 54° north latitude, and from the southern part of the Hudson Bay drainage southward through the Great Lakes, the St. Lawrence Basin to the Ottowa River, and through most of the Mississippi Valley. It was supposedly native as far west as eastern Colorado. Its range extends to Florida and northeastern Mexico, and it is found in the Potomac River. It has been widely introduced in other rivers. It is represented over much of Texas and northern Mexico south to the Rio Panuco system, by a variety of forms, several of which appear to be a subspecies of *Ictalurus punctatus*. A northern form, earlier called *lacustris*, has been reduced to synonomy.

In 1874 the United States Fish Commission liberated 56 white catfish in the San Joaquin River (16, p. 59). Also released were unknown numbers of channel catfish. The species was apparently introduced for the first time west of the Rocky Mountains by Livingston Stone, a U. S. Deputy Fish Commissioner. It was subsequently planted in various other California waters, such as the Feather River and Lake Cuyamaca in 1891 and in the Balsa-Chico River in 1895. Channel catfish were known to be introduced into the Colorado River near Rifle, Colorado, in 1898 or 1899. No records of the success of early introductions are available in Colorado, but by 1918 the fish were apparently well established in Moab, Utah.[1]

In 1892, 75 channel catfish were planted in Clear Lake in Skagit County, Washington. In the same year, other waters in the state of Oregon were planted with channel catfish. In the next year, 1893, the Boise River in Idaho, a tributary of the Snake River, received 100 adult yearling channel catfish. At the same time a few channel catfish were released in the Willamette River in Oregon near Salem (16, p. 63).

In 1894 various species of catfish were planted in the lower Columbia and Willamette Rivers, especially below

[1]John D. Hart, Deputy State Game and Fish Director (Ret.), Grand Junction, Colorado, 1962, in correspondence held by Ivan Donaldson, Fishery Biologist, Corps of Engineers, Bonneville.

Portland. Few, if any, of the original stock survived, since no report of catches before 1940 is recorded in any available literature (16, p. 64).

In the summer of 1945 positive identification of the channel catfish was made at Bonneville Dam by Charles B. Wade, an aquatic biologist for the U. S. Army Engineers. According to Lampman (16, p. 72), other reports of "fork-tail" catfish taken in 1946 in the Willamette and in the Columbia River near Bonneville Dam could have been *Ictalurus punctatus* or *Ameiurus catus*. Lampman did not have the advantage of information from Idaho indicating the points of release for 3,555 channel catfish in 1939, 1940, and 1941 in the Snake River drainage (Table 1).

Releases in 1941 were made in Idaho in the Little Wood River near Gooding, in the Snake River near Burley, and on the main stem of the Snake River from Glenn's Ferry to Weiser. No channel catfish have ever been reported taken from the Little Wood River or from the Snake River above Shoshone Falls.

Later in 1945 a shipment of blue catfish was received at the American Falls Hatchery in Idaho from the Fish and Wildlife Service salvage operations on the Mississippi River. They ranged in size from three to six inches.[1]

[1]B. D. Ainsworth, Superintendent, American Falls Hatchery, American Falls, Idaho, 1962.

Table 1

RECORD OF CATFISH PLANTINGS IN IDAHO

Date	Species	Number	Place
1939	Channel catfish	59	Canyon County*
"	" "	50	Jerome County*
5/11/40	" "	475	Canyon County in Snake River
"	" "	300	Canyon County in Boise River
"	" "	100	Canyon County in Parma Rearing Pond*
5/14/40	" "	460	Twin Falls County in Salmon Falls Creek
5/17/40	" "	200	Twin Falls County in Salmon Falls Creek
"	" "	300	Cassia County in Snake River
6/2/41	" "	390	Canyon County near Parma in Boise River
"	" "	165	Cassia County near Burley in Snake River
"	" "	300	Jerome County in Wilson Lake
"	" "	300	Lincoln County in Little Wood River
6/3/41	" "	306**	Gem County near Emmett in Payette River
1945	Blue catfish	150	Snake River (Glenn's Ferry-Hammett area) planted by American Falls Hatchery

*These plantings have not been entered on planting cards. Information was gained from Biennial Reports.

**According to a report from John Smith, 30 to 40 were flathead catfish.

Channel catfish arriving at the American Falls Hatchery in Idaho came from the Platte River in Nebraska. Two truck loads came from Utah and the Green River, and one small load from a salvage operation in Texas. The Platte River fish brought in from Nebraska in 1941 are reported to have contained 30 to 40 flathead catfish. Blue and flathead catfish have subsequently been reported in the Snake River and their introductions were verified.[1]

Several factors in the ecological requirements of the channel catfish influence its distribution in the waters of Oregon. The species is limited to rivers, lakes, and ponds which reach at least 70° F. in summer, a thermal level necessary for the species to complete the reproductive cycle. This requirement alone would limit its range in many Oregon streams and lakes which might otherwise be suited. The mean maximal temperatures in the Snake River in the area where the channel catfish is most abundant were consistently over 70° F. in the summer prior to the construction of Brownlee Dam (Appendix Table D).

Another factor limiting the range of the channel catfish is the presence of salinity at the mouth of the Columbia River. McCammon and LaFaunce (20, p. 11) believe that channel catfish avoid the lower delta region of the Sacramento River because of a regular seasonal increase in

[1]Forrest Hauck, Research Biologist, Idaho Game Department, Boise, Idaho, 1957.

the salinity in that area. Reduced river flows in late summer and early fall allow an intrusion of brackish water from San Francisco Bay. The resulting chloride content often exceeds two parts per thousand. They suspect that the channel catfish is much less tolerant of brackish conditions than the white catfish, which is abundant in the lower delta area. This explanation could also apply to the lower Columbia River, where the records of channel catfish taken do not occur west of Kalama, nearly 50 miles from the sea.

The influence of barriers on the movement of channel catfish was investigated by Hubley (13, p. 2) on the Mississippi River in Wisconsin. Individual channel catfish progressed through six navigational lock installations. Apparently the structures did not represent impassable barriers.

McCammon (19, p. 332) found no tagged fish in the area above the Palo Verde weir on the Colorado River in California. He reports that the absence of tagged fish above the weir is strong evidence that the loose rock structure is an efficient barrier to upstream movement. Many of the rapids in the Snake River are similar to the Palo Verde weir gradient, hydraulic jumps, and appearance of whitewater flow. It is likely that upstream movement of channel catfish may be limited in the Snake River in the areas of steep hydraulic gradient and swift turbulent currents. Such areas occur from below the Brownlee Dam through Hell's Canyon to approximately the mouth of the Salmon River, a distance of 75 miles.

E. Present range in Oregon waters

From releases in 1893, 1939, 1940, and 1941, the channel catfish has spread through the entire middle Snake River drainage from approximately Swan Falls, Idaho, through the main Columbia River. The penetration of channel catfish into smaller tributaries of the Snake and Columbia Rivers in Oregon is not common. Authentic records indicate that channel catfish have been taken at least four miles up the Grande Ronde River from its confluence with the Snake River. Unconfirmed reports indicate their presence as far as 20 miles upstream. Because of cold waters in the Imnaha and Salmon Rivers, no movement into these streams is recorded or even expected.

The Powder and Burnt Rivers present velocity and gradient barriers. Their small size may have precluded the upstream passage of channel catfish. On the Owyhee River, however, channel catfish have been taken as far upstream as the Highway 201 bridge, a distance of about three miles from the Snake River. Positive identification of channel catfish was made from catches near the Harper diversion on the Malheur River, about 30 miles from the Snake River. In 1962 one catfish was taken near Juntura, 75 miles upstream on the Malheur River, but it is believed to have originated from Warm Springs Reservoir, 25 miles upstream, which was stocked in 1956 (Appendix Table F).

On the Columbia River, the channel catfish is occasionally taken from the vicinity of McNary Dam down to the Sauvies Island area at the mouth of the Willamette River, and as far downstream as the Kalama River. Since the numbers of channel catfish recorded at McNary Dam are so much greater than those recorded at Bonneville Dam (along with the rarity of the channel catfish in the catch in the lower Columbia River), it is possible that the channel catfish is more suited to the upper areas.

There are confirmed reports[1] of channel catfish in the lower Umpqua River. An unknown number escaped from a private pond near Roseburg about 1950 after being illegally introduced from the Mississippi River.

[1]Jerry Bauer, Biologist, Oregon Game Commission, Roseburg, 1962.

II. AGE AND GROWTH

A. Length-weight relationships

The sport fishery which developed for channel catfish on the Snake River became important to the Oregon Game Commission and the success of the introduction was in need of evaluation to determine future management policies. The immediate need for knowledge of the growth of channel catfish is understandable when the management of an unknown, newly established species in Oregon waters is considered. A study of the age and growth of channel catfish began in 1955 when the development of the middle section of the Snake River for hydropower became a certainty.

The relationships between length and weight and between weight and age are important where the sport catch of channel catfish reflects the productivity of its environment. Of particular value to the fishery manager is the ability to estimate the weights of fish being produced in the waters of Oregon from length measurements. Knowledge of age and growth of channel catfish in the creel is also needed to formulate recommendations for management based on the best biological data available.

The analysis of length-weight data has usually been directed toward the description of a mathematical relationship so that one may be converted into the other. A measure of the variation from expected weight for a given length of individual fish is an indication of the general condition of individual members of the species.

The length of a fish is more readily taken in the field and more accurately measured than weight. Often the dressed fish in the possession of the angler yields only one measurement, which is total length. It is therefore convenient to determine a weight where only total length is known.

Data used in the determination of length-weight relationships for channel catfish in the Snake River and the Brownlee Reservoir were obtained from 694 specimens (Appendix Tables A and B). Fish less than six inches in length were not included in the sample because they rarely occur in the angler's catch, gillnets, trapnets or setlines.

The length-weight relationship is expressed graphically by:

$$\log W = \log a + b \log L$$

where b is the regression coefficient which indicates the slope of the line and log a represents its position. The line represents the log form of $W = aL^b$ (Figure 4). The regression coefficient b was calculated for 511 channel catfish from the Snake River and found to be 3.3320. Calculations appear in Appendix Table C.

The exponent b is the ratio of the specific growth rates for length and weight. Where there is no change of

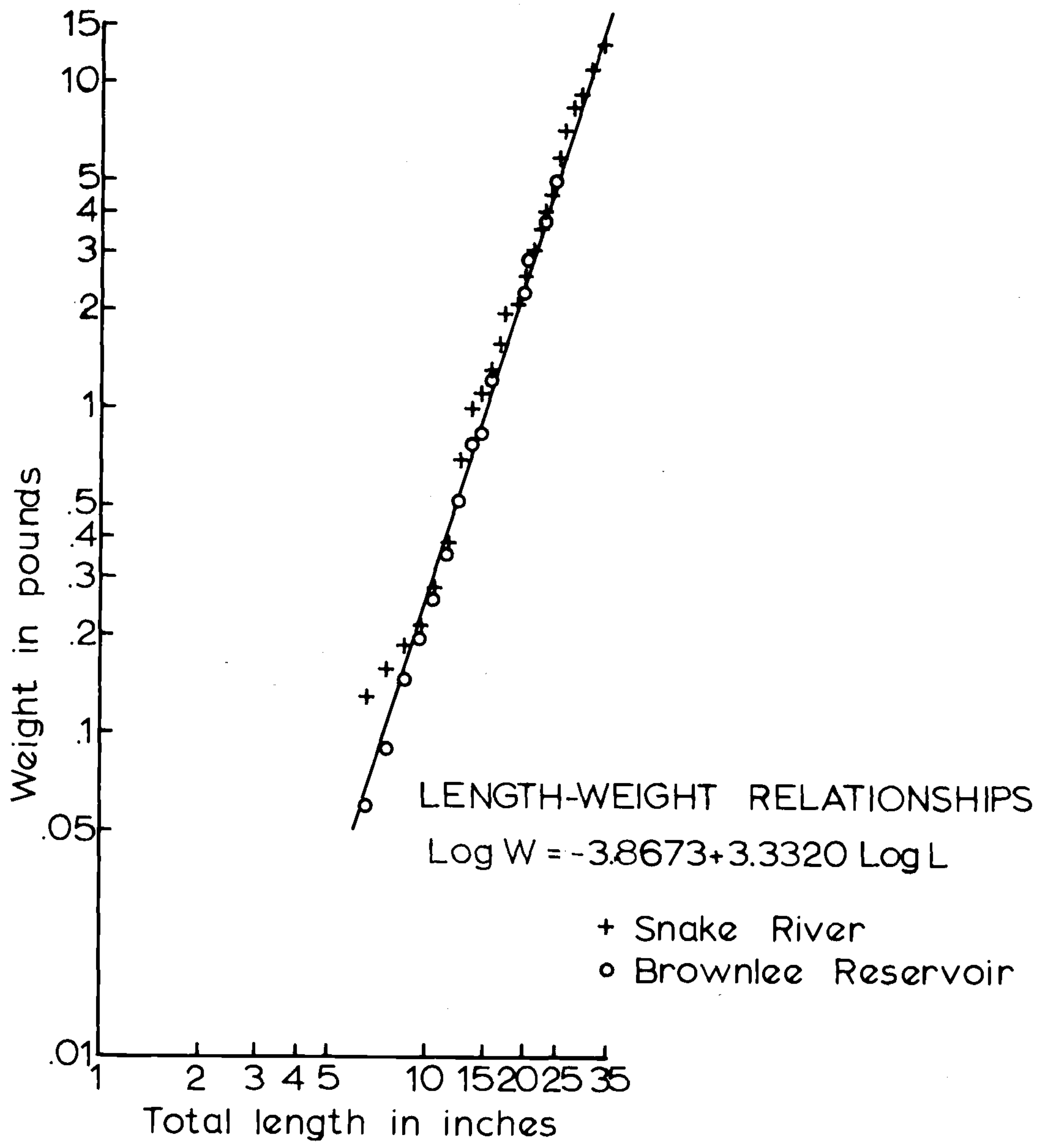


Figure 4

CALCULATED LENGTH-WEIGHT REGRESSION OF SNAKE RIVER CATFISH IN A COMPARISON WITH MEANS FROM BROWNLEE RESERVOIR shape during growth, then b = 3.0. Finnell and Jenkins (9, p. 11) found that the value of the exponent in length-weight relationships of channel catfish in Oklahoma was 3.4069. A similar condition was found by Appelget and Smith (1, p. 119) in upper Mississippi River specimens, where the exponent was found to be 3.66, and by Muncy (22, p. 131), who reports a regression coefficient of 3.1334 for 558 fish from the Des Moines River. Calculations for samples taken in widely separated areas justify a conclusion that the body shape of the channel catfish changes rapidly as the fish grows in length, and that weight increases by a power greater than the cube of its total length.

The average channel catfish from the Snake River in the area of study prior to the construction of Brownlee Dam weighed approximately one pound when it had reached a total length of 14 inches. In the Brownlee Reservoir four years after the impoundment was built, the mean weight of 14-inch channel catfish was only 0.85 pound. The mean weights of channel catfish in the Snake River increased rapidly with length and when Snake River catfish had reached 20 inches in total length, their average weight was three pounds. The largest specimen in the collection measured 30.5 inches and weighed 17.5 pounds. Other channel catfish taken in the course of study were longer (31 to 33 inches), but weights ranged to only 16 pounds.

The average weights of channel catfish taken from the Snake River before impoundment at Brownlee and the average weights of those fish captured in the reservoir in 1962 are represented in Appendix Tables A and B. The lack of samples from Brownlee Reservoir in the 15- to 20-inch length intervals precluded the use of comparable data except in the six- to 15-inch range in length, the size group most frequently found in the angler's creel.

Differences in mean weight at one-inch total length intervals for 694 channel catfish samples from the Snake River and Brownlee Reservoir are graphically illustrated in Figure 4.

B. Age determination as an interpretation of growth

1. Methods and materials

The collection of pectoral spines from 207 channel catfish from the Snake River and 118 from Brownlee Reservoir provided a sample for age determination and for the establishment of an approximate time of annulus formation. Channel catfish were taken for the study by trotline, conventional fishing tackle, gillnets, trap nets and seines (Figure 5). After the lengths, weights and other pertinent data were recorded for each individual fish, the soft rays were separated from the pectoral spines with a scalpel or knife. The left pectoral spine was then grasped between

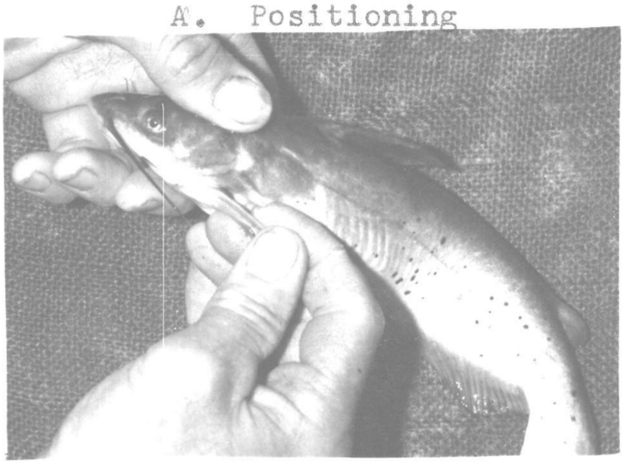
Figure 5

THE GILL NET METHOD OF OBTAINING SAMPLES the thumb and forefinger of the right hand and positioned by an outward pull, avoiding sharp barbs on the posterior edge of the spine. Then with a downward, clockwise motion through an arc of approximately 100°, the spine was "unlocked" from its articulating surfaces in the pectoral girdle and freed with a gentle prying motion downward (Figure 6). Usually the right pectoral spine was also taken in this manner. After practice, removal became quick and easy. Both spines were then placed in a scale collection envelope upon which all necessary data had been recorded.

Pectoral spines were allowed to dry for several weeks. To prepare a section for examination, a spine was placed in a small bench vise and a thin slice was made with a jeweler's saw equipped with a blade having 44 teeth per inch. The blade was too coarse to adequately section spines from fish less than 5.5 inches in total length. The cross-sectional slices, taken near the terminal end of the distal groove of the spine (29, p. 178), usually varied in thickness from 0.3 to 0.5 millimeters, and were polished slightly on 400-A emery paper and placed in a watch glass with a small amount of glycerin (Figure 7).

Cuerrier (5, p. 4) describes the use of water, alcohol, Canadian balsam and glycerin as a vehicle for differentiating the transparency of the zones which exist in the cross-sectional slices of pectoral fin rays of sturgeon. Marzolf

A. Positioning



B. Unlocking

C. Removal

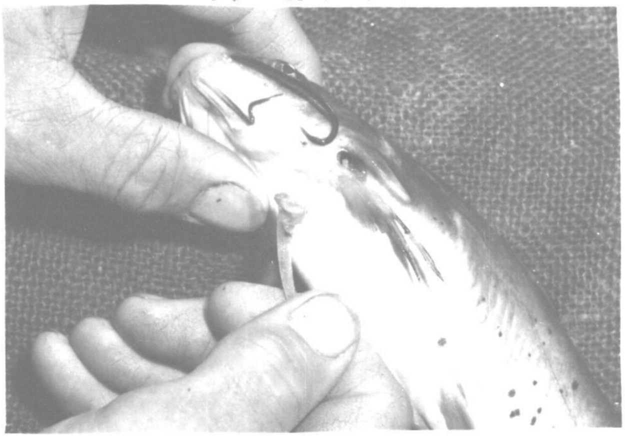


Figure 6

AN ILLUSTRATION OF PECTORAL SPINE REMOVAL

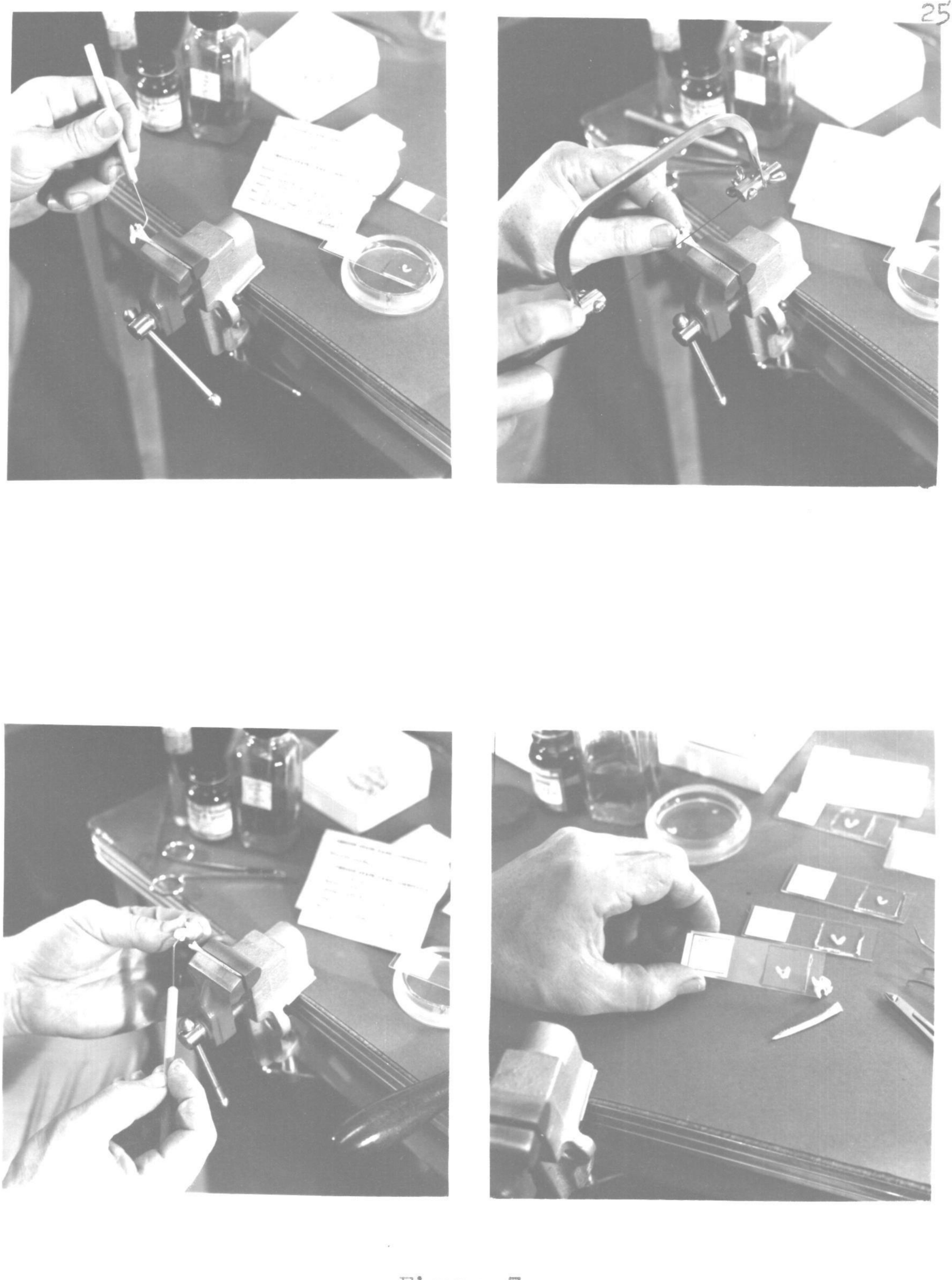


Figure 7

PREPARATION OF SPINE SECTIONS FOR AGE DETERMINATIONS

(18, p. 245) and Sneed (29, p. 177) placed cross-sectional slices in water for examination. The most satisfactory preparation medium was glycerin, which infiltrates the bony section. If the slice was too thin, the penetration of glycerin became uniform and the bony section was almost entirely transparent. For ease in handling and frequent re-examination for age determination, permanent mounting with a mixture of Canada balsam and xylene (1:1) on regular micro slides was the most satisfactory treatment. Glyptal, an alkyd resin, provided an excellent medium, but was more difficult to use. Corn syrup and warm water mixed to the proper consistency also made a satisfactory slide preparation medium, and dried faster on the edges than the balsam-xylene mixture. Spine sections examined eight years after preparation were found to yield age determinations identical to the first reading.

Under the microscope with low magnification and with transmitted light, the alternating light and dark zones are easily seen. Since the summer zones are presumed to be a deposit of calcium-contained material and therefore not easily penetrated by the glycerin, the area appears opaque as less light passes through. On a black background with reflected light, the transparent annulus areas are black and summer growth is seen as lighter distinct areas in the cross-sectional field. The reverse is obvious when a photomicrograph is prepared (Figures 8 and 9). Sharper differentiation was obtained by using the black plate with the microscope equipped with 1.5 nosepiece and 10x eyepieces.

The year markings, or annuli, were determined as a complete and separate series from the Snake River and Brownlee Reservoir. When discrepancies occurred because of damage to the spine section or the inability to differentiate annuli, the sample was rejected. After the entire lot of spine sections had been tabulated, re-reading was done. On the second reading, fewer than one percent of the individual samples were placed in a different age group as a result of comparative study.

Although Hall and Jenkins (10, p. 122) indicated that the dorsal spine of channel catfish was more satisfactory for aging catfish, Marzolf (18, p. 246) and Stevens (31, p. 13) concluded that the pectoral spine section required less time and effort in preparation, and was more reliable for age determination because erosion by the lumen was not as extensive.

Stevens (31, p. 13) reports a discrepancy in age calculation of large fish could be as much as two years if they had grown fast in early life. To reduce risk of error, portions of the first annulus remaining at the edge of the lumen were identified. If erosion around the lumen was severe in larger fish from the Snake River, the sample

Annulus pattern of a 14-pound female,
Snake River, age IX

Annulus pattern of a 13-pound female,
Snake River, age IX

Figure 8

PHOTOMICROGRAPHS OF PECTORAL SPINE CROSS SECTIONS

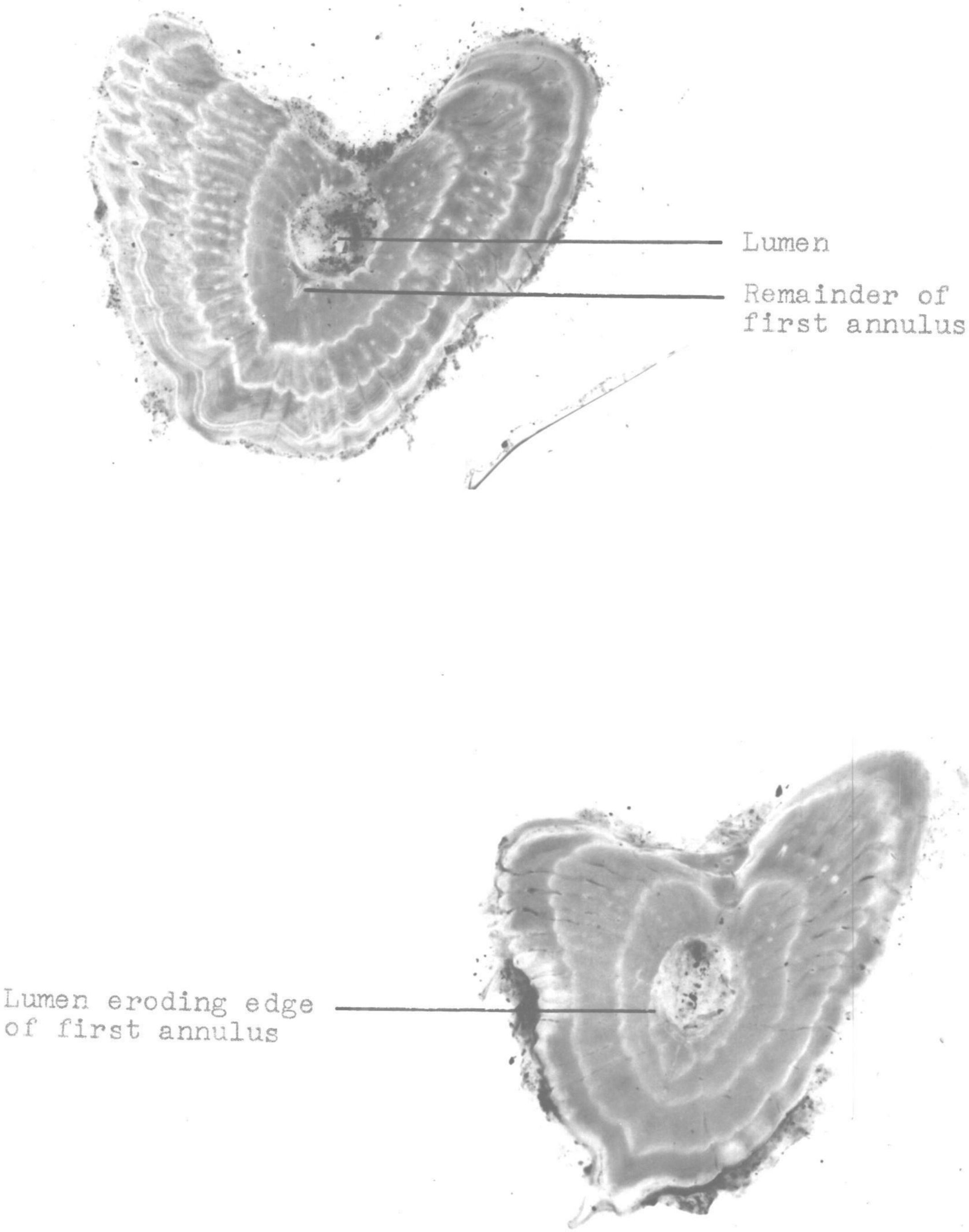


Figure 9

PHOTOMICROGRAPHS INDICATING EROSION OF THE FIRST ANNULUS BY THE LUMEN was either rejected or the position of the first annulus was established by comparison with other samples.

Noticeable in many samples was the appearance of what seems to be an annulus on the edge of the spine section. Since the annulus of channel catfish forms in May and June in the Snake River, the edge was considered the last annulus in samples which were taken from March to mid-June, provided that the last annulus was not already obviously formed.

Of the total Snake River sample, ten percent were eight years of age or older, evidence that the methods of collection were selective and failed to take the older and larger fish, or that very few channel catfish survive beyond age VII in the Snake River. In other studies in South Carolina and Oklahoma, no year classes are recorded beyond XIV. In the Snake River one specimen was taken with 11 annuli clearly visible, while another showed 13. In the Oklahoma study, only about three percent of a large sample of specimens were age VIII or older (9, p. 5).

Since none of the samples from the Snake River were represented by age I fish, the selectivity of the gear used in taking channel catfish is again noted. Limited availability resulted in 86 percent of the total sample being comprised of age II through age VI individuals, with age IV providing 30 percent of the total sample. In contrast, Stevens (31, p. 14) reports that 60 percent of the catfish samples from a highly selective fishery in the Santee-Cooper Reservoir and tailrace sanctuary were age VIII or older.

The mean empirical total lengths and weights for various age groups of channel catfish in the Snake River are recorded in Table 2. These data are arranged in a comparison with similar information recorded in Oklahoma, Brownlee Reservoir, and the upper Mississippi River.

Early life conditions through age III are apparently less limiting to growth in Oklahoma waters and the upper Mississippi River than those which influence growth in the Snake River area. At age IV, mean lengths of Snake River fish have surpassed the means used as comparisons and continue to exceed them through age IX. Mean total lengths of Brownlee Reservoir fish do not exceed those from Oklahoma or the upper Mississippi River until age V.

The examination of larger fish from the Brownlee Reservoir reveals the closeness of annuli located on the extreme edge of the cross section of the pectoral spine, indicating slower growth since the impounding of water in the Snake River in 1958. Because of the ages of these fish (five to nine years), they were assumed to be present prior to the impoundment of the Brownlee Reservoir or moved in at some time after the inundation of about 60 miles of the Snake River canyon. In all of the samples,

Table 2

A COMPARISON OF GROWTH OF CHANNEL CATFISH FROM THE SNAKE RIVER AREA WITH GROWTH IN THE UPPER MISSISSIPPI RIVER AND OKLAHOMA

Location	Number of fish	Average total length in inches at time of capture									
		Age: I	II	III	IV	V	VI	VII	VIII	IX	X
Snake River 1956-1961	207		7.7	11.1	15.5	20.2	21.2	23.1	24.4	25.9	27.0
Brownlee Reservoir 1962	118	3.7	6.4	9.9	11.5	18.2	19.5	22.5	23.7	25.3	25.9
Upper Mississippi River 1945-1946	535		9.8	12.7	13.7	15.7	18.1	20.9	22.3	24.9	28.0
Oklahoma average 1952	4,054	6.8	10.0	12.6	14.9	16.3	17.6	19.9	21.2	24.1	28.2

annuli for the first few years of growth are wide apart and uniform, indicating what might be expected as normal growth in the Snake River. The fact that the Snake River samples lack the closeness of the annuli in the last three seasons is further evidence that the impoundment is not providing conditions which stimulate rapid growth (Figure 8).

2. Time of annulus formation

The examination of pectoral spine cross sections taken from fish in Brownlee Reservoir in 1962 indicates that the annulus had formed from May 1 until approximately June 15. Fish from the Snake River collected over a period of several years appeared to have a somewhat wider range of annulus formation dates.

The formation of annuli on spines of channel catfish in Oklahoma ranges over a seven-week period, from the middle of April to the first of June (9, p. 14). Of interest is the fact that none of the channel catfish spine sections collected in March and April from either the Brownlee Reservoir or the Snake River were in an obvious state of annulus formation. This observation indicates that an estimate of formation in May and June is probably valid, but that the pinpointing of the exact time of the greatest annulus formation, particularly that of the first and second annulus, was not possible from the available samples.

3. Age and growth comparisons

The mean weights of channel catfish from the Snake River were found to be significantly different from mean weights of Brownlee Reservoir fish of the same age. The closeness of the mean weights of fish from each environment in the II, III, and IV age groups is illustrated in Figure 10.

Mean weight differences between Snake River and Brownlee Reservoir catfish of each age group were tested at the one percent significance level (Table 3).

The distribution of age groups of the 325 pectoral spine sections from Snake River and Brownlee Reservoir samples indicates a predominance of age II, III, and IV fish, while age III, IV, V, and VI fish predominate from the Snake River.

The total sample of 530 accurate lengths from Snake River fish did not always yield adequate data for aging. Many fish in the sample were weighed and measured (or measured only) in the field, but spines were not always

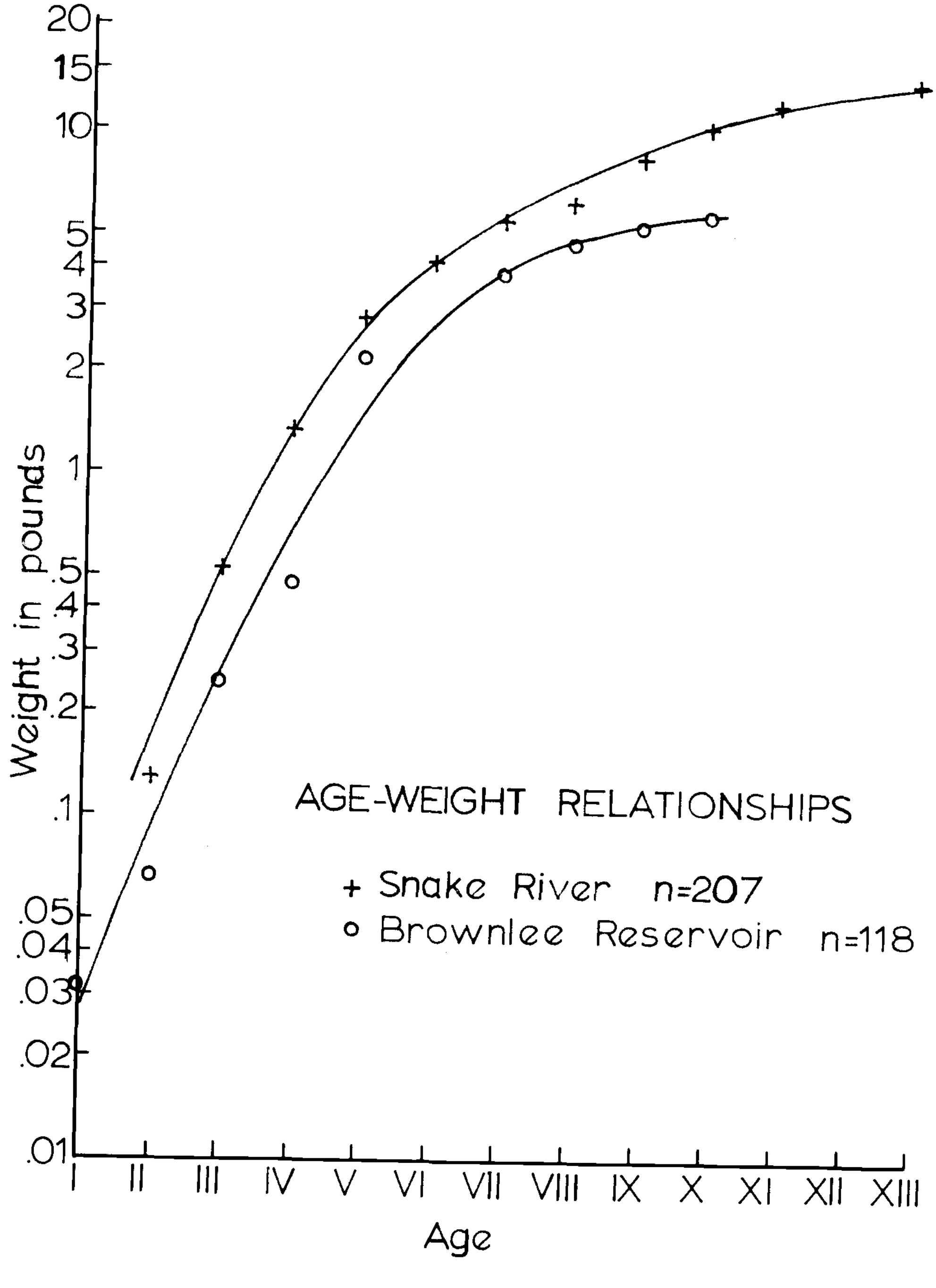


Figure 10

AGE-~~LENGTH~~ WT. RELATIONSHIPS OF 325 CHANNEL CATFISH FROM THE SNAKE RIVER AND BROWNLEE RESERVOIR

Table 3

SIGNIFICANT DIFFERENCES IN MEAN WEIGHTS OF
CHANNEL CATFISH IN THE II, III, AND IV YEAR CLASSES

	II		III		IV	
	Wt.	No.	Wt.	No.	Wt.	No.
Brownlee Reservoir	0.06	25	0.25	31	0.48	45
Snake River	0.13	26	0.51	58	1.34	61
	t = -5.29 with 49 d.f.		t = 2.63 with 87 d.f.		t = 6.32 with 104 d.f.	
probability	<.01		<.01		<.01	

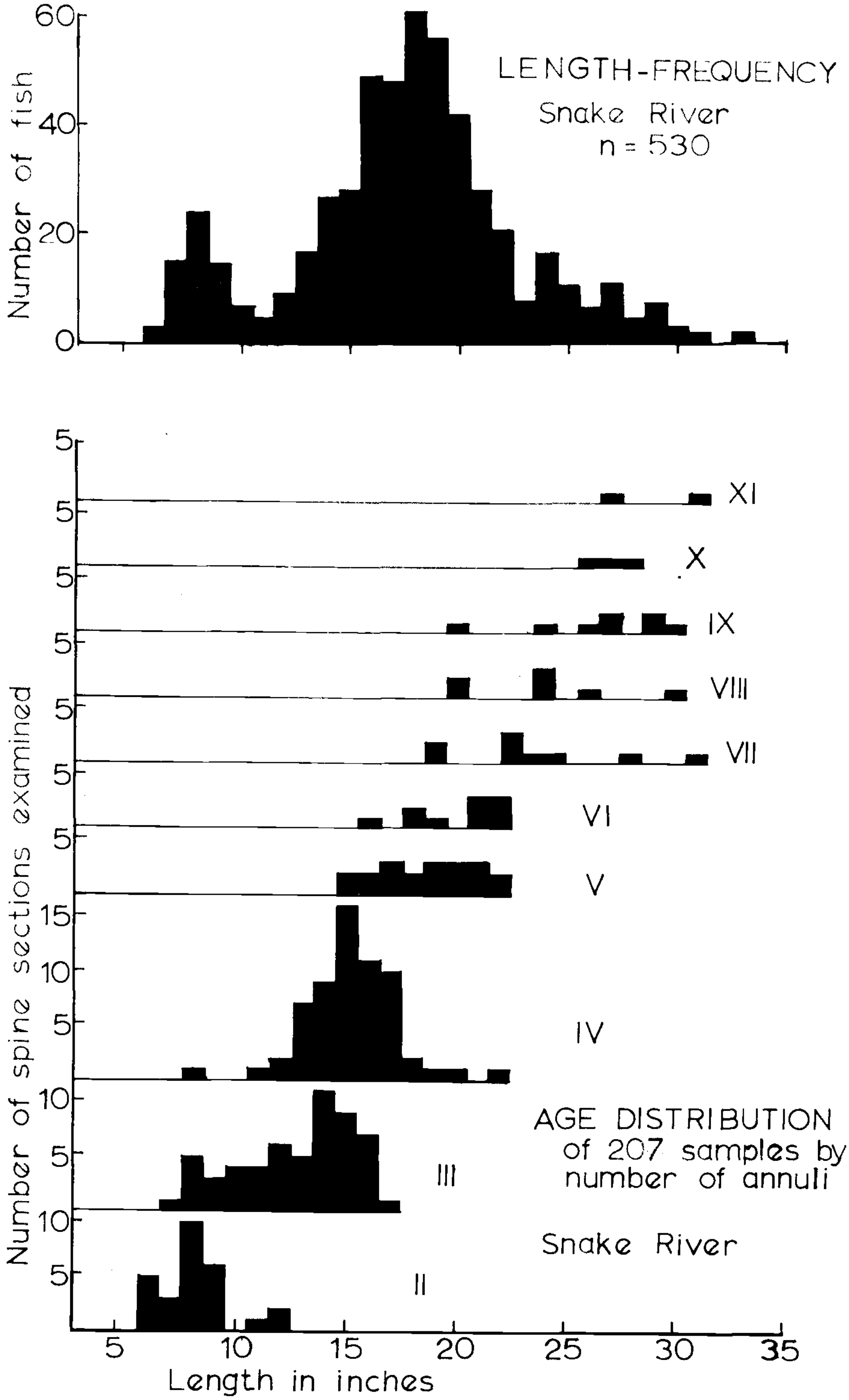


Figure 11

AGE DISTRIBUTION AND LENGTH FREQUENCY OF A SAMPLE OF 207 SPECIMENS FROM THE SNAKE RIVER

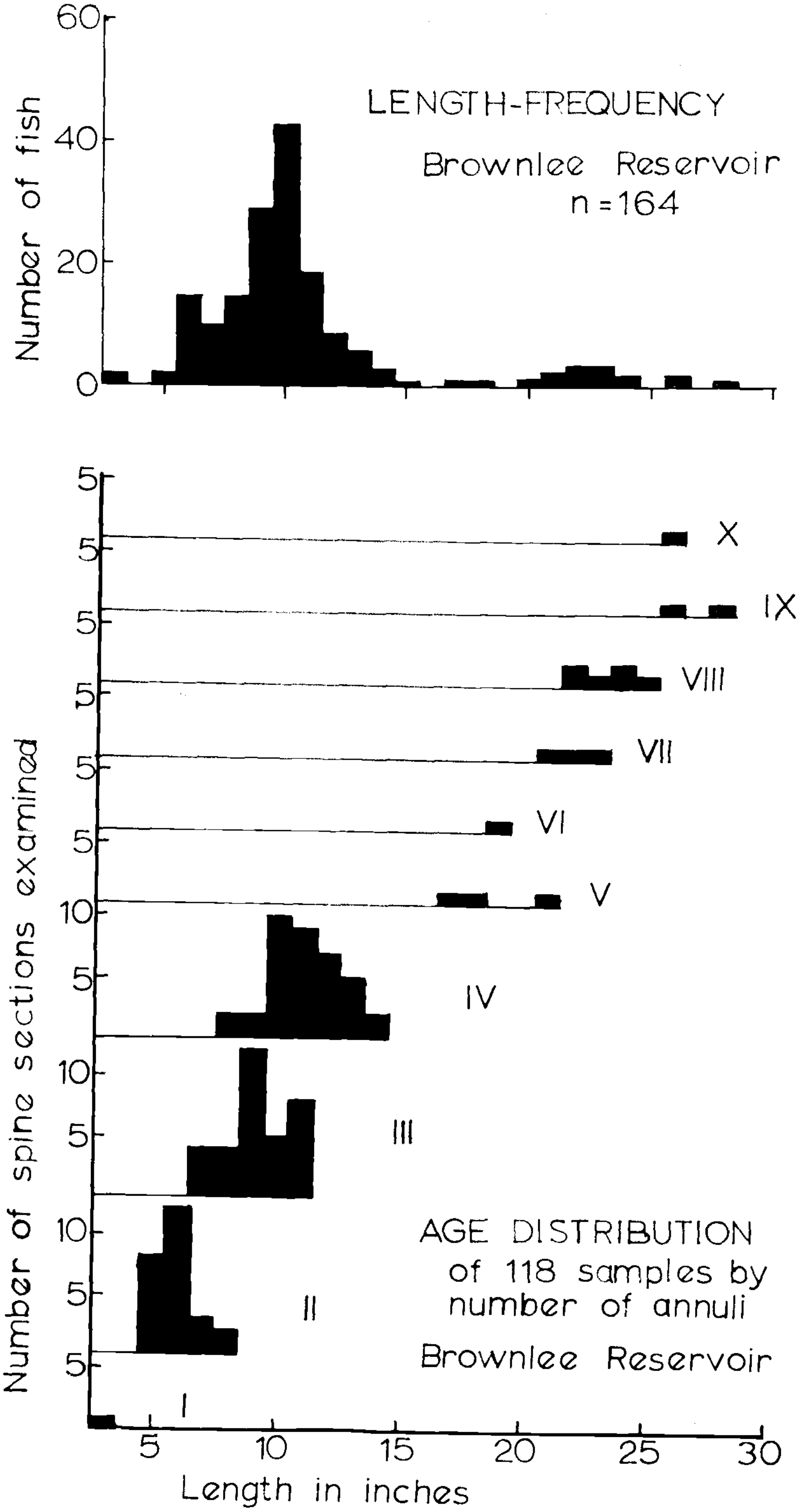


Figure 12

AGE DISTRIBUTION AND LENGTH FREQUENCY OF A SAMPLE OF 118 SPECIMENS FROM BROWNLEE RESERVOIR available. The result was a reduced number of samples in the 15- to 22-inch range, a predominant size in the catch prior to the construction of Brownlee Reservoir (Figure 16). The difficulty of taking spines from fish in the creel precludes aging of proportionate samples from all sources. The distribution of age groups by percentage might indicate a dominant year class among the age IV group that coincides, chronologically at least, with growth in the newly impounded Snake River at Brownlee Dam (Tables 4 and 5).

The age-weight and age-length relationships plotted on semi-logarithmic paper (Figures 10 and 13) from the data in Tables 4 and 5 suggest that significant differences found can be related to physical conditions in Brownlee Reservoir which limit fast growth. Those conditions are generally described as steep to near vertical shore line, a deep stratified lentic environment with extreme annual vertical fluctuations up to about 100 feet. Catfish from Brownlee Reservoir averaged 1.7 to 4.0 inches shorter than Snake River fish of the same age.

The predominance of significantly smaller fish from Brownlee Reservoir in the II, III, and IV age groups might be explained by the phenomenon of downstream movement of young catfish into the reservoir. A normal movement (or displacement) occurring each spring in the river

Table 4

THE MEAN TOTAL LENGTHS AND WEIGHTS FOR VARIOUS AGE GROUPS
OF 207 CHANNEL CATFISH FROM THE SNAKE RIVER
1956-1961

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Mean total length in inches		7.72	11.18	15.50	20.20	21.24	23.17	24.45	25.90	27.00	26.37		33.5
Mean weight in pounds		0.13	0.51	1.34	2.90	4.22	5.59	6.34	8.81	10.87	12.25		14.37
Number in sample		26	58	61	20	11	9	8	8	3	2		1
Percent of total		(13%)	(28%)	(30%)	(10%)	(5%)	(4%)	(4%)	(4%)	(1%)	(1%)		

Table 5

THE MEAN TOTAL LENGTHS AND WEIGHTS FOR VARIOUS AGE GROUPS OF 118 CHANNEL CATFISH FROM BROWNLEE RESERVOIR 1962

	I	II	III	IV	V	VI	VII	VIII	IX	X
Mean total length in inches	3.75	6.46	9.98	11.55	18.23	19.50	22.56	23.73	25.30	25.90
Mean weight in pounds	0.03	0.06	0.25	0.484	2.20		3.91	4.78	5.33	5.93
Number in sample	1	25	31	45	2	1	3	6	3	1
Percent of total	(1 %)	(22%)	(26%)	(38%)	(1%)	(1%)	(3%)	(5%)	(3%)	(1%)

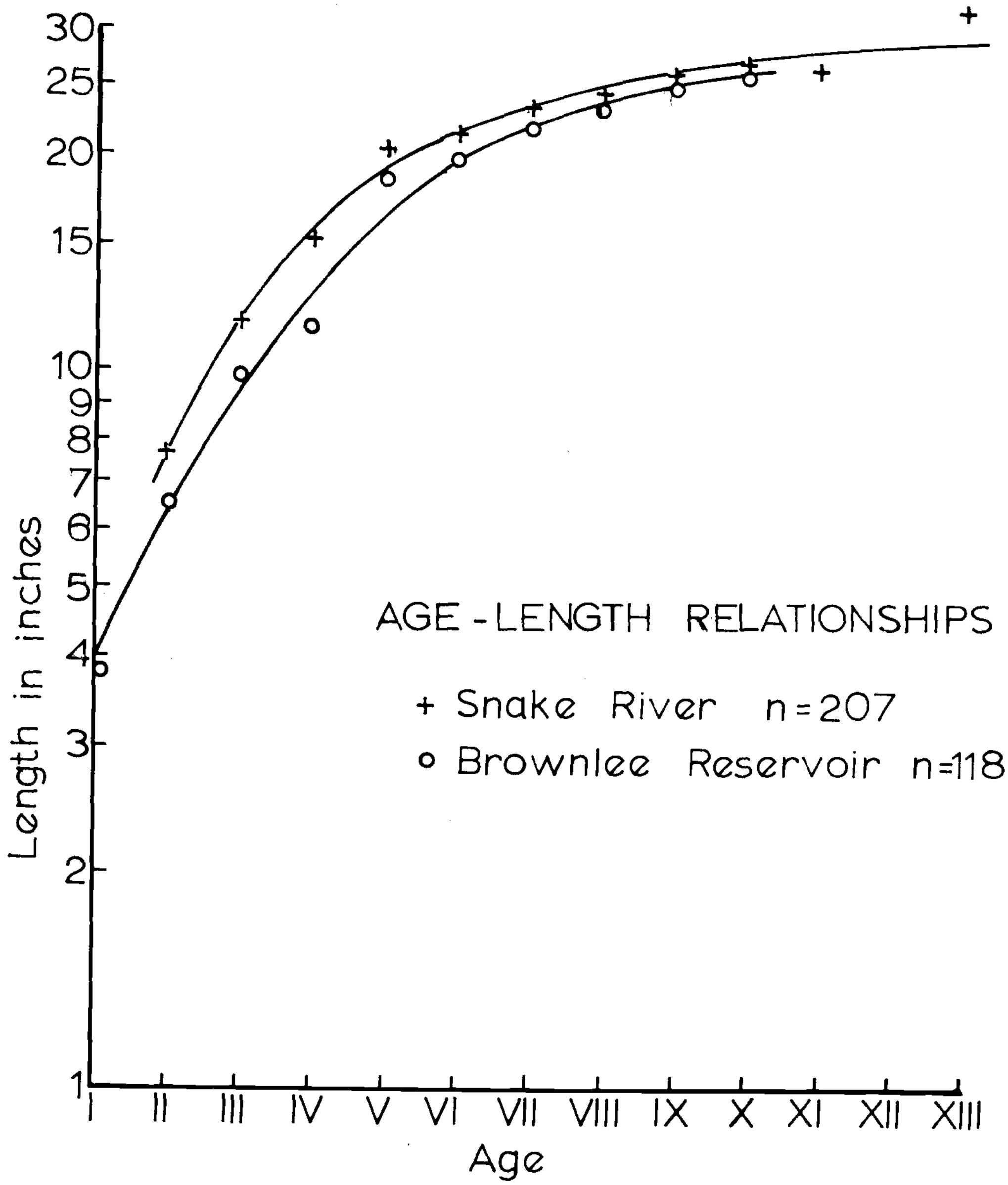


Figure 13

AGE-LENGTH RELATIONSHIPS OF 325 CHANNEL CATFISH FROM THE SNAKE RIVER AND BROWNLEE RESERVOIR adds large numbers of yearling catfish to the Brownlee Reservoir, presumably as residents. The high proportion of age IV fish from the 1962 Brownlee Reservoir sample could be an effect created by the initial impoundment of Snake River water in 1958.

III. MANAGEMENT

Sport fishery management, the science of producing or sustaining annual yields of fish for recreational uses, is principally concerned with growth, reproduction, migration, and the catch of a species once it is established in a new environment. The proper control of the catch of the channel catfish could not be resolved unless its reproduction and movement within the Snake River were understood. The complexity of factors influencing the perpetuation of channel catfish in a new habitat (the Snake River) is recognized when severe changes in temperature regime, flow pattern, and other environmental conditions created by hydroelectric dams, are considered. Although the channel catfish responded favorably to a new environment in the Snake River prior to the construction of Brownlee and Oxbow Dams, knowledge of its behavior in an environment far from its native range is essential to proper management. Studies of the channel catfish in the Mississippi drainage are helpful, but the need for information from the Snake River stocks is most desirable for future management.

A. Reproduction

Shira (27, p. 78) refers to an account of the spawning of the channel catfish in an aquarium, described in a report of the Commissioner of Fisheries for 1911, as the first authentic record of the breeding habits of the channel catfish.

Ryder (25, p. 226) describes the spawning, embryonic development, hatching, and the feeding of the Potomac catfish (A. albidus) in 1883, which is the earliest record of catfish propagation that the author has located. A well-documented paper by Clemens and Sneed (4, p. 1-11) thoroughly describes the spawning activity and behavior of the channel catfish in captivity. Although their observations of certain activities in spawning behavior are in conflict with earlier observers, the sequence of embryonic development as given by Toole (32, p. 7) was found to be much the same by the more recent observers.

The points of difference in previous reports of spawning behavior concern largely the preparation of the nest by either the male or by male and female. Clemens and Sneed (4, p. 3) indicate that male and female participate, the female being more active over the place where the eggs are to be deposited. Earlier observers believed that the female catfish inhaled air to exert inner pressure during the passage of eggs. Observations by Clemens and Sneed indicate that the contraction of the abdominal muscles of the female moved the eggs posteriorly and progressively produced a flattened area behind the pectoral fins. As the female lunges forward three to five inches, the eggs are released. A current of water causes the eggs to swirl up and at that moment they are fertilized by the male before they settle to the bottom.

In the range of temperatures tested (75° to 82° F.) the incubation period was generally close to seven days (4, p. 5). All of the observers of channel catfish embryonic development agree that the eye spots are visible on the fifth day after deposition of the eggs.

No authentic observation of the spawning activity of channel catfish in the Snake River has been recorded. In the course of study, gravid females were taken on June 10 through June 30 on several different years. Large spent females have been taken as early as July 12, while most females recognized as recently spent were taken between July 20 and August 7. The dates of these observations of gravid and spent female catfish coincide well with a record of the earliest date when maximal river temperatures usually persisted above 70° F. prior to dam construction (Table 6).

Channel catfish fry were seined from the Snake River in 1956 and 1957 in the vicinity of the Oxbow Dam site in September. Most authors agree that channel catfish do not

Table 6

A SEVEN-YEAR RECORD OF THE EARLIEST DATE WHEN MAXIMAL TEMPERATURES PERSISTED ABOVE 70° F. IN THE SNAKE RIVER BELOW THE OXBOW SITE

Year	Brownlee	Oxbow
1956	June 28	June 22
1957	June 28	June 27
1958	July 8	June 22
1959	August 16*	July 20*
1960	**	August 20*
1961	**	July 31*
1962	**	July 31*

* Delaying influence of Brownlee Dam

** Only surface temperatures of reservoir available at Brownlee spawn until water temperatures reach 70° F. and that the optimum may be near 80° F. From water temperature records, the assumption is made that spawning activities on the Snake River extended from a period beginning in late June through July.

Sharp differences in the temperature regime of live water below the Brownlee and Oxbow sites are recorded. Cold impounded water was released in 1959 and the earliest date that water temperatures between Brownlee Dam and the Oxbow site began to persist over 70° F. was August 16, a total of 38 days later than in 1958 and 49 days later than in 1956 and 1957. The influence of colder water on the maturation of channel catfish is unknown, but the inference can be made that a limiting or controlling factor in their reproduction is present. When the environment has changed, channel catfish must either adapt, move, or fail to reproduce.

Figure 14 illustrates differences in mean temperatures for each month that spawning could be expected to occur in the Snake River. Striking differences in maximal temperatures before and after the completion of Brownlee Dam occur, while the differences in minimal temperatures are slight. Since impounded water from the Brownlee pool is drawn off at a considerable depth, similar temperatures can be expected to persist.

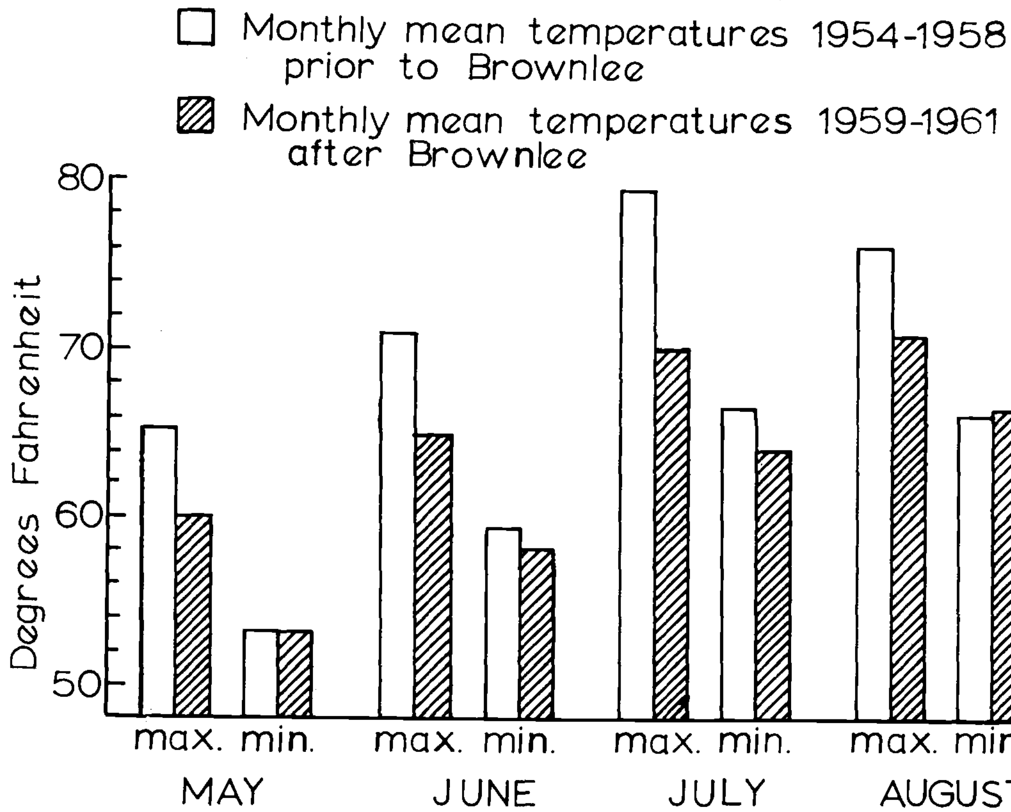


Figure 14

A DEMONSTRATION OF CHANGES IN MEAN TEMPERATURES OF SNAKE RIVER WATER AFTER THE CONSTRUCTION OF BROWNLEE DAM

In Figure 15, important differences are seen in the Brownlee pool surface temperatures (as recorded in the fish facility) and the Oxbow outflow temperatures. Below the Oxbow area, temperatures touch 70° F. in late July and August, corroborating an earlier assumption that the retarding or elimination of the spawning seasons for channel catfish downstream is a real possibility.

1. Size at maturity of females

In South Carolina, Stevens (31, p. 26) found several heavy females in March and April with large flaccid ovaries and they appeared to have spawned. Spent females were found in the first and third weeks of June. He concludes that since ripe females were taken throughout June, the most active spawning period is probably June and July. Muncy (22, p. 136) reports maturity and egg counts from females taken in Iowa from June 5 to July 16.

In the Snake River, mature females taken in the last week of May and the first week of June contained fully developed eggs. Gravid females taken on June 30 contained ripe eggs and would have spawned within the next few days. On July 10 two females, 22 and 24 inches in total length, were taken in a fully ripe condition and were ready to spawn. Four spent females from 20 to 25.9 inches in length were seen between July 12 and August 7. The evidence

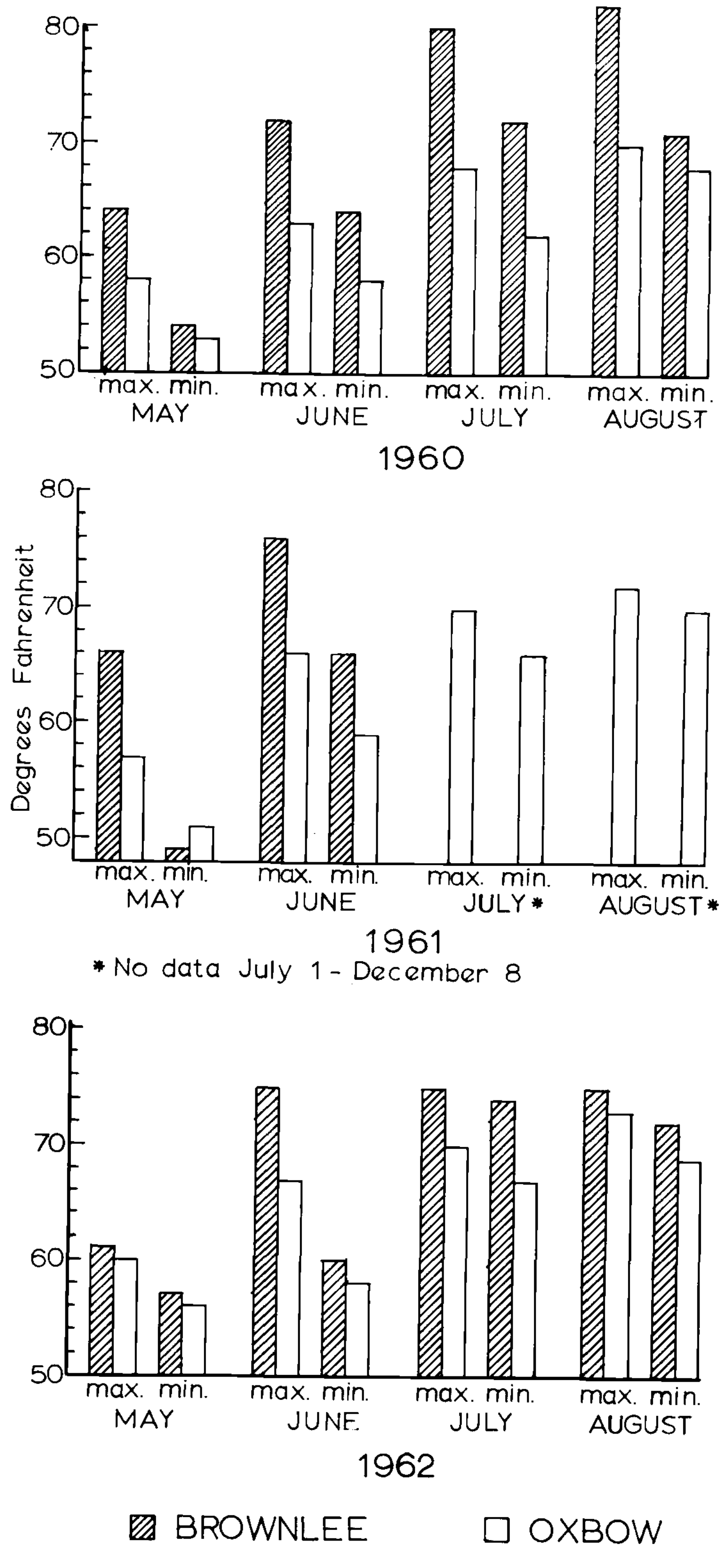


Figure 15

A THREE-YEAR COMPARISON OF MEAN WATER TEMPERATURES AT BROWNLEE AND OXBOW DAMS suggests that spawning probably begins in late June and continues through most of July in the Snake River, depending on temperatures.

2. Fecundity

The number of eggs in the ovaries of mature female catfish was estimated by Muncy (22, p. 137) from the Des Moines River in Iowa. He reports a logarithmic relationship of egg number to length and weight of mature fish and concludes that approximately 15 percent of the total weight of mature females was comprised of eggs. Only one specimen, a seven-pound female, was examined from the Snake River in mid-June. A total of 500 grams of eggs was taken, comprising 15.7 percent of its body weight.

B. Movement

Information concerning the time and extent of movement of channel catfish of any size in a particular stream is important to the fishery manager. Knowledge of whether regular migration or random movement occurs is necessary in planning regulations, formulating trapping schedules at fish passage facilities, or in providing information to the public concerning local availability.

The upstream movement of channel catfish recorded at McNary Dam counting facilities on the Columbia River for the years 1953 through 1961 indicates a peak in July and associated movement in June, August, September and October. No movement of channel catfish has occurred at McNary Dam in any other month.

At Bonneville Dam, records from 1938 to 1961 indicate a downstream movement of a few individual channel catfish in March, April, and May, while the upstream movement of catfish over the "boards" occurs most frequently in July and August, coinciding with movement recorded at McNary Dam.[1]

At Brownlee Dam, about 300 miles upstream from McNary Dam, peaks in August and September occur in the upward movement of larger channel catfish (Table 7).

Prior to 1956, fishery research activity in Washington, Oregon, or Idaho had not included a study of the movement of channel catfish in the Snake River. Incidental to a tagging program initiated to enumerate and determine the seasonal occurrence of anadromous fish in the Snake River, Oregon Fish Commission biologists tagged a total of 172 channel catfish in the Lewiston area. Upstream a distance of about 60 miles, the Idaho Department of Fish and Game tagged a

[1]Ivan Donaldson, Chief Biologist, Corps of Engineers, Bonneville, 1961.

Table 7

MOVEMENT OF CHANNEL CATFISH BY MONTHLY INTERVALS IN THE SNAKE RIVER *

Location	Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
							Upstream movement							
Brownlee Dam	1959						2	3	1	10	1			17
Oxbow trap	1960					1	4	16	41	7				68
Oxbow trap	1961	1					140	67	184	49	4	2		449
Oxbow trap	1962							14	1	50	26			91
Pleasant Valley Dam site	1956		7	25	56	48	88	21	7	24	1	1		277
Lewiston fyke traps (OFC)	1955					8	50	40	15					113
							Downstream movement							
Barge traps, Brownlee	1959	9	3	54	146	54	13	23	22	68	254	271	69	986
Brownlee Dam	1959	14	13	515	7249	854								8636
Brownlee Dam	1960				22	362	297	254	310	23	7		1	1276
Brownlee Dam	1961		18	42	28	58	222	(trapping ceased)						368
Brownlee Dam	1962		4	13	37	15	448	158	12	7				694

* Data supplied by Idaho Power Company, Idaho Fish and Game Department, and Oregon Fish Commission

total of 276 channel catfish at the Pleasant Valley-Mountain Sheep Dam site. The Peterson disc tag was used.

Of a total of 44 tagged catfish recovered, 22 had moved at least a mile or more either up or downstream from the point of tagging. Of the 22 fish which showed movement, 11 traveled an average of 19.7 miles downstream, while the other 11 fish moved an average of 8.7 miles upstream.

Brynildson[1] showed the average downstream movement of channel catfish before recapture was 12.6 miles, while the mean upstream movement distance was 6.7 miles, on the Wisconsin River.

Christenson (3, p. 17), reporting on a channel catfish tagging study in the Pecatonica River, Wisconsin, found that of 33 returns from 559 tagged channel catfish, 15 were caught upstream and 15 downstream from the point of tagging and release. The average distances traveled were 16 miles upstream and 25 miles downstream. He also recorded one fish which traveled 125 miles downstream in 36 days, averaging slightly more than three miles a day.

On the Snake River, a tagged catfish, 20.5 inches in length, moved 115.3 miles downstream from the tagging site in 40 days, traveling at an average rate of nearly three miles a day.

[1]Clifford L. Brynildson, Biologist, Wisconsin Conservation Department, Madison, 1962.

Tagging studies in several rivers indicate that when movement does occur among channel catfish, the mean distance in downstream movement is about twice the mean upstream distance (Table 8). No data have been presented in other studies concerning a size difference between the upward and downward moving catfish that were identified by tags.

At the time of tagging on the Snake River, the mean fork length of fish which later moved upstream was 19.9 inches. The fish which were recovered downstream averaged only 17.3 inches in length at the time of tagging. The mean fork length of all tagged fish recovered was 17.4 inches. The limited data suggest that larger fish migrated upstream in the Snake River. The inference is not supported by Muncy (21, p. 566) in a tagging study on the Des Moines River, Iowa, where the movement of channel catfish from a point of tagging was "without apparent direction." Hubley (13, p. 10), working with channel catfish in the upper Mississippi River, indicated that the direction of movement of resident catfish appears to be more downstream than upstream. Brynildson[1] indicates that differences in the size of catfish recovered either upstream or downstream from the tagging site were not significant. His reference to a "spawning run" in the Wisconsin River would appear that the movement of channel catfish is influenced by sexual

[1]Clifford L. Brynildson, op. cit.

Table 8

CHANNEL CATFISH TAG RECOVERIES
DEMONSTRATING MOVEMENT
FROM THE POINT OF RELEASE TO THE POINT OF CAPTURE

River	Number of tags returned	Location of recoveries		Mean distance traveled in miles	
		upstream (percent)	downstream (percent)	upstream	downstream
Wisconsin River	512	15	85	6.7	12.6
Pecatonica River	33	50	50	16.0	25.0
Lake Pepin River	158	35	65	21.0	44.0
Snake River	44	50	50	8.7	19.7

maturity. Evidence collected at the Brownlee Dam and at the Oxbow trap reveals that the upstream movement of channel catfish is not random, and the sizes of moving fish suggest a relationship to maturity.

McCammon (19, p. 332) reports a definite tendency for channel catfish to move downstream from a barrier on the Colorado River in the fall months. McCammon and LaFaunce (20, p. 13) indicate that a regular seasonal migration was not evident in an analysis of tagged catfish recoveries over a four-year period on the Sacramento River.

Until 1959 no facilities were available to trap downstream moving channel catfish except at the Pleasant Valley site, where the first indication of a strong movement of downstream channel catfish of rather small size was revealed.

When large downstream barge traps were installed at the Brownlee project, monthly records indicate peaks in April, May and June, as channel catfish, largely yearlings, moved downstream. The bulk of movement occurred from April 15 to June 15, a period coinciding with high water and the filling of the reservoir. It is significant that the sizes and times of movement between the upstream and downstream trap catch persists, indicating that movement is not random in the Snake River (see Table 7).

C. Catch and regulations

Prior to the construction of Brownlee Dam in 1958, channel catfish were taken by anglers on the Oregon shore from the town of Adrian downstream about 100 miles to the upper limits of Hell's Canyon. Periodic creel sampling in the spring and summer on the Oregon shore, conducted by Game Commission and State Police personnel from 1954 to 1961, resulted in the interviewing of 1,085 anglers, who took a total of 1,472 fish for a ratio of slightly over one fish per angler. Of the total, 75 percent were channel catfish. Also present in the catch were smallmouth bass, *Micropterus dolomieui* (Lacepede), brown bullhead, *Ictalurus nebulosus* (Le Sueur), and incidental catches of sturgeon, *Acipenser transmontanus* (Richardson), and yellow perch, *Perca flavescens* (Mitchill).

Catch sampling at Brownlee Reservoir in the spring and summer of 1962 provided information from 1,404 anglers, who took a total of 1,017 fish. Only five percent of the catch were channel catfish. Creel sampling in 1962 revealed that more channel catfish were caught above the upper limits of the reservoir than in it. In the slack water of the reservoir, 429 channel catfish were recorded in the catch, while in the strong current from Hibbard Creek to the Oasis, an observed catch of 631 channel catfish was recorded.

The catch of channel catfish per angler in 1962 in the Snake River outside the influence of the reservoir was 2.4 fish per angler (Table 9). The success ratio of anglers in the impounded water was 0.3 channel catfish per angler. The total use of Brownlee Reservoir as sampled in creels provided a seasonal average of 6.4 fish of all species per angler. The catch per angler as a measure of success in the reservoir would at first seem very desirable because of the tremendous available area under impoundment. The black crappie, *Pomoxis nigromaculatus* (Le Sueur), predominates. A comparison of the composition of catch from the Snake River and the Brownlee Reservoir is included in Table 10.

A difference in size of channel catfish entering the catch was noted by Game Commission personnel in 1962 when samples were inspected in the slack water of Brownlee Reservoir and in sections of the Snake River above the influence of the Brownlee Dam. The 1962 catch was recorded in two-inch increments and total length differences can be seen in Figure 16. The influence of impounded Snake River water in the Brownlee Reservoir on the catch is also seen to a lesser degree in the percentage of smallmouth bass entering the creel of anglers who fished in the reservoir. Since the channel catfish and the smallmouth bass are associated with flowing water, their numbers are understandably reduced in the catch from slack water of Brownlee Reservoir.

Table 9

A COMPARISON OF CATCH FROM
THREE ECOLOGICALLY DISTINCT AREAS
1962

Area	Anglers	Channel catfish	Fish per angler
Dam to Burnt River	1,404	429	0.3
Burnt River to Farewell Bend	181	631	3.5
Above Farewell Bend	240	572	2.4

Table 10

A COMPARISON OF THE COMPOSITION OF CATCH
FROM THE SNAKE RIVER IN 1956-61
WITH BROWNLEE RESERVOIR IN 1962

Species	Snake River 1956-61 catch (percent)	Brownlee Reservoir 1962 catch (percent)
Channel catfish	75	5
Black crappie	3	76
Smallmouth bass	14	3
Bullhead	6	10
Yellow perch	1	5
Sturgeon	1	1
	100	100
	(n = 1,472)	(n = 9,017)

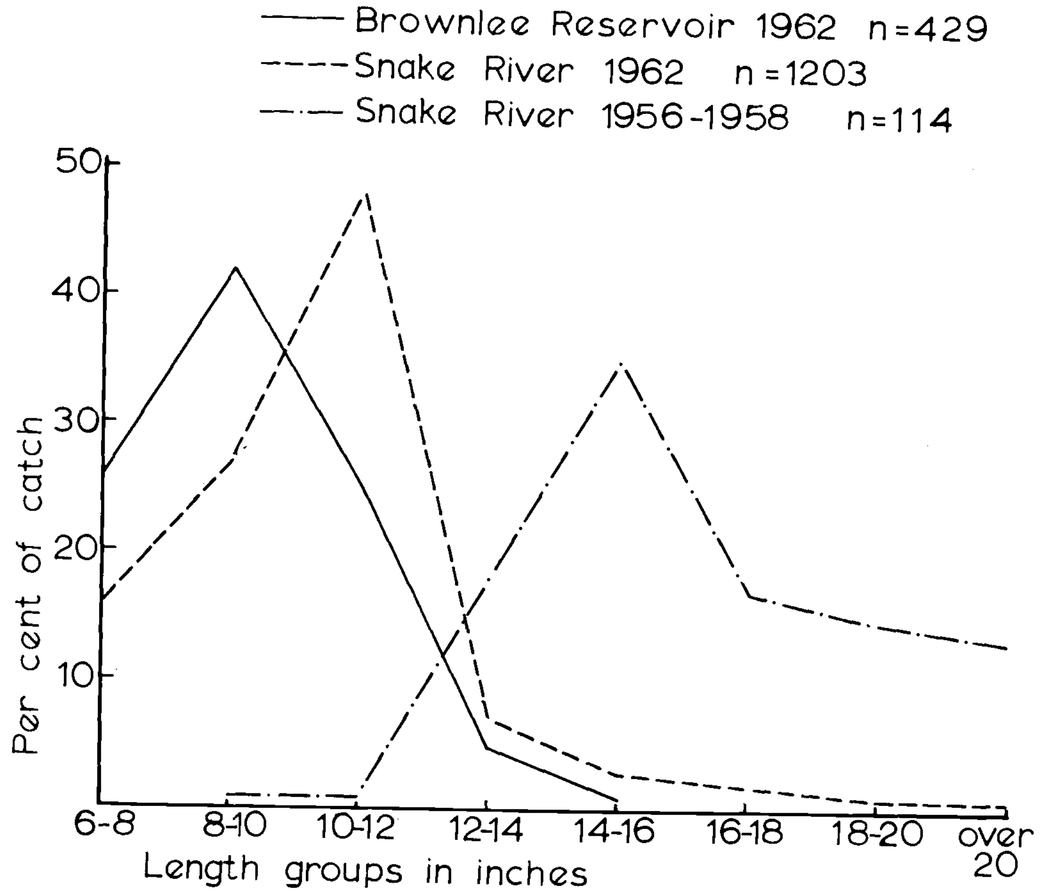


Figure 16

DIFFERENCES IN LENGTH GROUPS IN THE CATCH OF CHANNEL CATFISH FROM THREE ENVIRONMENTS OF THE SNAKE RIVER

There is a direct relationship in the level of the reservoir and the strong flows of the Snake River to the catch of channel catfish within an area periodically influenced by the Brownlee Dam. The reservoir is drawn down in late winter, exposing the upper reservoir to the normal channel for a considerable distance below the mouth of the Burnt River. By July, the reservoir is filled to capacity and the area of influence extends to the vicinity of Porter Island near the Oasis. A strong current is created by the Snake River as far down as Farewell Bend and some current is noticeable at the mouth of the Burnt River. The upper end of the Brownlee Reservoir throughout most of the year provides a lotic habitat which would be suitable for channel catfish reproduction.

Evidence of a shift in the size of channel catfish available in the Snake River since the construction of Brownlee Dam was seen in a comparison of length frequency groups of channel catfish taken in the Snake River from 1956 to 1958, with those from Brownlee Reservoir in 1962. Channel catfish sampled from creels by Game Commission and Oregon State Police personnel in the three years prior to the construction of Brownlee Dam were considerably larger than those sampled in 1962.

The regulation of channel catfish by the Oregon Game Commission was not in effect until 1953, when a limit of five per day or in possession or in seven consecutive days was established. The regulation was indicative of the increased popularity of the species, and the restriction was a temporary measure to provide time for study.

The regulation persisted until 1956 when a recommendation was submitted (and accepted) to incorporate a relaxed regulation on channel catfish under the warm water game fish law. The new regulation provided for ten channel catfish per day or 20 in possession or in seven consecutive days.

Further study in the period from 1956 to 1960 indicated that the fishery was not endangering the reproductive potential in any manner that could be determined by Game Commission biologists.

With the impoundment of the Snake River at Brownlee, forming a 60 mile long reservoir, the relaxation of the channel catfish law was again proposed and accepted by the Oregon Game Commission. In 1960 a 50 fish limit, in possession or in seven consecutive days, was established. The next year channel catfish and brown bullhead were being taken at the same time in the reservoir. Since the regulation was confusing to those who could not distinguish one species from another, and because of the lack of evidence concerning any detrimental effects of taking channel catfish, the regulation was again rewritten under Oregon's warm water game fish section. The regulation now allows the taking of

100 fish in the aggregate, but not more than 50 pounds per day or in possession. This regulation now prevails. In Oregon the channel catfish may be angled for at any time of the day or night, the year around.

D. Transplantation

In 1956 the Oregon Game Commission began a program of distribution of the channel catfish to waters which might be suitable for the species in Oregon. Appendix Table F indicates that channel catfish used for stocking Oregon waters have come from Texas, Oklahoma, California, Montana, Missouri, and from the Snake River near the Brownlee Dam site and near the mouth of the Malheur River.

Eight small ponds near Turner, Oregon were made available to the Game Commission for experimental use. The ponds were cleaned of fish and debris and stocked with various numbers and species of warm water game fish in 1957. In pond F, 12 channel catfish from ten to 18 inches in length were introduced from the Snake River. The objective was to provide channel catfish stock, as fry, for further distribution to suitable ponds in other areas of Oregon. No reproduction was observed in 1958, 1959 or 1960. In November 1960, 24 additional channel catfish were released, averaging three inches in length. In 1958, three channel catfish were recovered from Walton Pond F in a test of survival through a severe winter. Spawning kegs were placed in the pond but no reproduction has yet been observed.[1]

The utilization of channel catfish in Oregon rivers, lakes and ponds may be restricted to those which have summer temperatures conducive to the good growth and production of catfish for sport. The importance of experiments in Oregon and many other states lies in the fact that the channel catfish is versatile in a wide temperature and environmental range, and can be successfully utilized in clear or turbid ponds, either fertilized or unfertilized.

In May 1962, a total of 750 channel catfish from three to five inches in length were transported by air from Missouri to the experimental ponds operated by the Department of Fish and Game, Oregon State University.

Releases by the Oregon Game Commission were made in October 1962 throughout the Willamette Valley of approximately 50,000 catfish from California. These fish were distributed in groups of 10,000 each in the Willamette River at Harrisburg, Peoria, Corvallis, Albany, and Buena Vista. Their average length was three inches.

In July 1962, 2,500 fry, approximately three-fourths inch in length, were released in the Willamette River in the Independence area after being flown from Montana.

[1] Ralph Grenfell, Aquatic Biologist, Oregon Game Commission, Corvallis, 1962.

IV. SUMMARY

1. A study of the channel catfish, Ictalurus punctatus (Rafinesque), from the Snake River, was conducted to provide knowledge of their age, growth, and utilization as a basis for future management of the species. The history of the introduction of channel catfish into Oregon is discussed.

2. An analysis of length-weight relationships of channel catfish was based on a total of 694 specimens from the Snake River and Brownlee Reservoir. Samples ranged from 3.75 to 33.5 inches in length and from 0.03 to 17.5 pounds in weight. The regression coefficient of 3.332 indicated that weight increases by a power greater than the cube of the total length of the fish.

3. Of the 694 samples taken, 92 percent of the Brownlee Reservoir fish were six to 15 inches in length, while only 28 percent of the Snake River samples were in the same length group. The mean total length of Brownlee Reservoir samples was 10.89 inches, while the mean for Snake River fish was 17.93 inches.

4. The study of age of channel catfish was based on 207 specimens from the Snake River and 118 specimens from Brownlee Reservoir. Age groups were determined by examining thin cross sections of pectoral spines.

5. Methods were developed to prepare pectoral spine cross sections in Canada balsam and xylene in a 1:1 mixture,

in an alkyd resin (Glyptal), and in ordinary corn syrup for microscopic analysis. Spine sections examined eight years after preparation were found to yield age determinations identical to the first reading, suggesting good preservation of annulus definition.

6. Since erosion of the lumen in pectoral spine sections could result in an error of one or two years in age determinations, only those samples in which remnants of the first annulus appeared were utilized. Photomicrographs were prepared to illustrate lumen erosion and annulus formation.

7. Of the total Snake River sample, ten percent were age VIII or older. In other comparable studies in the midwest about one or two percent of channel catfish specimens were age VIII or older.

8. Snake River fish did not exhibit the closeness of annuli in the last three seasons as did those from the Brownlee Reservoir, suggesting that the impoundment is not providing conditions suitable for fast growth as recorded in the Snake River and other parts of the United States.

9. Wide differences in mean weight at age II, III, and IV were found between fish from the Snake River and from Brownlee Reservoir. The magnitude of the difference between the mean weights of each age group was determined. In the age groups tested, significant differences at the

99 percent level demonstrate much slower growth in the reservoir.

10. In every age group, the mean length and weight of channel catfish from the Snake River exceeded means for Brownlee Reservoir. Generally, growth in Brownlee Reservoir lags by about one year for each age class in the comparison. Slow reservoir growth in ages I, II, III, and IV coincide with impoundment in June 1958.

11. The formation of annuli on channel catfish spines was believed to occur from about the first of May to the middle of June in the Snake River.

12. The size at maturity of females was estimated on the basis of 13 mature individuals. The mean length of the sample was 22.4 inches and a gravid condition was noted from May 30 until July 10. Spent fish were examined from July 12 to August 7. Spawning probably occurs in late June and continues through the month of July in the Snake River.

13. The total effect of lowered water temperatures in the Snake River below Brownlee and Oxbow Dams is not understood. There is evidence that maximal temperatures persisting above 70° F., necessary for completion of the reproductive cycle of channel catfish, may no longer exist.

14. The time that Snake River temperatures persist at 70° F. as maximal temperatures has been delayed from 30 to 50 days since the dam was constructed.

15. The growth of channel catfish in the Snake River is quite comparable to the Oklahoma state average recorded in 1952, but from age V through age IX, the Snake River fish are consistently larger.

16. Of a total of 448 channel catfish tagged in the Snake River in the Lewiston and Pleasant Valley areas, 44 were recovered. Of 22 which showed movement of at least a mile, 11 traveled an average of 19.7 miles downstream while the other 11 moved an average of 8.7 miles upstream. The ratio of upstream to downstream movement is almost the same as that reported in other studies. One fish 20.5 inches in length moved 115 miles downstream from the tagging site in 40 days, an average rate of nearly three miles per day.

17. Trapping at the Brownlee Dam area revealed peaks in downstream migration of yearling channel catfish in April, May and June. A significant difference in size was found among the fish which moved upstream compared with the fish that moved downstream from tagging sites, the upstream moving fish being larger and more closely associated with size at maturity.

18. Periodic, non-random creel sampling along a 100-mile section of the Snake River prior to the construction of Brownlee Dam revealed that 75 percent of the total catch was made up of channel catfish. In 1962, four years after

Brownlee was constructed, five percent of the catch at the reservoir was comprised of channel catfish.

19. The number of channel catfish per angler in 1962 declined from 3.5 in the Snake River area above the Burnt River to 0.3 in impoundment slack water.

20. No basis for restrictive regulations on the channel catfish was found.

21. Transplantation to habitats believed to be suitable in ponds, lakes, and in certain sections of such rivers as the Malheur, Grande Ronde, and Willamette, might result in the establishment of a sport fishery where none now exists.

22. The increasing availability of the channel catfish in Oregon suggests a need for publicizing the merits of the species as a game fish of high quality.

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APPENDIX

Table A

LENGTH AND WEIGHT DATA FROM 530 CHANNEL CATFISH IN THE SNAKE RIVER

Total length interval (inches)	Number in sample	Mean total length (inches)	Mean weight (pounds)	Standard deviation of weight	Calculated weight (pounds)	Range in weight (pounds)
6.0 - 6.9	3	6.50	0.13	± 0.020	0.07	0.11 - 0.15
7.0 - 7.9	15	7.69	0.16	± 0.020	0.12	0.13 - 0.19
8.0 - 8.9	24	8.51	0.19	± 0.074	0.19	0.12 - 0.26
9.0 - 9.9	15	9.42	0.22	± 0.056	0.23	0.18 - 0.35
10.0 - 10.9	7	10.35	0.28	± 0.094	0.32	0.18 - 0.48
11.0 - 11.9	5	11.10	0.38	± 0.023	0.41	0.35 - 0.40
12.0 - 12.9	9	12.50	0.73	± 0.265	0.61	0.31 - 1.25
13.0 - 13.9	17	13.44	1.04	± 0.311	0.81	0.68 - 2.00
14.0 - 14.9	27	14.38	1.16	± 0.229	0.96	0.81 - 1.50
15.0 - 15.9	28	15.33	1.32	± 0.375	1.21	1.00 - 2.37
16.0 - 16.9	51	16.38	1.57	± 0.348	1.54	1.12 - 2.50
17.0 - 17.9	48	17.35	1.95	± 0.374	1.88	1.37 - 3.00

Table A (Continued)

Total length interval (inches)	Number in sample	Mean total length (inches)	Mean weight (pounds)	Standard deviation of weight	Calculated weight (pounds)	Range in weight (pounds)
18.0 - 18.9	61	18.31	2.13	± 0.330	2.26	1.50 - 3.00
19.0 - 19.9	56	19.39	2.62	± 0.514	2.70	1.75 - 4.00
20.0 - 20.9	42	20.30	3.06	± 0.696	3.18	2.75 - 5.75
21.0 - 21.9	28	21.41	3.48	± 0.562	3.45	2.75 - 5.00
22.0 - 22.9	21	22.25	4.03	± 0.447	4.03	3.43 - 5.50
23.0 - 23.9	8	23.37	4.37	± 0.819	4.67	3.50 - 6.12
24.0 - 24.9	17	24.29	5.24	± 1.471	5.39	3.50 - 7.00
25.0 - 25.9	11	25.45	6.03	± 0.985	6.17	4.19 - 7.62
26.0 - 26.9	7	26.32	7.63	± 1.178	6.57	6.75 - 10.00
27.0 - 27.9	11	27.34	8.42	± 1.515	7.99	6.50 - 12.00
28.0 - 28.9	5	28.31	9.72	± 2.801	9.55	7.75 - 14.62
29.0 - 29.9	7	29.11	11.46	± 2.223	10.15	8.75 - 15.00
30.0 - 30.9	3	30.13	13.37	± 4.870	11.30	8.00 - 17.50

Table A (Continued)

Total length interval (inches)	Number in sample	Mean total length (inches)	Mean weight (pounds)	Standard deviation of weight	Calculated weight (pounds)	Range in weight (pounds)
31.0 - 31.9	2	31.00	15.00	± 1.000	12.75	14.00 - 16.00
32.0 - 32.9	-	-	-	-	-	-
33.0 - 33.9	2	33.38	15.18	± 1.161	15.60	14.37 - 16.00

Table B

LENGTH AND WEIGHT DATA FROM 164 CHANNEL CATFISH IN THE BROWNLEE RESERVOIR

Total length interval (inches)	Number in sample	Mean total length (inches)	Mean weight (pounds)	Standard deviation of weight	Range in weight (pounds)
6.0 - 6.9	16	6.50	0.06	± 0.010	0.05 - 0.09
7.0 - 7.9	10	7.36	0.09	± 0.016	0.07 - 0.12
8.0 - 8.9	15	8.62	0.15	± 0.022	0.12 - 0.19
9.0 - 9.9	29	9.52	0.20	± 0.024	0.17 - 0.26
10.0 - 10.9	43	10.50	0.28	± 0.045	0.18 - 0.43
11.0 - 11.9	19	11.30	0.39	± 0.066	0.33 - 0.50
12.0 - 12.9	9	12.30	0.54	± 0.051	0.50 - 0.62
13.0 - 13.9	6	13.50	0.82	± 0.139	0.65 - 1.00
14.0 - 14.9	3	14.30	0.85	± 0.128	0.75 - 0.93
15.0 - 15.9	1	15.40	1.31	-	-
16.0 - 16.9	-	-	-	-	-
17.0 - 17.9	1	17.7	2.12	-	-
18.0 - 18.9	1	18.9	2.40	-	-

Table B (Continued)

Total length interval (inches)	Number in sample	Mean total length (inches)	Mean weight (pounds)	Standard deviation of weight	Range in weight (pounds)
19.0 - 19.9	-	-	-	-	-
20.0 - 20.9	1	20.5	3.00	-	-
21.0 - 21.9	2	21.5	3.10	± 0.678	2.62 - 3.58
22.0 - 22.9	3	22.3	4.08	± 0.651	3.56 - 4.81
23.0 - 23.9	3	23.8	5.03	± 1.017	3.93 - 5.93
24.0 - 24.9	2	24.5	5.49	± 0.858	4.93 - 6.06

Table C

REGRESSION CALCULATIONS FOR THE EQUATION USED TO PREDICT FISH WEIGHTS FROM TOTAL LENGTHS

$n = 511$

$\bar{x} = 1.2362$ $\bar{y} = 0.2517$

$SS_x = 10.1681$ $SP = 33.8810$ $SS_y = 116.4630$

where x = Log of total length of all size groups

and y = Log of total weight of all size groups

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then

$$b = \frac{SP}{SS_x} = 3.3320$$

$$y = a + bx$$

$$a = 0.2517 - 3.3320\ (1.2362) = -3.8673$$

$$\text{Log } y = -3.8673 + 3.3320 \text{ Log } x$$

Table D

MAXIMUM-MINIMUM TEMPERATURE RECORD OF AVERAGES
FOR MAY, JUNE, AND JULY, SNAKE RIVER

Location	Year	May max.	May min.	June max.	June min.	July max.	July min.
Oxbow	1954	68	50	72	59	81	68
	1955	65	51	74	57.5	80	65
	1956	65	57	67	60	80	63
	1956*	64	56	71	58	80	--
	1957	67	53	72	60	75	69.5
	1958	66	55	70	62	--	--
	1959	60	53	65	58	71	64
	1960	58	53	63	58	68	62
	1961	57	51	66	59	70	66
	1962	60	56	67	58	70	67
Brownlee	1957	64.5	51.5	70.5	59	73.5	67.5
	1958	62	54	68	60	71	65
	1959	57	50	63	54	68	59
	1960**	64	54	72	64	80	72
	1961**	66	48	76	66	--	--
	1962**	61	57	75	60	75	74

Oxbow location: 1957, 1958: 5/8 mile upstream from tunnel uptake
1959: 1/3 mile below Pine Creek

Brownlee location: 1957, 1958: 1/4 mile downstream from dam, Idaho shore
1959: west end powerhouse, downstream side
1960: at the reservoir, surface water

*Data supplied by Idaho Power Company
** Surface water at reservoir

Table E

A CHRONOLOGICAL RECORD OF REGULATION
OF THE CHANNEL CATFISH IN OREGON

1952	No regulation
1953 - 1955*	Five per day, five in possession or in seven consecutive days
1956 - 1959	Incorporated under warm water game fish: ten fish per day, 20 in possession or in seven consecutive days
1960	Under warm water game fish: 50 fish per day or in possession or in seven consecutive days
1961	Under warm water game fish - channel catfish and bullhead: 100 fish in aggregate, but not more than 50 pounds in possession per day
1962	Same

*Same regulation on Idaho side of Snake River since 1953. Idaho regulations first adopted in 1947 for five fish limit.

Table F

CHANNEL CATFISH RELEASES IN OREGON

Year	Number	Size (inches)	Planting location	Source of stock
1956	50,400	1 1/2	Warm Springs Reservoir	Austin, Texas
	10,946	3 3/4	"	Fort Worth, Texas
	1,354	3 3/4	Malheur River, Middle Fork	"
	3,200	3 3/4	Silvies River	"
	3,000	3 3/4	Devils Lake	"
	79	12-24	Malheur River	Snake River
	134	12-24	Silvies River	"
	10	6-22	Burnt River	"
	14	10-18	Grande Ronde River	"
1957	30,000	3	Warm Springs Reservoir	Oklahoma
1959	41	7-17	Devils Lake	Warm Springs Reservoir
1961	131	7-21	Grande Ronde River	Brownlee Reservoir
	34	5-10	Big Swamp Reservoir	Owyhee Reservoir
1962	50,000	3	Willamette River	California
	2,500	3/4	"	Montana
	1,279	2-11	Grande Ronde River	Snake River
	1,554	2-12	Burnt River	"
	45	7-12	Owyhee River	"
	450	3-5	OSU Ponds, Soap Creek	Missouri
	300	3	"	"