IOWA CONSERVATION COMMISSION
FISHERIES SECTION

FEDERAL AID TO FISH RESTORATION

ANNUAL PERFORMANCE REPORT

MAN-MADE LAKE INVESTIGATIONS

PROJECT NO. F-88-R-1

Study No. 501-2 - The Effects of Cage Reared and Released Channel Catfish on Established Fish and Benthic Fish Food Populations

Job 1. Vital statistics of cage reared and released channel catfish
Job 2. Dynamics of released channel catfish and native fish populations
Job 3. Benthic invertebrate standing crop and production

PERIOD COVERED: 1 JULY, 1973 to 30 JUNE, 1974

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

PROJECT NO.: F-88-R-1

STUDY NO.: 501-2

JOB NOS.: 1, 2 and 3

NAME: The Effects of Cage Reared and Released Channel Catfish on Established Fish and Benthic Fish Food Populations

TITLE: Job 1 - Vital statistics of cage reared and released channel catfish

Job 2 - Dynamics of released channel catfish and native fish populations

Job 3 - Benthic invertebrate standing crop and production

Period Covered: 1 July, 1973 through 31 June, 1974

ABSTRACT: *The effect of cage reared and released channel catfish on native fish and benthic invertebrate populations was evaluated at Williamson Pond. From 1971-1973, 8,291 catfish weighing 1,146 kg were released and mean annual stocking rate was 33 kg/ha. Harvest of catfish one year after release ranged from 48-80%. The 1971 release was almost entirely depleted by fishing and natural mortality within three years. Weight loss occurred in winter with a mean of 7.7% body weight. High overwinter mortality occurred in 1972-1973. Growth was accelerated by cage culture, but declined the year following release. Even with slow growth catfish were large enough to utilize fish as food items during their second year after release. Standing stock of catfish increased from 228 kg prior to release in 1971 to 950 kg after the third release in 1973. Availability of benthic food items to catfish was affected by severity and depth of the thermocline. In 1971, 67 kg/ha were available as food, while 83 kg/ha and 53 kg/ha were available in 1972 and 1973. Major food items in the catfish diet were dipteran larvae, but as catfish became larger they depended more on fish species. Also, released catfish ate food waste and droppings which escaped from the cages. More empty stomachs, poorer body condition and lowest benthic invertebrate production occurred in 1973.*

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Date approved: 30 September, 1974

STUDY OBJECTIVE

To evaluate the impact of stocking cage reared channel catfish at 50 kg/ha on endemic fish and benthic communities so this technique can be used to its maximum benefit in small impoundments.

JOB 1 OBJECTIVE

Determine the food consumption and selection, growth rate, body condition and length-weight relationship of released channel catfish after rearing in cages.

JOB 2 OBJECTIVE

Determine population density and the sources and extent of mortality for major fish populations.

JOB 3 OBJECTIVE

Estimate standing crop and production of benthic food organisms before and after releases of cage reared channel catfish.

INTRODUCTION AND STUDY BACKGROUND

Cage culture has recently become a popular fish rearing technique. Initial research on cage culture commenced in 1966 in Arkansas by the State College, at Auburn University in Alabama and Southern Illinois University in Illinois. The fish farming industry in southern states successfully adopted this procedure and many conservation agencies are experimenting with cage culture as an alternative to open pond and raceway culture.

The Iowa Conservation Commission initiated a cooperative program with 25 county conservation boards in 1971 to cage culture channel catfish. The main objective was to rear yearling catfish to a size large enough during one growing season to escape predation.

The Fisheries Section provided the catfish and technical assistance for care and feeding, while the county boards provided the cages, feed and personnel to feed the fish. Approximately 600 catfish were placed in a cage 2 m x 1 m x 1.3 m. Feeding commenced when water temperature approached 18°C in mid-May. Mean length of catfish was 110 mm and weighed 18 g. Fish were fed a pelleted ration daily at 3-4% of their body weight. Mean body weight was determined biweekly to compute daily food consumption.

Fish were released in September when water temperature declined to 18°C at an average size of 246 mm and 170 g. Statewide stocking rate was 32 kg/ha, but ranged from 6-144 kg/ha.

Success of this management technique will ultimately depend on the impact of the additional biomass on the fishery as a whole. Harvest rate of the released catfish will be of immediate and vital importance, but of equal importance will be the effect of the unharvested segment on indigenous fish and benthos populations. The impact of up to 144 kg/ha may be immediately advantageous to the angler, but over a long period the fishery will depend on the relationship of released catfish to native predator and forage populations. Catfish at 250 mm TL might compete with panfish for food and ultimately cause slower growth and stunted forage populations. The opposite might occur if the unharvested catfish population grew large enough to increase existing predator populations.

The effect of cage cultured and released channel catfish on native fish populations must be determined before this management technique can be utilized most effectively. An investigation was initiated in 1971 to evaluate the relationships between native fish species, benthos and released channel catfish.

Channel catfish were reared yearly at Williamson Pond from 1971-73 using identical procedures as county board cooperators. During the study 8,291 channel catfish were released weighing 1,146 kg. Population abundance, growth and body condition were determined for native fish populations before cage reared catfish were released. The standing crop and production of benthic food organisms was also determined previous to catfish releases. Native fish populations and benthic invertebrates were monitored after catfish were released to determine changes caused by an additional 30 kg/ha of catfish to the population. As groups of cage reared catfish were released they became discrete populations in the lake and food selection, growth rate, body condition, length-weight relationship and fishing mortality were determined.

DESCRIPTION OF WILLIAMSON POND

Williamson Pond is an 11.4 ha man-made impoundment two miles east of Williamson in Lucas County, Iowa. The lake was constructed in 1910 by the Rock Island Railroad Company as a water supply. In 1952 the lake was purchased by the Iowa Conservation Commission for a recreational area.

Maximum depth is 6.1 m with mean depth of 2.5 m. Volume development is 1.2 indicating a basin slightly concave toward the surface. Storage capacity is 285,000 m^3 at spillway crest elevation.

Thermal stratification was present from June-September in 1971-73. The metalimnion varied in depth from 1.5-3.5 m with complete oxygen depletion in the hypolimnion.

The watershed contains 693 ha of mixed row crop and pasture in the upper watershed and mature oak-hickory timber near the lake. Originally, the entire watershed was oak-hickory, but since 1950 much of the woodland was cleared for pasture or grain crop production. Lake surface to watershed ratio is 1:61 and siltation from heavy erosion on the light clay soil was a problem. In 1973, turbidity was so great from silt runoff that growth of the aquatic plants diminished greatly. Aquatic macrophytes were well established in 1971 and 1972 when water was less turbid.

The lake was drained and renovated in 1953 and restocked. Fish species present in 1971 include bluegill, white crappie, black crappie, largemouth bass, redear sunfish, green sunfish, black bullhead, channel catfish and carp. Panfish species were abundant with normal growth. Largemouth bass, redear sunfish, green sunfish, carp and bullhead were rare. Channel catfish were common before the cage rearing program.

METHODS AND PROCEDURES

Population estimates were determined for native channel catfish in 1971 by multiple census, mark and recapture method and in 1972 for crappie, bluegill, redear sunfish and bullhead. Catfish were caught with wooden slat traps baited with cheese trimmings. Traps were 1.3 m long by .3 m deep and .3 m wide and had two sets of fykes at one end of the box to contain the fish after they entered the trap. Other fish species were captured with .6 by 1.2 m frame-fyke nets with 23 mm mesh web and 12 m leads.

Growth and body condition of native fish were computed by SHAD, a computer program for age and growth studies (Mayhew, 1973). Cross sections of pectoral spines were used to estimate growth rate of channel catfish, while scales were used to compute growth of other species. Growth and condition of released catfish were determined from successive measurements of fish with serially numbered dart-type tags. In 1971, 446 tagged fish were released, while 1,010 were tagged in 1972 and 1,150 in 1973.

Food habits of released channel catfish were determined from 36 stomachs in 1971 and 52 stomachs in 1973. Stomachs were taken monthly from April-October for both native catfish and release groups. Total stomach contents were measured volumetrically and food items identified to subfamily. An electivity index was used to determine food selection. Ivlev's equation

$$EI = \frac{R_i - P_i}{R_i + P_i}$$

was used where EI was electivity index, R_i the percent occurrence of the i^{th} food item in the stomach and P_i the percent occurrence of the same food item in the benthic invertebrate sample.

Benthic invertebrates were sampled with core sampler. Dimensions of the extractor tube were 76 mm in diameter by 460 mm long. Both ends were open, but the upper end was fitted with a removable rubber stopper so the sampler could be set in the substrate with the stopper out. This position prevented the organisms from being swept away by hydrostatic pressure as the sampler was lowered. After the sampler was set in the substrate to a depth of 150 mm the stopper was secured in the upper end and the core was extracted without loosing the substrate. The tube was fitted with brackets and extension rods so samples could be taken to a depth of 5.8 m. Substrate samples were separated through a No. 30 sieve and preserved in 5% formalin for future separation. Organisms were identified to subfamily, enumerated and weighed to the nearest .001 g.

Fourteen stations were located at four transects and three cores were taken at each station biweekly from April - October. Depth of sampling ranged from 1 m at Stations 1, 5, 6, 10, 11 and 13 to 2-3.5 m at Stations 2, 12 and 14 and 3.5-5.5 m at Stations 3, 4, 7, 8 and 9.

Harvest inventory of native and released fish was estimated by an expandable survey technique from 15 September-28 October, 1971, and 15 April-30 September in 1972-73. Census period was from 8 AM-10 PM and divided into 14, one-hour periods. All fishermen were counted and interviewed during the period to determine the number of each species kept, length of time fished and if the trip was complete. Sampling was stratified by weekend and week days with census periods chosen randomly from each strata, so independent estimates were computed for weekend and week day fishermen.

FINDINGS

STOCKING

Channel catfish were cage reared and released at Williamson Pond in 1971, 1972 and 1973. On 5 May, 1971, 2,400 catfish were placed in four cribs. Each cage contained 7.1 kg with the mean weight of fish about 12 g. The following autumn, from 23 September-20 October, 1,743 catfish were released. The loss of 650 fish between initial stocking and release was primarily due to smaller individuals escaping from confinement by swimming through the hardware cloth. Mean length and weight at release was 260 mm and 179 g, with a total biomass of 313 kg.

The following year 2,400 catfish weighing 37 kg were placed in the four cribs. Mean body weight was 15 g on 18 May. From 11 September-2 October, 1,840 catfish weighing 299 kg were released. Again, escapement of smaller catfish from the crib was responsible for most of the difference.

On 24 April, 1973, 4,800 catfish were individually counted and placed in eight cribs. Mean weight was 32 g. Feeding continued through 5 October when 4,708 channel catfish weighing 533 kg were released. Total stocking from the

3 year program was 8,291 catfish weighing 1,146 kg. Approximately 1,300 escaped from cages, but they were small sized and survival was doubtful and they were not counted as released fish in the population.

HARVEST

Short term harvest of cage reared and released channel catfish was important to the success of the program. If fish were not caught, the population would gradually decrease from natural mortality. More important biomass of released and unharvested catfish would increase and exert additional competition on native fish species.

Releases started on 23 September, 1971, and anglers immediately started catching the fish. Catfish harvest was estimated through 28 October when fishing activity diminished. During this period 49 released catfish were taken weighing 9 kg.

Harvest inventory was resumed on 15 April, 1972, and continued through 30 September. During this census 4,632 anglers fished 14,869 hours and caught 13,669 fish. Channel catfish comprised 12% of the catch, or 1,640 fish. Catch composition of other species was 69.5% bluegill, 10.4% crappie, 4% largemouth bass, and 3.4% bullhead. Redear sunfish and green sunfish contributed < 1% to catch. Of the catfish caught, 187 were native, 1,345 were cage reared in 1971 and 108 were reared in 1972.

Mean weight of cage reared channel catfish was 220 g while mean weight of native catfish was 763 g. Biomass of catfish removed during 1972 was 439 kg or 38 kg/ha.

Fishing success for channel catfish at Williamson Pond was .08 fish per hour (F/H). Greatest success was .31 F/H from 19 September to 20 October when catfish cultured in 1972 were being released, but the high success lasted only two weeks. Poorest success was .03 F/H from 16 to 29 May. Bluegill were the most frequently caught fish and comprised nearly 70% of the catch, but only 10% of the anglers were fishing for them. Anglers fishing for any species contributed 37% to the sample, while 36% were specifically fishing for channel catfish.

In 1973, 3,861 anglers fished 9,528 hours and caught 3,857 fish. Bluegill were most abundant in the catch with 42%, while channel catfish ranked second with 36%. Bullhead, crappie and largemouth bass contributed 11%, 8% and 3%, respectively.

Anglers took 1,410 channel catfish in 1973 with 56% from the 1972 release, 37% from the 1971 group, 5% were native and 2% were from the 1973 group caught in September. Mean weight of reared catfish was 224 g and native catfish was 1,020 g. Total biomass removed was 370 kg. In 1973, anglers harvest of channel catfish was 32 kg/ha.

Fishing success in 1973 for channel catfish was .14 F/H. The period of greatest success was 5-18 September just prior to release of reared catfish when .25 fish were caught per hour. Poorest success was from 30 May-12 June when catch effort was .04 F/H.

In 1973, 57% of the anglers were fishing specifically for channel catfish, while 34% were fishing for any species. Six percent fished for bass, 2% for bluegill and 1% for crappie.

GROWTH AND CONDITION

Growth and body condition of bluegill, white crappie and channel catfish in 1971 and 1972 was compared to determine changes resulting from the release of 1,146 kg of catfish during the three years. Retarded growth and condition would indicate adverse competition, while no change or increased growth would indicate stocking channel catfish enhanced the fishery.

Growth history and condition of bluegill was determined from 83 scale samples and body measurements in 1972. Average calculated lengths were 48, 100, 137, 157 and 180 mm for ages I-V. Percent deviation of growth from mean annual increments showed 1967 was the best year of growth with 6% above the 1967-1971 average (Table 1). Poorest growth was 12% below average in 1968, while growth index in 1969-1971 was slightly above average. Condition factor (K) of bluegill in May, 1972 varied from 2.19-2.44 with a mean of 2.33.

Table 1. Growth indices of bluegill, white crappie and channel catfish in 1967-1971 at Williamson Pond.

Year	Bluegill	White crappie	Channel catfish
1967	+ 6	+10	+9
1968	-12	-11	+9
1969	0	-13	+8
1970	+ 3	+ 6	+4
1971	+ 2	+ 9	--

Growth of white crappie was determined in 1972 from 45 body and scale measurements. Mean lengths at ages I-V were 66, 135, 176, 201 and 218 mm. Best growth was in 1967 and 1971 when it was 9% and 10% above average. Poorest growth was -13% in 1969 and -11% in 1968. Growth in 1970 was slightly above normal. Condition factor of white crappie ranged from 1.23-1.60 with a mean of 1.41.

Growth of channel catfish indigenous to Williamson Pond was estimated in 1971 from body and spine measurements of 123 fish. Age V fish were most numerous and contributed 81% to the sample. The large year class was attributed to good survival of 3,000 channel catfish stocked fingerlings. Ages I-IV were rare or absent from the sample showing no natural reproduction nor survival occurred. Also, catfish were not stocked in those years.

Mean lengths for ages I-IX were 63, 157, 243, 307, 370, 414, 435, 458 and 489 mm. Best years of growth were in 1967 and 1968 when the growth index was +9% based on an average from 1963-1970 (Table 1). In 1969, the index declined slightly to +8% followed by another decline to +4% in 1970. Poorest growth was in 1966 when growth index was -20%.

Condition factor was computed for each 25 mm size interval beginning at 254 mm. Mean condition factor was .92 and ranged from .83-1.05. As length increased, condition remained constant.

First year growth for both cage reared and native channel catfish occurred at hatchery ponds. The difference was cage cultured fish were stocked in cages at 10 months, while native catfish were stocked directly in the pond at four months. Also, catfish used for the cage rearing program were obtained from Arkansas where the spawning season was earlier and greater growth was attained. Mean length of cage reared fish was 106 mm compared to 63 mm for native fish after one year of growth (Figure 1).

Growth of caged catfish was also accelerated compared to native fish during the second year of growth. Mean increment of growth for catfish in the cribs was 143 compared to 93 mm for age II native fish (Figure 1). When cage cultured fish were released length was 248 mm, while native fish were 157 mm.

Growth increment declined after cage reared catfish were released at Williamson Pond. Catfish released during September, 1971, had a growth increment of 57 mm in 1972. Those released in September, 1972, increased 79 mm during 1973. Growth increment for native catfish was 86 mm during the third year of

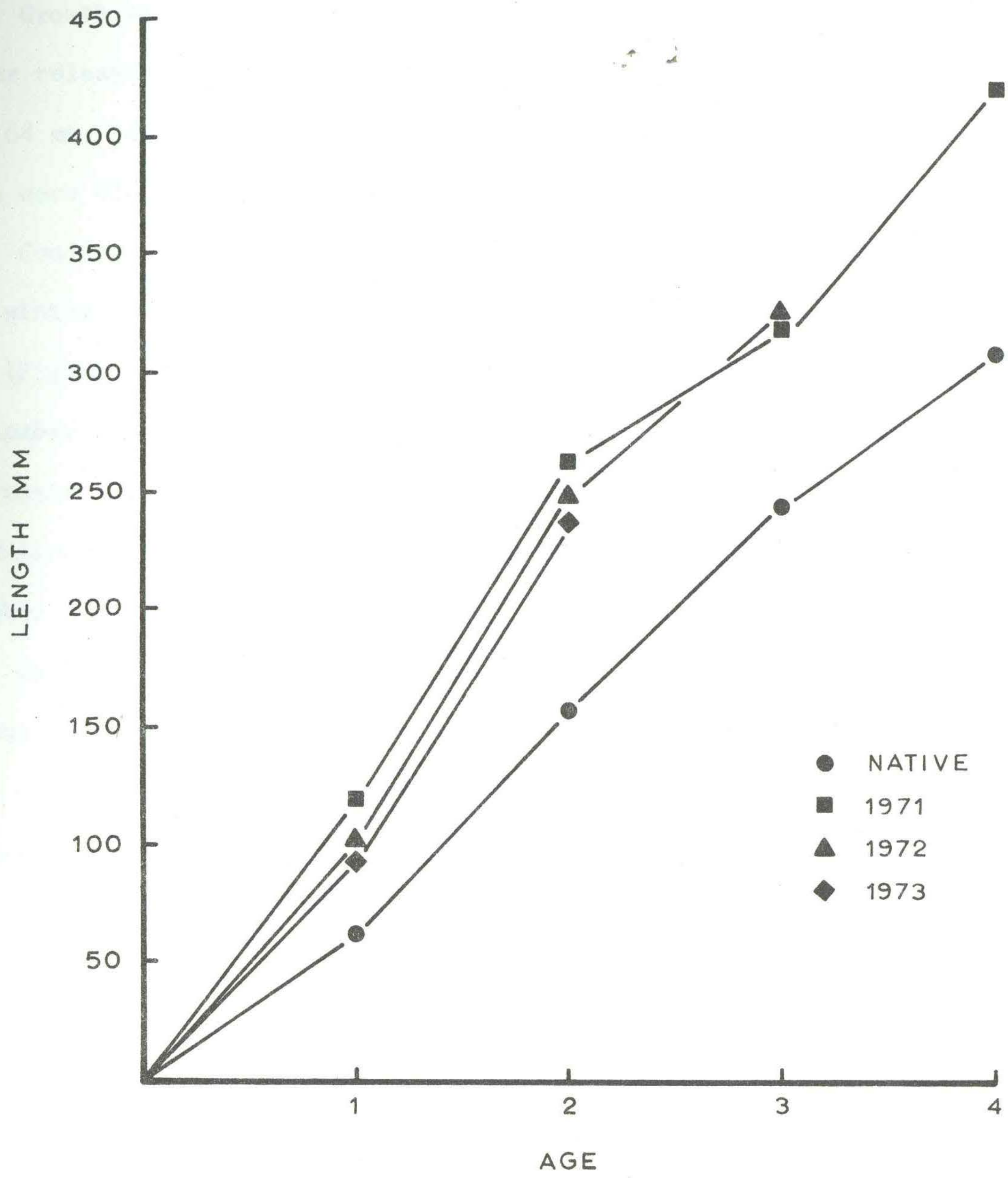

Figure 1. Growth of native and released channel catfish at Williamson Pond.

life. Although growth rate slowed after cage cultured fish were released they remained larger than native fish because of accelerated growth during the first and second year of life. Native catfish were 243 mm compared to 321 mm for cage reared fish after three seasons.

Growth rate of cage reared catfish increased during their second year after release. Annual increment was 101 mm, while increment for native catfish was 64 mm. After four years of growth native fish were 307 mm and cage reared fish were 420 mm.

Condition factor of channel catfish at release in 1971 was .99. During the winter period condition factor decreased and by May, 1972 the index was .80 (Figure 2). When growth commenced the condition factor increased and by September, 1973 condition factor was .94. Again, the condition factor decreased over winter to .88 in May, 1973. Unlike the 1972 growing season, condition factor failed to increase in 1973, but declined further to .74 by October.

Catfish released in 1972 showed a similar trend. Condition factor at release was 1.01 decreasing to .88 by May, 1973, and .83 by October, 1973. Mean condition of catfish released in October, 1973, was .82. Condition of native channel catfish was more stable and decreased gradually from .92 in September, 1971, to .88 in September, 1973.

STANDING STOCK

Standing stock of important native fish species and released catfish was estimated to determine changes in species biomass particularly after the cage reared catfish were released. In 1971, population estimates were made for native channel catfish, bullhead, bluegill, redear sunfish and crappie. Marking commenced on 9 June for channel catfish and continued through 12 August.

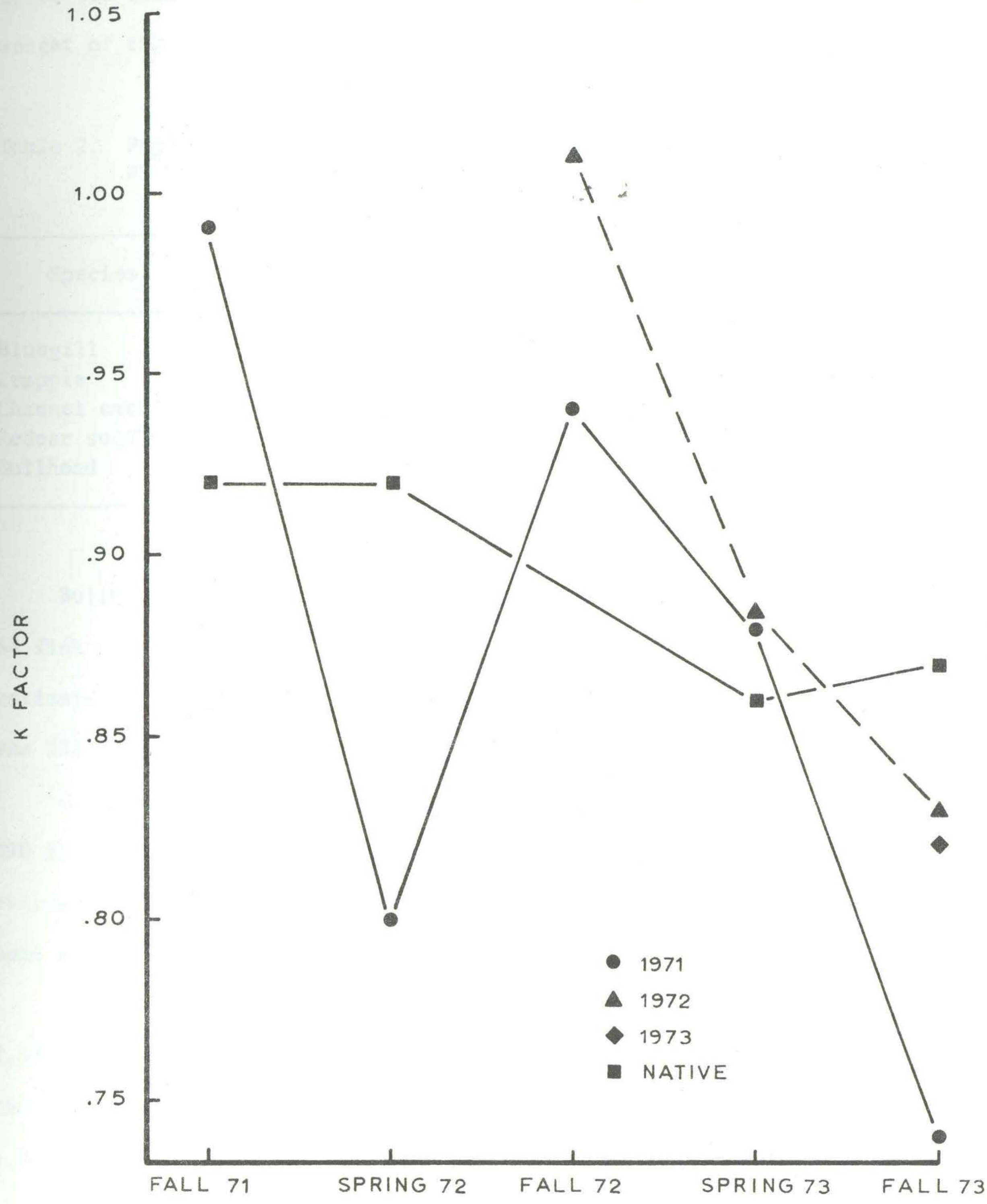

Figure 2. Condition factor (K) of channel catfish at Williamson Pond.

Cumulative population estimate was 364 with 95% confidence limits of 245-715 after 123 fish were captured, 100 marked and 16 recaptured (Table 2). Mean weight of the population was 626 g and standing stock 20 kg/ha.

Table 2. Population estimates and standing stock of important fish species at Williamson Pond in 1971.

Species	Estimate	95% confidence intervals	Kg/ha
Bluegill	29,084	21,210-46,049	221
Crappie	7,450	6,706- 8,380	71
Channel catfish	364	245- 715	20
Redear sunfish	573	492- 687	10
Bullhead	191	114- 586	4

Bullhead population estimate was determined from 25 April-6 October after 64 fish were captured, 48 marked and 8 recaptured (Table 2). Final cumulative estimate was 191 with 95% confidence from 114-586. Mean weight of bullhead was 256 g and standing stock was 4.3 kg/ha.

A population estimate was made for redear sunfish from April-October when 490 fish were captured, 322 marked and 140 recaptured. Final cumulative estimate was 573 with 95% confidence from 492-687. Biomass was computed from mean weight of 194 g at 9.7 kg/ha.

Population estimates of crappie were determined in the same period when 2,533 fish were captured, 2,065 were marked and 310 recaptured. On 6 October the cumulative estimate was 7,450. Confidence interval at the 95% level was 6,706-8,380. Mean weight of crappie was 110 g so standing stock was 71 kg/ha.

Bluegill population estimates varied from 21,210-46,049 during the period, but the final estimate was 29,084 after 1,643 fish were examined, 1,383 marked and 37 recaptured. Confidence interval at the 95% level was 22,097-42,534. Mean weight of bluegill was 111 g and standing stock 221 kg/ha.

Population estimates at Williamson Pond were made in 1957-1959 (Mayhew, 1960) for bluegill. In 1957 the estimate was 58,594, but after drawdown and intensive cropping the population declined to 34,736 in 1958 and 21,067 in 1957. Standing stock in 1958 was 302 kg/ha.

Standing stock of released channel catfish was determined by actual count and weight at release. Growth and mortality influenced numerical abundance and stock weight. Since natural mortality was not established in this phase of the study, standing stock was a maximum estimate. Standing stock of released catfish was computed in May and September before release, and October after release.

Standing stock of channel catfish at Williamson Pond prior to release of cage reared fish in 1971 was 364 fish weighing 228 kg. Numerical abundance increased to 2,107 and biomass to 541 kg after cage reared fish were released in October, 1971 (Table 3). After accounting for the 49 catfish that were harvested and body weight loss during the winter, catfish stock was estimated at 2,058 fish weighing 520 kg by April, 1972. During 1972 growth continued but harvest also became an important factor and by September, 1972, catfish stock was reduced to 526 fish weighing 252 kg. After the 1972 release, stock increased immediately to 552 kg (Figure 3). Fall harvest and weight loss over winter diminished the biomass to 2,271 fish weighing 493 kg by April, 1973.

There was a net loss of biomass from May-September in 1973. Angler harvest was greater than increase in growth and by September estimated stock was 1,057 catfish weighing 417 kg. Weight more than doubled after caged catfish were released and by October, 1973, population weight was 950 kg.

Table 3. Standing stock and numerical abundance of channel catfish at Williamson Pond. Values in parentheses are biomass in kg.

	1971		1972			1973		
Group	September	October	May	September	October	May	September	October
Native	364 (228)	364 (228)	364 (228)	177 (159)	177 (159)	177 (159)	104 (119)	104 (119)
1971		1,743 (313)	1,694 (292)	349 (93)	349 (93)	349 (77)	0 (0)	0 (0)
1972					1,840 (300)	1,745 (257)	953 (298)	953 (298)
1973								4,708 (533)
Total	364 (228)	2,107 (541)	2,058 (520)	526 (252)	2,366 (552)	2,271 (493)	1,057 (417)	5,765 (950)

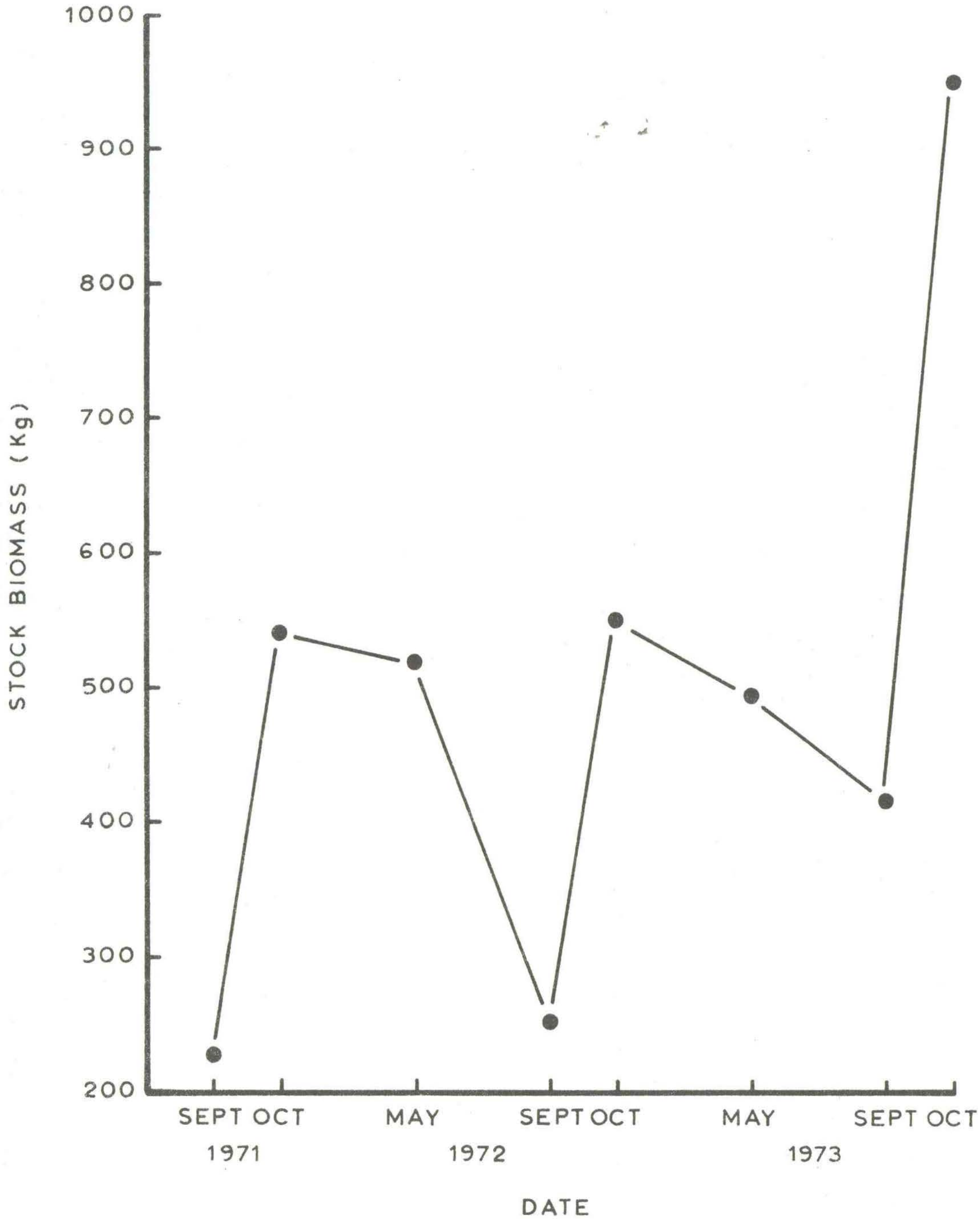

Figure 3. Standing stock of channel catfish at Williamson Pond.

BENTHIC INVERTEBRATES

Major groups of benthic invertebrates found in core samples were Diptera, Annelida and Mollusca. Combined they comprised 97% of all invertebrates. Other insect orders were Odonata, Ephemeroptera, Trichoptera and Coleoptera, but each contributed < 1%. Macrocrustacea such as amphipods and crayfish were extremely rare.

Dipteran larvae were further identified because more diversity occurred in this order. Families represented were Ceratopogonidae, Tendipedidae, Tabanidae and Culicidae. Tendipedidae was further identified to subfamilies Chironominae and Tanypodinae. Culicidae was wholly represented by the genus *Chaoborus*.

Cluster analysis was used to determine the relationship of Chironominae, Tanypodinae, Culicidae and Annelida with each of 14 sampling stations. The analysis is a multivariate technique forming a hierarchical arrangement of stations which have statistically similar means for each major taxa. The stations were ranked to form a cluster arrangement (Figure 4).

The analysis showed diversity at Stations 6 and 11 were most similar. Second most closely associated stations were 3 and 4, followed by 7 and 8, 1 and 5, 10 and 13 and 12 and 14. Station 9 was similar to 3 and 4, while 2 was associated with 12 and 14.

Further analysis showed 1, 5, 10, 13, 6 and 11 were very similar, but differed widely from 2, 12 and 14. Likewise Stations 2, 4, 9, 7 and 8 had means which were similar, but their combined means were different from the former two sets.

The three larger divisions were related most strongly to substrate depth. Stations 1, 5, 10, 13, 6 and 11 were near the shoreline of the transects with

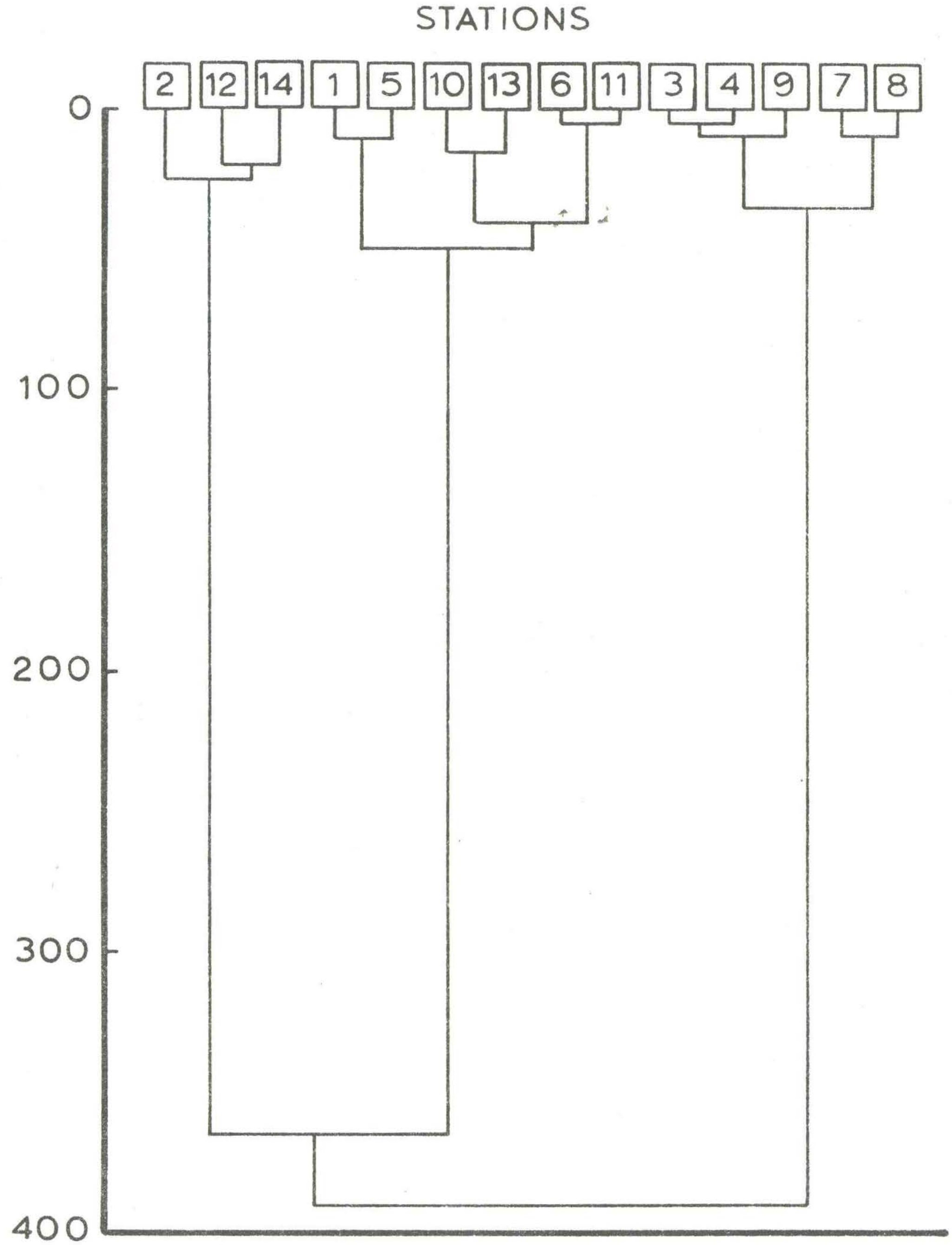

Figure 4. Cluster analysis of stations at Williamson Pond based on mean number of Chironominae, Tanypodinae, Culicidae and Annelida from each sample.

mean depth of 1 m. Stations 2, 12 and 14 were deeper with mean depth of 2.7 m, while Stations 3, 4, 7, 8 and 9 were deepest with mean depth of 4.9 m.

Species composition in 1971 was dominated by Culicidae which comprised 38.6% of all invertebrates (Table 4). The second most abundant family was Chironominae with 26.4% followed by Tanypodinae, 15.4%; Annelida, 7.5% and Ephemeroptera, 4.1%. In 1972, Culicidae made up by 46.1% and Chironominae, 17.8%. Tanypodinae decreased to 6.9%, but Annelida increased to 19.3%. In 1973, benthic invertebrate composition was similar except Culicidae and Annelida increased slightly, while Odonata and Ceratopogonidae declined.

Table 4. Percent composition of major invertebrate taxa at Williamson Pond in core samples.

Taxa	1971	1972	1973
Culicidae	38.6	46.1	47.9
Chironominae	26.4	17.8	17.6
Tanypodinae	15.4	6.9	6.8
Annelida	7.5	19.3	22.8
Ephemeroptera	4.1	1.0	1.0
Odonata	2.2	2.5	.6
Ceratopogonidae	1.8	1.0	.3
Mollusca	1.6	2.6	1.5
Other	2.4	3.0	1.5

Food availability is vital to the well being of native and released channel catfish. Benthic invertebrates were not homogeneously distributed in the reservoir with certain taxa more abundant during different periods of the season. The most important factor determining benthos availability was the depth and intensity of thermal stratification. This was particularly pronounced when dissolved oxygen concentration was low in the hypolimnion.

Chironominae and Culicidae were associated with deep water, while the other taxa were sampled primarily at shallower stations. When there was a well defined thermocline Chironominae and Culicidae were unavailable for catfish consumption.

Stratification in the reservoir began by 1 May and lasted to 1 October each year. The depth of thermocline during that period was inversely associated with the percent of lake bottom available to fish feeding activity. In 1973, the thermocline was at 1.3 m which reduced available area of substrate to 27% (Table 5). Normal thermocline depth was near 3 m. The upper range during midsummer was 73% available on 15 August, 1971, but mean available substrate was approximately 55% during the study.

Table 5. Percent available substrate to channel catfish at Williamson Pond.

Period	1971	1972	1973	Average
15 April	--	100	100	100
1 May	--	94	93	94
15 May	--	81	83	82
1 June	60	61	40	54
15 June	61	57	53	57
1 July	64	70	34	56
15 July	69	65	27	54
1 August	72	58	41	57
15 August	73	35	50	53
1 September	80	46	48	58
15 September	94	71	90	85
1 October	98	100	98	99

More important to catfish feeding and production than percent available area was available standing stock of benthic organisms above the thermocline. Peak standing stock of 122 kg/ha occurred on 15 July, 1972 and 206 kg/ha on

1 August, 1971 (Table 6). In 1973, standing stock was consistently lower with greatest biomass of 79 kg/ha on 1 October. Mean standing stock during the study was 67, 98 and 53 kg/ha in each of the three years.

Table 6. Standing stock of benthic invertebrates above the thermocline at Williamson Pond in kg/ha.

Period	1971	1972	1973
1 June	53	91	67
15 June	83	21	55
1 July	18	102	2
15 July	32	122	43
1 August	206	96	61
15 August	65	65	38
1 September	49	42	56
15 September	61	106	72
1 October	19	66	79
15 October	86	123	58
Mean	67	83	53

Production of benthic invertebrates was estimated from standing stock and mean annual temperature as determined by Johnson (1971). Production was defined as

$$P = \overline{B} \left[\frac{T^2}{10} \right]$$

where P is production in kg/ha/year, $\overline{B}$ is mean annual biomass and T is mean annual water temperature in °C. The component $T^2/10$ was the estimated turnover rate.

Mean annual temperature at Williamson was 13.4°C. Production estimates of available benthos was 1,206 kg/ha/year in 1971, increasing to 1,763 kg/ha/year in 1972 and decreasing to 955 kg/ha/year in 1973.

FOOD HABITS

Body length of the released channel catfish was about 250 mm and they were wholly dependent on benthic invertebrates for food. Food habits of 36 catfish captured in 1972 and 56 in 1973 showed consumption was mainly dipteran larvae. Most prominent in the diet were Chironominae, Tanypodinae, Culicidae and Ceratopogonidae and accounted for about 95% of the food items. Less frequent in the diet were fish remains, Odonata, Mollusca, Annelida and Ephemeroptera (Table 7).

Table 7. Percent composition of food items in stomachs and percent of stomachs containing each item for channel catfish at Williamson Pond in 1972 and 1973.

Food item	Percent composition of food item in stomachs		Percent of stomachs containing each item	
	1972	1973	1972	1973
Chironominae	43.3	19.0	54	64
Tanypodinae	36.8	.1	47	2
Culicidae	11.8	69.1	33	60
Ceratopogonidae	4.7	0	28	0
Odonata	1.8	.5	17	18
Mollusca	.9	.1	3	2
Annelida	.5	.4	6	4
Ephemeroptera	.2	2.3	3	12
Fish remains	.4	.5	14	54
Catfish food	----	----	3	30
Unidentified	4.1	3.7	20	62
Empty	----	----	17	22

Most prevalent items in 1972 were Chironominae, 43%; followed by Tanypodinae, 37%; Culicidae, 12%; and Ceratopogonidae, 5%. In 1973, percentage of food items in stomachs changed markedly. The most abundant food item was

Culicidae, 69%; followed by Chironominae, 19%. Tanypodinae and Ceratopogonidae contributed < .1%. Other food items remained about the same.

Occurrence of empty stomachs was greater in 1973 with 22% compared with 17% empty in 1972. Of the stomachs with at least one food item Chronominae was most important. In 1972, they were found in 54% of the stomachs compared to 64% of the samples in 1973 (Table 7). The greatest difference in food habits between these years was channel catfish ingested a greater diversity of food items in 1972. In 1973 they consumed mainly Chironominae and Culicidae.

Frequency of fish remains increased in stomach contents in 1973. During 1972, 14% of the stomachs contained fish remains, while 54% of the stomachs contained fish in 1973. Also, larger fish had a greater proportion of fish remains in the stomach contents. Fish remains were found in 80% of native catfish stomachs compared to 43% for 1971 released fish, 57% for 1972 released fish and 40% for 1973 released fish.

Commercial catfish food was also found in the stomachs. The only source of catfish food was waste from crib fed catfish. In 1972, 3% of the stomachs contained catfish food, but in 1973, 30% of the fish were eating at least some catfish food. Native catfish were more opportunistic with 60% containing catfish food. Stomachs from the 1971 and 1972 releases showed 29% of the fish were consuming catfish food, but only 20% of the 1973 released fish ate catfish food.

More fish were consuming catfish food in 1973 and the stomach volume was much greater than stomachs with invertebrate contents. Mean volume of stomachs containing invertebrates was 1.1 ml compared to 22 ml for fish which consumed catfish food.

Electivity indices varied widely during the season. Most food items ranged from -1 to +1 (Table 8). Chironominae ranged from +.26 in April to .76

Table 8. Electivity indices of four main food items found in stomachs of channel catfish at Williamson Pond.

Month	Chironominae	Tanypodinae	Culicidae	Ceratopogonidae
April	+ .26	+ .45	- .49	-1.0
May	+ .68	+ .72	+1.0	+ .85
June	+ .76	+ .38	+1.0	- .06
July	0	- .32	+ .88	+ .50
August	- .78	-1.0	+ .76	+1.0
September	- .65	+ .56	+ .26	+1.0
October	- .08	-1.0	+ .01	+ .92

in June when it steadily declined through August to -.78. By October it was near 0. Electivity indices for Tanypodinae were positive from April-June, but negative in July, August and October. Culicidae was selected as a food item by catfish. Positive electivity indices ranged from +1 in May to +.01 in October. Ceratopogonidae had electivity indices of -1 to +1. Positive selection occurred from June-October.

DISCUSSION OF FINDINGS

When cage reared channel catfish were released at Williamson Pond in 1971-1973 fish populations were immediately altered by several concommitent factors. First, standing crop was instantaneously increased by 33 kg/ha. Second, the biomass was altered more slowly by growth, natural mortality, fishing mortality and initial loss in body weight.

Angler harvest was the most obvious factor affecting population structure. Channel catfish were caught within two days after release and by freeze-up 50-100 were caught. Most of the fish were harvested the following summer. In

1972, 80% of the 1971 release were harvested while 48% of the 1972 release were taken during 1973. By October, 1973, nearly all of the 1971 release were taken by anglers.

Angler effort declined from 14,869 hours in 1972 to 9,528 hours in 1973, but fishing success increased. In 1972, angler catch was .08 catfish per hour compared to .14 catfish per hour in 1973. This was primarily due to more people fishing for channel catfish in 1973 than bluegill or crappie. Also, the cage rearing program gained popularity and the 1971 released fish were larger and highly desirable to anglers. Total fish removed was not greatly different between 1972 and 1973 when 1,640 and 1,410 catfish were harvested, respectively.

Removal of catfish by anglers was augmented by natural mortality which was not measured during this study segment. Considerable mortality was observed during the 1972-1973 winter and population estimates in 1974 will determine natural mortality of each release group. Standing stock estimate will be reduced further when natural mortality is computed.

Another factor contributing to decreasing biomass was the initial weight loss. This was expected because released catfish were expending more energy in movement and finding food items. Also, catfish were totally unfamiliar with feeding on benthic organisms for at least 5 months, but stomach analysis showed all released fish were consuming benthos within 12 days after release. Mean loss in weight from release date to 20 May was 7.7% with maximum loss of 33.1%. Seventy-three percent of the catfish lost weight, while 27% gained slightly or retained the same body weight.

Weight loss was accompanied by a decline in body condition. Condition factor increased slightly during the growing season, but during the study there was an overall decline in body condition. The decrease was particularly pronounced for cage reared fish, but native channel catfish condition factor also declined from .93 in 1972 to .87 in 1973.

Loss in weight of recently stocked fish and fishing mortality was compensated for by growth of larger unharvested fish. There was an increase in catfish standing stock from 228 kg before stocking in 1971 to 950 kg after the release in 1973. Factors influencing the increased standing stock of catfish was additional stockings in 1972 and 1973 combined with accelerated growth of fish released in 1971. Food habits showed larger fish were consuming fish and became less dependent on benthic invertebrates which were a major food source until catfish attained 325 mm. There were few catfish remaining in the 1971 release group after fishing mortality, but their growth, combined with releases in 1972 and 1973, increased standing stock over fourfold.

The accumulation of standing stock may not appear as great when natural mortality is computed, but natural mortality would have to be unusually high for standing stock to remain stable. This is particularly true since fishing mortality was high. The function

$$a = m + n - mn$$

where a is total mortality, m is fishing mortality and n is natural mortality shows that when both a and m are large then n must also be large. In 1972, fishing mortality was .8 and annual mortality was near .85-.9. Natural mortality would then be 25%-50%. Hence, standing stock at Williamson Pond would continue to increase until natural mortality became quite high.

The channel catfish cage rearing program at Williamson Pond was successful in two respects. First, channel catfish were large enough to escape predation at release and second, the released fish were readily caught by anglers. Also, a few catfish which weren't harvested started to become piscivorous.

This study is incomplete, but preliminary results indicate annual stocking of channel catfish at 30 kg/ha in a lake with thermal stratification is successful, but the stocking rate may be too great for long term utilization of the benthic invertebrate community unless exploitation by the sport fishery is high.

After 1974, practically all of the 1971 release group should be reduced by fishing and natural mortality and become of little consequence to the fishery. The 1972 release group should be reduced by approximately 90%. When the study is terminated in 1974 at least 80% of all stocked fish will be harvested or die of natural causes.

RECOMMENDATIONS

The study should continue through 1974 to determine harvest, body condition, growth and food habits of released channel catfish. Of particular importance to the study is natural mortality of released channel catfish. This should be determined by population estimates in 1974. Benthic invertebrate abundance and growth and condition of bluegill and crappie should also continue.

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