Question: Why do you set the optimum total hardness level at 15-40 p.p.m.?
Answer: Water could be made too alkaline. It was not meant to imply that this figure was the upper limit.
Question: How long will the effects of the lime persist?
Answer: Not definitely established. At a rate of 3,000 pounds per acre the effect extended into the second year after treatment.
Question: Would continued liming be harmful?
Answer: Yes, might render phosphorus unavailable.
Question: Have you worked with water having 100-200 p.p.m. total hardness?
Answer: No. There is no water this hard in Georgia.
Question: Have you used lime to clear turbid waters?
Answer: No.

INFLUENCE OF FISHING PRESSURE ON BASS FISHING SUCCESS

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INTRODUCTION

The implication of most literature dealing with the influence of fishing pressure on bass fishing success has been that bass populations can withstand unlimited fishing pressure without undue duress. Results emerging from recommendations from these findings such as abandonment of closed seasons and removal of size restrictions have proven satisfactory in almost every instance. In Virginia studies, total harvest, rate of catch, bass reproduction and growth rates, remained essentially the same following the adoption of year-round fishing. At the same time, little or no increase in total fishing pressure was noted.

However, the author's experience in fishing privately owned ponds and other waters closed to the general public indicated that the rate of catch in restricted waters was far better than from most public waters. Likewise, creel, tagging, and population sampling data obtained in conjunction with previous Dingell-Johnson projects suggested that bass harvests were more extensive than commonly recognized. These observations led to the preparation of this paper dealing with the influence of fishing pressure on bass fishing success.

Thanks are due to fisheries biologists N. R. Bowman and D. L. Shumate, Jr., for field assistance in collecting data, G. W. Buller, Chief of the Fish Division for his valuable guidance and assistance, and I. T. Quinn, Executive Director of the Commission of Game and Inland Fisheries for making the study possible.

DESCRIPTION OF STUDY AREAS AND CREEL CENSUS METHODS

Complete creel census data including estimates of total harvest and fishing pressure was obtained from five public and two private ponds. In addition tag return data was obtained from three of these smaller public ponds, Douthat Lake, Carvin Cove Reservoir, and Fairystone Lake. Creel and tagging data were also available from three larger bodies of water, Back Bay, Claytor Lake and South Holston Reservoir. Pertinent descriptive information concerning these waters is presented in Table I.

The smaller ponds ranged between 60 and 650 acres in size. They were distributed generally over the state and were considered representative of average fishing ponds. Fertility levels were uniformly low and none of the ponds were fertilized or otherwise managed. Fish populations in all but one newly created pond, Lake Burton, would be considered mature. The remainder of the ponds were over 15 years of age. One of the public ponds, Airfield Pond, and both private ponds were abandoned grist mills that date back over 200 years. Largemouth bass, bluegill, and black crappie comprised the principle sport fish species. Chain pickerel were also present in three of the public ponds and in both private ponds. All contained substantial populations of suckers and bullheads.

TABLE I

MISCELLANEOUS DESCRIPTION OF STUDY IMPOUNDMENTS

Name	*Geographic Location*	*No. Acres*	*Principal Usage*	*Years Censured*
Public Waters:				
Airfield Pond *	Coastal Plain	200	Fishing	1951–56
Holliday Lake †	Piedmont	140	Recreation	1953–56
Carvin Cove Reservoir	Mountain	650	Water Supply	1952–56
Douthat Lake †	Mountain	60	Recreation	1954
Lake Burton *	Piedmont	76	Fishing	1954–55
Fairystone Lake †	Piedmont	160	Recreation	1952
South Holston Reservoir	Mountain	7,580	Multiple Purpose (TVA)	1952
Claytor Lake	Mountain	4,495	Hydroelectric Power	1948–49
Back Bay ‡	Coastal Plain	25,000	Water Fowl Refuge	1951–52
Private Waters:				
Custis Mill Pond	Coastal Plain	——	Fishing	1951–56
Providence Forge	Coastal Plain	——	Fishing	1951–56

* Owned and operated as Public Fishing Lakes by Virginia Commission of Game and Inland Fisheries.

† Part of Virginia State Park System operated by the Department of Conservation and Development.

‡ A slightly brackish, two percent sea water salinity, natural bay in the extreme Southeastern tip of Virginia. (Northernmost extension of Currituck Sound.)

The collection of creel data was spread over a six-year period, 1951-1956. Three of the public ponds, Carvin Cove, Holliday Lake and Airfield Pond were censused for four or more consecutive years and Douthat Lake and Fairystone Lake for one year. A full-time census clerk was employed to collect creel data at each of the ponds. Techniques employed at each of reservoirs varied because of differences in fishermen accessibility and availability of census clerks. A resident caretaker and limited access made it possible to check approximately 90 percent of the fishermen at Airfield Pond. The resident manager at Carvin Cove Reservoir was estimated to have recorded two thirds of the total angling pressure. Estimates of total fishing pressure and harvest from Holliday Lake, Fairystone Lake and Douthat Lake were derived by a combination of fishermen counts and fishermen interviews of completed trips obtained by one full-time census clerk. The method followed was comparable to that used by Kathrein (1953) on Clearwater Lake in Southeast Missouri. The census clerk worked a nine-hour day, six-day a week schedule. Fishermen counts were made every four hours on a prearranged statistically sound schedule. Since each of these reservoirs was relatively small, census clerks were able to interview more than half of the estimated number of fishermen.

Creel census records from the two private ponds were recorded routinely by full-time custodians employed by the fishing club or by club members. Although only six years data, 1951-56, were summarized for inclusion in this paper, creel data had been recorded traditionally for many years.

RESULTS

A comparison of creel census data from five public fishing ponds with data from two privately owned club ponds is presented in Table II. The public ponds ranged in size from 60 to 650 acres and were considered typical of most small public fishing impoundments in Virginia. These ponds included Airfield Pond, Holliday Lake, Fairystone Lake, Carvin Cove Reservoir, and Douthat Lake. The private ponds were 108 and 125 acres in size.

Fishing pressure in public waters was over four times that in private ponds, 18.5 trips per acre to 4.4 trips per acre, while the bass catch per trip in the private ponds was almost four times that in public ponds; .7 bass per trip to .18 bass per trip.

Annual estimates of bass harvests averaged 3.6 bass per acre from public ponds and 1.7 bass per acre from private ponds. Since bass creeled from private ponds averaged considerably larger, differences in the yield per acre would not be as pronounced as indicated by the above empirical figures. A 14-inch mini-

mum size limit was enforced at the private ponds for four years and an 11-inch limit the remaining years. Almost 85 percent of the bass creeled from public waters were under 15 inches.

Although other factors such as variance in fish population composition, fertility levels, relative number of skilled anglers, etc., undoubtedly contributed to the observed differences, it is believed that fishing pressure played a major role in determining the rate of catch. It is noteworthy that anglers at the private ponds threw back almost 50 percent of the bass creeled. Thus, the actual bass fishing pressure at the ponds was even less than indicated.

TABLE II

SIX-YEAR AVERAGE OF FISHING PRESSURE, CATCH PER UNIT EFFORT, AND ANNUAL HARVEST FROM PUBLIC AND PRIVATE PONDS, 1951-56

	No. of Ponds	*Size Range*	*Fishing Trips/Acre*	*Bass/ Trip*	*Bass/ Acre*
Public	5	60–650 acres	19	.2	3.6
Private	2	108–125 acres	4.4	.7	1.7

Changes in fishing pressure appeared to influence bass fishing success at three public ponds from which several consecutive years data was available. It will be noted from Table III that the catch per unit effort dropped from .52 bass per trip in 1953 at Holliday Lake to .23 bass per trip average in 1954-56 following a fifty percent increase in fishing pressure. Two other ponds, Carvin Cove Reservoir and Airfield Pond, showing a moderate decline in fishing pressure over this same period, exhibited a modest increase in catch per unit effort.

Annual harvest, expressed as bass per acre, varied only slightly during this period. Thus, while fishing pressure influenced the rate of catch, it apparently had little effect on total harvest. This suggests that near maximum harvests were being obtained from the study ponds.

Another example of increased fishing pressure resulting in a reduction in the catch per unit effort was indicated at two city water supply reservoirs located in Eastern Virginia. Although creel data was not available from either area, local game wardens reported that the bass rate of catch fell substantially following the opening of these ponds to the public after several years of light fishing by permit only.

TABLE III

RELATIONSHIP OF FISHING PRESSURE WITH BASS CATCH PER UNIT EFFORT AND TOTAL HARVEST AT THREE PUBLIC PONDS

	Holliday Lake		*Carvin Cove Res.*		*Airfield Pond*	
	1953	*1954-56*	*1952-53*	*1954-56*	*1951-53*	*1954-56*
No. Trips	2,477	5,019	9,359	8,892	2,323	1,915
No. Bass	1,400	1,134	698	955	614	610
No. Trips/Acre	17.7	35.9	14.4	13.7	11.6	9.5
No. Bass/Trip	.52	.23	.07	.11	.26	.31
No. Bass/Acre	10.0	8.1	1.1	1.5	3.0	3.1

The pattern of fishermen usage and catch per unit effort immediately following the opening of Lake Burton to the public further illustrates the close relationship between fishing pressure and fishing success. This 75-acre pond located in Piedmont Virginia was heavily stocked, 10,000 two-year-old bass, in the fall prior to its opening for public fishing on June 1, 1954. The bulk of these bass were between 10 and 14 inches by the opening of the season. As may be seen in Table IV, almost half of the fishing pressure and 82 percent of the harvest for the entire year was registered on opening day. The drastic decline in the rate of catch following opening day, 1.5 bass per trip to .3 bass per trip, was believed to be simply a reflection of the terrific fishing pressure and harvest made on opening day. Catch per unit effort and fishing pressure for the remainder of the year and in succeeding years remained relatively stable at much reduced levels.

TABLE IV

LAKE BURTON—COMPARISON OF OPENING DAY FISHING PRESSURE AND RATE OF CATCH WITH REMAINDER OF YEAR. JUNE 20–DECEMBER 31, 1954

	Fishing Trips		*Bass Caught*		*No. Bass/*
	No.	*Percent*	*No.*	*Percent*	*Trip*
Opening Day	1,500	46.8	2,185	82.4	1.5
Remainder of Year	1,704	53.2	465	17.6	.3

The extremely high tag returns from 373 stocked bass in Douthat Reservoir on opening day, June 20th, 1954, furnished additional evidence of the effects of fishing pressure. These two-year-old hatchery bass were planted in April, 1954. Seventy-six percent of the total number of tagged bass recovered during the first year were caught on opening day and 92 percent had been taken within the first 30 days (Table V). The overall recovery reported during the first year amounted to 48 percent. The bass catch per trip declined rapidly after the first day in apparent reflection of the heavy harvest of bass made earlier.

TABLE V

DOUTHAT LAKE—NUMBER AND PERCENT OF TAGGED BASS RECOVERED DURING EACH 30-DAY PERIOD FOLLOWING THE OPENING OF THE FISHING SEASON, JUNE 19–DECEMBER 31, 1954

	Opening Day		*June 20–July 19*		*July 19–Aug. 18*		*Aug. 19–Dec. 31*	
	No.	*Percent*	*No.*	*Percent*	*No.*	*Percent*	*No.*	*Percent*
Total	135	75.4	29	16.2	8	4.5	7	3.9
Cumulative Total		75.4	164	91.6	172	96.1	179	100

Tag returns from indegenous fish in many of these same waters pointed out relationships between fishing pressure and catch per unit effort similar to those described by creel data. In addition, the tagging data indicated the probability that maximum bass harvests, commensurate with adequate catch per unit effort, were being obtained from most public ponds. The bass were collected by pre-season angling and tagged with number three Monel, strap tags attached to the upper jaw. While every effort was made to recover the tags, utilizing creel clerks and offering a one dollar reward for returned tags, the rate of return must be considered minimal. Evidence of tag loss from the fish and failure to turn in tags on the part of fishermen was available from each of the study ponds and reservoirs. If as some quarters have indicated, jaw tagged fish are more prone to capture than untagged fish, it is believed that the failure to report fish tags and the loss of tags more than compensates for any such over emphasis.

The rate of tagged bass recovery was high from most small impoundments, ranging from a low of 30 percent at Fairystone Lake to over 50 percent at Douthat Reservoir. The relatively high returns for Virginia waters as listed in Table VI do not appear unique in recent years. Bowers and Martin (1956)

TABLE VI

RETURN OF TAGGED BASS FROM SIX VIRGINIA IMPOUNDMENTS DURING THE FIRST YEAR

Name	*Acreage*	*Year*	*No. Fish Tagged*	*Percent Recaptured*	*Est. No. Fish. Trips/Acre*
Douthat	60	1952	34	53	18.5
Carvin Cove	650	1952	84	46	14.4
Fairystone Lake	160	1952	75	30	24
Claytor Lake *	4,495	1949	324	34	. . .
South Holston Res.†	7,580	1952	383	41	. . .
Back Bay	25,000	1951	1,738	7	.2

Roseberry * (1951)
Includes 146 smallmouth bass returned at rate of 40 percent
171 spotted bass returned at rate of 28 percent, and
7 largemouth bass returned at rate of 29 percent.
Chance † (1955)
Includes 279 largemouth bass returned at rate of 41.2 percent and
104 smallmouth bass returned at rate of 42.3 percent

reported recoveries of 46 percent in three small Kentucky impoundments. Chance (1955) reported recoveries of 40.8 percent in Wautauga Reservoir in North Carolina and 41.5 percent for South Holston Reservoir on the Virginia-Tennessee line.

Returns from three larger impoundments varied to a greater degree, 7.3 percent at Back Bay, 34 percent at Claytor Lake, and 41.5 percent at South Holston Reservoir. Although there was no measure of fishing pressure at South Holston or Claytor Lake, local observation indicated that fishing pressure was much lighter at Back Bay where less than an estimated .2 trips per acre were recorded.

DISCUSSION

It seems apparent that there is an easily harvested segment of any bass population which can be readily taken by light fishing pressure at a relatively high rate of catch. After this "harvestible surplus" is removed, additional fishing pressure has little effect on further harvest and the catch per unit declines rapidly. In the present study this sequence of events was substantiated by creel comparison of public vs. private ponds, by the pattern of excellent fishing the first few days followed by a drastic decline in newly opened public fishing ponds; by the substantial number and early return of tagged fish, and by the abrupt decline of the rate of catch in impoundments experiencing an increase in fishing pressure.

In as much as a back log of apparently unharvestible fish will remain regardless of the degree of fishing pressure, it appears almost impossible to "fish out" any pond. In this study the rate of catch declined rapidly with increased fishing pressure, but no long term reduction in harvest occurred. Since adequate brook stock as well as bass reproduction was found each year, bass populations apparently were not affected seriously.

The rate of fishing pressure, 19 trips per acre per year, apparently capable of adequately removing this "harvestible surplus" from these relatively infertile and unmanaged fishing waters was surprisingly low. Likewise, total harvest figures were correspondingly low. Only 3.6 bass per acre, averaging approximately one pound each, were removed annually. It is firmly believed that additional fishing pressure would have resulted only in a meager increase in total harvest and would have further reduced the rate of catch. Fishermen tend to harvest the ponds to their maximum commensurate with an adequate rate of catch.

Other factors, including the assumed inclination of bass to become "hookwise" have been advanced by many workers to explain the drastic decline in rate of catch following an initial heavy harvest in new impoundments. While this thesis cannot be discounted in its entirety, it would appear that the undoubted vast changes in fish population compositions following an extremely high harvest are of more importance. Factors such as the decline in the number of catchable sized bass and increased forage for the remaining bass appear to have much more practical significance in explaining the decline in the rate of catch. Recruitment of fishable populations following a heavy harvest seldom keeps pace with continued heavy fishing pressure. When a significant number of fishable sized bass are suddenly removed from the population a like amount of predator pressure is removed, resulting in higher survival rates of forage species. Subsequently, the number of intermediate sized pan fish increases and the relative amount of smaller sized forage available to young bass decreases. As a result growth and survival of the younger bass suffer. These observations were suggested by population samples from many reservoirs and by analysis of population data obtained from draining 15 small, one to five acres, ponds to be reported at a later date. Likewise, continued heavy fishing pressure tends to harvest these recruits at an early age and thus the average size of bass taken from heavily fished lakes is usually smaller than those creeled under conditions of reduced fishing pressures.

Also, it appears, in Virginia waters at least, that underfishing of predator species is never a problem and that heavy fishing pressure is the probable cause of poor catch per unit effort figures. Little can be done to control fishing pressure on public waters. The annual trend is upward. Closed season regulations have been found totally ineffective in reducing fishing pressure and definitely are of no benefit to bass populations. Likewise, it is extremely doubtful if

minimum size regulations would be of value. The value of creel limit reduction would be psychological, in that it would spread the catch over a greater number of trips, since potential fishing pressure on most waters is high enough to offset any possible reduction in the total number of bass creeled. It appears that the only way to materially increase the bass catch per trip rate by regulation would be by instituting a "Hazzard Type" program and require all or most of the bass to be returned. This type of program may have merit in privately owned ponds or for some public waters not otherwise manageable but it obviously would have little value for general public application. General fish management, including fertilization and population manipulation measures designed to increase the standing crop and yield of catchable sized game fishes, appears to be the best answer to better public fishing.

SUMMARY

Almost without exception creel census and tag return data from the various waters investigated revealed an inverse relationship between fishing pressure and the bass catch per unit effort. Private ponds, in which fishing was severely restricted and where it was a common practice to return many of the bass, exhibited much higher rates of catch than in the more heavily fished public ponds. Likewise, bass creeled from private ponds averaged larger than from the more heavily fished public waters.

Fishing pressure, harvest, and fishing success were uniformly high in newly constructed ponds and older ponds opened to the public for the first time. However, fishing pressure and rate of catch declined drastically after the first few weeks. The subsequent decline in the harvest and rate of catch seems to be simply a reflection of the heavy fishing pressure early in the season. The harvest pattern resulting from the stocking of catchable size bass in mature ponds immediately before the season was almost identical to the harvest from newly developed ponds.

An increase in fishing pressure seldom resulted in increased harvests from public ponds, but was reflected by a reduced catch per unit effort. This suggests that near maximum harvests are being attained by observed levels of fishing pressure. Relatively high tag returns, 30-50 percent, from these same waters produce additional evidence of this supposition. However, it likewise is apparent that the degree of fishing pressure recorded from these waters is not sufficient to adversely affect future harvest or reproduction. The average harvest remained essentially the same throughout the six years of the study period and reproduction was excellent at all times.

The amount of fishing pressure these unmanaged public ponds can support without substantial reduction in fishing success appears exceptionally low. The yield of bass per acre is also disappointingly low. An average of 19 fishing trips per acre at five public ponds resulted in the harvest of 3.6 bass per acre, averaging approximately one pound, at a rate of .2 bass per trip. These findings of low harvest and fishing pressure on unmanaged public waters emphasize the low sport fishing potential of such waters and the need for better management practices.

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Question: Would data apply to large reservoirs?

Answer: Yes.

Question: Would you recommend a limit on the catch?

Answer: No, controlling fishing pressure is out of our hands. Need to get the fisherman to fish for sport instead.

Question: Should the opening day limit be reduced?
Answer: No, the effect would only be delayed one or two days and spread among more people.
Question: Was the 70% return you mentioned tagged fish?
Answer: Yes, but they were native fish tagged during the closed season.
Question: Was the data obtained where size limits were in effect?
Answer: Yes. Ten inch minimum.

WHAT SIGNIFICANT INFORMATION CAN BE GAINED FROM ROTENONE POPULATION STUDIES IN IMPOUNDMENTS

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The term, population study, as most often used, denotes certain field activities from which data are gathered regarding the kinds of fishes present in a body of water, or a section thereof, and the relationship and/or interrelationship of these fishes one to the other. This definition is rather broad and all encompassing and is given as such because in the past most studies have been conducted with these broad objectives in mind. However, it is believed that the attainment of such overall objectives is not possible using the procedures and methods most commonly used in the Southeast.

The most widely used method for conducting population studies in impounded waters has been to select a cove area or mid-lake area of one acre or more in size, treat the area with rotenone, recover all fishes possible, and make whatever counts, measurements and collections the investigator deems essential.

If all the interrelated complexities of population dynamics cannot be determined from more or less routine population studies what can the fishery investigator determine from these operations and of what value will the findings be to his understanding of the population?

Assume that a population study or a series of studies is made in an impoundment using the method described above and also, and most pertinent, that these studies are conducted during the warmer months, May through October. The following is a listing of at least most of the information which could be secured.

1. *Success and Survival of Reproduction.*

Cove studies made monthly from May through October will furnish a relative approximation of the number of fingerling fishes present per acre immediately after the spawning season and a continuing inventory of the mortality of these fingerlings. The studies conducted in May the following year will furnish information on relative survival of young-of-year fishes throughout their first year of life. Additionally, the monthly growth of these fishes can be charted and compared to previous years' growth rates if these data are available.

By knowing the strength of each year class and the growth and survival of these year classes it is possible to predict with some accuracy the immediate future of the fishery and to help the investigator to better plan for future regulation and management.

2. *Material for Age and Growth Studies.*

Scale samples collected from fishes taken in population studies can be used to determine the growth rates of the fishes. Knowledge of the age and rate of growth of the different fishes will help predict the time when a particular year class will enter the fishery, the age at which they will reproduce, the approximate age and size when mortality is greatest in the adult fishes and will help in the evaluation of the effects of experimental management programs as reflected in growth changes. Studies of the effects of selective poisoning are known to be in progress in Texas, Virginia and Kentucky.