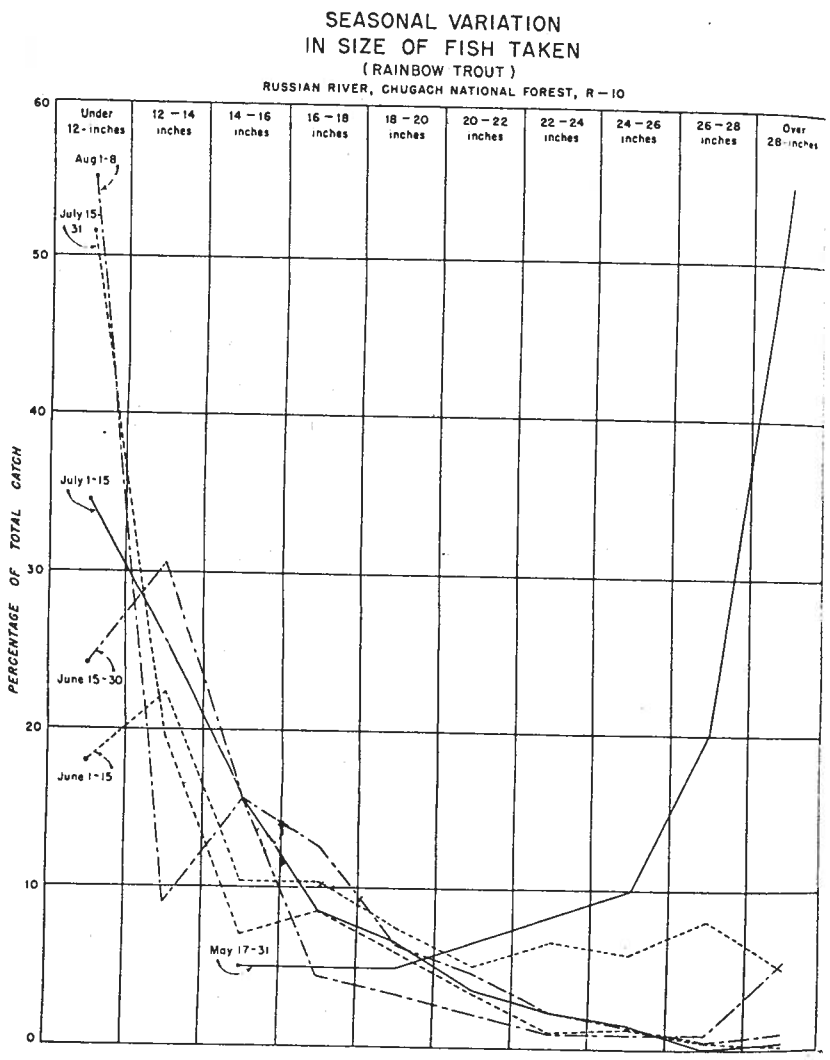

The regulations governing the taking of rainbow trout on the Russian River are at present as follows:

Season—No season defined, unrestricted.

Legal methods—No restriction, except commercial fishing is prohibited.

Limits—Daily limit, forty fish or 10 pounds and one fish. Possession limit, eighty fish or 20 pounds and one fish.

Dolly Varden trout may be taken at any time, by any method, in any numbers and commercial fishing is permitted. This status is universal throughout the territory.

Recommendations: It is recommended that fishing on the Russian River be so regulated as to provide the maximum yield from these waters. To secure this end it is imperative that the following restrictions be placed in effect on this stream:

1. Prohibit the taking of trout of all species by any method other than rod and line.
2. Establish a closed season on all species prior to June 5.
3. Reduce bag limit on rainbow trout to twenty fish or 10 pounds and one fish, and possession limit to forty fish or 20 pounds and one fish.

Regulations should be duly publicized in the territorial newspapers and suitable notices posted in the vicinity.

It is important that accurate catch records from the Russian River be secured annually with the use of standard forms and instructions such as were employed in the 1939 study.

It is planned to investigate conditions on the Russian River during the spring and summer of 1940 in conjunction with other work on the Kenai. The primary objective of such an effort will be to determine ways and means of securing a maximum sustained yield and utilization of the sport fishing resources. It is not believed that a detailed technical stream survey is either necessary or desirable at this time.

EXPERIMENTS ON THE STOCKING OF FISH PONDS

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The great increase in the number of fishermen during the past twenty years has resulted in the overfishing of many streams and natural lakes. As the number of fishermen further increases, it becomes evident that adequate fishing can be provided only by the construction and proper management of artificial ponds. Thousands of these ponds have been constructed, and hundreds of new ones are being made each year, especially throughout the Southern and Mid-Western States. No information, based upon actual experiments, has been available as to the most suitable combination of species, the sizes, and the numbers of each which should be used in stocking these ponds or lakes. As a result, ponds have been stocked in any fashion appealing to the owner,

[1]Published with the approval of the Director.

often with extremely poor results from the standpoint of the fishing. In some of these ponds, good fishing has resulted within one or two years after the pond was stocked, while in others, fishing was extremely poor even after a 4, 5 or 10 year period. This great variation in results has been found to be due almost entirely to the initial method of stocking the pond.

In order that a body of water may provide good fishing it must meet the following conditions:

1. It must be capable of producing sufficient food to support in excess of 100 pounds of fish per acre.
2. Most of the weight of fish in the pond must be in the form of desirable game and pan fish.
3. Most of the weight of game and pan fish in the pond must be in the form of legal-sized fish.

Most natural ponds and lakes in the South and elsewhere are capable of supporting in excess of 100 pounds of fish per acre. Where an increase in the yield of fish is desired, this can be obtained by the fertilization of the pond waters (Swingle and Smith, 1939). Thus most ponds and lakes can be made to meet the first condition.

The second and third conditions can be met only by the elimination of undesirable species and by the proper stocking of ponds. In artificial ponds, provided with a means for draining, the removal of undesirable species is a relatively easy matter. When draining is not possible, poisoning all species and restocking with desirable fish only is becoming a recommended practice (Thompson and Bennet, 1939). The proper stocking of these ponds is of great importance if fishing in them is to be improved.

Experiments on various methods of stocking fish ponds were begun at the Alabama Agricultural Experiment Station in 1934. These experiments were conducted in ponds ranging in size from 0.5 acre to 12 acres. The ponds were stocked in the winter or early spring with various combinations of species of fish, and the results determined after an interval of one or more years by draining the ponds and counting and weighing the fish. While the results reported herein must be considered largely as a progress report, sufficient information has been gained to enable pond owners to enjoy excellent fishing within less than a year after the ponds have been properly stocked.

The fish used in these experiments were the bluegill bream (*Lepomis macrochirus* Rafinesque), the white crappie (*Pomoxis annularis* Rafinesque), the largemouth black bass (*Huro salmoides* Lacépède), the top minnow (*Gambusia affinis* B. & G.) and the golden shiner minnow (*Notemigonus crysoleucas* Rafinesque).

Stocking with bluegill bream—The bluegill bream (*Lepomis macrochirus* Rafinesque) is one of the best pondfish and should be stocked in all ponds. It provides good sport for pole or fly-fishing, is one of the best flavored of the fresh-water fish, and has a sufficiently high reproductive capacity to serve as a forage fish for use with the carnivorous species.

Numerous analyses over a 5-year period have been made of the stomach contents of bluegills from various types of ponds. Aquatic insects were found to make up over 95 per cent of the total volume of food consumed. Chironomid larvae were the most important single group of insects. Small bluegills, weighing less than one gram, were found to be feeding upon the same organisms as the legal-sized bream. While large bluegills were occasionally found to have fed upon other fish, such cases were rare. Even in heavily overstocked ponds, these fish did not feed to an appreciable extent upon their own young.

It therefore would appear logical that, due to the high reproductive capacity of the bluegill bream and to its lack of cannibalistic habits, ponds containing this species only would soon be so overcrowded with young fish that growth would be impossible.

This was found to be the case in all ponds stocked with bluegill bream only. For example, a 0.5 acre pond was stocked in March, 1938, with 750 fingerling bluegills. This pond was moderately fertilized (Swingle and Smith, 1939) and when drained the following November was found to be supporting 388 pounds of fish per acre. The pond was seined periodically to determine the rate of growth of the fish originally added. The results are briefly summarized below:

Date	*Average weight of bluegills collected*
March 24 (when stocked)	5.8 grams
June 15	70.0 grams
July 13	68.9 grams
August 13	56.0 grams
November 30	54.2 grams

It will be noted that the bluegills added grew rapidly until spawning occurred. By June 15, thousands of small bream were observed in the pond, and, from this time on, competition for food became so severe that the bream originally added lost weight during the remainder of the summer and actually weighed approximately 20 per cent less when the pond was drained in November than they had weighed in June.

Even after five or ten years, ponds stocked with only bluegills contain very few legal-sized fish. Carnivorous fish must be added to eat up most of the small fish if the pond is to be successful.

Stocking with bluegill and white crappie fingerlings—The white crappie (*Pomoxis annularis* Rafinesque) feeds largely upon aquatic

insects and small fish. There is no sharp transition point during the life of the crappie at which it changes from one type of food to the other. The food of the smaller crappie consists largely of insects and that of the larger crappie mainly of fish. However, a 1-pound crappie may be found to have fed entirely upon insects and a 5-gram crappie may have made its meal on a smaller fish. Crappie, therefore, compete with bream for food over a rather extended period in their life, but will eat a considerable number of small bream whenever the latter are available.

In order to determine the value of a bluegill-crappie combination, a 1.2-acre pond was stocked in March, 1938, with bluegill and crappie fingerlings at the rate of 1,500 and 200 per acre, respectively. Top minnows (*Gambusia affinis* B. & G.) were added for mosquito control. This pond was fertilized lightly during 1938 and 1939 to increase fish production. Unfortunately the area of the pond was reduced to approximately 0.3 acre during the drought of 1938. The pond was drained that fall, half the legal-sized bream and crappie removed and all the rest of the fish returned to the pond. The pond was drained again and the fish counted and weighed one year later (December, 1939), when the experiment was closed.

The results of this experiment (Table 1) indicate that crappie cannot be depended upon to balance a pond containing bluegill bream. At the end of two years, the total weight of young bream was twice that of the older bream, and but few of the large bream had reached a size in excess of 2 ounces. A few of the oldest crappie had reached a size of 1.5 pounds, but the medium-sized crappie averaged less than a quarter-pound. In addition, the crappie had not eaten a sufficient number of their own young, with the result that, after a 2-year period, the pond was overstocked with both bream and crappie. With this combination, however, a considerable number of each species may reach a legal size by the end of the first year after stocking. It is believed that trouble will be experienced in maintaining a proper balance after fishing begins and the large crappie are removed.

TABLE 1—FISH POPULATION IN A 1.2-ACRE POND STOCKED WITH BLUEGILLS AND WHITE CRAPPIE

Fish	Stocked March, 1938, with		Recovered on draining pond, Dec., 1939	
	Number	Weight Pounds	Number	Weight pounds
Bluegills (large)	.....	.....	2,462	114.6
Bluegills (small)	1,800	18.4	15,554*	229.6
Crappie (large)	.....	.....	135	35.7
Crappie (small)	240	2.5	2,368*	52.6
Gambusia	100	0.2	10,397	14.6
Total fish	.....	21.1	.....	447.2
Tadpoles	.....	.....	.....	470.0

*Hatched during 1939.

Stocking with bluegill and largemouth black bass fingerlings—The largemouth black bass (*Huro salmoides* Lacépède) does well in ponds, but is often objected to, especially in small ponds, because of its voracious appetite and cannibalistic habits. It competes with bream only until it reaches several inches in length. Growth thereafter is extremely slow unless a diet of small fish is available. Where food is abundant, bass are capable of making very rapid growth.

In order to determine the value of a bluegill-largemouth bass combination, a 1.3-acre pond was stocked in February, 1939, with bluegill and bass fingerlings at the rate of 1,500 and 100 per acre, respectively. Top minnows (*Gambusia affinis* B & G) were added to the pond for mosquito control. The pond was fertilized with inorganic fertilizer to increase production. The following December, the pond was drained and the fish counted and weighed (Table 2).

TABLE 2—FISH POPULATION IN A 1.3-ACRE POND STOCKED WITH BLUEGILL AND LARGEMOUTH BLACK BASS FINGERLINGS

Fish	Stocked Feb., 1939, with		Recovered on draining, Dec., 1939	
	Number	Weight pounds	Number	Weight Pounds
Bluegills (large)	.....	.....	1,663**	432.4
Bluegills (small)	1,950	65.4	8,216	49.0
Largemouth bass (large)	.....	.....	90***	71.8
Largemouth bass (small)	127	5.3	193	28.8
Crappie (large)	.....	.....	4	4.5
Crappie (small)	4*	0.3	241	36.3
Gambusia	4,721	10.9	207	0.4
Total fish	.....	81.9	.....	623.2
Tadpoles	None	.....	.....	None

*Apparently overlooked when pond was drained in 1938. Number and weight estimated.
**51 bream removed previously for samples.
***5 bass removed previously for samples.

The results of this experiment indicate that largemouth black bass can effectively balance a pond containing bluegill bream when the pond is stocked with fingerlings of both species at the same time. The number of small bream in the pond was kept down by the bass and consequently the bream originally placed in the pond continued to grow throughout the year. When the pond was drained, the number of small bream left was approximately sufficient to carry the bass through the winter and replace any bream removed by fishing. Over 89 per cent of the total weight of bream was in the form of legal-sized fish.

In addition, the bass had reduced their own young from the thousands which hatched in the spring to approximately the correct number for the size of the pond. If all the legal-sized bass had been removed, just the right number of bass would have remained to properly balance the pond the next spring. Similar results have been obtained upon draining several other ponds containing bass. Cannibalism among bass causes much concern in fish hatcheries, but without this

cannibalism in ponds, lakes, and streams, the production of legal-sized fish would be impossible. Because of its carnivorous and cannibalistic habits, the bass must be regarded as the "boss" of the pond and must be depended upon to keep a proper balance between the number of fish and the food supply. In the above pond, over 81 per cent of the total weight of fish was made up of legal-sized bass and bream (Figure 1).

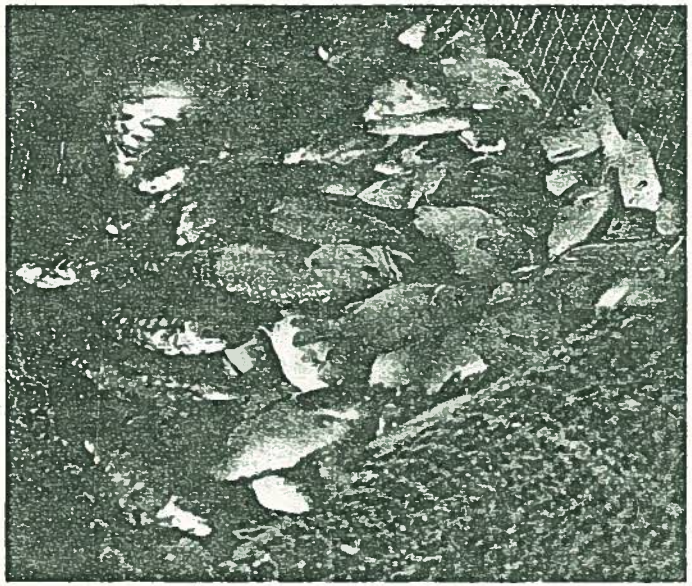

Figure 1. Fish from a 1.3-acre fertilized pond 10 months after stocking with the correct numbers of fingerling largemouth bass and bluegill bream. This pond contained 623 pounds of fish and over 80 per cent of this weight was in the form of legal-sized bass and bream. Properly stocked ponds provide good fishing within less than a year.

When a pond is stocked in the above manner, the bass should be as small as, or smaller than, the bream so that the bream added in stocking cannot be eaten. The bass will then be unable to feed upon bream until after spawning occurs. Previous to spawning they must feed upon tadpoles and gambusia minnows. While they will not grow much on this diet, it will keep them alive until the young bream hatch. While this procedure is admittedly somewhat hard on the bass, it gives much better results than waiting a year or two for the building up of a large population of bream before adding the bass, as is often recommended. By this time, the pond is overcrowded with bream and since young bream and young bass feed upon the same food organisms, bass have an extremely hard time getting started and may require three or more years to properly balance the pond. Ponds stocked in this manner may never produce good fishing.

Stocking with adults of bluegills, white crappie, yellow bullheads, and largemouth black bass—The stocking of ponds with adult fish is occasionally recommended, especially when it is difficult to secure sufficient hatchery fish. In order to test this method of stocking, a 1.8-acre unfertilized pond was stocked in December, 1936, with ten adults of each of the following species: bluegill bream, yellow bullhead, white crappie, and largemouth black bass. One year later (November, 1937) the pond was drained and the fish counted and weighed. The ten bluegills had produced 20,615 young; the ten bullheads had produced 668 young; the ten crappie had produced 3,848 young, and, finally, the ten largemouth black bass had produced none, probably because of the lack of food for the adults prior to spawning. In this 1.8-acre unfertilized pond, therefore, there were enough bream for a 60-acre pond, enough catfish for a 12-acre pond, enough crappie for a 70-acre pond, and insufficient bass for one acre. All these fish were replaced in the pond and the experiment continued for two more years. In December, 1939, the pond was drained and the fish again counted. At this time there were still sufficient bream for a 70-acre pond, sufficient crappie for a 34-acre pond, and enough catfish for a 6-acre pond. Throughout this period only three small bass were produced by the ten adults. After getting a late start in the pond, small bass were unable to survive due to the intense competition for food. Very few fish in this pond reached legal size during the 3-year period of this experiment.

These results are summarized below:

Legal-sized fish added to pond Dec., 1936		Legal-sized fish present in pond Dec., 1939
10	Bluegills	28
10	Crappie	8
10	Bass	9
10	Yellow bullheads*	212

*One-half pound or larger. There is no legal size for this species.

It is evident that this method of stocking cannot be depended upon for good results.

Stocking with bluegills, golden shiners, and largemouth bass—The golden shiner minnow (*Notemigonus crysoleucas* Rafinesque) has been recommended by Davis and Wiebe (1930) for use as a forage minnow for bass. A large portion of its food may consist of phytoplankton, but it also feeds to a considerable extent upon microcrustacea, aquatic

insects, and to some extent upon small fish. It therefore competes more or less with bream for food.

A 1-acre pond was stocked with a combination of bluegills, golden shiners, and bass in January, 1936. It was drained in January, 1939. This pond produced 200 pounds of bass, 238 pounds of bluegills, and 134 pounds of golden shiners. While the bass production was excellent, the presence of the golden shiners apparently reduced the weight of bluegills which the pond could support, and consequently reduced the total poundage of desirable fish which could be caught in the pond.

The ratios of forage and carnivorous fish in ponds—In addition to stocking with the best combination of species in a pond, it is extremely important to stock with as near the correct numbers of each species as possible. Since the carnivorous species are directly dependent upon the forage species for food, the proper balance between the two should be secured by proper stocking.

Little information is available as to just what constitutes the proper balance between the forage and carnivorous species in ponds. This is a problem which can be solved only by extensive experiments. In order, however, to establish an approximate ratio for stocking purposes, the weights of forage and carnivorous species present in eight ponds were determined by draining the ponds and counting and weighing the fish (Table 3).

In these ponds, the ratio of the weight of forage to carnivorous fish varied from 1.9:1 to 3.5:1. The average was a ratio of 2.8:1.

In stocking ponds, the ratio of 2:1 was arbitrarily accepted. If a pond can support 150 pounds of fish per acre of water, this ratio means that bream or other forage fish will make up 100 pounds of this weight, and bass or other carnivorous species 50 pounds. Since bluegills can reach a weight of 4 ounces or better in one year and bass a weight

TABLE 3—RATIOS OF FORAGE AND CARNIVOROUS FISH IN VARIOUS PONDS

Size of pond acres	Age of pond years	Forage Fish (F)		Carnivorous Fish (C)		Ratio
		Kind	Weight pounds	Kind	Weight pounds	F:C
1.8	1	Bluegills, Yellow bullheads, Chub suckers	230	Largemouth bass & white crappie	65	3.5:1
1.8	1	Bluegills, Yellow bullheads, Chub suckers	173	Largemouth bass & white crappie	68	2.5:1
1.8	2	Bluegills, Yellow bullheads, Chub suckers	280	Largemouth bass & white crappie	105	2.7:1
1.8	3	Bluegills, Yellow bullheads	358	Largemouth bass & white crappie	120	3.0:1
1.5	2	Bluegills	256	White crappie	88	3.0:1
1.0	3	Bluegills, Golden shiners	380	Largemouth bass	200	1.9:1
25.0	13	Bluegills	1,326	Largemouth bass	607	2.2:1
1.3	1	Bluegills	482	Largemouth bass	141	3.4:1

of approximately a pound, the above pond should support 400 bream (averaging a quarter-pound) and not more than 50 bass (averaging one pound) per acre. Similarly, if a pond will carry 600 pounds of fish, it should support approximately 1,500 bream and not over 200 bass of the above sizes. In actual stocking, the above numbers of bream are used, but only half the above numbers of bass. This reduction in the number of bass is advisable for the following reasons:

1. Little food is available for the bass until bream have spawned.
2. The above ratio is only approximate.
3. The young bass produced in the pond will also require forage fish for food.

Where ponds have been stocked in the above manner with fingerling bluegills and bass, both have reached a legal size in less than a year after the pond was stocked.

SUMMARY

Experiments have been conducted over a 5-year period upon methods of stocking ponds for the most efficient production of fresh-water fish. These experiments have been conducted in ponds ranging in size from 0.5 to 12 acres. Ponds were stocked in various ways during the winter or early spring and the results determined, after an interval of one or more years, by draining the ponds and counting and weighing the fish.

Stocking with adult fish (a combination of bluegills, white crappie, yellow bullheads, and largemouth black bass) gave extremely poor results. This procedure resulted in overcrowding the pond with some species and in the total failure of others to reproduce.

Stocking ponds only with bluegill bream fingerlings resulted in rapid growth of the bream until spawning occurred. Growth then ceased entirely, due to the increased competition for food by the thousands of small fish produced. Very few fish ever reach a legal size in ponds stocked in this manner.

Stocking ponds with various combinations of bluegill bream and white crappie gave better results, but usually resulted in ponds overstocked with either bream, or crappie, or both.

Stocking ponds with a combination of bluegill bream fingerlings and largemouth black bass fingerlings gave the best results, measured both by the growth of bream and bass. In these ponds, the bass had reduced the numbers of small bream and small bass, leaving approximately the right numbers for rapid growth. Good results were secured only by the addition of the correct numbers of fingerlings of both species; the basis upon which these numbers are calculated is given.

Properly stocked ponds provide good fishing within less than a year,

while improperly stocked ponds have required as long as five or more years to reach this condition.

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AN ATTEMPT TO EVALUATE THE EFFECT OF STREAM IMPROVEMENT IN CONNECTICUT

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Since 1932 when federal aid became available for the purpose, stream improvement has become a recognized part of the trout restoration program in Connecticut as well as in a number of other states. Various types of structures, as advocated by Hubbs, Greeley and Tarzwell (1933), Davis (1935), Davis, Hazzard and MacIntyre (1935) and James (1935), have been installed and tested for durability. During these years it has been considered as self-evident that these devices did, indeed, improve conditions for trout but actually few data based upon experimental evidence were available to support this assumption (Greeley, 1936; Hazzard, 1937; Hubbs, Tarzwell and Eschmeyer, 1934; Tarzwell, 1938).

Connecticut is forced to provide fishing in streams that are, in general, relatively poor trout water. Summer temperatures often reach the upper limits of tolerance of trout, water levels become exceedingly low exposing wide expanses of stream bed, considerable anchor ice may be formed in winter and the spring break-up is usually followed by excessive flooding and scouring. For this reason the foundation of the program rests in the hatcheries producing legal-sized trout which are liberated just prior to, and during, the fishing season. The problem is primarily one of attaining the greatest possible catch in relation to plant.

In 1933 over 15,000 legal-sized brook and brown trout were marked with the Nesbit internal tag (Cobb, 1934) and planted in thirty-six

representative streams of the state. On the basis of returns from these tagged trout, Elkins (1934 unpublished) reported that between 58.2 per cent and 66.7 per cent of the legal-sized trout liberated were lost from the streams some time between the end of one fishing season and the beginning of the next. From these data it becomes evident that if stream improvement were effective in decreasing the annual loss of hatchery trout even 50 per cent, it would improve fishing to a tremendous extent within a short period of years and at a lower cost to the angler.

In 1937 the senior author suggested the desirability of cooperating with the Connecticut State Board of Fisheries and Game in an attempt to check the effect of stream improvement on a typical Connecticut stream. It was desired to know what effect certain types of stream improvement had on the physical condition of the stream bed, the chemistry and temperature of the water and the change, if any, in bottom fauna. It was hoped that these data would indicate the practicability of extensive stream improvement work on the principal streams of the State. It was not feasible, however, to check all of the numerous stream improvement devices. Consequently, it was decided to confine the work to the "V"-dam as modified by Thorpe from James (1935). This type of structure created striking physical changes in the character of streams and seemed to hold promise of being best adapted for use in Connecticut.

After examining several brooks, it was decided to place the experimental dam on a portion of the Blackledge River. In years gone by this body of water was a natural trout stream of some reputation but due to environmental changes it has now become rather poor trout water, particularly during the summer months. At the present time it is heavily stocked by the State with legal-sized trout, but few trout hold over from year to year.

After examining several portions of the stream, an area was selected that possessed a relatively uniform depth, width and slope. The bottom was quite uniformly of the gravel-rubble type and so flat and unattractive that it was consistently avoided by experienced fishermen.

The area chosen for study was 53 feet in average width and had an average depth of 1½ feet.

The velocity varied from 1.65 feet per second (March, 1937) to 1.38 feet per second (May, 1939) although this does not represent maximum velocity in flood periods. Two volume flow determinations were made using the formula advocated by Hoover (1937). In March, 1937, the volume was 118 cubic feet per second, and in April, 1939, it was 65.3 cubic feet per second.

Three areas 25 yards long were marked off—the lower two here-