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Catfish Management in the James River, Virginia

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CATFISH MANAGEMENT IN THE JAMES RIVER, VIRGINIA

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APPROVAL SHEET

This thesis is submitted in partial fulfillment of
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ABSTRACT

Data from 3958 channel catfish, Ictalurus punctatus; 710 white catfish, I. catus; and 1648 brown bullheads, I. nebulosus collected during February of 1969 and 1970 from the James River, Virginia, were used to estimate parameters of importance in management.

Estimates of populations indicated that channel catfish are the most numerous of the catfishes in the James River, and that brown bullheads are more numerous in the oxbows than in the main channel. White catfish were scarce in both areas. Biomass of the four youngest age groups of these species was estimated.

Age was determined by length frequency analysis and examination of pectoral spine sections. The decline in abundance of successive age groups was used in estimating rate of survival (s), annual mortality rate (a), and instantaneous rate of total mortality (i) for all three species.

Analysis of current prices and estimated survival rate indicated that the greatest economic activity could be generated in the channel catfish fishery by harvest of Age Group II fish.

CATFISH MANAGEMENT IN THE JAMES RIVER, VIRGINIA

INTRODUCTION

This is a report of data gathered for eventual use in management of three species of catfish in the tidal portion of the James River, Virginia: the channel catfish, Ictalurus punctatus (Rafinesque); the white catfish, I. catus (Linnaeus); and the brown bullhead, I. nebulosus (Le Sueur). Population size, change in biomass of a year class from year to year, and mortality rates were estimated. These estimates were used as the basis of an economic comparison of two alternative uses of the resource, and for management recommendations.

Virginia catfish landings declined each year from 1959, when 3,079,700 pounds were taken, through 1965, when the harvest was 939,700 pounds. In 1966, a rise to 1,513,300 pounds was recorded. The catch in 1967 was 939,000 pounds valued at $125,334. The catfish industry was then 12th in value and 20th in volume among all U. S. fisheries. The cause of these changes in catch may be population variation, different levels of fishing effort, or a combination of factors. The average catch during the period from 1958 to 1967 was 2,026,320 pounds (Power, 1960, 1961, 1962, 1963; Power and Lyles, 1964; and Lyles, 1965, 1966, 1967, 1968, 1969).

Menzel (1945) presented length and weight measurements of channel catfish and white catfish in Virginia, while Carlander (1969) summarized life history information on all three species included in the present study.

MATERIALS

During 1969, channel catfish, white catfish, and brown bullheads were taken from the main channel and two oxbows of the James River, Virginia (Table 1). At two stations, J-40 and J-45, collections were also made in depths of approximately 15 feet adjacent to the channel. In 1970, the main channel and Turkey Island Oxbow were sampled. All specimens were collected from the R/V LANGLEY, owned by the Virginia Institute of Marine Science. A 30-foot semi-balloon trawl, with an inner liner of 1/2 inch stretch mesh in the cod end, was towed at a vessel speed of 2.5 knots.

In 1969, samples were taken at 5 mile intervals between points 25 miles and 84 miles above the mouth of the river (Fig. 1). Fishes were weighed in grams, measured to the nearest millimeter of fork length, and pectoral spines were removed from some specimens. In 1970, only fork lengths were recorded.

TABLE 1

Dates and location of catfish collections in the James River, Virginia.

River Mile	Date	Number of Channel Catfish	Number of White Catfish	Number of Brown Bullheads
J25	17 Feb 1969	0	0	0
J30	"	0	0	1
J35	"	0	0	1
J40	"	35	4	0
J40	6 Feb 1969	18	3	0
J40 (North of Channel)	"	86	3	0
J45	17 Feb 1969	98	9	1
J45	6 Feb 1969	368	78	0
J45 (North of Channel)	"	14	6	0
J50	17 Feb 1969	242	26	11
J50	6 Feb 1969	162	164	7
J55	"	349	5	11
J60	"	231	2	8
J65	12 Feb 1969	66	3	1
Turkey Island Oxbow	"	0	2	185
Turkey Island Oxbow	18 Feb 1969	104	13	594
J70	12 Feb 1969	26	0	0
Jones Neck Oxbow	18 Feb 1969	65	86	259
J75	12 Feb 1969	0	0	1
J80	"	0	0	0
J84	"	0	0	0
	1969 Totals	1864	404	1080
J30	19 Feb 1970	12	0	2
J35	"	5	8	0
J40	"	68	17	0
J41	24 Feb 1970	260	23	0
J42	19 Feb 1970	26	9	0
J44	24 Feb 1970	33	36	0
J46	19 Feb 1970	144	50	1
J46	24 Feb 1970	23	28	3
J50	19 Feb 1970	125	35	6
J52	"	54	25	4
J52	24 Feb 1970	389	18	75
J55	19 Feb 1970	203	9	78
J55	24 Feb 1970	139	25	113
J57	"	130	7	36

TABLE 1 (Cont.)

River Mile	Date	Number of Channel Catfish	Number of White Catfish	Number of Brown Bullheads
J60	20 Feb 1970	19	6	0
J65	"	49	0	2
J66	"	15	0	0
J66	24 Feb 1970	15	0	1
J67	20 Feb 1970	47	0	0
Turkey Island Oxbow	"	42	6	47
Turkey Island Oxbow	"	198	4	164
Turkey Island Oxbow	"	98	0	36
	1970 Totals	2094	306	568
	Grand Total	3958	710	1648

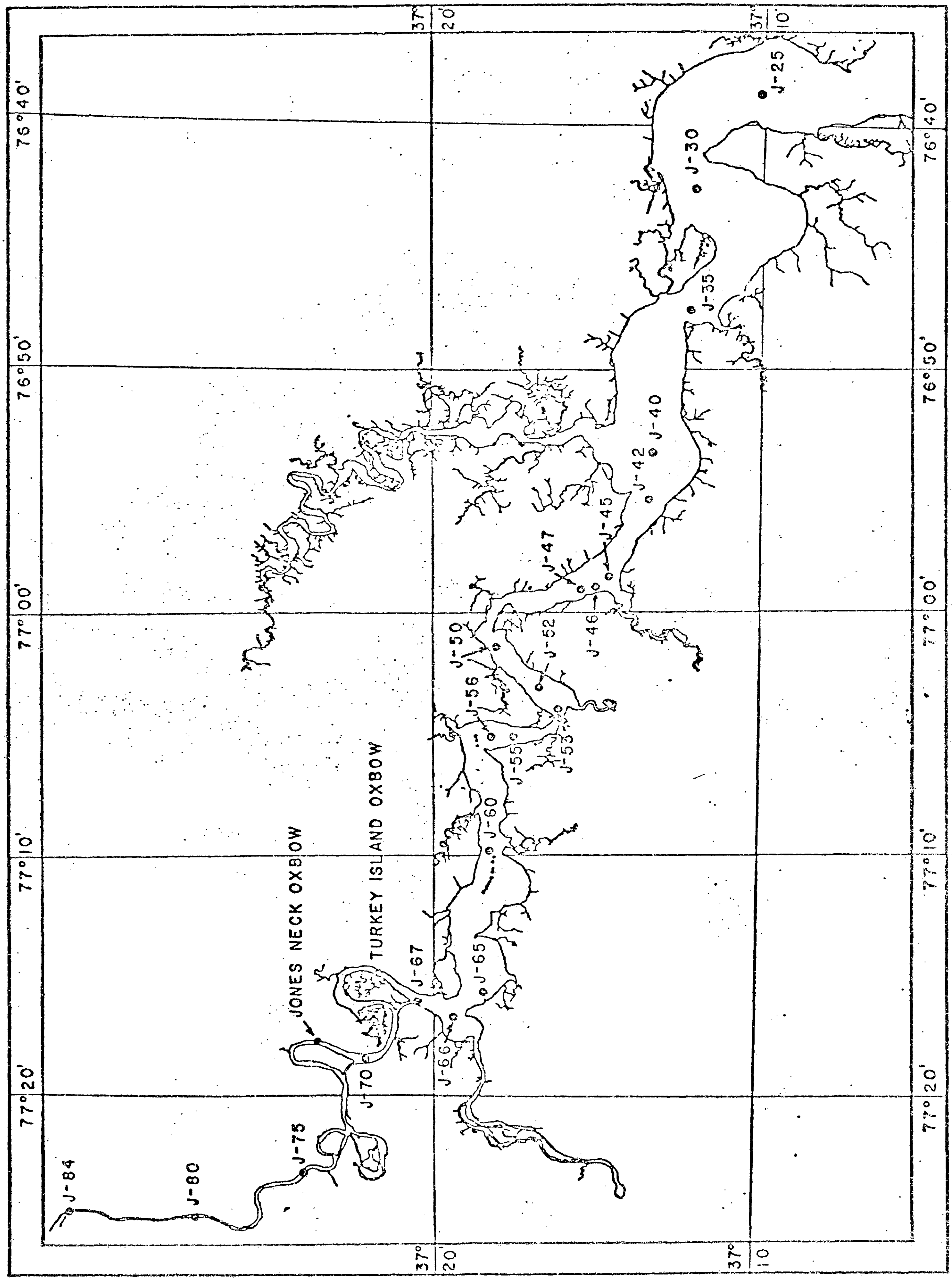

Figure 1. Locations of trawl stations in the James River, Virginia.

POPULATION AND BIOMASS

The area-density method, which is based on direct enumeration of representative samples, was used to estimate the total populations in the areas sampled in 1970. Requirements for the use of this method include a population which is nonmigratory during the sampling period and sufficient knowledge of the environment to establish areas of similar habitat, in order to randomly sample in such areas (Rounsefell and Everhart, 1953).

The 1969 collection indicated that most catfishes were in the 30 mile section of river between points 40 and 70 miles above the mouth. This section was divided into three subsections of 10 miles each. Six random samples were taken in each of the lower two subsections, while only four were possible in the upper because of time limitations. An oxbow was also sampled, since 1969 collections indicated that species composition there differed from that in the main channel. The 1969 collections covered 13 days, while in 1970, samples were taken within a six day period. All collections were made under winter conditions (Table 1).

The number of fish per hectare (Table 2) was determined by dividing the total catch of a given species by the total area covered by tows within the indicated limits of that species. Tows were made between charted buoys or landmarks to insure accurate estimation of distances covered. Main channel samples above river mile 59 were not used in the calculations for brown bullheads because

TABLE 2

Estimate of the catfish population in the James River, Virginia, in February, 1970.

	Channel Catfish		White Catfish		Brown Bullheads	
	Channel	Oxbow	Channel	Oxbow	Channel	Oxbow
Fish per Hectare	58	104	11	4	20	92
Total Number	129,652	6,379	24,187	266	20,644	5,608
Kilograms per Hectare	2.3	4.2	0.2	0.1	1.6	7.4
Total Biomass (Kilograms)	5,223	255	501	6	1,654	449
Area Sampled (Hectares)	30	2	27	2	16	2
Total Area (Hectares)	2,236	61	2,236	61	1,018	61

specimens found there were apparently stragglers from areas normally populated by this species.

Samples used to estimate the number of fish per hectare (Table 1) were taken from the area within the 20 foot isobath as indicated on U.S. Coast and Geodetic Survey Charts 530 and 531. It was assumed that all catfishes were concentrated within this boundary since it has been found that channel catfish, which are scattered in shallow water during warm weather, form tight schools in deeper water under cold conditions (Bureau of Commercial Fisheries, 1968). This area was determined by planimeter and multiplied by the number of fish per hectare to compute the total populations (Table 2).

Age data collected in 1969 were used to estimate the numbers of individuals present in each age group in 1970. Mean weights of these groups were then used to estimate the number of kilograms per hectare, the total biomass (Table 2), and the yearly change in biomass (Table 3). No more than 3.8% of the fish of any species were four years old or older, and a maximum of 0.8% were five years old or older. Scarcity of older fishes results partly from net escapement and partly from mortality. This selectivity and the presence of fishes outside the sample areas make this estimate a minimum.

Length-weight relationships were calculated on an IBM 1130 computer using the least squares method and data from 504 channel catfish, 146 white catfish, and 732 brown bullheads. Males and females were not separated. Measurements to the nearest millimeter and gram were used to compute the equations in Figure 2.

TABLE 3

Abundance and biomass of the four youngest age groups of catfishes in the James River, Virginia, in February, 1970.

	Age Group							
	I		II		III		IV	
	Channel	Oxbow	Channel	Oxbow	Channel	Oxbow	Channel	Oxbow
	Number of Individuals							
Channel Catfish	78,310	3,853	30,857	1,518	15,558	766	3,890	191
White Catfish	18,745	206	2,927	32	3,322	26	121	1
Brown Bullheads	8,712	2,367	8,258	2,243	3,386	920	248	67
	Biomass (kg)							
Channel Catfish	963	47	1,438	71	1,648	81	674	33
White Catfish	152	2	116	1	174	2	18	< 1
Brown Bullheads	316	86	732	199	523	142	71	19

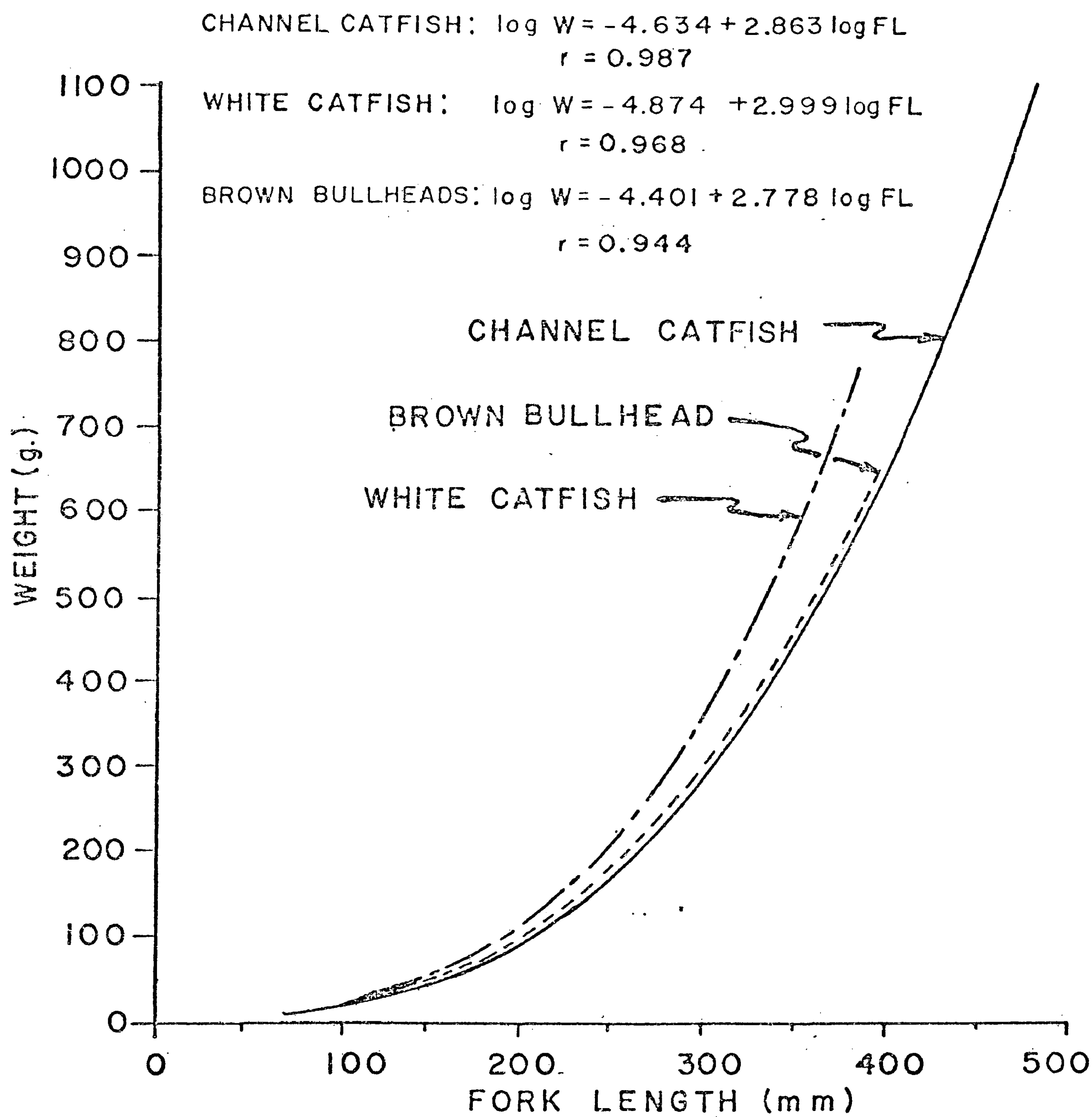

Figure 2. The relationship between fork length (FL) and weight (W) of catfishes collected from the James River, Virginia, during February 1969.

MORTALITY

Rate of survival (s), annual mortality rate (a), and instantaneous rate of total mortality (i) (Table 4) were estimated from the decline in abundance of successive age-groups by the method of Ricker (1958: 41, eq. 2.2). Data are insufficient to establish that recruitment is constant, a prerequisite for validity of this method. The 1969 year classes (one year old in 1970) of channel catfish and brown bullheads were in fact smaller in numbers than the 1968 year classes of these species at a similar age (in 1969). The 1969 year classes were, however, subjected to a near-record flood late in the summer of their first year, which may have reduced their survival rate. Data collected in February of 1969 were therefore used to estimate mortality (Table 5). All specimens were assigned an age, either by length-frequency analysis or by examination of pectoral spine sections.

Age was assigned on the basis of length to the extent that it was feasible to do so. The presence of at least three age groups was indicated by the length-frequency distributions of channel catfish and white catfish collected in 1969 and 1970 (Figures 3 and 4). Modes for the two and three year old brown bullheads were less distinct (Figure 5). Examination of pectoral spines from fishes representing each mode indicated that age groups I and II could be determined with reasonable accuracy from the length-frequency distributions.

TABLE 4

Estimates of mortality rates in the catfish population of the James River, Virginia, February 1969.

	Channel Catfish	White Catfish	Brown Bullhead
Rate of survival (s)	0.396	0.224	0.579
Annual mortality rate (a)	0.604	0.776	0.421
Instantaneous rate of total mortality (i)	0.926	1.494	0.547

TABLE 5

Abundance, lengths, and weights of catfish age groups in samples taken from the James River, Virginia, in February, 1969.

	Age Group						
	I	II	III	IV	V	VI	VII
			Number of Individuals				
Channel Catfish	1126	444	223	55	12	2	2
White Catfish	313	49	39	2	-	-	1
Brown Bullheads	456	432	177	13	2	-	-
			Mean Fork Lengths in mm				
Channel Catfish	87	155	210	245	282	413	442
White Catfish	83	140	177	202	-	-	383
Brown Bullheads	137	192	228	276	274	-	-
			Mean Weights in gm				
Channel Catfish	12	47	106	173	260	866	2050
White Catfish	8	40	75	151	-	-	846
Brown Bullheads	36	88	154	285	301	-	-

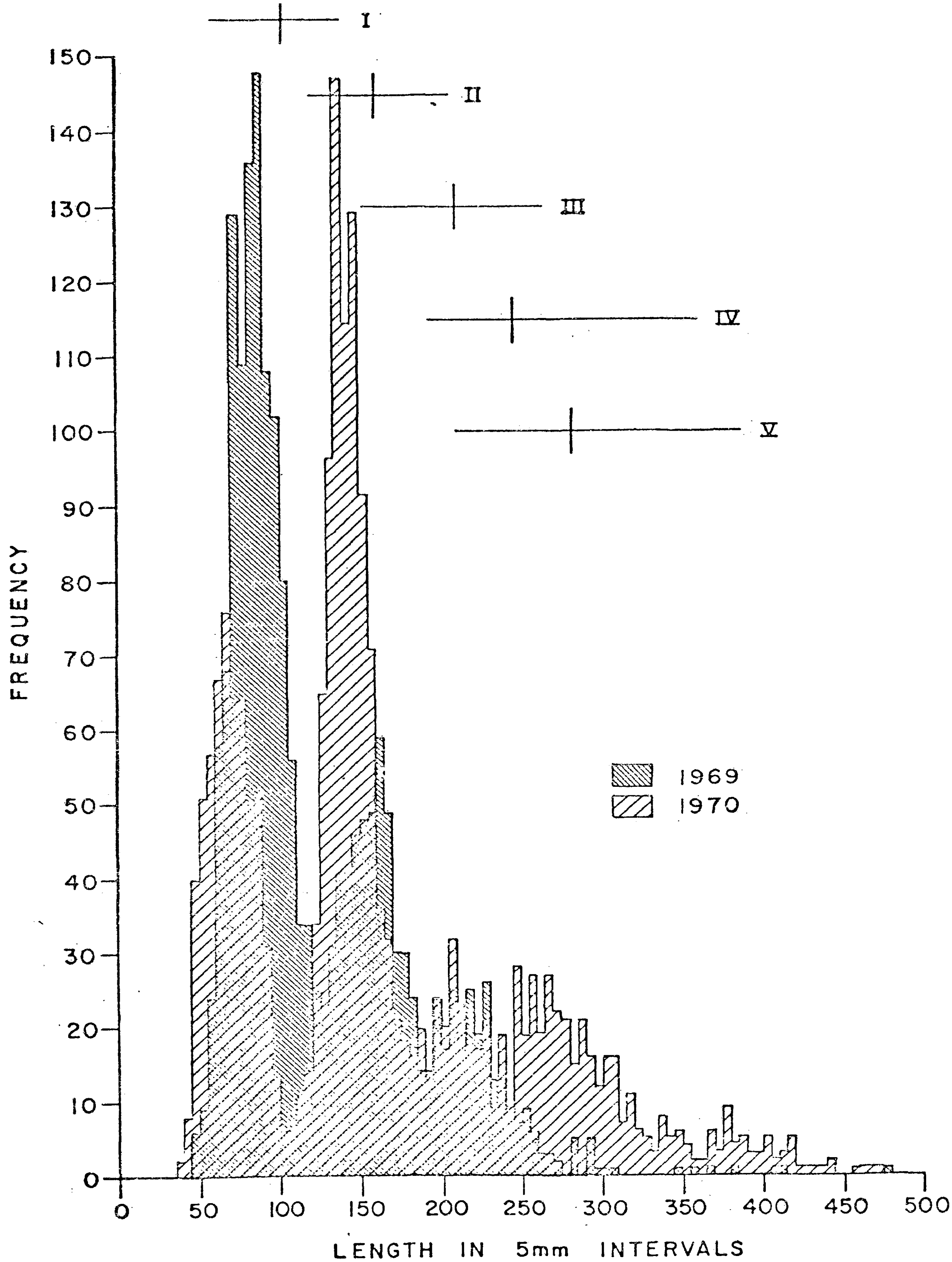

Figure 3. Length frequency distribution of channel catfish collected from the James River, Virginia, during 1969 and 1970. The crosses above represent mean length and range for each age group as determined by analysis of pectoral spines taken in 1969.

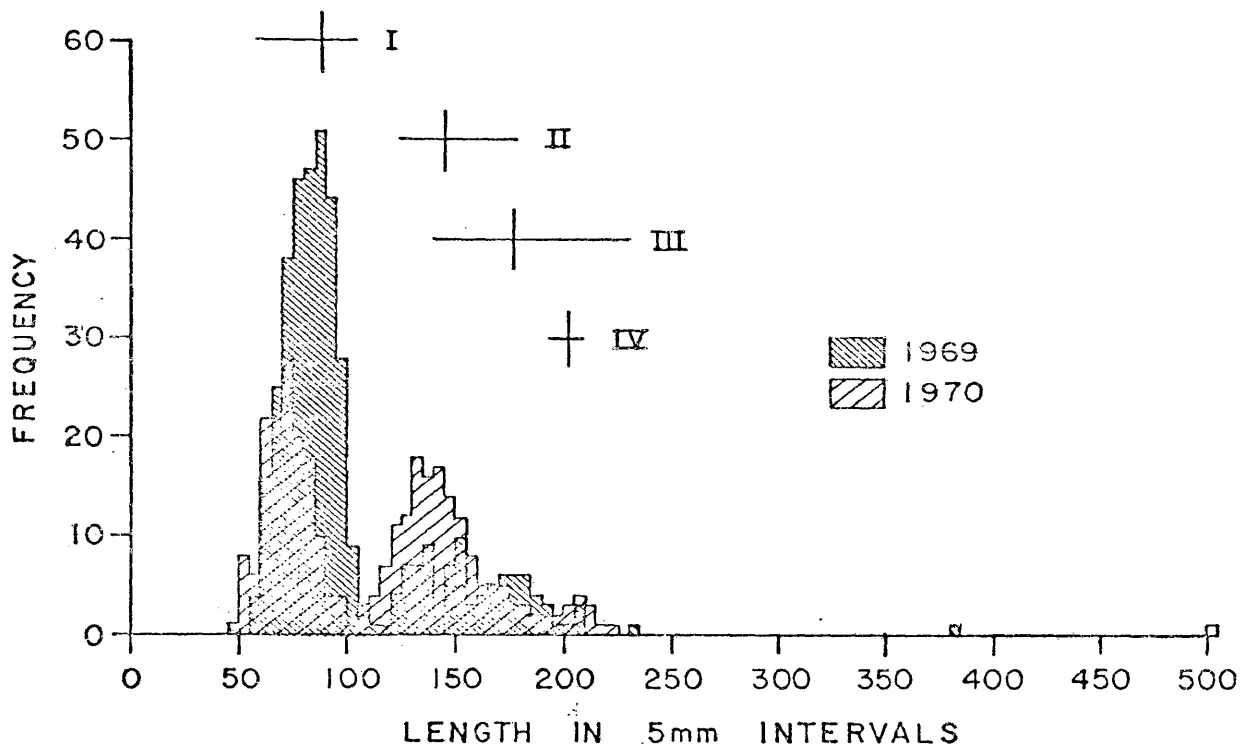

Figure 4. Length frequency distribution of white catfish collected from the James River, Virginia, during 1969 and 1970. The crosses above represent mean length and range for each age group as determined by analysis of pectoral spines taken in 1969.

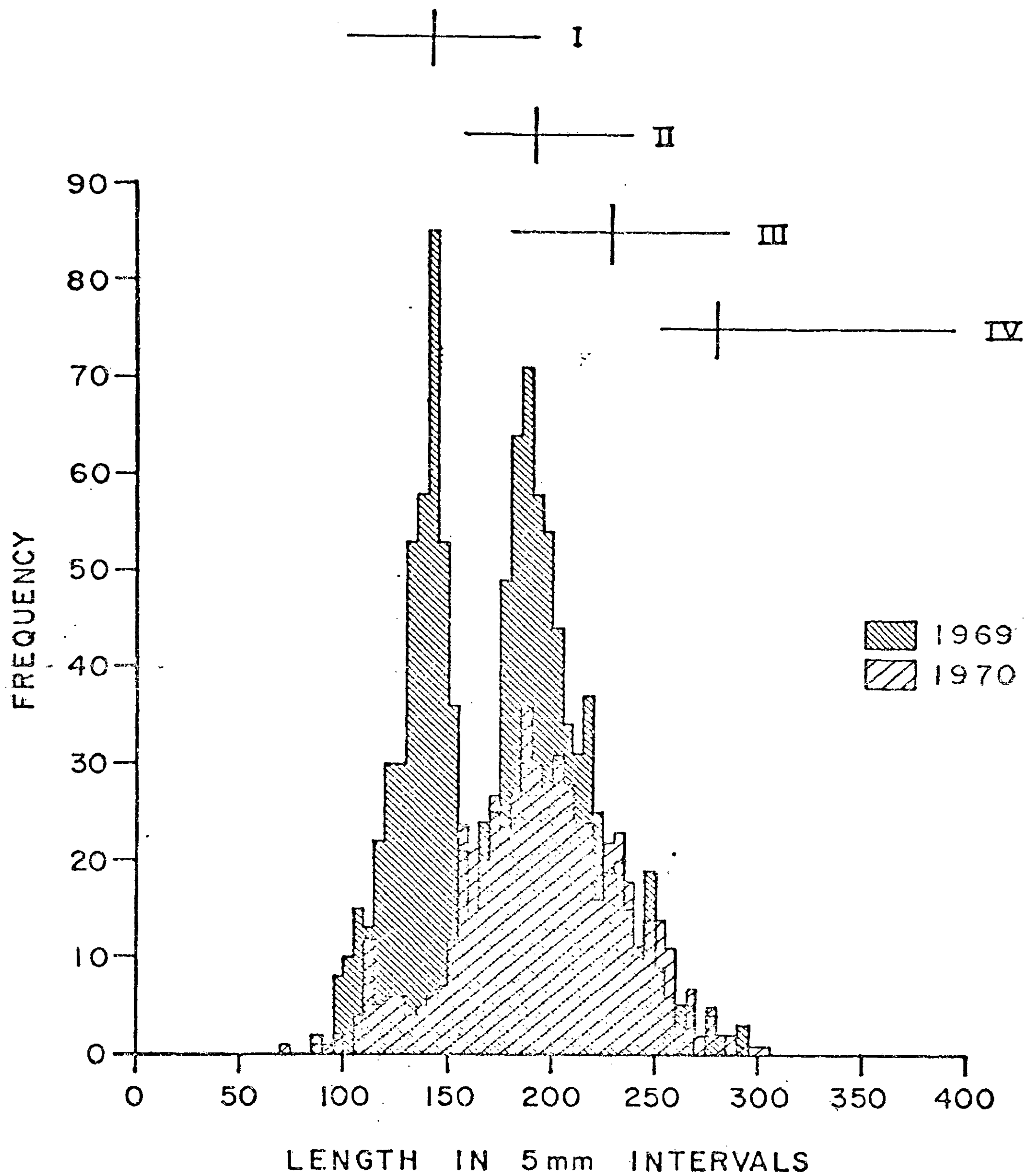

Figure 5. Length frequency distribution of brown bullheads collected from the James River, Virginia, during 1969 and 1970. The crosses above represent mean length and range for each age group as determined by analysis of pectoral spines taken in 1969.

Mean lengths of yearlings indicated by length-frequency distributions correlated well with those determined by pectoral spine analysis (Table 6). The differences between the two methods resulted from a bias toward large yearlings in the collections of spines. Since these large fishes had no annulus, it was assumed that the smaller ones had none and their pectoral spines were not examined.

Pectoral spines were collected in February, 1969, and used for determining the ages of 633 channel catfish, 101 white catfish, and 516 brown bullheads. Sneed (1951) was first to report the use of growth rings in pectoral spines of channel catfish and to check their validity as annuli by examining spines from fish known to be one and two years old. Marzolf (1955) verified this method using known-age fish of up to five years old.

Pectoral spines were labelled with waterproof tape, decalcified in bottles of "Decal" (Scholl, 1968), washed in running water for at least 1/2 hour, and sectioned with a scalpel. Spines immersed in "Decal" for as little as 15 hours were easily sectioned, but decalcification was incomplete after 26 hours when the bottle was tightly packed with spines. Immersion for more than a week seemed to clarify the annuli of some brown bullhead spines.

Several cross sections of pectoral spines were cut from the area at the distal end of the basal groove, as proposed by Sneed (1951). These sections were placed in a watch glass, covered with water, and viewed by transmitted light through a binocular microscope. Spine sections were similar in appearance to those illustrated by Marzolf (1955), except that decalcified spine sections

TABLE 6

Mean fork lengths in millimeters of yearlings collected in 1969 as determined by length frequency analysis and by examination of pectoral spine sections.

	Channel Catfish	White Catfish	Brown Bullhead
Length Frequency Analysis	88	83	136
Examination of Pectoral Spine Sections	102	88	141

showed broad light bands alternating with narrow dark rings. The dark rings were regarded as annuli caused by slower winter growth.

The annuli were clear and easily distinguished in channel catfish spines, but white catfish spines often showed false annuli which made interpretation difficult. Spine sections from brown bullheads often had barely discernable annuli which made age determination in this species the least certain. The edge of the spine section was counted as an annulus since none had been formed by any specimen for the year of its capture. Fishes possessing no annulus were counted as yearlings, hatched during the previous spring or summer.

IMPLICATIONS FOR MANAGEMENT

Channel catfish bring the highest prices and are the most numerous (Table 1) of the commercially valuable catfish in the James River. Specimens longer than one foot in total length (Age Group V and older) are sold as food, while those 7 to 11 inches long (Age Groups II, III and IV) are sold for stocking purposes. Some larger fish are also sold alive on special order. Computation of the value of the fishery when fish of various ages are utilized reveals that the greatest economic activity from the James River fishery is generated by the harvest of Age Group II fish. Demand for younger fish is met by catfish farms (Table 7).

A channel catfish year class also attains its maximum biomass when it is two years old (Table 7). If the fish could be harvested all at once, that would be the best time. Since this would only be possible under controlled conditions, cropping must be spread over a period of time with some loss in efficiency. In order to minimize such losses, some of the population should be harvested before this point of maximum biomass, and some after (Ricker, 1958). Development of markets for wild fish younger than Age Group II is desirable from this point of view.

Provision must be made, however, for the survival of sufficient brood stock to maintain the population. Menzel (1945) stated that female channel catfish in Virginia waters reach sexual maturity at a total length of from 9 to 10 inches, a size probably

TABLE 7

Compilation of survivors and annual economic yield from 10,000 channel catfish of Age I. The rate of survival (s) is .3964.

Age Group	Population		Exvessel Value Alive		Wholesale Value Alive		Exvessel Value as Food		Wholesale Value as Food		Retail Value as Food	
	Numbers	Pounds	$ / lb.	Total $	$ / lb.	Total $	$ / lb.	Total $	$ / lb.	Total $	$ / lb.	Total $
I	10,000	260	-	-	*1.54	400.40	-	-	-	-	-	-
II	3,964	412	.15	61.80	**1.44	593.28	-	-	-	-	-	-
III	1,571	368	.15	55.20	** .64	235.52	-	-	-	-	-	-
IV	622	237	.15	35.55	** .39	92.43	-	-	-	-	-	-
V	246	141	.15	21.15	*** .44	62.04	.13	18.33	.45	64.45	.74	104.34
VI	98	62	.15	9.30	.50	31.00	.13	8.06	.45	27.90	.74	45.88
VII	39	28	.15	4.20	.50	14.00	.15	4.20	.52	14.56	.85	23.80

* Price for farm raised fingerlings.
** Based on $.15/fish.
*** Based on $.25/fish.

attained late in their second year. Three year old fish would therefore be the youngest to spawn, so that some protection for this and younger age groups seems reasonable. A limitation on numbers caught, by a quota or licensing system, would be more desirable than a simple size limit. If a size limit were imposed, protection of large brood stock could yield better results both economically and biologically.

The exvessel prices in Table 7 are those paid locally. Wholesalers must ship live catfish to Kentucky and dressed ones to Indiana, Illinois and Kentucky, where the wholesale and retail prices are realized. In the South, plentiful supplies of both cultured and wild fish have minimized the market for outside sources of catfish generally. Foreign suppliers are another growing source of competition (Bureau of Commercial Fisheries, 1970) and a surplus may drive down the price for farm raised fingerlings in some areas (Grizzell, 1971). Almost all retail sales are for food and therefore no retail values were computed for live fish.

Since only three channel catfish examined in this study were six years old or older, a Walford line and the mathematical description of increase in length derived from it (Ricker, 1958: 194, eq. 9.6) were used to estimate the lengths of six and seven year old fish. The relationship between length and weight (Figure 2) was then used to derive the weights used for these age groups in Table 7. A mathematical description of increase in weight with age could not be used directly, since the point of inflection, at which the change from an increasing to a decreasing growth increment occurs, was not detected in the weight data, but was present in the observed progression of lengths.

White catfish have the lowest total population and population density (Table 2) and suffer the highest mortality rate (Table 4) of the species under consideration. While they are smaller fish of lesser value than the channel catfish, white catfish are heavier at the same lengths (Figure 2), and the flesh of the two species is nearly indistinguishable. Since white catfish prefer slower moving waters than the channel catfish, and more rapid currents than the brown bullhead (Carlander, 1969), an increase in their population would not necessarily increase their competition with these species. Causes for the high rate of mortality suffered by this species are not known.

Although brown bullheads are relatively scarce in the main channel of the James, they are abundant in the oxbows (Table 2). While they attain a smaller maximum size than either the channel catfish or white catfish, they grow more rapidly when young (Table 5). They also have the highest survival rate of the commercially important James River catfish (Table 4). More intensive fishing in the oxbows should be attempted.

Additional management information would be helpful. The number of brood stock necessary for maintenance of the desired population size should be determined, and methods of assuring survival of these fish devised. Partitioning the mortality rate into portions resulting from fishing and natural causes could rule out the imposition of restrictions on the harvest of fish which would be lost even if given such protection. Further study might also determine any changes in the growth rate of younger fish which might result from population changes, thus changing the yield from each age group.

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