# *hnical Papers*

## HE U.S. FISH AND WILDLIFE SERVICE

95. Lake Francis Case, a Missouri River Reservoir: Changes in the Fish Population in 1954-75, and Suggestions for Management

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

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# *Technical Papers*

## OF THE U.S. FISH AND WILDLIFE SERVICE

# 95. Lake Francis Case, a Missouri River Reservoir: Changes in the Fish Population in 1954-75, and Suggestions for Management

**By Charles H. Walburg**



**UNITED STATES DEPARTMENT OF THE INTERIOR**

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# Lake Francis Case, A Missouri River Reservoir: Changes in the Fish Population in 1954-75, and Suggestions for Management

by

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## Abstract

Studies conducted during the first 23 years of impoundment of Lake Francis Case indicated that fish abundance in the early 1970's was about half that in the late 1950's. Of 39 species collected, 12 were abundant in the 1950's and 8 in the 1970's, but only 4 were abundant throughout the impoundment period.

Changes in fish abundance and species composition were mainly a result of poor reproductive success caused by water-level fluctuations during the spring and early summer, and physical changes in the shoreline environment. Fish reproduction was most successful in years when the reservoir was filled in the spring and a nearly constant level was maintained through July. Survival and growth would probably improve if the pool drawdown in the fall were reduced. Fish abundance could be increased if water-level management conformed more closely to requirements for fish reproduction. This is only possible in some years, however, because of the multipurpose function of the reservoir. In consideration of this restraint, I recommend a 3-year cycle in pool level management: maintenance of a relatively low level for two consecutive years, to encourage the growth of shoreline vegetation, and a high level during the 3rd year, through July. This flooding of the vegetation should significantly increase the likelihood of successful spawning and survival of the young of a number of important game species, as well as increase the abundance of food (forage fishes and invertebrates).

If future water management is similar to that of the early 1970's the fish population is expected to continue to be dominated by seven species: Goldeye (*Hiodon alosoides*), emerald shiner (*Notropis atherinoides*), river carpsucker (*Carpiodes carpio*), channel catfish (*Ictalurus punctatus*), yellow perch (*Perca flavescens*), white bass (*Morone chrysops*), and walleye (*Stizostedion vitreum vitreum*).

Lake Francis Case is one of six main stem reservoirs constructed since the 1930's by the U.S. Army Corps of Engineers (USACE) on the upper Missouri River in Montana, North Dakota, South Dakota, and Nebraska. The reservoirs are managed as a system by the Reservoir Control Center in the Missouri River Division of the USACE, Omaha, Nebraska, for flood control, hydroelectric power, downstream navigation, irrigation, and other purposes.

Lake Francis Case, the first Missouri River reservoir completed in South Dakota, was impounded in 1952. The fish population was studied in most years in 1954-75 to document its development over time and to determine methods for increasing sport fish abundance. The South Dakota Department of Game, Fish and Parks carried out the studies in 1954-63, and the North Central Reservoir Investigations (NCRI) of the U.S. Fish and Wildlife Service in 1962 and 1965-75. Gasaway (1970) reported on the fish population in Lake Francis Case through 1968, the first 16 years of impoundment. He emphasized changes in abundance, growth, reproduction, and distribution of the major species. The present report contains information collected through 1975 and describes changes in the fish population during 23 years of impoundment, suggests causes for the changes observed, and predicts fish species composition in future years, assuming water management remains similar to that in the early 1970's. Measures to increase fish abundance are also suggested.

## Description of Reservoir

Fort Randall Dam, near the town of Lake Andes, South Dakota, was closed in July 1952 to create Lake

Francis Case (Fig. 1). Water levels rose significantly in 1953 but did not reach the base of annual flood control, elevation 411.5 m above mean sea level (msl), until 1957. At that elevation, the reservoir is 172 km long (ending at Big Bend Dam), has a mean width of 1.86 km, an average depth of 15.2 m, a surface area of 320 $km^2$, and a shoreline length of 870 km. It has steeply sloping shores of clay, clay loam, and exposed glacial till. Trees and brush were not cleared from the reservoir bottom before flooding except in some bays. In 1975 flooded timber was evident only in the upstream end of the reservoir and in embayments. The White River, which enters the reservoir from the west and is the only major tributary, is an extremely turbid stream with an average annual flow (1955-73) of about 14.7 $m^3/s$.

Lake Francis Case is characterized by large annual water level fluctuations. Spring and summer water levels depend on winter and spring precipitation over the Upper Missouri River Basin. Most of the water that enters the upper Missouri River passes through Lake Francis Case. May-August water elevation averaged 413 m above msl in 1974, a year of near-average precipitation, and 415 m in 1975, a year of higher-than-average precipitation. The reservoir is drawn down each fall to provide storage for winter water releases from upstream reservoirs for hydropower production. From 1956 to 1970, the reservoir was drawn down to 402.3 m above msl and the annual change in water elevation ranged from 10 to 12 m. After 1970, as a result of a change in reservoir water management, the drawdown was reduced to elevation 407.6 m above msl and the annual change in water elevation in 1971-75 ranged from 6 to 7 m. The drawdown usually occurs during October and November. Water elevation is lowest in early December and then rises, reaching the base of annual flood control (411.5 m above msl) by about March 15 (Fig. 2).

The reservoir rarely stratifies thermally or chemically. Wind velocities of 50-80 km/h are common. The average annual water exchange time is about 6 months. Other physical and chemical features of the reservoir were given by Benson (1968), Cowell (1970), and Gasaway (1970).

## Methods and Location of Sampling

Fish were collected in different years by the South Dakota Department of Game, Fish and Parks and the North Central Reservoir Investigations (Table 1). South Dakota biologists sampled the adult fish population in 1954-56 and 1959, and young-of-the-year (YOY) fish in 1956-61. (The YOY were also sampled in

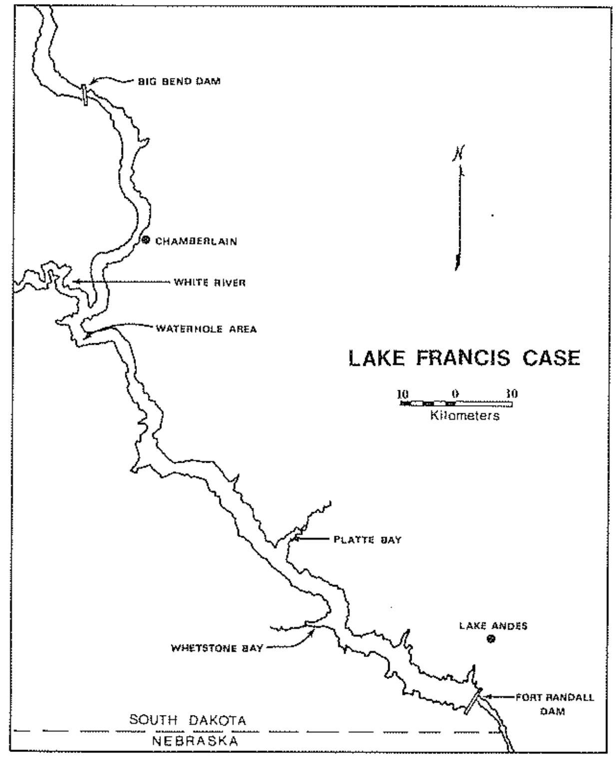


**Fig. 1.** Lake Francis Case, Missouri River, South Dakota.

1954-55 and 1962-63, but methods were not comparable—see Gasaway 1970.) Adult fish were collected with gill nets of various mesh sizes and frame nets, and YOY with seines. Studies were conducted during the summer, and similar locations were sampled each year.

Biologists of NCRI sampled adult fish with gill nets and frame nets in 1962, and with gill nets, frame nets, and trap nets in 1965 and 1967. Sampling was in June, July, and August in 1962 and 1967 and in September and October in 1965. Sample locations were similar in the different years. YOY were sampled with seines in 1966-68; sampling was restricted to Platte and Whetstone Bays in 1966-67, but in 1968, eight stations in the lower third of the lake, including Platte and Whetstone Bays, were sampled. Details on methods and locations of sampling in 1954-68 were given by Gasaway (1970).

After 1968, adults (age I and older) were sampled in 1970 and 1973, and YOY in 1969-75. Adults were sampled during alternate weeks with gill nets in June, July, and August at 12 stations between the dam and

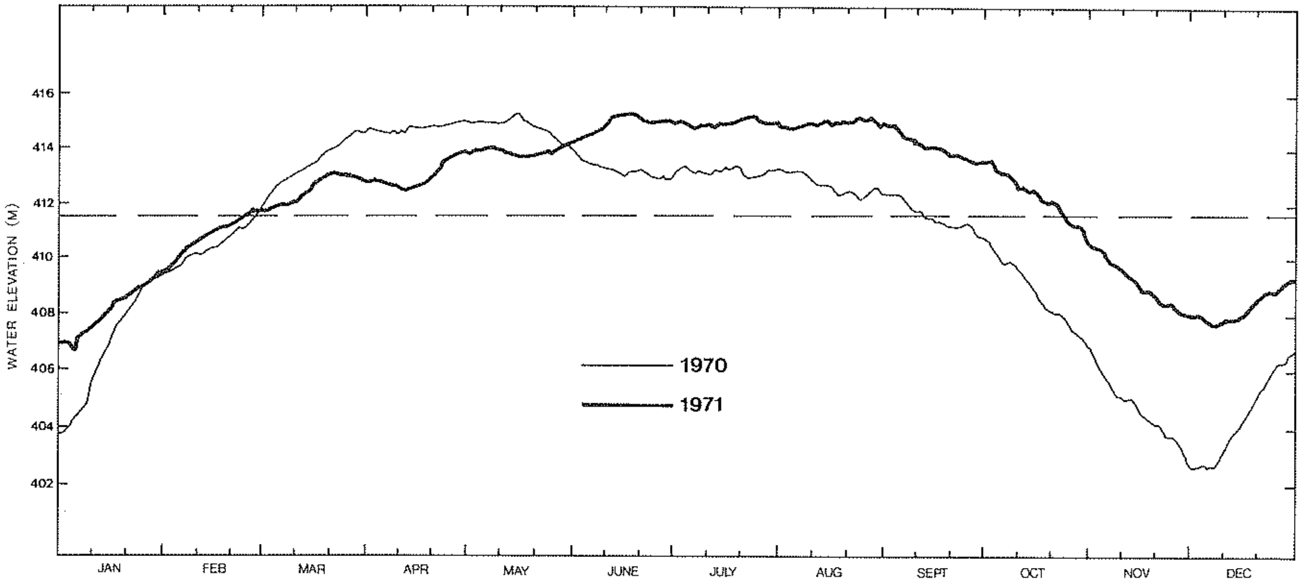


Fig. 2. Daily water elevation above mean sea level, Lake Francis Case, 1970 and 1971. The broken line shows the base of annual flood control, 411.5 m above msl.

Table 1. *Fish collections in Lake Francis Case, 1954-75: collecting agency, time and frequency of sampling, gears fished, and areas sampled.* (See Fig. 1 for location of areas.)

| Fish size, and years | Agency[a] | Sampling period | Frequency of sampling[b] | Gears[c] | Areas sampled |
|---|---|---|---|---|---|
| Adult | | | | | |
| 1954-56, 1959 | SD | June-Aug. | M | G,F | Comparable among years |
| 1962 | NCRI | June-Aug. | M | G,F | Comparable among years |
| 1965 | NCRI | Sep.-Oct. | W | G,F,T | |
| 1967 | NCRI | June-Aug. | AW | G,F,T | |
| 1970 | NCRI | June-Aug. | AW | G | 17 stations[d] |
| 1973 | NCRI | June-Aug. | AW | G | 17 stations[d] |
| Young of the year | | | | | |
| 1956-61[e] | SD | June-Aug. | AW | S | Comparable among years |
| 1966-67 | NCRI | July-Aug. | AW | S | Platt and Whetstone Bays |
| 1968 | NCRI | July-Aug. | AW | S | 8 stations in lower third of lake |
| 1969-75 | NCRI | July-Aug. | AW, M | S | 11 stations[f] |

[a]NCRI = North Central Reservoir Investigations; SD = South Dakota Department of Game, Fish and Parks.
[b]AW = alternate weeks; M = monthly; W = weekly.
[c]F = frame net; G = gill net; S = seine; T = trap net.
[d]Twelve stations between Fort Randall Dam and Platte Bay, and five between the Waterhole Area and Chamberlain.
[e]Young of the year were also collected in 1954-55 and 1962-63 but data are not included in this paper. See text.
[f]Eight stations between Fort Randall Dam and Platte Bay sampled in alternate weeks, and three near Chamberlain sampled monthly.

Platte Bay and at 5 stations between the Waterhole Area and Chamberlain (Fig. 1). The gill nets were 106.8 m long and 1.8 m deep, and consisted of seven 15.2-m panels of mesh sizes (stretched measure) 3.8, 5.1, 6.4, 7.6, 10.2, 12.7, and 17.8 cm. Nets were fished on the bottom overnight. YOY were sampled by seine during alternate weeks in July and August at eight stations between the dam and Platte Bay, and monthly at three stations in the Chamberlain area. The nets were 30.5 m long and 2.4 m deep, and the mesh size was 0.6 cm (stretched measure).

Fish collections by gill nets, frame nets, and trap nets were used for growth comparisons. Total length (mm) was recorded for all fish collected. Scale or spine samples were taken from a subsample which included the entire length range of age I and older fish of each species captured. Age was determined from plastic impressions of three or more scales from each fish or, for channel catfish, from cross sections of pectoral spines. From the sample aged, the age distribution of each species was assigned on the basis of the length frequency of the catch. Growth was calculated by direct proportion, without an intercept correction.

Estimates of relative abundance and year-class size were based on catch per standard unit of effort (CPE)—e.g., the catch in one gill net fished on the bottom overnight or (for YOY) the catch per hectare seined. Annual estimates of species abundance from gill net and seine catches may not be strictly comparable because of annual differences in locations fished; however, comparison of CPE's gives a reasonable estimate of the change in abundance of each species over time. The 1965 collections were not used to estimate adult abundance because the fish were collected in the fall, whereas in other years they were taken in the summer; the 1965 data were used for growth comparisons.

## Fish Population Changes

There were obvious changes in the fish population of Lake Francis Case during the 23 years after the reservoir was impounded in 1952. Most evident were changes in species composition, abundance, and growth. Some of these changes, especially for species that were abundant during the early years of impoundment, were discussed by Gasaway (1970).

### *Species Composition*

A total of 39 species were collected from the reservoir in 1954-75 (Table 2), but species composition changed considerably during these years (Tables 3 and 4). Eight species common during the early years of impoundment were considerably reduced during the later years: silvery minnows, flathead chubs, black bullheads, bluegills, largemouth bass, white crappies, black crappies, and saugers. Three species were common in the later years, but not in the earlier ones: red shiners, white bass, and walleyes. Eleven species were common in all years: shovelnose sturgeons, gizzard shad, goldeyes, carp, emerald shiners, river carpsuckers, smallmouth buffalo, bigmouth buffalo, channel catfish, yellow perch, and freshwater drum. The other 17 species, except paddlefish, were apparently never common in the reservoir.

### *Relative Abundance*

The annual seine catch of YOY, which was assumed to be indicative of reproductive success, varied widely for all species during 1956-75 (Table 3). Gizzard shad, emerald shiners, white bass, and yellow perch were most common in the catches, especially in 1966-75. Gizzard shad were abundant in 1958 and 1967, but only moderately abundant in the 1970's. Emerald shiners were more common in seine catches in 1960 and 1974 than in other years; few were collected in 1966, 1972, and 1973, and moderate numbers in most other years. White bass were not present in the reservoir during the early years of impoundment; they were introduced from upstream sources (Gasaway 1970) and became common in 1967; most were captured in 1975. Yellow perch were most abundant in 1967 and 1971; relatively few were collected in 1956, 1970, and 1974, and catches in other years were intermediate.

Although the total annual CPE of YOY fish was extremely variable in 1956-75, general abundance apparently decreased during the 1970's. The average CPE during the last 6 years of sampling (1970-75) was about 40% less than that for a 6-year period (1956-61) during the early years of impoundment (Table 3).

Adult fish collections were dominated by goldeyes, river carpsuckers, carp, channel catfish, and walleyes (Table 4). Goldeyes were the most abundant fish captured in 1962, 1970, and 1973; only moderate numbers were taken in other years. More river carpsuckers were taken in 1970 than in other years; the numbers in most other years were similar, but less than half that in 1970. Carp were abundant in catches during the first several years of impoundment (1954-56), but later declined, and in the 1960's and 1970's were only about one-third to one-half as numerous as in the early years. Channel catfish were most abundant in the catches in 1970 and 1973; numbers taken in other years were variable, and only about one-half to two-thirds as large as those in the 1970's. The walleye was best represented in the catches in 1970 and 1973, and was the

Table 2. *Apparent abundance and population trend of fishes collected from Lake Francis Case, 1954-75.*

| Common name | Scientific name | Abundance[a] | Population trend[b] |
|---|---|---|---|
| Pallid sturgeon | *Scaphirhynchus albus* | R | N |
| Shovelnose sturgeon | *S. platorynchus* | C | D |
| Paddlefish | *Polyodon spathula* | C | D |
| Shortnose gar | *Lepisosteus platostomus* | C | D |
| Gizzard shad | *Dorosoma cepedianum* | A-C | D |
| Rainbow trout | *Salmo gairdneri* | R | N |
| Goldeye | *Hiodon alosoides* | A | I |
| Northern pike | *Esox lucius* | C-R | N |
| Carp | *Cyprinus carpio* | C | D |
| Silvery minnow | *Hybognathus nuchalis* | R | D |
| Flathead chub | *Hybopsis gracilis* | R | D |
| Emerald shiner | *Notropis atherinoides* | A | N |
| Red shiner | *N. lutrensis* | C | N |
| Sand shiner | *N. stramineus* | C-R | N |
| Fathead minnow | *Pimephales promelas* | C-R | N |
| River carpsucker | *Carpiodes carpio* | A-C | N |
| White sucker | *Catostomus commersoni* | R | D |
| Blue sucker | *Cycleptus elongatus* | R | N |
| Smallmouth buffalo | *Ictiobus bubalus* | C | D |
| Bigmouth buffalo | *I. cyprinellus* | C | D |
| Shorthead redhorse | *Moxostoma macrolepidotum* | R | D |
| Black bullhead | *Ictalurus melas* | R | D |
| Channel catfish | *I. punctatus* | A | I |
| Blue catfish | *I. furcatus* | R | D |
| Stonecat | *Noturus flavus* | R | D |
| Flathead catfish | *Pylodictus olivaris* | R | N |
| Burbot | *Lota lota* | R | N |
| White bass | *Morone chrysops* | A-C | I |
| Green sunfish | *Lepomis cyanellus* | R | N |
| Orangespotted sunfish | *L. humilis* | R | N |
| Bluegill | *L. macrochirus* | R | N |
| Largemouth bass | *Micropterus salmoides* | R | N |
| White crappie | *Pomoxis annularis* | C | D |
| Black crappie | *P. nigromaculatus* | C-R | D |
| Johnny darter | *Etheostoma nigrum* | R | N |
| Yellow perch | *Perca flavescens* | A | D |
| Sauger | *Stizostedion canadense* | C | D |
| Walleye | *S. vitreum vitreum* | A | I |
| Freshwater drum | *Aplodinotus grunniens* | C | N |

[a]A = abundant; C = common; R = rare.
[b]I = increasing; D = decreasing; N = no trend.

second-most-numerous species taken in those years. Walleye catches increased almost steadily from 1954 to 1973.

Four less common species (on the basis of CPE in gill nets) were white bass, yellow perch, saugers, and freshwater drum (Table 4). The yellow perch and freshwater drum were abundant during the mid-1950's, but the numbers caught then declined and annual numbers varied widely. Adult white bass were not collected until 1965; later their numbers increased, and their CPE's in 1970 and 1973 were equal. Saugers were abundant in the mid and late 1950's, but thereafter their numbers decreased, especially after the closure of Big Bend Dam in 1963.

The CPE for adult fish of all species was highest in 1955, the 3rd year of impoundment, and lowest in 1959 and 1967 (Table 4). Catches increased in 1970 but decreased again in 1973 to about half that in 1955.

Three species—bigmouth and smallmouth buffalo and paddlefish—were not readily captured in gill nets of the mesh sizes used in this study, but were nevertheless important in Lake Francis Case. Bigmouth and smallmouth buffalo are the major species taken by contract commercial fishermen (Donald C. Warnick, South Dakota Department of Game, Fish and Parks,

Table 3. *Average number of young-of-the-year fish of different species seined per hectare, Lake Francis Case, 1956-61 and 1966-75.*[a]

| Species | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gizzard shad | 391 | 500 | 1,216 | 64 | 46 | 113 | 12 | 1,088 | 255 | 72 | 73 | T | 390 | 117 | 309 | 123 |
| Goldeye | — | — | 37 | 4 | — | 25 | 2 | 2 | 2 | — | 4 | — | T | 2 | T | 2 |
| Carp | 6 | 33 | 3 | 4 | 5 | 72 | T | 15 | T | 1 | 1 | 6 | 1 | T | — | 6 |
| Silvery minnow | 98 | 158 | 52 | 1 | 390 | 17 | — | — | — | — | — | T | — | T | T | T |
| Flathead chub | 80 | 8 | 2 | 1 | 1 | 31 | — | — | T | — | T | T | T | T | 1 | — |
| Emerald shiner | 273 | 368 | 474 | 158 | 782 | 288 | 30 | 516 | 184 | 110 | 236 | 270 | 46 | 14 | 797 | 323 |
| Red shiner | 2 | — | — | — | T | — | 33 | 24 | 2 | 3 | 22 | 17 | 7 | 1 | 55 | 11 |
| Sand shiner | — | T | — | — | 8 | — | 1 | — | T | — | T | 3 | 34 | T | 2 | 1 |
| Fathead minnow | T | 1 | 12 | — | T | 2 | 3 | 1 | — | — | T | 1 | 7 | — | 1 | — |
| River carpsucker | 248 | 16 | 12 | 16 | 33 | 10 | T | 4 | 6 | 1 | 10 | T | 4 | 2 | 134 | 5 |
| Smallmouth buffalo | T | 3 | — | T | — | — | 2 | 13 | — | 1 | 1 | 7 | 4 | 7 | 2 | 32 |
| Bigmouth buffalo | 1 | 13 | 6 | 31 | 1 | 201 | 20 | 10 | — | 4 | 35 | 31 | 10 | 11 | 1 | 8 |
| Black bullhead | 42 | 115 | T | — | — | — | — | — | — | — | — | — | — | — | — | — |
| White bass | — | — | — | — | — | 1 | 20 | 130 | 635 | 624 | 103 | 181 | 142 | 86 | 127 | 917 |
| Orangespotted sunfish | — | 5 | — | — | — | — | 7 | 5 | — | 1 | 1 | 7 | 4 | — | 1 | 6 |
| Bluegill | 34 | 77 | 3 | 37 | 31 | 9 | — | 1 | T | T | 4 | 8 | 2 | T | — | T |
| Largemouth bass | 75 | 50 | 226 | 37 | 12 | 74 | T | 3 | T | T | — | T | 1 | T | T | 4 |
| White crappie | 4 | 21 | 243 | 29 | — | 55 | 582 | 197 | 1 | 4 | 1 | T | 32 | T | — | 12 |
| Black crappie | 18 | 1,034 | 545 | 168 | 12 | 861 | 433 | 61 | 1 | 3 | T | 4 | 9 | — | — | 4 |
| Yellow perch | 47 | 542 | 289 | 128 | 908 | 94 | 202 | 1,533 | 720 | 125 | 37 | 1,460 | 149 | 119 | 68 | 322 |
| Sauger | 5 | 7 | 15 | 12 | 7 | 4 | T | 1 | — | T | 1 | T | — | T | T | T |
| Walleye | — | — | — | — | — | — | 4 | 10 | 5 | 8 | 2 | 12 | 2 | 3 | 2 | 5 |
| Freshwater drum | 22 | 9 | 36 | T | 14 | 5 | 30 | 71 | 87 | 21 | 20 | 2 | 32 | 27 | 38 | 58 |
| Other species[b] | 2 | 4 | 3 | 1 | 1 | 4 | T | 4 | — | T | T | 1 | 1 | T | T | 2 |
| Total catch/hectare | 1,348 | 2,964 | 3,174 | 691 | 2,251 | 1,866 | 1,381 | 3,689 | 1,898 | 978 | 551 | 2,010 | 877 | 389 | 1,538 | 1,841 |
| Total area seined (ha) | 2.38 | 2.10 | 2.26 | 1.98 | 1.86 | 1.05 | 11.36 | 6.75 | 8.17 | 8.73 | 11.20 | 10.39 | 11.56 | 8.21 | 7.72 | 7.57 |

[a]T = less than 0.5 fish/ha.

[b]Shortnose gar, northern pike, blue sucker, shorthead redhorse, flathead catfish, channel catfish, burbot, green sunfish, and johnny darter.

Table 4. *Average catch of fish per gill net lift, Lake Francis Case, 1954-73.*[a] *Similar gill nets were used in all years except that in 1967-73 the nets included two additional 15.2-m panels of mesh sizes 12.7 and 17.8 cm. Few fish were collected in the added panels.*

| Species | 1954 | 1955 | 1956 | 1959 | 1962 | 1967 | 1970 | 1973 |
|---|---|---|---|---|---|---|---|---|
| Shovelnose sturgeon | 2 | 1.4 | 0.1 | 0.1 | 0.3 | 4.9 | 0.8 | 1.2 |
| Shortnose gar | 2 | 0.6 | 0.6 | 0.1 | — | 0.1 | 0.9 | 0.2 |
| Gizzard shad | 1 | 14.9 | 3.6 | 0.3 | 0.1 | T | T | — |
| Goldeye | 4 | 2.9 | 7.8 | 4.3 | 18.8 | 4.8 | 16.6 | 10.0 |
| Northern pike | — | 0.1 | T | 0.3 | 0.1 | 0.1 | 0.2 | 0.1 |
| River carpsucker | 1 | 3.9 | 4.3 | 3.4 | 0.7 | 2.4 | 9.7 | 4.0 |
| Smallmouth buffalo | 1 | 2.7 | 1.0 | 0.5 | 0.2 | 0.2 | 0.7 | 0.3 |
| Bigmouth buffalo | 4 | 4.3 | 0.8 | 0.2 | — | 0.1 | 0.5 | 0.3 |
| Shorthead redhorse | 1 | 0.3 | 0.4 | — | — | T | 0.1 | T |
| Carp | 13 | 16.6 | 10.8 | 5.9 | 3.8 | 2.6 | 5.4 | 4.2 |
| Channel catfish | T | 2.7 | 4.4 | 3.7 | 1.7 | 4.1 | 7.7 | 5.9 |
| Black bullhead | 2 | 11.2 | 4.7 | — | — | 0.2 | T | 0.1 |
| White bass | — | — | — | — | — | 0.2 | 0.9 | 0.9 |
| White crappie | T | 4.5 | 4.9 | 2.9 | 3.1 | 0.1 | 0.1 | 0.2 |
| Black crappie | T | 1.3 | 2.1 | 0.3 | 0.2 | T | T | 0.1 |
| Yellow perch | 4 | 3.5 | 7.2 | 1.1 | 3.1 | 3.9 | 1.6 | 2.7 |
| Walleye | — | T | 0.5 | 0.1 | 0.8 | 4.3 | 14.1 | 9.8 |
| Sauger | T | 3.8 | 6.9 | 5.5 | 2.6 | 1.2 | 1.6 | 0.7 |
| Freshwater drum | 1 | 6.3 | 4.5 | 1.2 | 1.1 | 0.8 | 1.2 | 1.5 |
| Other species[b] | 1 | 1.1 | 0.3 | T | — | 0.3 | 0.3 | 0.2 |
| Total CPE | 37 | 82.1 | 64.9 | 29.9 | 36.6 | 30.3 | 62.4 | 42.4 |
| Gill net sets | — | — | 37 | 35 | 12 | 163 | 95 | 98 |

[a]T = Less than 0.5 in 1954, and 0.05 in the other years.

[b]Pallid sturgeon, paddlefish, rainbow trout, white sucker, blue sucker, blue catfish, stonecat, flathead catfish, burbot, green sunfish, orangespotted sunfish, bluegill, and largemouth bass.

personal communication). Only large fish are marketed; most are older than 5 years and weigh more than 2.3 kg. The fishery began in 1959, and catches reached a peak of 220 metric tons in 1960, but gradually declined to 54 metric tons by 1975 (Fig. 3). Gears used in the fishery are large-mesh gill nets and hoop nets. Gill nets were fished in all years, and hoop nets were added in 1966; catch by gear was not recorded. Landings during the early 1970's were fairly stable and averaged about 57 metric tons.

The paddlefish is declining steadily in Lake Francis Case because the closure of Big Bend Dam at the upper end of the reservoir in 1963 apparently eliminated its river spawning grounds (Friberg 1972). The fish concentrate in the tailwaters below Big Bend Dam each spring, and a snag fishery for paddlefish began in 1967. Studies in 1969-71 (Friberg 1972) indicated that 80% of the fish landed were over 14 years old. Average weight was 28 kg, and fish weighing less than 11.5 kg were rare. Angler harvest decreased from a peak of 2,831 fish in 1971 to 900 in 1974 (Kallemeyn 1975). The South Dakota Department of Game, Fish and Parks is attempting to determine the feasibility of maintaining a fishable population in the reservoir by artificial propagation (Kallemeyn 1975).

## *Growth*

Growth was determined for species for which collections were adequate to enable comparison between two or more time periods. Species were goldeyes, river carpsuckers, carp, white bass, yellow perch, saugers, walleyes, and freshwater drum; time periods were 1954-59 (fish collected in 1954, 1955, 1956, and 1959), 1962-67 (fish collected in 1962, 1965, and 1967), and 1970-73 (fish collected in 1970 and 1973). Growth comparisons indicated that changes occurred as the reservoir aged. For goldeyes, river carpsuckers, yellow perch, and freshwater drum, growth was best during the 1950's, poorest in the 1960's, and intermediate or somewhat improved in the early 1970's (Table 5). For carp, saugers, and walleyes, growth generally decreased during each successive time period; the decrease was most pronounced for walleyes. White bass, first collected in 1965, differed little in growth between 1965-67 and 1970-73.

The exact cause for changes in fish growth could not be determined but is probably related to changes in reservoir productivity and food supply. Neel (1968) discussed the decrease in productivity of Lake Francis Case during the first 5 years of impoundment.

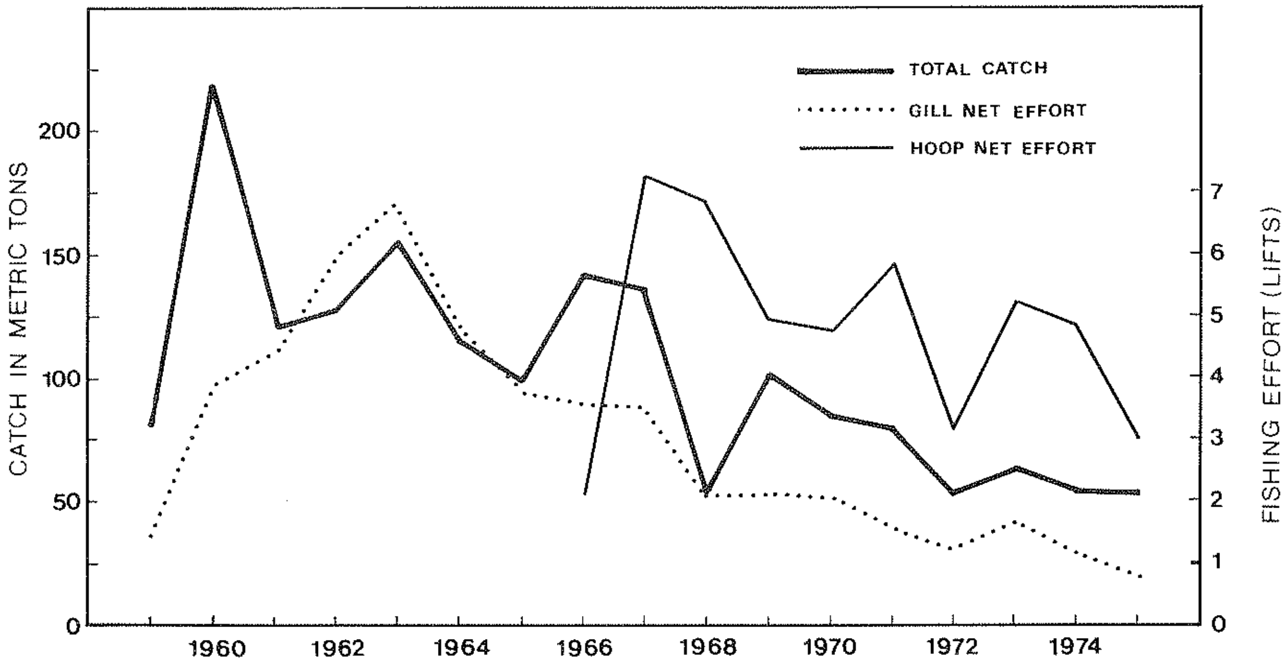


Fig. 3. Commercial catch (scale at left) of buffalofish in Lake Francis Case, 1959-75. Fishing effort for gill nets in thousands of lifts and for hoop nets in hundreds of lifts (scale at right).

## Some Causes for Population Change

Apparent trends in abundance of the 39 fish species collected in Lake Francis Case from 1954 through 1975 were as follows: 4 were increasing, 18 were decreasing, and 17 showed no trend (Table 2). Abundance of individual fish species depends partly on reproductive success, and spawning requirements differ among species. Fishes whose spawning requirements were provided in the reservoir reproduced successfully and others did not.

The species whose abundance increased between the early years of impoundment and the mid-1970's were goldeyes, channel catfish, and walleyes; white bass increased in abundance between the mid-1960's (when they were introduced) and the 1970's. Suitable spawning habitat developed within the reservoir for these species, although most goldeyes probably spawn in the White River (NCRI, unpubl. data).

Species whose abundance decreased require either a riverine habitat or shallow backwater areas with flooded vegetation to complete their early life stages. Common fishes whose abundance was most affected by the nearly total loss of riverine spawning habitat when Big Bend Dam (Fig. 1) was closed in 1963 were shovelnose sturgeon, paddlefish, and sauger. Decrease in abundance of the remaining species was apparently related to water-level fluctuations during their spawning and early nursery periods, and deterioration of spawning habitat. Embayments and backwaters are relatively few in Lake Francis Case, and aquatic vegetation is scarce because of water-level fluctuations. Terrestrial shoreline vegetation is flooded only in high-water years. Spawning habitat in embayments has deteriorated over the years because of shoreline erosion.

Most species whose numbers changed little in collections over the years were relatively scarce, and it was not possible to determine trends in abundance. Conditions necessary for successful reproduction of these species are limited or lacking in Lake Francis Case. The exceptions were emerald shiners, river carpsuckers, red shiners, and freshwater drum, whose spawning requirements were provided in the reservoir, and which remained either abundant or common.

### *Water-Level Regimen*

Most fish species collected from Lake Francis Case spawn in shallow water, and shallow areas occur only in tributary embayments or in the upper reservoir. Water-level fluctuations during spring and early summer, when fish spawn or when the young are in nursery areas, can be critical to the hatching of eggs and survival of the young. Water levels during spring and summer are determined by climatic factors and the annual water-management plan of USACE.

Table 5. *Calculated total length at end of each year of life for eight fish species from Lake Francis Case collected during 1954-59[a], 1962-67[b], and 1970-73[c]. Includes postimpoundment growth only. (Numbers of fish in parentheses.)*

| Species and years | Average length (mm) at end of year | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Goldeye | | | | | | | | | |
| 1954-59 | 124(422) | 243(319) | 300(101) | 325( 12) | — | — | — | — | — |
| 1962-67 | 108(181) | 224(170) | 283(142) | 313(100) | 328( 40) | 338( 8) | 346( 1) | 355( 1) | — |
| 1970-73 | 116(386) | 238(317) | 290(212) | 316(158) | 335(115) | 345( 62) | 350( 24) | 365( 5) | — |
| River carpsucker | | | | | | | | | |
| 1954-59 | 75(123) | 177(114) | 276( 85) | 347( 36) | 392( 19) | 437( 7) | — | — | — |
| 1962-67 | 55(194) | 154(194) | 250(193) | 322(189) | 374(164) | 413(126) | 441( 67) | 461( 27) | — |
| 1970-73 | 64(161) | 165(158) | 257(148) | 328(137) | 380(126) | 420(107) | 447( 59) | 462( 9) | — |
| Carp | | | | | | | | | |
| 1954-59 | 147(742) | 273(556) | 348(261) | 399( 15) | — | — | — | — | — |
| 1962-67 | 90(253) | 205(250) | 308(209) | 404( 63) | 468( 34) | 550( 7) | 668( 1) | 694( 1) | — |
| 1970-73 | 121(156) | 213(156) | 276(156) | 320(156) | 351(147) | 377(101) | 397( 32) | — | — |
| White bass | | | | | | | | | |
| 1965-67 | 124(256) | 218(129) | 271(102) | 324( 1) | — | — | — | — | — |
| 1970-73 | 122(167) | 225( 63) | 275( 45) | 318( 25) | 340( 10) | 369( 4) | — | — | — |
| Yellow perch | | | | | | | | | |
| 1954-59 | 81(518) | 150(458) | 191(204) | 216( 19) | — | — | — | — | — |
| 1962-67 | 57(105) | 134( 63) | 173( 16) | — | — | — | — | — | — |
| 1970-73 | 65(232) | 147(185) | 183( 46) | 205( 9) | — | — | — | — | — |
| Sauger | | | | | | | | | |
| 1954-59 | 141(536) | 312(478) | 424(115) | 488( 22) | 519( 3) | 576( 1) | — | — | — |
| 1962-67 | 134(225) | 263(183) | 339(142) | 413( 69) | 480( 29) | 536( 7) | 593( 1) | — | — |
| 1970-73 | 146(148) | 263(137) | 344( 92) | 408( 52) | 461( 21) | 499( 10) | 548( 2) | — | — |
| Walleye | | | | | | | | | |
| 1954-59 | 123( 22) | 325( 22) | 460( 2) | — | — | — | — | — | — |
| 1962-67 | 148(402) | 277(270) | 369(194) | 442(137) | 505( 80) | 562( 55) | 586( 26) | 606( 11) | 629( 2) |
| 1970-73 | 102(404) | 237(326) | 320(240) | 389(127) | 456( 50) | 511( 26) | 548( 13) | 586( 8) | 616( 2) |
| Freshwater drum | | | | | | | | | |
| 1954-59 | 91(501) | 172(380) | 227(147) | 272( 25) | 320( 4) | — | — | — | — |
| 1962-67 | 68(211) | 146(180) | 197(167) | 234(120) | 259( 72) | 296( 37) | 324( 19) | — | — |
| 1970-73 | 72(225) | 154(212) | 203(174) | 237(106) | 263( 68) | 290( 42) | 315( 26) | 328( 13) | 352( 1) |

[a]Fish collected in 1954, 1955, 1956, and 1959.
[b]Fish collected in 1962, 1965, and 1967 (except white bass, which were taken only in 1965 and 1967).
[c]Fish collected in 1970 and 1973.

The annual water-level regimen in Lake Francis Case is affected by hydrologic events over the upper Missouri River Basin—primarily snowfall—during the previous winter. Spring-summer water elevations in the reservoir were relatively low in years when snowfall was average or less and relatively high in years when snowfall was above average. This relation is illustrated in Fig. 2 for 1970 and 1971. In 1970, when the snowpack was near normal, the reservoir water level reached a peak near 415 m above msl during early May, and then fell to 413 m by the end of June. It remained near this elevation until early August and then fell to about 411 m by late September. In 1971, when the snowpack was about 150% of normal, the water level rose from 414 m above msl in early May to about 415 m by mid-June. It remained near this elevation until the end of August and then decreased to slightly less than 414 m by the end of September.

In low-water years such as 1968-70 (Table 6), terrestrial plants (mostly annuals) or semiaquatic vegetation invade the shore and shallow-water areas of embayments. Colonization and growth by the pioneer species become intense, especially after several consecutive low-water years. When the vegetation is flooded in a high-water year such as 1971 (Table 6, Fig. 2), and especially during the May-June spawning period, excellent spawning and nursery conditions are provided for species that spawn near shore. These findings are in agreement with studies on other main stem Missouri River reservoirs (Elrod and Hassler 1971,

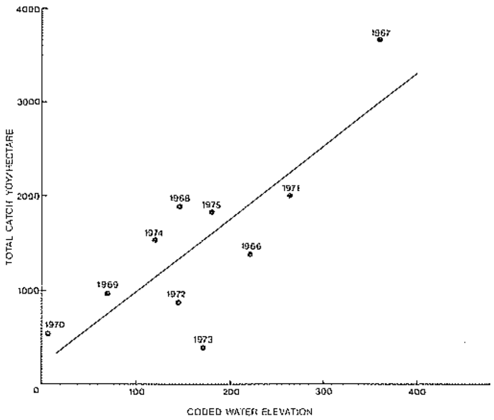


Fig. 4. Relation of difference between average May and June water elevation (cm) and total YOY fish seined per hectare, Lake Francis Case, 1966-75. Water elevation was coded by adding 160 to each year's elevation to eliminate minus values.

June 1976, and Walburg 1976), and in Russian reservoirs with similar fish species (Il'ina and Gordeyev 1972). Water levels leading to these favorable conditions have occurred in only 5 of the 18 years since the reservoir water elevation reached the base of annual flood control (411.5 m above msl) in 1957.

The relation between change in May-June water levels in 1966-75 and the total annual catch of YOY fish during these years (Fig. 4) was highly significant ($r=0.80$; $P<0.01$). Species whose YOY abundance was most closely associated with water levels were yellow perch ($r=0.80$; $P<0.01$) and walleyes ($r=0.62$; $P\cong 0.05$). However, as is shown later, abundance of YOY walleyes was also directly related to the abundance of YOY yellow perch.

The detrimental effect of the fall drawdown on reservoir benthos and periphyton was shown by Cowell and Hudson (1968) and Claflin (1968). The benefit to benthos that resulted from a reduction of this drawdown from 10-12 m to 6-7 m, beginning in 1971, was demonstrated by Benson and Hudson (1975). A fall drawdown of 6-7 m dewaters about 73 $km^2$ of reservoir shore. It seems clear from these studies that maintaining high water levels in the fall and winter would result in a significant increase in standing crops of bottom fauna.

If the water management regimen of 1971-75 is continued, the fish population in the reservoir will probably remain similar to that of the early 1970's. Common sport species will be walleyes, channel catfish, and white bass; commercial species will be goldeyes, river carpsuckers, carp, bigmouth buffalo, and smallmouth buffalo; and forage species will be emerald shiners, gizzard shad, and yellow perch.

Table 6. *Average monthly water elevation in meters above mean sea level, Lake Francis Case, May-August, 1966-75.*

| Year | May | June | July | August |
|---|---|---|---|---|
| 1966 | 413.5 | 414.1 | 413.5 | 412.8 |
| 1967 | 412.9 | 414.9 | 415.6 | 414.7 |
| 1968 | 412.8 | 412.7 | 412.4 | 412.1 |
| 1969 | 414.3 | 413.4 | 413.7 | 412.8 |
| 1970 | 414.7 | 413.2 | 413.2 | 412.7 |
| 1971 | 413.8 | 414.8 | 414.7 | 414.8 |
| 1972 | 415.7 | 415.5 | 415.2 | 414.6 |
| 1973 | 413.3 | 413.4 | 413.1 | 412.7 |
| 1974 | 412.9 | 412.5 | 413.0 | 412.3 |
| 1975 | 414.9 | 415.1 | 414.9 | 413.4 |

## *Shoreline Modification*

Wind-generated waves, together with seasonal water-level fluctuations, have caused considerable bank erosion which straightened irregular shores, eliminated small embayments, and reduced habitat diversity (N.G. Benson, NCRI, unpubl. manuscr.). Further, soil cover has been eroded from exposed shores, and the beach in many areas is now sand and gravel with scattered rubble and boulders. In the main reservoir, the basin is steep and has a relatively narrow littoral shelf that lacks aquatic vegetation. Shallow water (1-2 m) is generally confined to embayments and the upper end of the reservoir. The development of gravel-rubble shorelines created ideal spawning conditions for the walleye (Nelson and Walburg 1977) which is now one of the most abundant reservoir species (Table 4).

The upper portions of embayments generally have soft bottoms composed of silt and clay washed from surrounding hills or deposited from tributary streams. This condition has been aggravated by overgrazing of cattle pastured adjacent to the reservoir and is especially critical on lands surrounding embayments. This sedimentation has eliminated or severely reduced the quality and quantity of spawning and nursery habitat available to fishes that spawn near shore. Declining populations of bluegills, crappies, largemouth bass, and black bullheads (Table 3) are related to sedimentation and aging of the reservoir. Studies in Lake Oahe, another main stem Missouri River reservoir, have also shown that degradation of littoral spawning areas was responsible for the decrease in numbers of fish species and in the abundance of the species that remained (June 1976).

### Forage

The annual abundance of YOY walleyes in 1966-75 (Table 3) was closely correlated with the abundance of YOY yellow perch during these years ($r=0.85$; $P<0.01$). This suggests a dependence or preference of YOY walleyes for YOY yellow perch as food, which was verified in studies of the food of YOY walleyes collected from Lake Francis Case in 1966-69 (NCRI, unpubl. data). The diet consisted primarily of YOY yellow perch, especially during the early summer.

Other investigators have also shown a close relation between walleyes and yellow perch. Nelson and Walburg (1977) found that abundance of YOY walleyes and yellow perch in Lake Sharpe, another main stem reservoir in South Dakota, was highly correlated ($r=0.85$; $P<0.01$). Forney (1974) found that the abundance of YOY yellow perch indirectly controlled the size of the walleye population in Oneida Lake by regulating cannibalism. Heyerdahl and Smith (1971) found a close correlation between estimates of relative strength of year classes for yellow perch and walleyes in the Red Lakes. They believed that the two species were dependent on some common factor for survival.

## Management Recommendations

Fish abundance and growth in Lake Francis Case could be improved if the annual water management plan for the reservoir were modified. Modification is possible because the main stem reservoirs are managed as a system and portions of one reservoir's function can be assigned temporarily to another. Shoreline vegetation must be flooded during the spring to ensure the survival of young fish. Such flooding would not only increase fish abundance but should also improve growth of predators by increasing the forage base. Abundance of bottom fauna could also be increased by maintaining a higher reservoir pool during the fall and winter.

It is suggested that summer reservoir pool levels be kept low (range 411-413 m above msl) for two consecutive years to encourage growth of shoreline vegetation, and then raised the 3rd year (415 m above msl or higher) to flood the vegetation. The high pool should be maintained through July. This 3-year management cycle could then be repeated, beginning with the 4th year. Increased growth of shoreline vegetation has value also in reducing shoreline erosion. Cattle must be kept from grazing this vegetation, especially along shores of embayments, either by fencing or by some other method.

A water management plan similar to that described above to increase the abundance of young fish in main stem Missouri River reservoirs was suggested by Benson (1976). McClendon (1976) wrote that any departure from present operational plans of the main stem Missouri River reservoirs creates conflicts with major project purposes—flood control, hydroelectric power, and navigation—and judgment decisions must be made as to which will prevail. He further stated, however, that operations to enhance fisheries are important to the overall development of the water resource and that they would be pursued to the degree practical without undue interference with other project purposes.

## Acknowledgments

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