PROCESSING FISH FROM FARM PONDS

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This is to certify that the

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PROCESSING FISH FROM FARM PONDS

By

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A Thesis

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INTRODUCTION

At present there is an increasing utilization of farm ponds in the state of Michigan. Many ponds are in use at the present time and more are being constructed each year. These ponds are useful for water conservation, erosion control, fire protection, irrigation, orchard spray water supply, recreation, and fish production.

In the matter of fish production, Michigan's ponds are of more importance for food production than for recreational fishing since the large number of natural lakes in the state offer excellent sport fishing. There is no reason why the owner should not harvest from the water as well as the soil, especially since fish can be raised without hampering the other purposes of the pond and grown with very little care from the owner.

One of the principal problems in relation to farm pond management is how best to harvest and utilize the fish produced. A large number of farm ponds throughout the country are not being used to their greatest capacity because, although they are producing fish, the owner may not know how best to utilize the fish in his ponds.

This study presents a method of processing and utilizing pond fishes so as to provide an economical source of animal protein food. Phases considered include an estimation of the potential poundage of edible fish that can be raised per acre of pond; ways in which the fish can be processed; weight loss to be expected in processing; comparison of the final yield with the amount of poultry or beef that can be raised on a similar area; and an estimate of the average time

consumed in processing three species of pond fish.

Special emphasis was placed upon determining the per cent of usable meat in the finished product. This has already been determined for many fish which are sold commercially and Tack (1944b) has done the same for lake herring (Leucichthys artedi), carp (Cyprinus carpio), and suckers (Catostomus commersonii). No specific information regarding weight loss for the common pond fish has been available. Such knowledge should prove helpful in determining the number of fish to catch or harvest, the number of fish to package together so that enough for one meal can be removed from the freezer in one package, and the total net yield in edible food that a pond can supply.

For the sake of convenience the main body of this work has been divided into the following topics.

1. Harvesting and Yield
2. Freezing
3. Per Cent of Usable Weight in Processing
4. Smoking Fish
5. Comparison of Yield with Beef and Poultry
6. Time Study
7. Relation between Size of Fish and Per Cent of Usable Meat

The writer wishes to express his thanks to Dr. Robert C. Ball under whose supervision this study was made and whose aid and suggestion have been invaluable. Dr. Ball furnished all photographs. The ponds for the experimental work on fish production were made available through the cooperation of the Michigan Department of Conservation.

Thanks is due to Dr. Peter I.Tack for advice on the problem; to Dr. William D. Baten for checking the statistical data; and to

Dr. L. J. Bratzler and Mr. C. C. Sheppard of the School of Agriculture for information concerning beef and poultry.

Source of Material

In June 1947, six ponds at the Wolf Lake Hatchery, Kalamazoo County, in southwestern Michigan, were stocked with largemouth black bass (Micropterus salmoides) and bluegills (Lepomis m. macrochirus). These ponds were drained in 1948, the fish counted, weighed, measured, and returned to the pond.

On September 8 - 10, 1949 these ponds were again drained and all fish of usable size (five inches or more) were taken to a local freezer plant where they were immediately sharp frozen at -20° F. without having been processed in any way.

The larger fish, which included most of the bass, were wrapped individually in freezer paper and labeled with the pond number. The smaller fish were placed in paper containers and wrapped in bundles of about two or three pounds each. They were then taken to Michigan State College where they remained in a freezer at 0° F. until processed.

The bullheads (Ameiurus m. melas) and some of the largemouth bass were from experimental ponds located at Hastings, Barry County, Michigan. The bass were taken from ponds stocked with bass and fathead minnows (Pimephales p. promelas). All bass from Hastings were from Pond 4 and Pond 6. The bullheads were stocked with golden shiners (Notemigonus crysoleucas auratus) in a combination where the shiners were used as forage fish and bait minnows and the bullheads raised for food. These were also sharp frozen at -20° F. without any preliminary processing and sent to Michigan State College for holding until processed.

PROCEDURE AND METHODS

General Technique

All fish used in this study were weighed in grams since some of the bluegills processed were quite small. A spring balance dietetic scale was employed for all weighing. The total length of the fish was used in all cases and was measured in inches to the nearest tenth.

A section of two-inch-thick oak plank was used as a cutting board. Knives used were of the butcher knife and slicing type. A knife with a medium length thin blade was used for filleting. Bluegills were scaled with an ordinary hand type scaler.

For the purposes of this study a dressed fish was defined as one which had the head, entrails, skin and/or scales, and fins removed. This included removal of the kidney from along the ventral surface of the backbone. Some of the bluegills were scaled and some were skinned. Many people like the skin of bluegills to eat but the skin of bass often has an objectionable muddy flavor which most people do not enjoy and so consequently all of the bass were skinned rather than scaled.

In processing, one or two packages were removed at one time from the freezer and a package was opened and allowed to start thawing while the necessary knives, scales, charts, and other equipment were assembled. In general, it took from fifteen to twenty minutes for the fish to thaw enough so that they could be separated. In the case of the larger fish wrapped individually, six or eight packages were opened at one time.

As the fish were cleaned, records were kept of each fish, listing the total length of the fish, the total weight, and the weight of the dressed fish or fillets. As each lot of fish was processed, the amount of time spent in cleaning was recorded.

Cleaning Bluegills and Pan dressed Bass

Cleaning operations on the bluegills and bass were started by removal of the head. Holding the fish upright and starting just back of the head, the knife was forced down and slightly to the rear so as to avoid the operculum. At this point the knife was angled forward slightly so as to pass directly posterior to the pectoral fins. The belly was split open back to the vent and the entrails removed, care being taken to scrape out the kidney from along the underside of the backbone.

Lateral cuts were made along either side of the dorsal fin and extending all the way forward to the head. The dorsal fin was pulled out by holding it at the posterior end and pulling up and forward. The anal fin was removed in the same manner.

This procedure left the skin attached to the fish but divided along the entire dorsal and ventral midlines. For those fish which were skinned, the skin was pulled away starting at the anterior dorsal end and pulled off to the rear until it separated from the caudal fin. The caudal fin was cut off and the dressed fish was wiped clean, weighed, and packaged in pliofilm or cellophane freezer bags.

Essentially the same technique was used for those bluegills which were scaled. In this case the scaling was done first. This work

was done with an ordinary toothed fish scaler. The fish was held flat on the board and the scales removed from each side starting at the tail and working to the head. The head, entrails, and fins were removed in the same manner as for the skinned fish.

Filleting

The method used for filleting was similar to that of Dendy (1946). A thin, medium length blade was used for this work. Because the fish were only partially thawed, the meat was still very hard and a somewhat heavier knife was used than would be used to fillet fresh fish. The method is illustrated in Chart I.

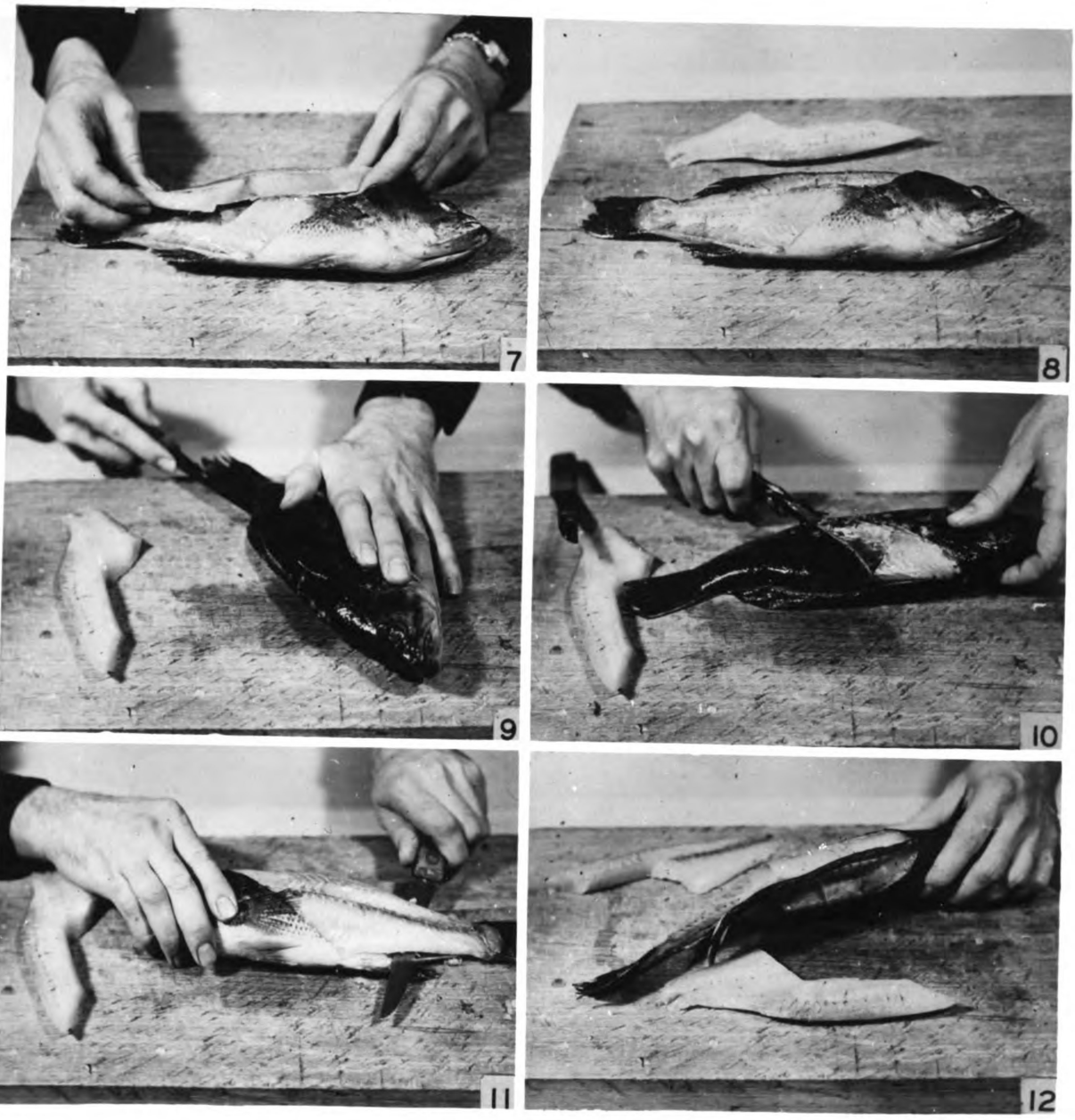


Fig. 7. The fillet should separate from the fish in one piece if all the cuts have been made correctly.

Fig. 8. Shows one side filleted and the fish from which the fillet was taken.

Fig. 9. The same dorsal cut is made for the other side.

Fig. 10. The skin is removed in the same manner as shown for the first fillet.

Fig. 11. Shows knife being pushed all the way through the fish after passing the last rib.

Fig. 12. Finished fillets and fish carcass.

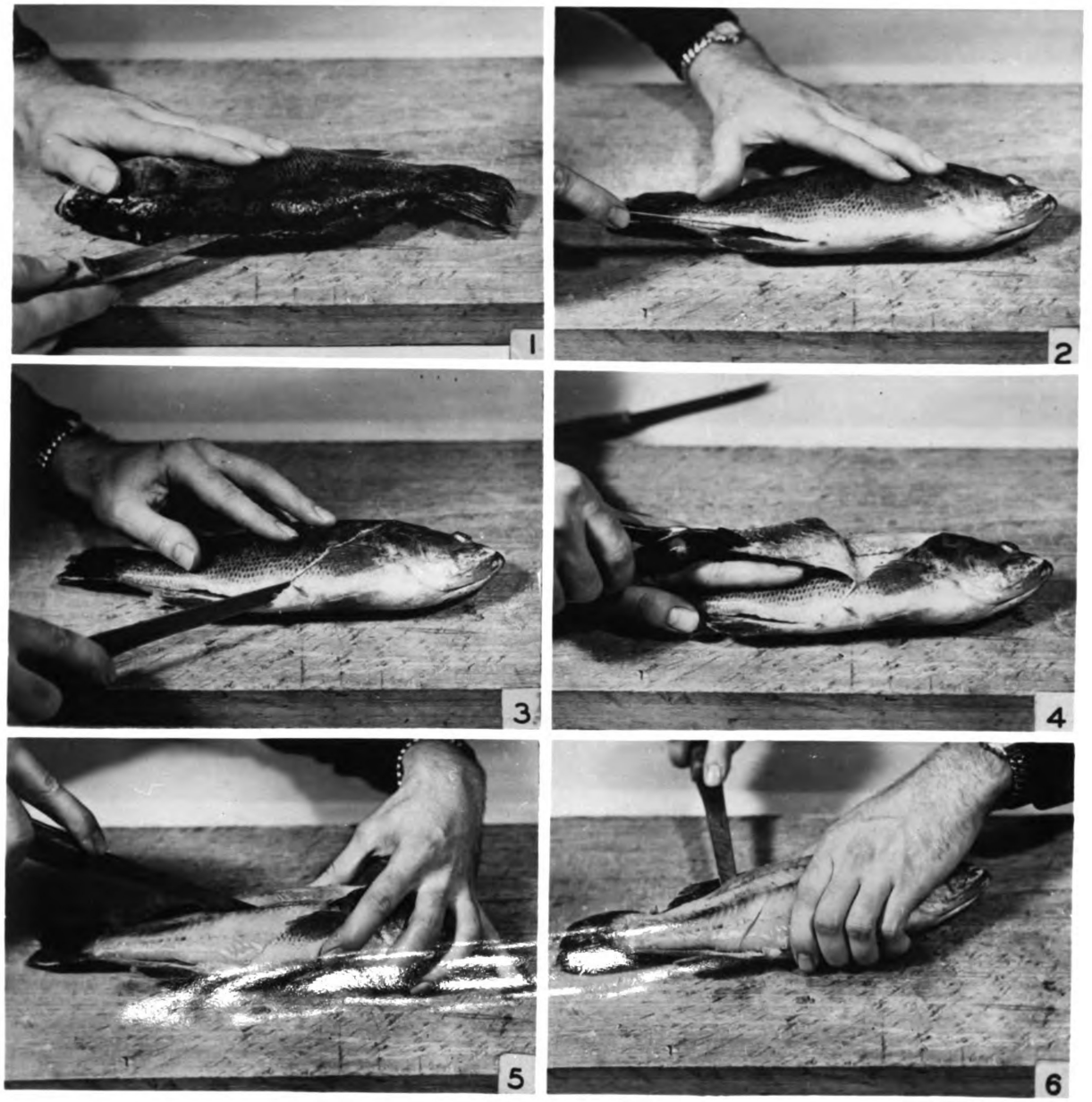


Fig. 1. A cut is made all along the back and going straight down alongside the dorsal fin.

Fig. 2. A cut is made alongside the anal fin extending from the vent to the tail.

Fig. 3. The skin is cut diagonally down from the anterior end of the dorsal cut to the vent.

Fig. 4. Starting at the anterior dorsal edge, the skin is loosened and pulled back and off at the tail.

Fig. 5. A cut is made just dorsal to the lateral line and extending to just beyond the ribs. From here the cut is angled down to the ventral cut. (shown in Fig. 6.)

Fig. 6. The dorsal cut is deepened to extend down to the ribs. After the knife passes the last rib, it is pushed all the way through to join with the ventral cut.

PRESENTATION AND ANALYSIS OF DATA

Harvesting and Yield

Harvesting Fish used in this study were all harvested by draining the ponds. This is the quickest method and the best way of obtaining the entire yield from the pond. As Davison (1947) points out, a drain is also an important aid in pond management. For natural ponds or those constructed without a drain, some other method of harvesting must be used. Seines of various types are sometimes employed but this is a slower method and probably fails to take all the fish.

If the owner wishes to remove only a few fish from his pond at one time, hook and line fishing can be used. Bass are most easily taken in the Spring when their food supply is lowest, and bluegills are most easily removed from the spawning beds. While this is not sport fishing, it is justified by the fact that the best managed pond is the one in which the entire annual crop of usable fish is harvested. If the entire usable crop is not harvested, there is waste not only from the standpoint of yield but also because the small fish will grow at a slower rate. Small fish can convert food into tissue more efficiently than large fish and can grow only as fast as the available food supply allows. This fact was brought out quite clearly by Davison (Ibid) when in speaking of bass he said that after spawning had occured once, there was no danger of hurting the breeding stock and stated: "If you catch a fish large enough to eat, its removal and use is good sense at any time of the year."

Hook and line fishing is not a good means of harvesting the entire crop of fish. One can hope to harvest only about half of the adult fish by this method because as the number of fish decreases, the remaining fish find enough food so that they do not readily take the fisherman's bait until, by their increasing size they reach the carrying capacity of the pond and again have to compete for food. (Mo. Con. Comm. 1950).

Yield Many factors enter in the determination of the number of pounds of usable fish that an acre of pond will support. The number of pounds of fish of all sizes which a pond can support is called the carrying capacity of the pond and is more easily determined.

The numbers and pounds of fish harvested per acre of pond are given in tables 1 and 2. The average yield for four ponds at Wolf Lake was 195.3 pounds per acre. This figure represents usable fish only. In this study bluegills of five inches or more and bass of eight inches or more in length were considered usable fish. The yield for the four ponds is as follows:

Pond	12	17	20	21
Pounds	195.9	121.4	309.0	155.0

The carrying capacity of these ponds is estimated to be about twice the yield. As can be seen in table 3, the total yield of fish of all sizes in Pond 20 was actually 669 pounds per acre. This is considered to be an exceptionally high total yield for this locality. Edminster (1947) found that the carrying capacity for bass - bluegill combinations ranged from 300 to 600 pounds per acre with the yield averaging about half this amount. This would be a yield of about 200

Table 1. Production of Bass and Bluegills - Wolf Lake - Fall Draining 1949

Pond # and Size	Species	Size	Number of Fish per Acre	Average Length in Inches	Pounds of Fish per Acre	Number of Fish/Pound	Size range in Inches
12	Bass	Small	1,043	2.5	7.7	134	2.1-3.0
(1.8 acres)	Bass	Medium					
	Bass	Large	109	12.8	83.2	1.44	7.5-13.4
12	Bluegills	Small					
	Bluegills	Medium					
	Bluegills	Large	665	6.1	112.7	5.9	4.2-7.4
17	Bass	Small	164	5.8	13.8	12	2.9-8.3
(1.3 acres)	Bass	Medium					
	Bass	Large	129	8.3	39.2	3.4	7.3-11.5
17	Bluegills	Small	2,335	3.1	53.0	44.0	1.8-4.3
	Bluegills	Medium	375	5.0	30.0	12.5	3.4-5.6
	Bluegills	Large	187	6.1	28.4	6.6	4.9-7.2

Table 2. Production of Bass and Bluegills - Wolf Lake - Fall Draining 1949

Pond # and Size	Species	Size	Number of Fish per Acre	Average Length in Inches	Pounds of Fish per Acre	Number of Fish/Pound	Size range in Inches
20	Bass	Small	1,162		20.00	57.3	2.7-4.8
(1.3 acres)	Bass	Medium					
	Bass	Large	116	13.1	131.00	.887	12.2-14.0
20	Bluegills	Small	3,180	4.05	340.00	24	3.0-5.4
	Bluegills	Medium					
	Bluegills	Large	1,591	5.3	178.00	8.9	4.1-6.6
21	Bass	Small	149		8.7	22.2	3.2-6.3
(2.3 acres)	Bass	Medium					
	Bass	Large	134	10.5	67.5	2	9.6-11.8
21	Bluegills	Small	2,826	2.0	22.6	125.4	1.2-5.1
	Bluegills	Medium	692	4.7	51.5	13.5	3.4-5.8
	Bluegills	Large	480	6.1	87.5	5.5	4.9-9.3

pounds per acre except in the northernmost tier of states where it would probably average 150 pounds per acre or less. Also commenting on yield, Davison (1947) believes that natural ponds support as little as 20 and seldom more than 200 pounds of fish per surface acre. He says these same ponds with the addition of commercial fertilizer can support 400 - 600 pounds of fish. Wunder (1949) has reported yields as high as 616 pounds per acre from carp grown in fertilized ponds in Silesia, Germany. Pond 20 was a fertilized pond but as can be seen by comparison with other reports its yield was outstanding. The other three ponds, two of which were also fertilized, did not have as great a yield but the average of all four ponds was high.

Freezing

Modern freezing has revolutionized the fish eating habits of the nation by providing an effective way to keep fish in the fresh state. Previously the only means known to preserve fish for any length of time was drying, salting, or canning.

Many ocean fishing boats are now freezing their catch in the round as soon as they are taken aboard. Later they are thawed, filleted, packaged, and refrozen without injury to quality. This is contrary to the long established belief that fish once frozen should never be thawed and refrozen. It is believed that sharp freezing of freshly caught fish prolongs the state of rigor and autolytic and bacterial breakdown such as occurs in fish that are iced is very much reduced. (Punochar 1948)

In speaking of commercial fisheries Zarotschenzeff (1948) states that there are no rigid rules or laws governing the conditions under which fish should be frozen for marketing and notes that the British Ministry of Food has set up certain specifications for the quick freezing of fish.

1. Fish selected should be of the freshest and best quality and frozen with a minimum of delay.
2. Fish should be cooled at such a rate that the time taken to cool the fish through range 32° F. to 23° F. shall not exceed two hours, and the temperature of the fish leaving the freezing plant should not exceed zero degrees F.
3. The frozen fish should be carefully "glazed" by immersion in or by spraying with cold water and/or sealed in water and vapour proof wrappers.
4. The holding temperature of around zero degrees F. is considered best for frozen fish held for 8 - 10 months.

This study has attempted to employ the same technique in freezing as has proved effective for the commercial fisheries. As has been stated, the fish were sharp frozen without processing of any kind. The actual work of processing was started one week after the fish had arrived at Michigan State College and work was continued over a period of four months. This method would allow the pond owner to harvest all his fish at once and to process them from time to time as they were needed for food or as the time allowed. Even after a period of four months, the fish were in good condition. A few showed slight drying or "freezer burn" due probably to poor wrapping.

Studies made at Michigan State College show that there is a species variation in the keeping properties of fish. Whitefish, trout, and carp are relatively fat and show a breakdown of the fatty tissue when held for four months or longer in a freezer. This study included nine freshwater species of fish and showed that, in general, fish compared well with beef and pork in amount of vitamins, amino acids, and protein content. It was also shown that frozen storage did not significantly alter the nutritive value of fish. (Ingals et al, 1950)

Bratzler (1950) in studies made with ground beef found that there was a wide variation in the amount of shrinkage during storage. Various types and brands of freezer wrappings were tested. Some showed as much as 30 per cent shrinkage when held for a period of fourteen months but it was shown that with the proper type of freezer paper and careful handling, the amount of shrinkage could be kept to a fraction of one percent.

No great amount of shrinkage was noted though an accurate check would probably have revealed some shrinkage especially in those fish which had been processed and refrozen and due to poor wrapping exhibited some degree of "freezer burn".

One very definite advantage to freezing fish before they are processed was found to be the ease with which they could be processed. The bluegills were very easy to pan dress as compared with fish freshly caught. It was not as difficult to remove the scales and when the proper cuts about the head had been made, the head and entrails were very easily removed together. It was also found that the skin came off without adhering to the flesh as it often does in freshly caught

fish. The flesh of the bass was very firm because of the partially frozen condition and this made filleting much easier also.

Per Cent of Usable Meat

Bluegills All of the bluegills were processed by pan dressing. The weight loss by size interval groups is shown in supplementary tables 9, 10 and 11. This same data is summarized in table.3. Actually not all this weight is available for food as in fillets because some bones are still present but the pan dressed fish compares with dressed chicken or dressed cattle. Therefore, in this study, dressed weight was considered the same as per cent usable and was listed as a percentage of the total weight of the fish. The weight loss can be determined as the reciprocal of the per cent of usable meat as shown in the tables.

Table 3. Summary Data on the Processing of Bluegills

Pond Number	Number Processed	Average Weight in grams	Average Length in inches	Total Weight in pounds	Per cent Usable
17	311	75.9	6.10	51.7	47.7*
20	645	51.4	5.56	72.2	50.9*
21	63	141.4	7.42	21.2	51.6*

A total of 1019 bluegills was processed from the three ponds. Their combined weights totaled 145.1 pounds. The weighted average*

* Represents a weighted average obtained by multiplying the per cents of usable meat by the number of fish, adding the resultant numbers and dividing by the total number of fish.

of all the bluegills was 64.4 grams or slightly more than two ounces.

Bluegills used in this study varied in weight from 30 to 315 grams. Thirty-eight fish below this range were processed but showed no appreciable difference in the per cent usable as food.

Sizes covered the range 5.0 to 9.7 inches with the weighted average being 5.8 inches for the group.

The dressed weight for the entire number of bluegills averaged 49.9 per cent of the live weight. This figure compares well with the findings of Tack (1944b) on the dressed weight of carp and suckers which he lists as 53.7 per cent and 52.9 per cent respectively. It should be noted that Tack's fish retained the caudal fin. A few bluegills were prepared in this manner and it was estimated that this added about 1.5 per cent to the dressed weight.

Pan dressed Bass Supplementary tables 12, 13, 14 and 15 list the percentage of usable meat found in processing the bass by pan dressing.

A total of 175.1 pounds of bass were pan dressed. The number of bass pan dressed totaled 276. Sizes ranged from 5.6 inches to 13.7 inches with the weighted average being 10.5 inches.

Total weights varied through the range 33 grams to 631 grams and the weighted average for all bass pan dressed was 312.7 grams. Table 4 gives the summary data for each pond.

Table 4. Summary Data for Pan Dressed Bass

Pond Number	Number Processed	Average Weight in grams	Average Length in inches	Total Weight in pounds	Per cent Usable
17	61	315.4	11.2	42.6	54.2
20	84	481.6	12.8	86.5	49.5
4	32	70.7	6.6	5.0	50.8
6	99	286.2	9.5	41.0	52.7

When the averages of per cent usable meat for each pond were weighted, it was found that 51.8 per cent of the live weight was usable. This is very close to the percentage found for bluegills and also compares with the findings of Tack (1944b) for carp and suckers. It is however considerably less than Tack's data for lake herring which was reported as 71.9 per cent of live weight.

Filleted Bass A total of 145 bass were filleted. Their weight totaled 144.3 pounds. The total weights of the individual fish ranged from 39 grams to 649 grams with the weighted average being 454 grams or exactly one pound each.

The size ranged from 5.6 inches to 13.8 inches for an average of 12.3 inches. Supplementary tables 16, 17 and 18 give the percentage of usable meat and detailed data for each pond by size interval groups. Total numbers and pounds are shown in table 5.

Table 5. Summary Data on Filleted Bass

Pond Number	Number Processed	Average Weight in grams	Average Length in inches	Total Weight in pounds	Per cent Usable
12	49	430.4	12.5	51.4	31.0
17	6	293.1	10.3	3.2	30.9
20	67	471.6	12.7	71.5	30.4
6	23	369.9	11.4	18.2	30.5

The weighted averages of all percentages for filleted bass was 30.6 per cent usable.

This figure of 30.6 per cent usable meat is somewhat lower than those figures cited by Tack (1944b) for fillets of lake herring, carp, and suckers. His findings, based on fillet weights of both sexes, were: carp 37.4 per cent; lake herring 63.0 per cent; and suckers 42.3 per cent of the whole weights. Likewise Krumholtz (1945) reported the fillet weight of yellow pikeperch (Stizostedion v. vitreum) to be 45 - 50 per cent of the total weight.

More nearly comparable are figures given in an article (Anon. 1945) appearing in the Canadian Fisheries Manual which stated "Two-thirds of the weight of whole fish (known by the fishermen as 'round fish') as it is taken off the fishing boats is made up of waste - head, tail, bones, fins, etc." This article was speaking of waste in dressing haddock and continues" . . . a filleted haddock is but 33 - 40 per cent of the whole fish."

It is true that fillet weights did not equal dressed weights for bass but it should be remembered that all of a fillet is edible.

Moreover, fillets take up less space in a freezer and more edible meat can be stored in the same space than for pan dressed fish. For bass, at least those of good size, there is much merit in a statement made by Tack (1944b) in reference to lake herring, carp and suckers. He said, "There is little reason for preparing fresh fish as dressed fish unless they are to be canned, since it is no more work to prepare fillets, and the product is more compact and ready to cook."

Bullheads All bullheads were pan dressed. A total of 349 fish weighing 119.2 pounds were processed. These fish varied in size from a small one 5.5 inches long and weighing 33 grams to one 10.5 inches long weighing 290 grams.

The weighted average of all fish of this species was found to be 40.7 per cent usable meat in relation to the whole weights of the fish. Table 19 gives the per cent usable by size groupings.

Possibility of Error Several persons aided in the processing of the fish and even though the same technique and methods were used, it is to be expected that some variation in weight loss in processing would be due to the operator.

The percentages of male and female fish in this study is unknown. It has been found by several investigators that there is a slightly higher weight loss in dressing females, especially when they are gravid.

Smoking Fish

Smoking of fish as an aid in preservation is no longer necessary since the advent of modern home freezers and community lockers. Nevertheless, there are those who enjoy the particular flavor and texture

imparted during the smoking process and smoked fish are in demand. Smoking also is a means of utilizing fish not generally eaten. Cary (1949) in urging the use of more "rough fish" as food says: "It's a peculiar phenomena of smoke fish that the so-called 'rough fish', the carp and catfish, smoke up better than most game fish."

Cleaning While it is possible to smoke fish which are filleted or pan dressed, it is often more desirable to prepare them in another way when smoking is to be done. Perhaps the easiest way,,and in many cases the best, is to drew the fish by slitting open the belly and removing the entrails. This method works very well for carp and bullheads. Fish thus prepared do not tend to dry out as much during smoking and do not easily fall apart. They may be strung up by the head or placed on pegs or nails. For fillets or pan dressed fish, some type of rack must be provided in the smoker. Such a rack made from hardware cloth was found to be satisfactory.

In order to gain some idea of the per cent of total weight left when a fish has been drawn, a study was made on small numbers of largemouth bass, smallmouth bass (Micropterus d. dolomieu) and black bullheads. All of these fish were drawn (had the entrails removed) and in addition each group had some added processing. The smallmouth bass were divided into three groups: 1. anal fin removed; 2. dorsal fin removed; 3. anal and dorsal fins and scales removed. The largemouth bass were divided into two groups: 1. anal fin removed; 2. anal and dorsal fins and scales removed. The bullheads were all gilled in addition to being drawn. The data concerning cleaning and smoking of these fish is shown in table 6.

Table 6. Drawn Weight in Relation to Total Weight

Species	Number	Drawn plus	Per cent loss	Per cent of total weight
Bullheads	33	gills	9.7	90.3
	9	anal fin	7.9	92.1
Smallmouth	13	dorsal, anal fin, scales	13.7	86.3
Bass	11	dorsal fin	11.8	88.2
Largemouth	25	anal fin	7.1	92.9
Bass	25	dorsal, anal fin, scales	10.0	90.0

The largemouth bass averaged 10.9 inches in length and 10.6 ounces in weight. The smallmouth bass averaged 11.4 inches in length and 13.3 ounces in weight. Both species of bass were taken from rearing ponds in November, 1947. The bullheads averaged approximately 10 inches in length and 10 ounces in weight and were removed from rearing ponds in September 1947.

One can expect a loss of about 10 per cent in weight when a fish of the species treated here has been drawn and gilled or drawn and rough dressed by removing one or more fins.

Curing Some kind of curing should be done prior to smoking. There are many methods and different formulae for brining solutions that can be used successfully (Jarvis 1950).

A standard type brine solution and the one used in this study was made up of salt, sugar, and saltpeter (potassium nitrate). The amounts used were those recommended by Tack (1944a) and are as follows: four pounds of salt, one and one-half pounds of sugar, and one and one-half ounces of saltpeter, to six gallons of water.

Fish of medium size should be soaked in the brine for 24 - 30 hours with less time needed for smaller fish and more time for larger ones. Brining should be done at low temperatures such as prevail in the ordinary home refrigerator. Widmer (1949) states: "Brining of meat is a race between bacterial action and the penetration of the salt solution. The cooler the brine, within reason, the slower the bacterial action, and the safer the process."

Smoking There is an infinite variety in the types and designs of smokers. They range from the simple barrel with a small fire in the base to rather intricate devices involving dampers and fans such as was used in this study at Michigan State College. Any smoker is satisfactory which provides sufficient smoke while still allowing the heat to be regulated to a moderate degree.

Apple wood was used to give heat though many other substances will serve as well. Hickory, oak, and cherry are frequently used. Green wood is best as it gives more smoke with less heat. If dry materials such as sawdust or corn cobs are used, they should be dampened with water. Tack (1950 oral communication) recommends peeling the bark from apple and cherry in order to eliminate resins that may give the fish an objectionable flavor.

One hundred and five bullheads were smoked in this study. After standing in the brine solution for 24 hours, they were removed and drained. A fire was started in the smoker and when the temperature had reached 90° F. to 95° F., the fish were hung inside by placing the heads on nails. A dense volume of smoke was maintained and the temperature was kept below 120° F. for three hours. The temperature

was then permitted to rise for the last hour of smoking but it was not allowed to go above 150° F. The heat was stopped at the end of four hours and after several hours of cooling the fish were removed. The heads were taken off the bullheads and the weights of both heads and fish were recorded. The flesh of the bullheads appeared oily and had turned a salmon-red in color. Weights were recorded throughout the entire processing and smoking and the results are given in table 7.

Table 7. Weight Loss in Smoking 105 Bullheads

	Pounds and ounces	Per cent Removed	Per cent of total remaining	Pounds and ounces left
Total wt.	64 - 0	---	---	---
Entrails	5 - 2	8.2	91.3	58 - 14
Smoking loss	8 - 7	14.4	75.6	50 - 7
Weight of heads	5 - 4	11.9	70.7	45 - 3

A Comparison with Beef and Poultry

In comparing the amount of fish harvested per acre of pond to the number of pounds of beef or poultry that an acre can support, one should be cognizant that these fish were not fed while most cattle and poultry are fed a considerable amount of feed over and above that supplied by the range.

In the southern part of Michigan it is customary to range from 125 - 150 head of cattle per section of land. This averages from four

to six acres per animal. With good pasture, three acres should be sufficient. A steer will gain about 250 pounds on the grass per season. In two seasons there would be a gain in weight of 500 pounds for the animals for each three acres. It takes about 500 pounds of corn or 750 pounds of hay or roughage to put 100 pounds of beef on feeder calves.

The average live weight of all cattle slaughtered for beef between the years 1930 and 1945 was 944 pounds. The average dressed weight was 55 per cent of the live weight. The per cent varied from prime steers which dressed out at 62 - 67 per cent to cutters and canners which dressed out from 40 - 52 per cent of the live weight. (Ziegler 1945)

As for poultry, there is no limit to the number that can be kept on an acre of ground. As many as 400-500 pullets may be kept on one acre but they can not be maintained without feeding. At the time of writing, it cost around 25 cents to raise one pound of broiler. Feed represents 60 per cent of this cost. It requires 3.5 pounds of feed per pound of broiler. The amount of feed that can be saved by pasture is 10 - 15 per cent.

Dressed broilers lose 33 per cent of their live weight. Turkeys lose about 25 per cent. This dressed weight consists of bone as well as meat and only about 40 per cent of a broiler's live weight can be considered edible.

Analysis If no supplementary feed was given, the yield of beef per acre would probably have been less than the yield for fish shown in this study. A gain in weight of 500 pounds for three acres would be about 166 pounds per acre whereas the fish from the Wolf Lake ponds showed an average yield of 195 pounds per acre. As for the percentage

usable, the cattle are slightly higher, with the dressed weights averaging 55 per cent as opposed to 50 per cent for the fish.

Supplementary feeding would be necessary to raise poultry. If pasturing will save 10 - 15 per cent of the feed cost, this would be one and a half to two cents a pound saved on the cost of production. However, the owner would still be paying about 23 cents a pound for his broilers and this is considerably more than the fish would cost him.

The production of fish in the Wolf Lake ponds compared favorably with the production figures for beef and poultry in cost and yield per acre.

Time Study

A check was made on the time necessary to process the fish. As shown in table 8, the bluegills averaged nearly twenty an hour or three minutes a fish. The average for pan dressed bass was four minutes each and for filleted bass six minutes each. The average rate for each bullhead was two minutes and 24 seconds.

Table 8. Time Study in Processing Fish

Species	Process	Pounds	Time (hours)	Number	Number per hour
Bluegills	Pan dressed	145.1	58	1019	18.4
Bass	Pan dressed	175.1	21	276	14.8
Bass	Filleted	144.3	16	145	9.3
Bullheads	Pan dressed	119.2	14	349	25.0

This study was intended only to give an estimate of the time needed for the various kinds of processing. It is to be understood that the time would vary considerably according to the skill and experience of the operator.

All of these fish were carefully measured and each one had to be weighed before and after processing. In addition scales and gonads were taken from a number of the bass and bluegills. In figuring the number of fish processed per hour, the time consumed in these extra processes is included.

Relation Between Size of Fish and Per Cent of Usable Meat

As a supplement to this study, it was thought advisable to determine whether or not there was any difference in the dressed weight percentages of large and small fish of the same species. The percentage of loss on dressing was analyzed by standard statistical procedure and it was found that the bass and bullheads showed a positive correlation between size of fish and percentages of dressed weight. In both species the larger fish showed a somewhat larger percentage of dressed weight in relation to total weight. The results are shown graphically in charts II and III.

Chart II. Linear Relation between Length of Largemouth Bass in Pond 20 and Per Cent of Dressed Weight

The vertical axis shows percentage of dressed weight. The horizontal axis shows length in tenths of inches. The predicting equation is $y = a + b x$ or, $y = 35.0 + 1.15 x$. The standard error of estimate is 1.18 per cent.

e.g. A fish 12.45 inches in length should dress out at 49.6 ± 1.18 per cent. The figure shows the bass of this size actually dressed out on an average of 49.0 per cent.

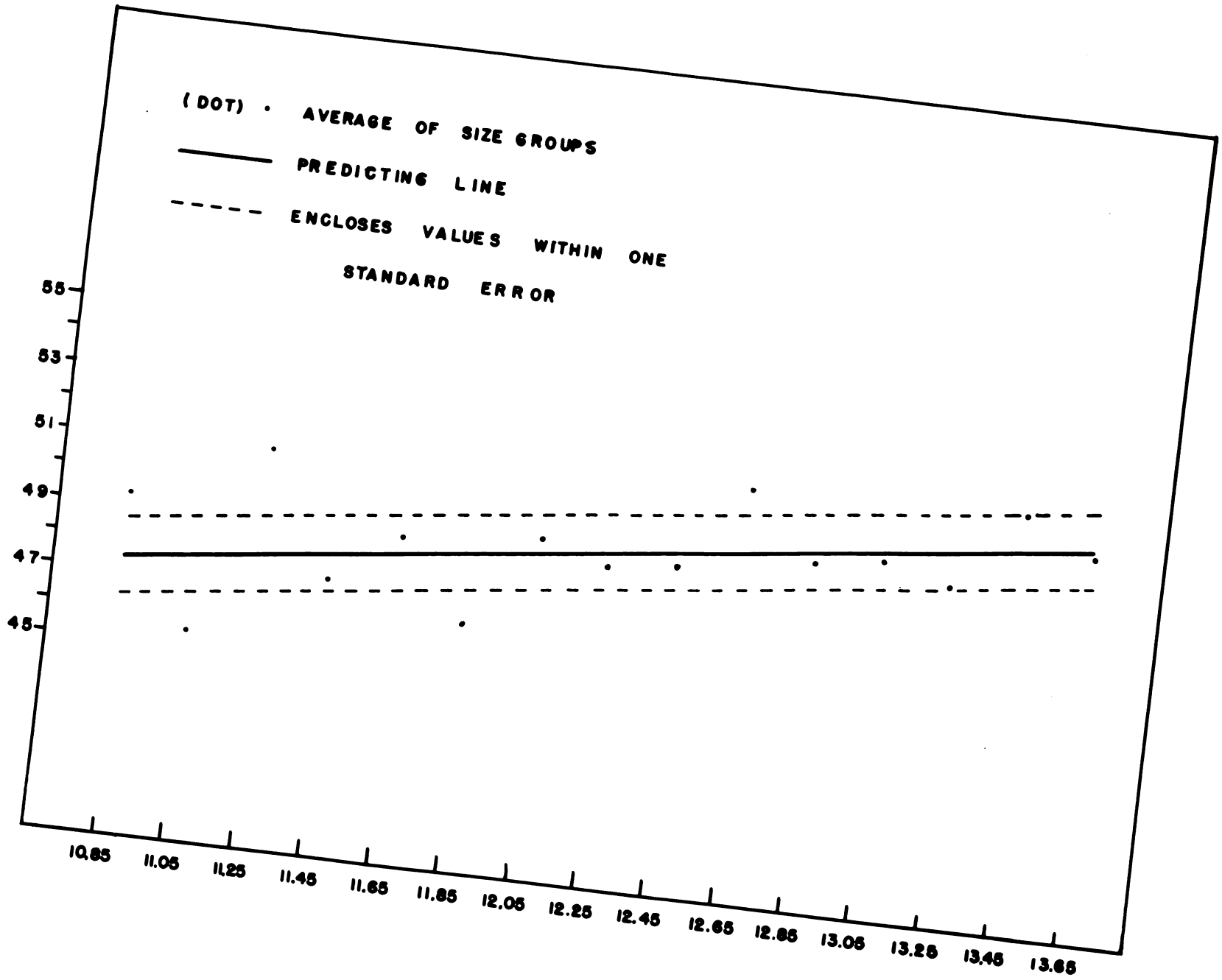
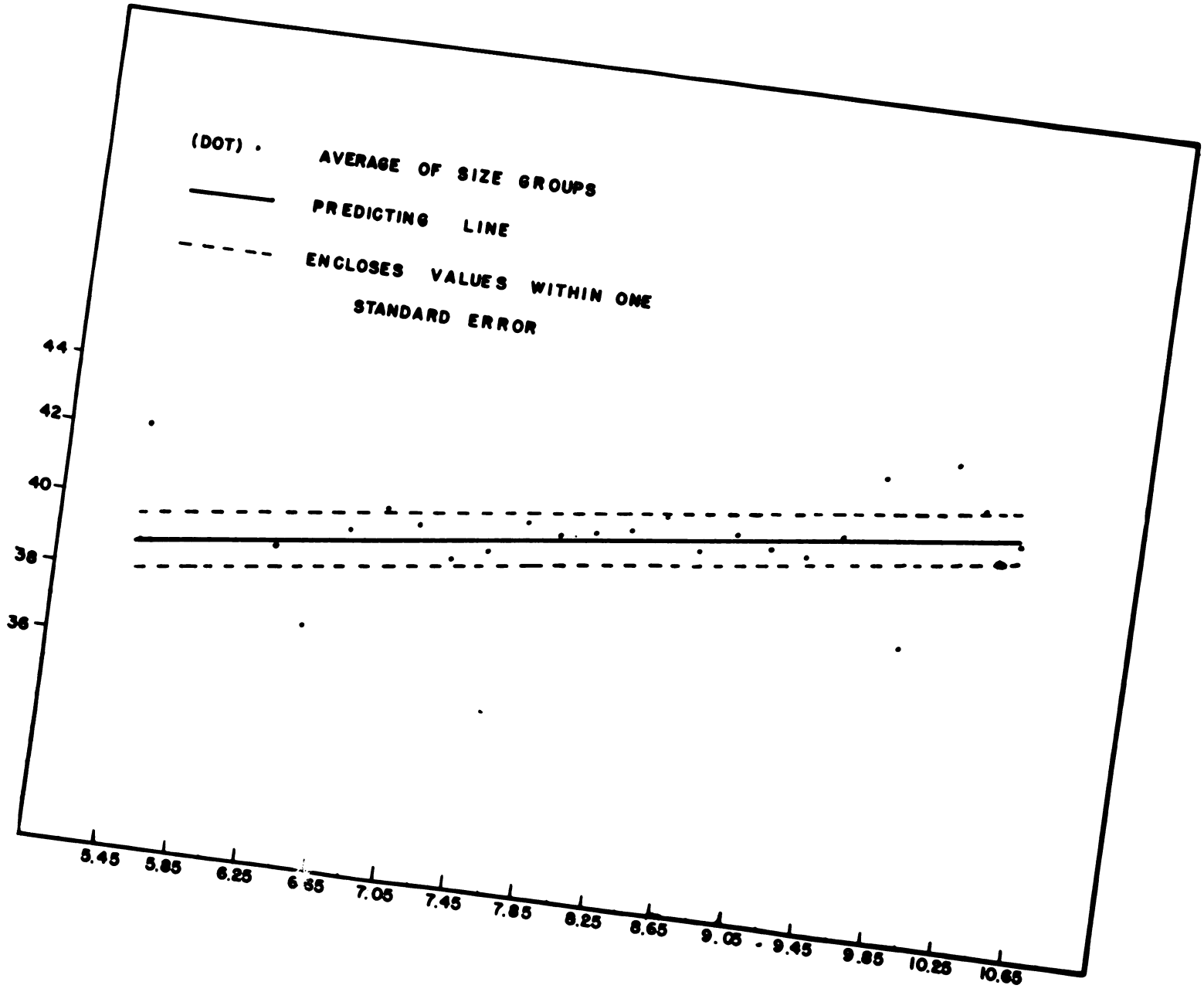

(DOT) . AVERAGE OF SIZE GROUPS
PREDICTING LINE
ENCLOSES VALUES WITHIN ONE STANDARD ERROR
55
53
51
49
47
45
10.85
11.05
11.25
11.45
11.65
11.85
12.05
12.25
12.45
12.65
12.85
13.05
13.25
13.45
13.65

Chart III. Linear Relation between Length of Bullheads from Hastings ponds and Per Cent of Dressed Weight

The vertical axis (y) shows percentage of dressed weight. The horizontal axis (x) shows length in tenths of inches. The predicting equation is $y = a + b x$ or, $y = 35.41 + .63 x$. The standard error of estimate is .83 per cent.


(DOT) . AVERAGE OF SIZE GROUPS
PREDICTING LINE
ENCLOSES VALUES WITHIN ONE STANDARD ERROR
44
42
40
38
36
5.45
5.85
6.25
6.65
7.05
7.45
7.85
8.25
8.65
9.05
9.45
9.85
10.25
10.65

These findings are in agreement with those of Krumholtz (1945) who found that the weight loss in filleting was proportionally greater in the smaller yellow pikeperch.

The bluegills in Pond 20 showed a slight negative relationship. This would indicate a higher percentage of dressed weight in the smaller fish. The bluegills in Pond 21 showed a very slight positive relationship. The increase was seven tenths of one per cent for each inch increase in length. In view of these differences, it was believed best to await the accumulation of more data before making any inferences regarding the relation of length and percentage of dressed weight for the bluegills.

DISCUSSION

Fish of the species usually grown in farm fish ponds were harvested two years after planting in order to determine yield, weight loss after processing, and ways of preserving for use.

The usable yield from the ponds studied was as high as 200 pounds per acre and this production compares favorably with the production of other types of edible meats grown on farms and with fish production from ponds in other parts of the country. A size of five inches total length for bluegills and eight inches for bass was established as the minimum size for which it is economical to process from the standpoint of time consumed and yield of food.

Weight losses in pan dressing are approximately 50 per cent of the total weight for bass and bluegills and 40 per cent for bullheads. These losses are similar to those of most food animals. In pan dressing, large bass and bullheads show less weight loss than smaller ones of the same species. Larger fish can be filleted nearly as rapidly as they can be pan dressed, take up less space in the freezer, and due to the absence of bones are highly preferable. Filleted bass dress out at about 30 per cent of the total weight.

Fish of the species raised in experimental ponds were processed by smoking to determine the quality of the product and desirable methods. In preparing for smoking, it was found necessary for good results only to draw the fish and remove the gills. This drawn weight for bass and bullheads is about 90 per cent of the total weight. A weight shrinkage of approximately 14 per cent was found to occur during smoking.

The method of sharp freezing fish "in the round" and later thawing, processing, and refreezing is satisfactory providing the holding temperature is kept near 0° F.

Fish compare well with beef and poultry in nourishment and can be grown with little cost and effort.

SUMMARY

1. The method of harvesting fish and immediately sharp freezing them "in the round" without any previous processing proved to be satisfactory.
2. The average yield of usable fish of five inches or more in length was 195 pounds per acre in the four ponds harvested at Wolf Lake.
3. The dressed weights of the bluegills and bass which were pan dressed averaged 50 per cent and 52 per cent of the total weights.
4. Bass which were filleted yielded 30 per cent usable meat.
5. Bullheads averaged 40 per cent usable meat.
6. The amount of time necessary to process the fish varied considerably according to the species and size of the fish.
7. For the 83 fish that were drawn the average weight loss was 10 per cent.
8. The 105 bullheads that were smoked showed an average loss of 14.4 per cent of the drawn weight due to the smoking process.
9. A comparison with beef and poultry showed that from the standpoints of cost, time, and yield, the production of food in farm ponds is worthy of consideration.

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Table 9. Bluegills processed from Pond 17, Wolf Lake, Michigan

Interval in tenths of inches	Number of Fish	Whole Weight in grams	Processed Weight in grams	Percent Usable
5.0 - 5.1	5	205	97	47.3
5.2 - 5.3	13	604	287	47.5
5.4 - 5.5	27	1445	693	48.0
5.6 - 5.7	37	2187	1029	47.0
5.8 - 5.9	45	2955	1404	47.5
6.0 - 6.1	54	3838	1815	47.3
6.2 - 6.3	40	3158	1522	48.2
6.4 - 6.5	30	2569	1224	47.5
6.6 - 6.7	23	2247	1058	47.0
6.8 - 6.9	15	1599	762	47.6
7.0 - 7.1	17	2046	1015	49.6
7.2 - 7.3	4	517	252	48.7
7.4 - 7.5	1	122	55	45.0

Table 10. Bluegills processed from Pond 20, Wolf Lake, Michigan

Interval in tenths of inches	Number of Fish	Whole Weight in grams	Processed Weight in grams	Percent Usable
4.2 - 4.3	1	20	10	50.0
4.4 - 4.5	16	428	249	58.1
4.6 - 4.7	8	244	139	56.9
4.8 - 4.9	13	431	235	54.5
5.0 - 5.1	82	2980	1547	51.7
5.2 - 5.3	120	4961	2509	50.5
5.4 - 5.5	126	5806	2923	50.3
5.6 - 5.7	98	4909	2500	50.9
5.8 - 5.9	57	3390	1688	49.7
6.0 - 6.1	54	3623	1829	50.4
6.2 - 6.3	30	2805	1372	48.9
6.4 - 6.5	24	1961	970	49.9
6.6 - 6.7	9	827	452	52.2
6.8 - 6.9	3	310	179	57.7
7.0 - 7.1	1	104	58	55.7

Table 11. Bluegills processed from Pond 21, Wolf Lake, Michigan

Interval in tenths of inches	Number of Fish	Whole Weight in grams	Processed Weight in grams	Percent Usable
5.4 - 5.5	1	53	26	49.0
5.6 - 5.7	1	56	29	51.7
5.8 - 5.9	0			
6.0 - 6.1	1	85	44	51.7
6.2 - 6.3	2	168	84	50.0
6.4 - 6.5	4	368	188	53.8
6.6 - 6.7	6	608	323	53.1
6.8 - 6.9	7	733	368	49.8
7.0 - 7.1	6	754	378	50.2
7.2 - 2.3	11	1327	696	52.4
7.4 - 7.5	2	303	154	50.8
7.6 - 7.7	1	146	74	50.6
7.8 - 7.9	2	378	199	52.6
8.0 - 8.1	2	357	190	53.2
8.2 - 8.3	3	613	317	51.7
8.4 - 8.5	2	415	216	52.0
8.6 - 8.7	2	511	266	52.0
8.8 - 8.9	2	504	258	51.1
9.0 - 9.1	1	262	132	50.3
9.2 - 9.3	5	1379	717	51.9
9.4 - 9.5	1	315	154	48.8
9.6 - 9.7	1	304	164	53.9

Table 12. Largemouth bass from Pond 17, Wolf Lake, Michigan which were pan dressed

Interval in tenths of inches	Number of Fish	Whole Weight in grams	Processed Weight in grams	Percent Usable
9.4 - 9.5	1	166	85	51.2
10.6 - 10.7	1	253	124	48.0
10.8 - 10.9	11	3032	1662	54.8
11.0 - 11.1	21	6135	3356	54.1
11.2 - 11.3	9	2854	1570	55.0
11.4 - 11.5	8	2497	1421	56.7
11.6 - 11.7	2	728	381	52.3
11.8 - 11.9	0			
12.0 - 12.1	2	810	445	54.9
12.2 - 12.3	3	1359	701	51.5
12.4 - 12.5	2	956	507	53.0
12.6 - 12.7	1	515	257	49.9

Table 13. Largemouth Bass from Pond 20, Wolf Lake, Michigan which were pan dressed

Interval in tenths of inches	Number of Fish	Whole Weight in grams	Processed Weight in grams	Percent Usable
10.8 - 10.9	2	657	324	49.3
11.0 - 11.1	3	995	452	45.4
11.2 - 11.3	2	670	342	51.0
11.4 - 11.5	2	723	343	47.4
11.6 - 11.7	2	829	406	48.9
11.8 - 11.9	1	469	195	46.5
12.0 - 12.1	2	829	409	49.3
12.2 - 12.3	12	5143	2507	48.7
12.4 - 12.5	13	5935	2913	49.0
12.6 - 12.7	7	3449	1781	51.6
12.8 - 12.9	7	3377	1673	49.6
13.0 - 13.1	13	6507	3258	49.9
13.2 - 13.3	7	3941	1942	49.2
13.4 - 13.5	8	4669	2416	51.7
13.6 - 13.7	3	1122	568	50.6

Table 14. Largemouth Bass from Pond 4, Hastings, Michigan which were pan dressed

Interval in tenths of inches	Number of Fish	Whole Weight in grams	Processed Weight	Percent Usable
5.6 - 5.7	1	39	20	51.2
5.8 - 5.9	2	84	43	51.1
6.0 - 6.1	1	49	25	51.0
6.2 - 6.3	3	170	89	52.3
6.4 - 6.5	6	378	185	48.9
6.6 - 6.7	3	210	107	50.9
6.8 - 6.9	6	437	215	49.0
7.0 - 7.1	4	329	167	50.7
7.2 - 7.3	4	354	191	53.9
7.4 - 7.5	2	186	101	54.3

Table 15. Largemouth Bass from Pond 6, Hastings, Michigan which were pan dressed

Interval in tenths of inches	Number of Fish	Whole Weight in grams	Processed Weight in grams	Percent Usable
5.6 - 5.7	2	66	36	54.7
5.8 - 5.9	9	347	182	52.4
6.0 - 6.1	14	575	309	53.8
6.2 - 6.3	12	552	280	50.7
6.4 - 6.5	10	512	271	52.9
6.6 - 6.7	5	291	147	50.5
6.8 - 6.9	1	60	32	53.3
7.0 - 7.1	0			
7.2 - 7.3	1	75	39	52.0
7.4 - 7.5	3	244	134	54.9
7.6 - 7.7	2	182	95	52.1
7.8 - 7.9	1	90	48	53.3
8.0 - 8.1	1	103	61	58.2
10.6 -10.7	1	317	160	50.4
10.8 - 10.9	1	326	176	53.9
11.0 - 11.1	1	323	168	52.0
11.2 - 11.3	2	684	349	51.0
11.4 - 11.5	7	2739	1455	53.1
11.6 - 11.7	7	2807	1480	52.7
11.8 - 11.9	10	4407	2356	53.6
12.0 - 12.1	8	3568	1891	52.9
12.2 - 12.3	1	496	260	52.2

Table 16. Largemouth Bass from Pond 12, Wolf Lake, Michigan which were Filleted

Interval in tenths of inches	Number of Fish	Whole Weight in grams	Processed Weight in grams	Percent Usable
8.2 - 8.3	1	104	37	35.5
11.4 - 11.5	1	349	110	31.5
11.6 - 11.7	3	1050	326	31.0
11.8 - 11.9	0			
12.0 - 12.1	2	854	250	29.2
12.2 - 12.3	9	4059	1318	32.4
12.4 - 12.5	7	3280	1065	32.4
12.6 - 12.7	8	3907	1146	29.3
12.8 - 12.9	9	4717	1441	30.6
13.0 - 13.1	5	2707	832	30.7
13.2 - 13.3	3	1708	492	29.2
13.4 - 13.5	1	605	192	31.7

Table 17. Largemouth Bass from Pond 20, Wolf Lake, Michigan which were Filleted

Interval in tenths of inches	Number of Fish	Whole Weight in grams	Processed Weight in grams	Percent Usable
12.0 - 12.1	5	1709	510	27.8
12.2 - 12.3	4	1573	473	30.0
12.4 - 12.5	8	3487	1048	30.0
12.6 - 12.7	7	3410	1050	29.9
12.8 - 12.9	6	2287	867	30.0
13.0 - 13.1	15	7540	2301	30.5
13.2 - 13.3	11	5702	1754	30.7
13.4 - 13.5	5	2837	919	32.3
13.6 - 13.7	3	1699	519	30.5
13.8 - 13.9	3	1887	612	32.4

Table 18. Largemouth Bass from Pond 6, Hastings, Michigan which were Filleted

Interval in tenths of inches	Number of Fish	Whole Weight in grams	Processed Weight in grams	Percent Usable
10.8 - 10.9	1	288	98	34.0
11.0 - 11.1	3	953	272	28.4
11.2 - 11.3	6	1953	604	30.9
11.4 - 11.5	5	1819	555	30.5
11.6 - 11.7	4	1562	497	31.8
11.8 - 11.9	2	861	241	27.9
12.0 - 12.1	1	397	129	32.4
12.2 - 12.3	1	508	159	31.2

Table 19. Bullheads from Ponds at Hastings, Michigan

Interval in tenths of inches	Number of Fish	Whole Weight in grams	Processed Weight	Percent Usable
5.4 - 5.5	1	38	16	42.1
5.6 - 5.7	0			
5.8 - 5.9	0			
6.0 - 6.1	0			
6.2 - 6.3	5	316	124	39.2
6.4 - 6.5	8	572	212	37.1
6.6 - 6.7	13	958	383	39.9
6.8 - 6.9	4	317	129	40.6
7.0 - 7.1	9	796	321	40.3
7.2 - 7.3	11	1052	415	39.4
7.4 - 7.5	6	595	237	39.8
7.6 - 7.7	17	1812	741	40.8
7.8 - 7.9	17	1941	788	40.5
8.0 - 8.1	14	1763	718	40.7
8.2 - 8.3	26	3571	1463	40.9
8.4 - 8.5	29	4388	1817	41.4
8.6 - 8.7	45	7131	2887	40.5
8.8 - 8.9	29	5054	2081	41.1
9.0 - 9.1	42	7914	3238	40.9
9.2 - 9.3	21	4329	1767	40.8
9.4 - 9.5	25	5271	2089	41.4
9.6 - 9.7	11	2493	1083	43.4
9.8 - 9.9	9	2088	804	38.5
10.0 -10.1	4	940	414	44.0
10.2 -10.3	1	264	113	42.8
10.4 -10.5	2	544	228	41.9

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