THE DEVELOPMENT OF CATFISH AS A FARM CROP AND AN ESTIMATION OF ITS ECONOMIC ADAPTABILITY TO RADIATION PROCESSING

by

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ABSTRACT

The catfish farming industry during the next few decades will face some crucial challenges. First, in order to adapt to the apparent increased production, well-organized efficient markets must be developed. The success of this industry during the next 10 years will primarily depend on the adequacy of this marketing structure. In addition, it will be necessary for the catfish industry to improve productivity and lower production costs to make catfish products competitive.

These challenges notwithstanding, it is clear that the catfish industry will expand significantly during the next 15 to 20 years.

The structure of the expanded catfish industry by that time will differ markedly from the current industry. Production techniques will be changed; the market will be more organized and progressive; and it is also likely that the fish will represent an improved genetic species, more adaptable to fish farming.

At the present, pond reared catfish are marketed either live for fee pond fishing or as a fresh (unfrozen) product. Although the market for fresh catfish can be expanded, the analysis in this study shows clearly the need to develop new products to absorb the increased output of catfish.

Radiation-pasteurization processing, it was found, will undoubtedly pay substantial dividends in terms of direct public benefits. If the entire farm output were marketed in the fresh-irradiated form, then

depending upon the discount rate, benefits would range between $31 and $45 million discounted value over an 11 year period.

Likewise, the development of irradiation processed catfish products will increase net returns over and above all costs, including irradiation costs, to the industry. It would be expected that during the period 1975-1985, an irradiated product, selling in an unfrozen form, would generate 5 percent greater net revenue for the industry than would be generated by the sales of fresh catfish. This increase in net revenue will primarily be due to:

(1) reduced spoilage loss

(2) increased sales because of the elimination of the practice of short-buying, i.e., buying less than expected sales as a hedge against spoilage loss.

Although there is little doubt that radiation processing can pay for itself in both the public and private sector, frozen catfish products represent a feasible alternative. If it were possible to market the same amount of catfish in the frozen form as in the fresh form, net revenues generated for the industry with frozen would nearly equal the net revenues from irradiated catfish. Marketing in the frozen form, in any case, adds less to the national income stream than irradiated. What is likely is that some combination of fresh and frozen catfish will make up the marketed forms. In this case, it is fully expected that irradiation-pasteurization will provide substantial public and private benefits.

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I. A Survey of the Resource

A. Identity

North American catfish--Ictaluridae--are a family of scaleless fishes that inhabit fresh water from Canada southward to Guatemala. There are more than two-score species in the family, but all share the distinguishing characteristic of prominent whisker-like sensory barbels. The family breaks down into two major groups: the large edible species, which include the bullheads, and the small inedible madtoms. 1/

Several species of catfish are highly prized as sources of excellent sport and food. The list includes channel, blue, white and flathead catfish, along with some varieties of bullheads. Channel catfish (Ictalurus punctatus) are the aristocrats of the upper-strata species. Sportsmen acclaim them for their challenging resistance at the end of a line, while the high prices they bring in commercial channels suggest an epicurean quality. The channel catfish is a long, slender fish and, unlike most of its brethren, prefers the channels of large, clear, swift-flowing streams. Its habitats stretch from the Great Lakes Region through the Mississippi Valley and into the tributary waters of the Gulf of Mexico, including areas in Mexico. 2/

1/ Carl L. Hubbes and Karl F. Lagler, Fishes of the Great Lakes Region, Ann Arbor, The University of Michigan Press, 1964.

2/ A. J. McClane (ed.), McClane's Standard Fishing Encyclopedia, Holt, Rinehart and Winston, New York, 1965.

Blue catfish (Ictalurus furcatus), are considered the king of the Mississippi River catfish. Fish of this species have been known to reach a maximum of 150 pounds, although they usually weigh 20 pounds or under when taken. In contrast, channel catfish rarely exceed 5 pounds. The "blues" are numerous in the lower Mississippi Valley, and also are found from Ohio and Iowa to Texas.

There are several foodfish varieties of bullheads and one or more of these can be found in most of the important water drainage systems of the United States. These receive consumer acceptance as a foodfish in areas where catfish are also present, but they are sold at a substantially lower price. Bullheads typically prefer sluggish water, are extremely tenacious of life, and often tolerate environmental conditions obnoxious to all other fish varieties. 3/

There are also varieties of marine catfish (mainly gafftopsail and sea catfish). These are usually found in bays and harbors along the Atlantic and Gulf Coasts in summer, but most that are taken are not marketed as a foodfish. One species of marine fish commonly marketed as "ocean catfish" is actually wolffish (Anarhichas lupus), a minor species taken by trawlers in the North Atlantic incidental to major species such as haddock. 4/

3/ Karl F. Lagler, Fresh Water Fishery Biology, William C. Brown, Co., Dubuque, Iowa, 1956.

4/ Herbert S. Zim and Hurst H. Shoemaker, Fishes, Golden Press, New York, 1963.

B. Commercial Importance in the United States

Domestic supplies of catfish are available from both public (or natural) waters and fish farms. Those caught in public waters rank among the top 20 of the more than 50 species of fish landed commercially in the United States.

Catfish are a relatively high-priced species, and rank 12th--in the United States in terms of catch value. In 1966, the catch of catfish from public waters was 34 million pounds, or about 1.2 percent of total United States foodfish landings. This catch was sold for more than $7 million which was about 1.7 percent of the United States foodfish total. 5/ The harvest of catfish on fish farms in 1966 exceeded 15 million pounds and had a value of more than $5 million. Pond production was spread through a ten-state area in the South and South Central states, with heavy concentrations in the delta areas of Arkansas and Mississippi. 6/

C. Foreign Sources of Supply

Catfish are imported into the United States from Mexico and other Latin American countries in minor quantities. The annual level of imports exceeds 1 million pounds of dressed fish, which is equivalent to 1.7 million pounds of live weight catfish.

5/ Charles H. Lyles, Fisheries of the United States, 1966, U. S. Department of the Interior, Bureau of Commercial Fisheries, 1967.

6/ Estimates based on information furnished by J. Mayo Martin, Extension Biologist, Fish Farming Experimental Station, U. S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, Stuttgart, Arkansas.

As yet, no separate entry records for the species are tabulated by the U. S. Department of Commerce. Entries are included in a "not-elsewhere classified" category.

II. The Commercial Harvest of Catfish from Public (Natural) Waters

A. Production Patterns and Trends

Since 1955, the volume of catfish harvested in public, or natural, waters has fluctuated between 30 and 39 million pounds. Catfish are caught over a wide area that extends southward from the northern tributaries of the Mississippi River (Figure 1, Table 1). The most productive waters for catfish in recent years have been those in the South Atlantic Sector, chiefly eastern Florida. In 1966, the South Atlantic states accounted for more than half the commercial catch of catfish. The Mississippi River Basin and the Gulf Coast Region followed in importance, in that order. 7/ (See Appendix Table II-1.)

Production trends have varied considerably among the catfish producing areas. In the South Atlantic area--mainly eastern Florida--landings have been increasing at a 7 percent average annual rate since 1955, and catches in Gulf Coast areas also have been gaining. In contrast, the quantities caught in the Mississippi River Basin areas and the Great Lakes Region have been diminishing. Table 2 summarizes trends in catfish landings from public waters during the period

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7/ U. S. Department of the Interior, Bureau of Commercial Fisheries, Fishery Statistics of the United States (annual publication).

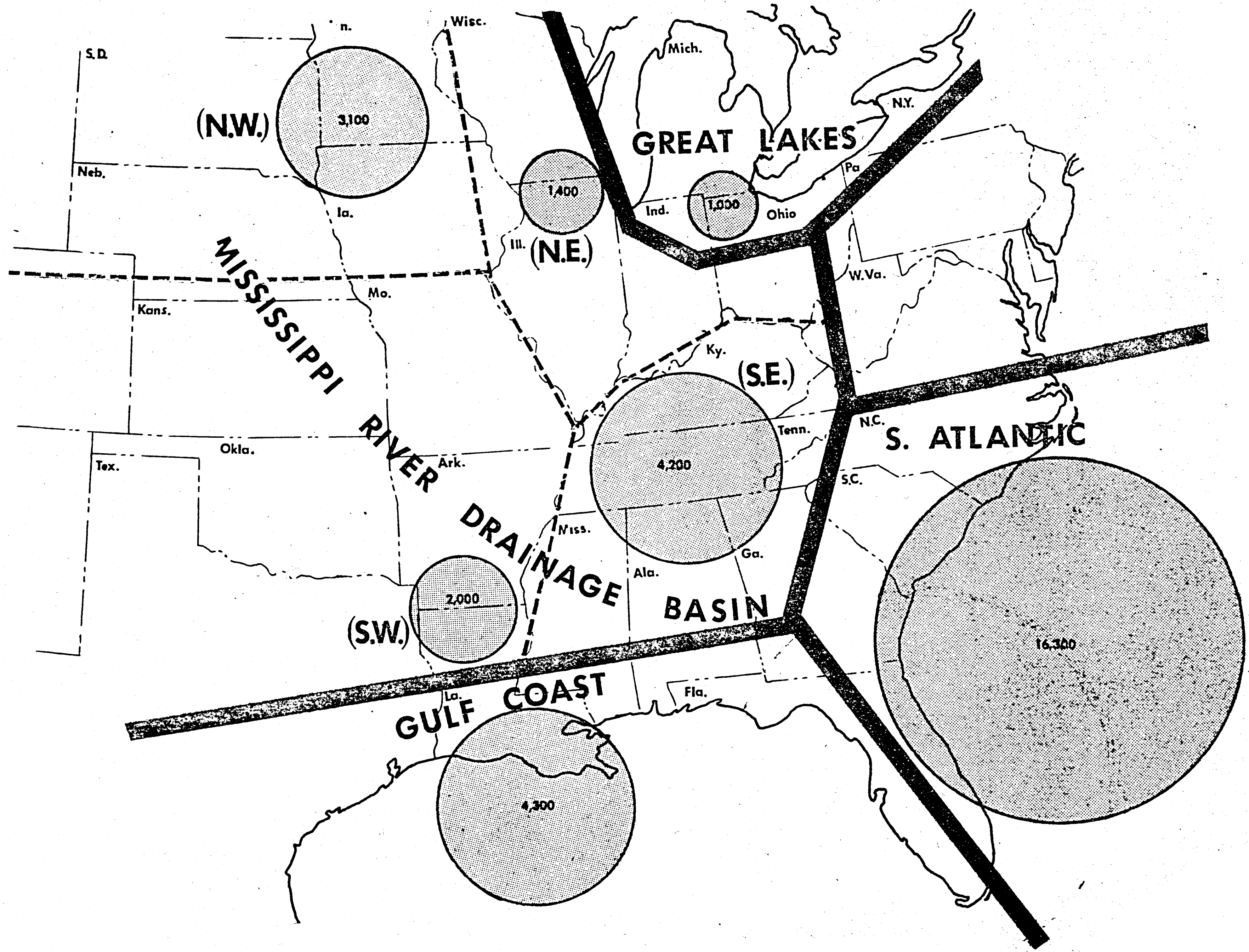

Figure 1.--Areas of catfish landings from public waters, 1966

Table 1.--United States catfish landings, by area, 1950 and 1955-1966

Year	Mississippi River Drainage Basin					Great Lakes	South Atlantic	Gulf	Other	Total United States
	Northeast Sector	Southeast Sector	Northwest Sector	Southwest Sector	Total Miss. River					
	thousand pounds									
1950	1,074	4,656	3,613	5,149	14,492	1,421	1,397	3,725	2,419	23,454
1955	1,365	6,900	3,046	3,338	14,649	2,777	7,360	2,978	2,408	30,172
1956	1,326	6,467	4,422	3,477	15,692	2,376	9,055	4,253	3,450	34,824
1957	1,311	5,007	3,418	2,406	12,142	2,097	10,588	2,918	3,427	31,172
1958	1,781	3,765	4,225	4,500	14,271	1,992	8,776	3,529	3,138	31,706
1959	1,842	3,465	3,498	4,258	13,063	1,933	10,212	4,911	3,757	33,876
1960	1,557	4,120	3,957	3,811	13,445	2,058	9,661	6,045	3,623	34,832
1961	1,528	4,195	2,562	3,603	11,888	2,087	14,254	6,561	3,678	38,468
1962	1,652	3,969	1,979	3,473	11,073	1,529	15,885	6,364	2,768	37,619
1963	1,547	6,130	2,459	3,341	13,477	1,506	15,391	6,157	2,083	38,614
1964	1,845	5,822	3,525	2,382	13,574	1,530	14,835	6,223	1,900	38,062
1965	1,493	4,840	3,523	2,061	11,915	1,286	16,229	5,215	1,357	36,002
1966	1,427	4,210	3,133	1,961	10,731	1,027	16,340	4,259	1,549	33,906

Source: U. S. Department of the Interior, Bureau of Commercial Fisheries, Fishery Statistics of the United States

Table 2.--Supply trends -- catfish landings, by area, 1955-1966

Area	Average year-to year change [1]	Range		1966 Actual	1966 Percent of trend value
		Low (Yr.)	High (Yr.)		
	Percent	Thousand pounds			
Gulf Coast	5.3	2,918 (57)	6,561 (61)	4,259	67
South Atlantic	7.6	7,360 (55)	16,340 (66)	16,340	92
Great Lakes	- 7.5	1,027 (66)	2,777 (55)	1,027	86
Mississippi River Drainage System:					
Northwest Sector	- 2.3	1,979 (62)	4,422 (56)	3,133	110
Southwest Sector [2]	-11.2	1,961 (66)	4,500 (58)	1,961	97
Southeast Sector	- 1.4	3,465 (59)	6,900 (55)	4,210	95
Northeast Sector	1.0	1,311 (57)	1,845 (64)	1,427	87
U. S. Total	1.5	30,172 (55)	38,614 (64)	33,906	

1/ Based on least squares curve, fit to data of the form $Y = AB^x$.

2/ Period covered, 1958-1966. (No measureable trend for 1955-1966)

Source: U. S. Department of the Interior, Bureau of Commercial Fisheries

1955-1966. It can be seen that the Gulf and South Atlantic States have increased output substantially; that the Northeast Sector of the Mississippi River System has increased slightly; and that all other areas have been declining.

If the present trends continue, the harvest of catfish from public waters in the United States will be in the neighborhood of 47 million pounds by 1985. The large bulk of this catch will be taken in the South Atlantic and Gulf Regions, chiefly Florida and Louisiana. If the catch in areas outside the present centers of concentration continues to decline, industry will become more concentrated in Florida and Louisiana. These events could lead to the development of modern facilities for processing the expanded production of catfish in the latter two states.

Supplies of catfish from natural waters also are subject to marked seasonal changes, with two peak seasons. Receipts of fresh catfish in three market areas--Chicago, Baltimore, and New Orleans--show that catfish landings are highest during the spring and fall and are lowest during the winter months. (Figure 2, Table 3.)

B. Harvesting Characteristics

The harvesting of catfish from natural waters, as noted above, is widespread geographically, and is characterized by small-scale operations. The high cost of conducting a harvest-cost survey under these conditions could not likely be justified by the value of the

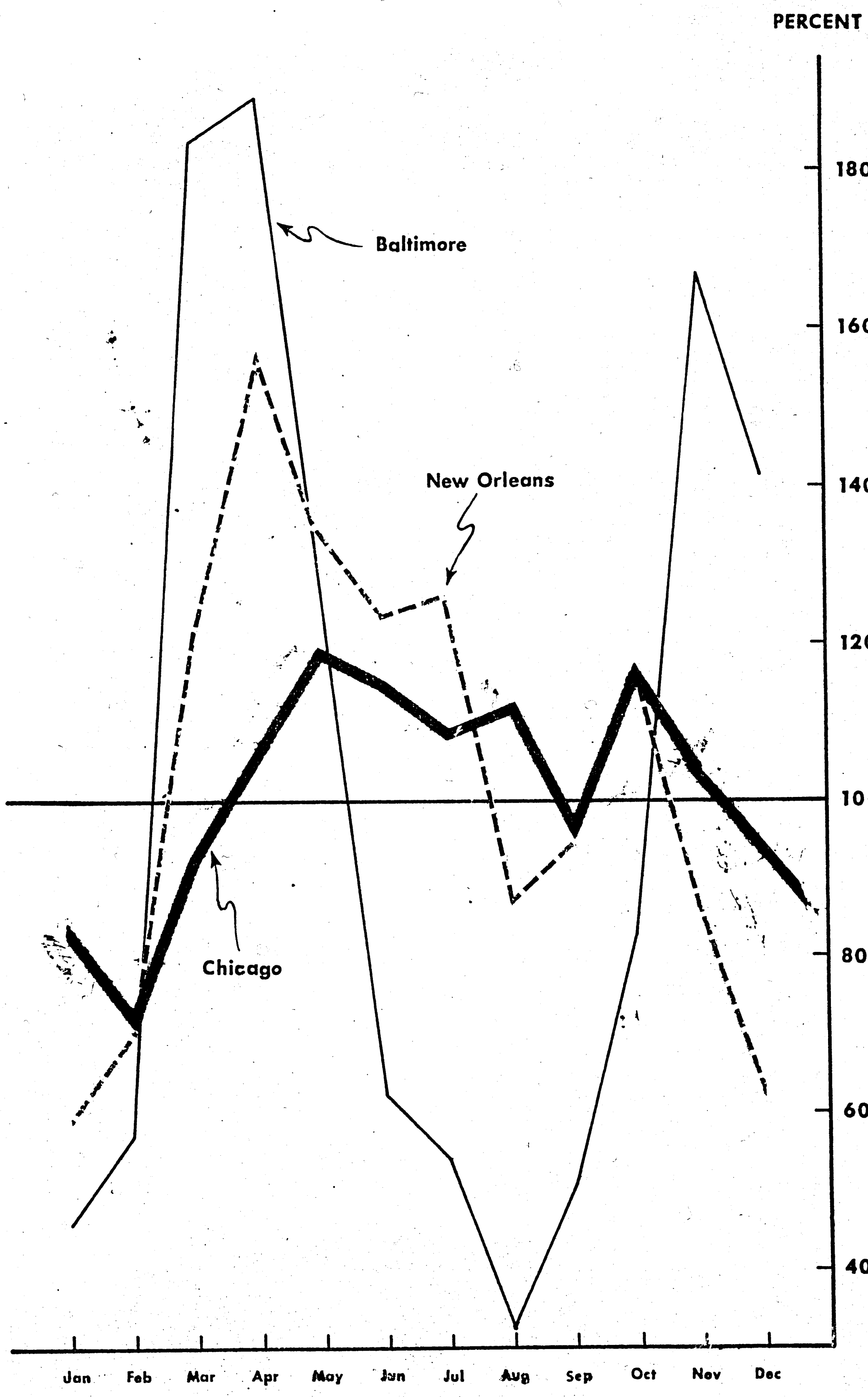

Figure 2.--Seasonal indices of catfish receipts at 3 important wholesale markets

Table 3.--Seasonal indices of receipts of catfish at 3 important wholesale markets

Month	Chicago	New Orleans	Baltimore
January	83.8	59.0	46.1
February	71.0	70.3	57.3
March	92.6	123.5	183.8
April	100.3	156.6	189.5
May	118.5	134.0	130.6
June	114.6	103.9	62.2
July	108.6	105.9	54.4
August	111.7	87.1	32.8
September	95.9	93.9	51.0
October	116.1	116.2	83.0
November	104.1	86.8	167.4
December	82.8	62.8	141.9

Source: U. S. Department of the Interior, Bureau of Commercial Fisheries, Market News Service

return, hence, such data have not been collected for this study. Nevertheless, some cost characteristics are identifiable from known parameters.

The outstanding characteristic of catfish harvesting is that it is highly labor intensive. The chief methods of catch, as shown in Table 4, are by long, or set line; by pots and traps; and by stationary nets of the "fyke" or "hoop" net variety. The "long" line, which is the favored method in the South, is a single line set with many hoops which is anchored in a waterway. Pots and traps, widely used in the Carolinas, are relatively small sized trapping devices attached as single units to stakes and placed on the bottom of a waterbed. The stationary net devices, most widely used in northern sectors of the Mississippi River Drainage Area, are large entrapment devices held in place by stakes or poles. Baiting generally is not required for the net devices.

The methods described for catching catfish do not require much investment capital. Fishermen who tend the devices use small boats, which may or may not be equipped with outboard motors. Hauling is done by hand. Since fixed costs are small, the costs of harvesting catfish largely represent the value that fishermen--who are largely self-employed--are able to command for their labor. There has been little change over the years in methodology of harvesting catfish. Little change can be expected in future years, for there are insufficient concentrations of the catfish resource to attract investments in more sophisticated

Table 4.--U. S. catch of fresh water catfish, 1965, by gear used and by region

Type of gear	New England	Middle Atlantic	Chesapeake	South Atlantic	Gulf	Mississippi River	Great Lakes	Total
	Thousand pounds							
Haul seine	---	20.6	124.6	51.5	34.3	1,060.8	694.6	1,986.4
Fyke and hoop nets	1.7	1.0	282.4	452.2	1,437.8	3,612.3	24.8	5,812.2
Gill net	---	2.5	85.6	190.7	385.4	501.6	15.8	1,181.6
Pound net	---	---	69.3	515.4	---	---	---	548.7
Trammel nets	---	---	---	---	47.7	600.8	---	648.5
Lines	---	2.5	71.0	9,432.0	2,983.9	5,210.6	207.2	17,907.2
Pots and traps	---	---	695.7	5,586.9	325.8	711.8	---	7,320.2
Trap nets	---	---	---	---	---	170.6	343.9	514.5
Miscellaneous	---	---	---	---	---	44.4	---	44.4
Total	1.7	26.6	1,328.6	16,228.7	5,214.9	11,912.9	1,286.3	35,999.7

Source: U. S. Department of the Interior, Bureau of Commercial Fisheries, Fishery Statistics of the United States

harvesting equipment. (See Appendix, Table II-2.)

C. Price Patterns and Trends--Harvest Level

Average live weight prices for "natural-water" catfish in 1966 ranged between 10 and 31 cents per pound. Prices, as a rule, vary between regions, with differences due to the variation in quality of the fish caught, as well as local market characteristics. Water pollution in many areas has eliminated the more desirable catfish species, and the changed harvest mix has higher proportions of the more durable but less desirable species, which do not command as high a price. Catfish prices, in 1966, were lowest in the northwest Mississippi River Drainage System, which includes waters in Minnesota, the Dakotas, Iowa, Nebraska and Montana. Top prices were received in the southwest sector of the Mississippi River Drainage System--Louisiana, Arkansas, Texas, Oklahoma, Missouri, and Kansas--where there is a predominance of the select channel and blue catfish in the catch, as well as a strong local demand for catfish.

In the South Atlantic area--which leads in production--live-weight catfish prices in 1966 averaged 16.8 cents per pound. The bulk of the catch in this region is concentrated in eastern Florida, where local markets for fresh catfish are limited. Most of what is produced, therefore, is shipped to centers of demand outside the region (e.g., Atlanta and Chicago). This distance from markets helps to explain why prices in this area are below prices received for catfish in the lower Mississippi areas where local markets absorb available supplies. (Figure 3, also Appendix Tables II-3 through II-9.)

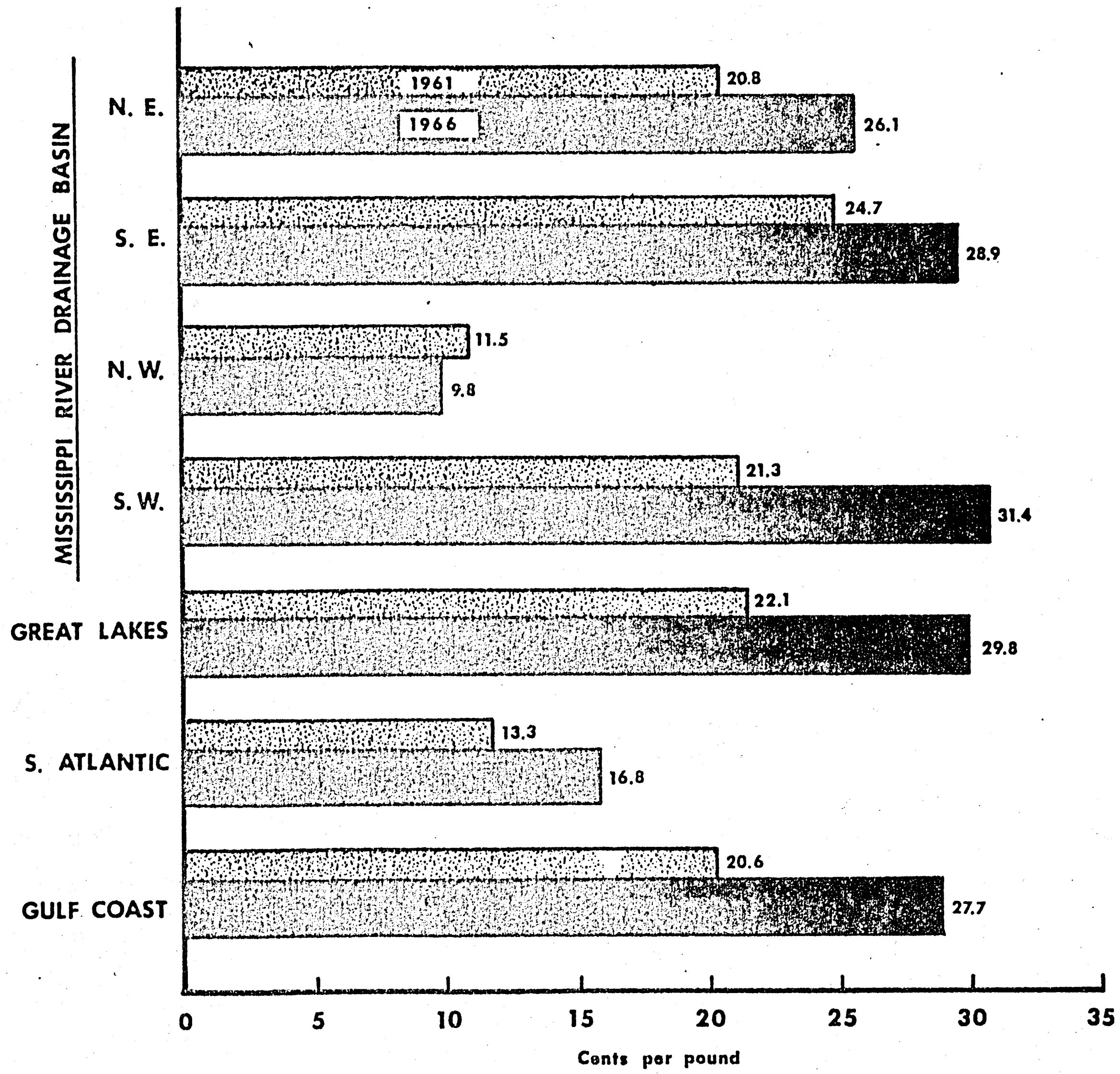

Figure 3.--Average prices received by fishermen from catfish harvested from public waters, by area, 1961 and 1966

Prices received by fishermen for catfish have been moving upward throughout the industry, and increases have been largest in those areas where landings are on a sharp descent. In the southwest Mississippi River area for example, annually, prices have been advancing about 4.4 percent per year, as landings have declined about 11 percent annually. Prices in the Great Lakes Region have been increasing about 3.8 percent per year, in concert with a 7.5 percent annual drop in landings. Table 5 summarizes the long-run trends in prices.

D. Marketing Profile

Catfish are distributed in wholesale markets in an unprocessed form, or dressed (cleaned and beheaded) and skinned. Unprocessed fish are more commonly marketed at points nearby the area of catch. Shipments to more distant markets generally consist of dressed fish and the larger sized fish--those exceeding 2 pounds live weight--may be further processed into steaks. (Catfish dress out to 60 to 65 percent of their live weight; steaks equal about 35 percent of the live weight of the fish.) Most catfish are marketed fresh, but there are indications that frozen catfish products are increasing in importance. In 1967, about 25 percent of Chicago's catfish receipts were in frozen form, compared with 7 percent in 1962. 8/

8/ U. S. Department of the Interior, Bureau of Commercial Fisheries, Chicago Market News Service.

Table 5.--Price trends -- catfish landings, by area, 1955-1966

Area	Average year to year change[1]	Range: Low (Yr.)	Range: High (Yr.)	1966 Actual	1966 Percent of trend value
	Percent	cents per pound	cents per pound	cents per pound	
Gulf Coast	2.2	19.4 (60)	27.7 (66)	27.7	114
South Atlantic	1.7	11.6 (56)	16.8 (66)	16.8	113
Great Lakes	3.8	17.2 (55)	29.8 (66)	29.8	108
Mississippi River Drainage System:					
Northwest Sector	- 3.7	7.9 (65)	16.0 (55)	9.8	107
Southwest Sector[2]	4.4	20.7 (60)	31.4 (66)	31.4	113
Southeast Sector	0.7	24.5 (59)	28.9 (66)	28.9	109
Northeast Sector	[3]	18.7 (62)	26.1 (66)	26.1	[3]

1/ Based on least squares curve, fit to data of the form $Y = AB^X$.

2/ Period covered, 1958-1966. (No measurable trend for 1955-1966)

3/ Prices from 1962 have risen at a compound rate of 8.7% per year.

Source: U. S. Department of the Interior, Bureau of Commercial Fisheries, Fishery Statistics of the United States

The predominance of "fresh" catfish sales over frozen reflects the atomistic structure of the industry, rather than the physical characteristics of the fish. Catfish landings are not sufficiently concentrated to support specialized processing plants which could produce a packaged frozen product. Nor do these inland caught fish have access to the facilities supported by the marine fish operations, which may process a variety of species. Catfish, nonetheless, hold up extremely well under freezing, and it is a common practice for consumers--institutional and individual--to freeze and store dressed and steaked catfish.

The primary consumer markets for catfish are in a rectangular north-south belt through central United States, cornered by Chicago and Davenport, Iowa in the north and New Orleans and Dallas/Fort Worth in the south. There is also an active catfish market in Baltimore--supplied mainly by North Carolina and Virginia waters. On the west coast of the United States, catfish are marketed in the Los Angeles area.

A recent survey of wholesale distributors in catfish in 12 large cities indicates that Chicago is probably the top ranking catfish market. Distributors in Chicago reported sales of 848,000 pounds of dressed catfish in 1966, which was nearly one-fifth of the 4.6 million pounds total in the 12 cities. Dallas/Fort Worth and Memphis, each with 13 percent of the total, ranked behind Chicago. Other important cities included Memphis, New Orleans, St. Louis, and Little Rock (Table 6). 9/

9/ John R. Donahue, Fishery Marketing Specialist, U. S. Department of the Interior, Bureau of Commercial Fisheries (unpublished report, 1967).

Table 6.--Survey of marketing distribution of catfish from natural waters - 1966

(Dressed weight)

City	Quantity	Percent of total
	Thousand pounds	
Chicago	848	18.3
Dallas/Fort Worth	600	13.0
Memphis	600	13.0
New Orleans	500	10.8
St. Louis	500	10.8
Little Rock	475	10.3
Peoria	275	5.9
Davenport/Moline	250	5.4
Kansas City, Missouri	250	5.4
Louisville	200	4.3
Baltimore	100	2.2
Cincinnati	30	0.6
Total	4,628	100.0

Source: John R. Donahue, Fishery Marketing Specialist, U. S. Department of the Interior, Bureau of Commercial Fisheries

E. Wholesale Marketing Trends--Supplies

The Bureau of Commercial Fisheries tabulates the fish marketing activities in the six leading coastal seafood distribution centers, and in Chicago. Two of the coastal cities covered by regular reporting--New Orleans and Baltimore--are centers of catfish distribution. The movements of catfish in these three representative markets reflect both the seasonal cycles and long run trends of catfish production and prices.

The record of fish receipts in the major distribution centers shows marked changes in the sources of supplies of natural water catfish. Chicago receipts, for example, now are largely sustained by shipments from Florida where formerly other sources supplied the major quantity. Over one-half the catfish sold through the Chicago's wholesale market in 1966 were from Florida, whereas, in 1960, Florida catfish accounted for less than one-third of the marketings and in 1954, less than one-fifth. (Table 7 and Appendix Table II-10)

Despite the fact that catfish landings in the U. S., overall, are on a slightly rising trend, there has been a decline in quantities marketed through Chicago's wholesale market. At the beginning of 1962, monthly catfish receipts at Chicago averaged about 130,000 pounds, but have since been declining at an average rate of about 1,000 pounds per month. Incoming shipments had dropped to about 68,000 pounds per month by the end of 1966. The annual total for 1966--1 million pounds--was a third below the 1962 total. (Appendix Table II-11)

Table 7.--Annual receipts of catfish in the Chicago Wholesale Market, from Florida and all other sources for selected years, 1954 to 1966

Year	Florida	All other states	Total	Florida of total
	----------Thousand pounds----------			-Percent-
1954	334	1515	1849	18.0
1956	343	1489	1832	18.7
1958	433	1008	1441	30.0
1960	478	1154	1632	29.2
1962	722	770	1492	48.4
1964	606	778	1384	43.8
1966	540	452	992	54.4

Source: U. S. Department of the Interior, Bureau of Commercial Fisheries, Market News Service

The decline in the Chicago wholesale catfish market may be partly a reflection of changes in marketing practices that have diminished the role of wholesale distribution centers in favor of direct shipments to large retailers. 10/ Direct shipments would not be included in the data for wholesale receipts. It is also likely that local demand for catfish in areas of catch is increasing, and less is available for export to distant markets.

New Orleans market receives its catfish supplies mainly from nearby areas, for example, the Cameron-Morgan City area. Catfish landings in these areas, however, have been declining since the end of 1963 when the monthly catch averaged about 190,000 pounds. By the end of 1966, the areas were producing only 120,000 pounds of catfish per month. A similar situation confronts the Baltimore market, which draws mainly on supplies from the Chesapeake area and from other parts of Virginia and North Carolina. Baltimore's annual catfish receipts during the 1960's ranged between 150,000 and 200,000 pounds, but in 1967 receipts dropped to 65,000 pounds.

It is of interest to note that the decline in catfish supplies at major markets has been paralleled by a general decline in the commercial availability of fresh water fish. Per capita supplies of

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10/ In meat distribution, it has been observed that direct sales by packers to retailers have been increasing relatively. See Willard F. Williams and Thomas T. Stout, Economics of the Livestock Meat Industry, The Macmillan Company, New York, 1964, pp. 390-392.

fresh water fish in the United States are down by more than one-half from 1952 levels. (See Table 8.) At Chicago, total receipts of fresh water fish, unfrozen, dropped more than 50 percent, between 1956 and 1967. Catfish receipts during this time fell more than 60 percent. To a small extent, receipts of "fresh" salt water fish have taken up the slack. These products, which are mainly east coast varieties, now account for about 5 percent of the total "fresh" fish marketed in Chicago's wholesale markets. (Table 9 and Appendix Table II-12)

F. Wholesale Marketing Trends-Prices

As supplies of catfish in major markets declined, wholesale prices have increased. In New Orleans, prices have climbed about 10 percent per year (compound rate) since 1961. In December 1967, "round" (not dressed) catfish was selling for 37.5 cents per pound; during the same month in 1961, prices averaged just over 21 cents per pound. In Chicago price increases have averaged about 6 percent a year. Dressed and skinned catfish in the latter market brought about 61 cents per pound at wholesale, in 1967--up from a 1961 average of 42.5 cents per pound. (See Figures 4 and 5, also Appendix Tables II-13 and II-14.)

G. Seasonality of Prices

Generally, catfish prices are highest in the months of low supply, but weaken in response to increasing quanitities on the market. In both the Chicago and New Orleans market, the seasonal drop in prices is most pronounced during the early months of the summer when heavy supplies

Table 8.--Trend in U. S. supplies of fresh water fish for selected years 1952 to 1966

	Unit	1952	1954	1956	1958	1960	1962	1964	1966
Domestic landings-major species fresh water fish 1/	000 lbs. live wt.	172190	152773	164427	152934	149588	149892	137585	127520
Imports-whole and/or dressed 2/	000 lbs. prod. wt.	54890	34770	37915	42074	39655	41000	36175	31346
Imports-fillets 2/	000 lbs. prod. wt.	------	12	15	15	14	14.1	9.9	15.0
Total fresh water supplies	000 lbs.	227080	187555	202357	195023	189257	190906	173770	158881
U. S. resident population	000	157553	163026	168903	174882	180684	186656	192120	196920
Total fresh water supplies per capita	pounds	1.44	1.15	1.20	1.12	1.05	1.02	.90	.65
<u>Indices</u>: 1952=100									
Domestic landings	1952=100	100.0	88.72	95.49	88.81	86.87	87.05	79.90	74.05
Imports-whole and/or dressed	1952=100	100.0	63.34	69.07	76.65	72.24	74.69	65.90	57.11
Total fresh water supplies	1952=100	100.0	82.59	89.06	85.84	83.33	84.05	76.84	69.83
Per capita fresh water supplies	1952=100	100.0	79.86	83.33	77.77	72.91	70.83	62.50	45.13

1/ Includes 18 species of food fish.

2/ Includes fresh and frozen

Source: U. S. Department of the Interior, Bureau of Commercial Fisheries, Fishery Statistics of the United States.

Table 9.--Receipts of "fresh"(not frozen) fish, Chicago Wholesale Market, 1956-1967

Year	Receipts			Percent of 1956		
	Catfish	All fresh water	All salt water	Catfish	All fresh water	All salt water
	---------Thousand pounds------			------Percent (1956=100)-----		
1956	1832	42,746	1,511	100	100	100
1957	1527	35,451	1,158	83	83	77
1958	NA	NA	NA	--	--	--
1959	1551	36,041	1,099	85	84	73
1960	1632	34,250	1,154	89	80	76
1961	1551	29,749	1,055	85	70	70
1962	1424	28,054	1,030	78	66	68
1963	1330	23,913	1,146	73	56	76
1964	1294	22,713	1,197	71	53	79
1965	1009	23,307	1,264	55	55	84
1966	848	26,451	1,334	46	62	88
1967	718	18,563	1,191	39	43	79

Source: U. S. Department of the Interior, Bureau of Commercial Fisheries, Market News Service

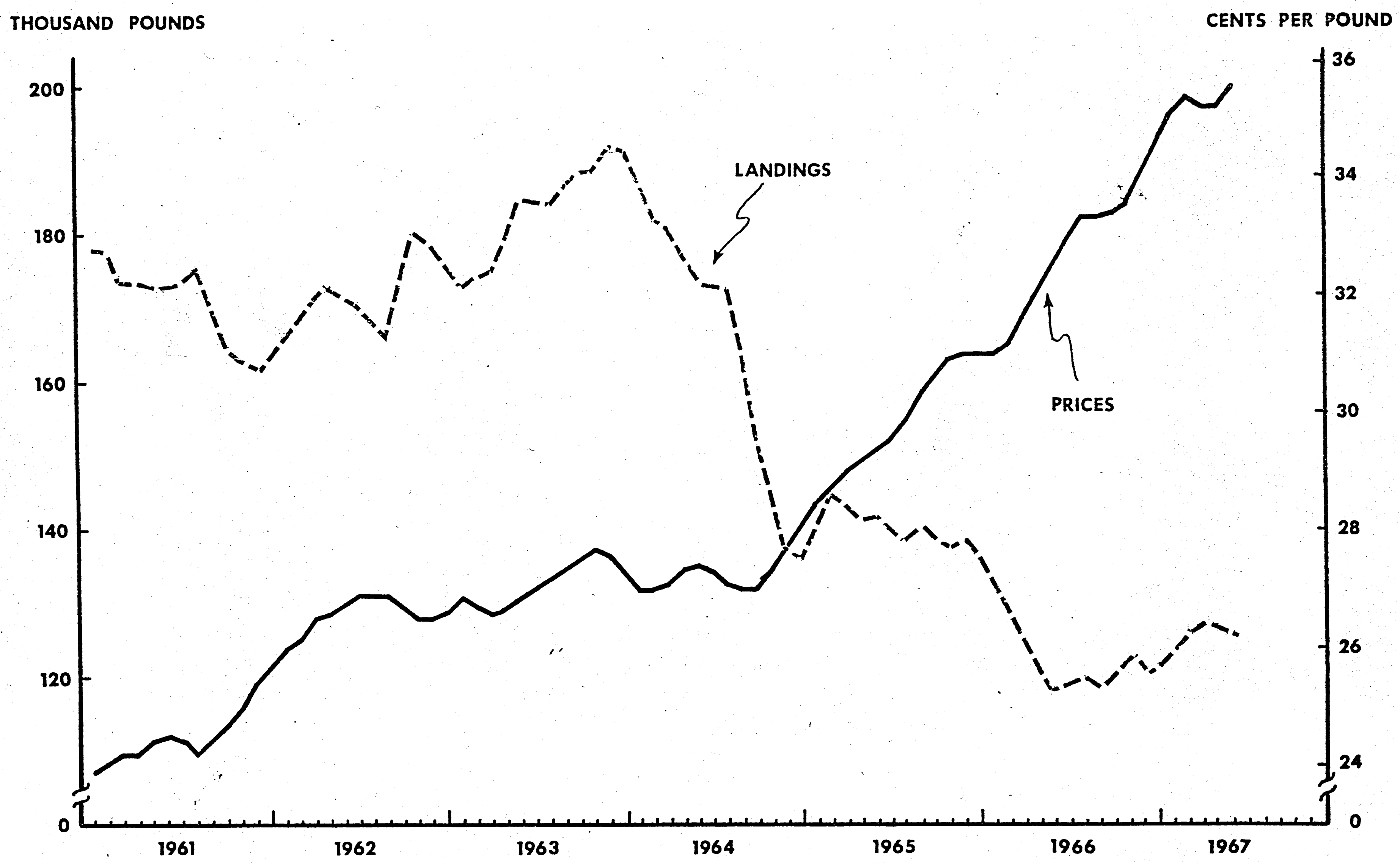

Figure 4.--12-month moving average of catfish landings in the New Orleans area and wholesale prices at the New Orleans French Market, by months, 1961-1967

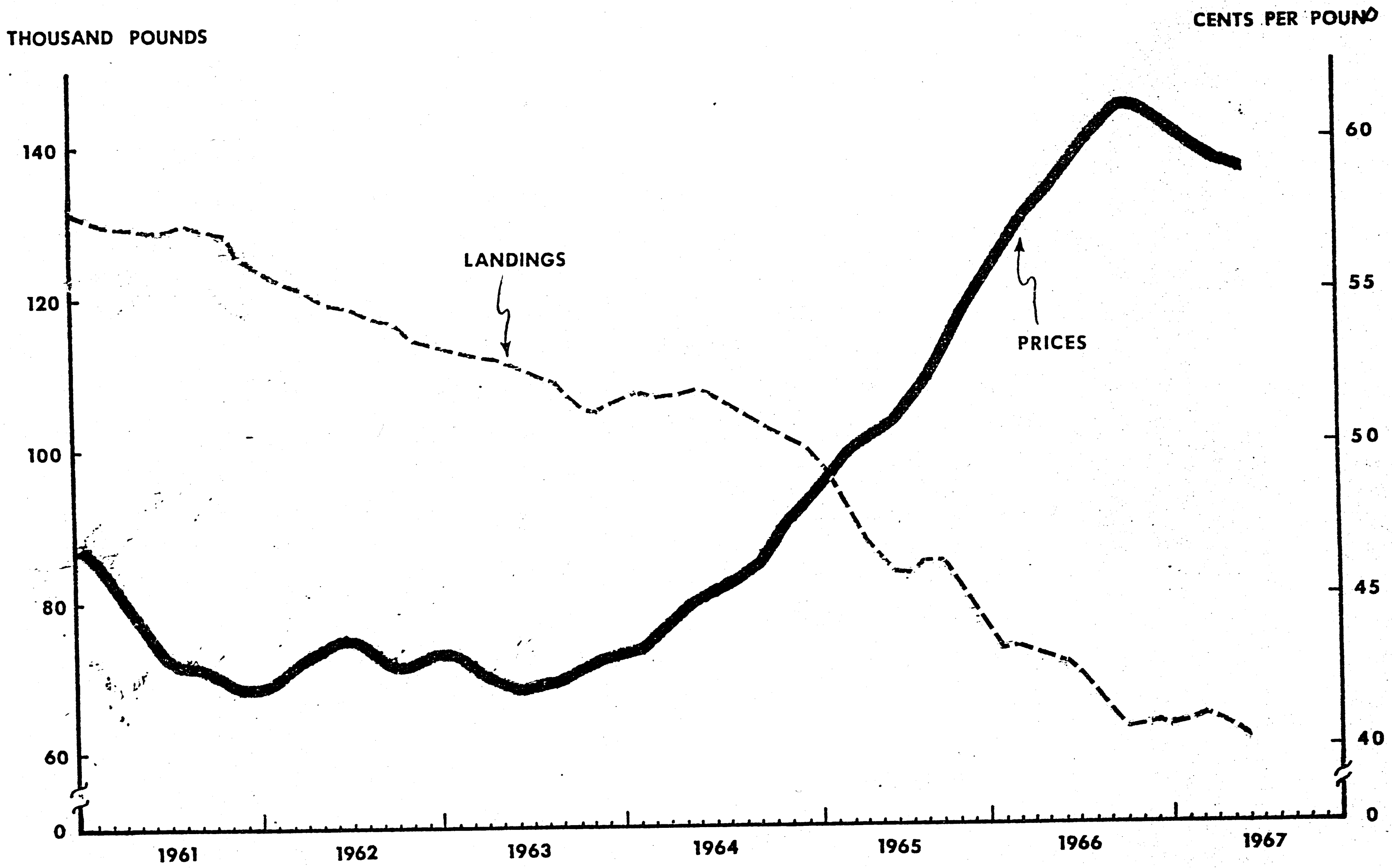

Figure 5.--12-month moving average of catfish receipts and wholesale prices at Chicago, by months, 1961-1967

of catfish are competing with heavy supplies of other species. In Chicago for example, monthly receipts of all fresh water fish are heavy from April through October, similar to the seasonal cycle for catfish. (Figure 6) In New Orleans heavy catfish receipts during the spring and early summer months enter a market with seasonally heavy quantities of both shrimp and finfish. (Tables 10 and 11)

H. Market Flow and Margins

Restaurants are the prime outlets for catfish, especially the higher priced channel catfish. Specialty fish markets distribute both the lower and the higher priced varieties, while retail grocery stores specialize in the lower priced catfish. Prices vary considerably between cities. (Table 12) At the primary wholesale level, which is the first point in the marketing chain beyond the processor, the average price of dressed catfish at 10 cities, in 1966, ranged from $0.52 to $0.64 per pound. Retail prices in these same cities averaged between $0.83 and $0.99 per pound. There is also an intermediate wholesale market--between primary wholesale and retail--in which prices average from $0.62 to $0.81 per pound. [11] Based on weighted average prices, the market spread between primary wholesale and retail prices was $0.339, or 58 percent of the primary wholesale price. (Table 13)

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[11] Ibid.

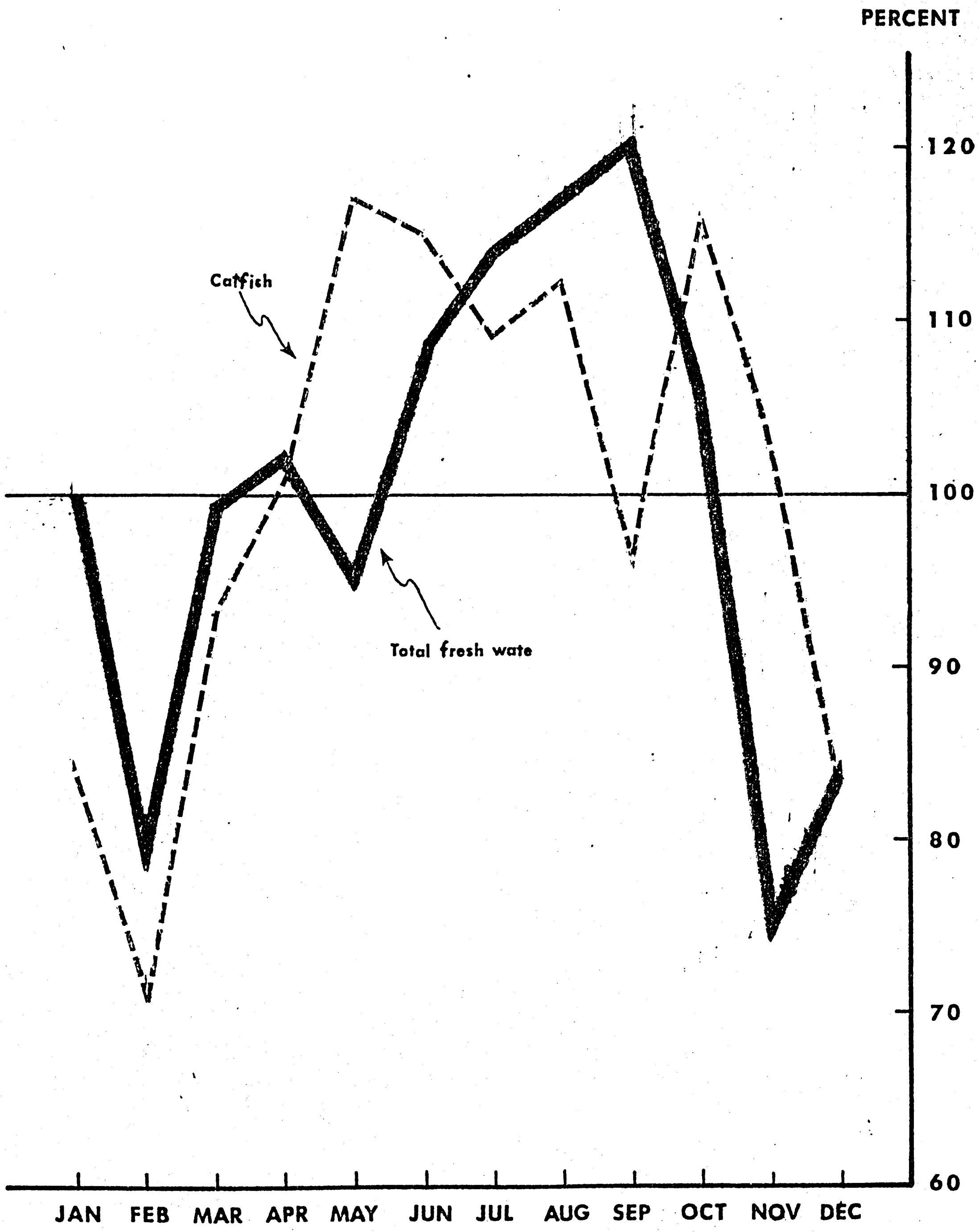

Figure 6.--Seasonal indices of catfish receipts and total fresh water receipts at Chicago.

Table 10.--Seasonal indices[1] of total fresh water receipts, catfish receipts and catfish wholesale prices - Chicago market

Month	Total fresh water receipts	Catfish receipts	Catfish wholesale prices
January	100.0	83.8	108.2
February	79.1	71.0	110.2
March	98.8	92.6	110.7
April	102.4	100.3	104.1
May	95.4	118.5	95.0
June	107.6	114.6	89.3
July	114.3	108.6	91.9
August	117.2	111.7	92.1
September	120.1	95.9	96.7
October	106.4	116.1	99.0
November	74.9	104.1	99.9
December	83.8	82.8	102.9

1/ Based on ratio to moving average 1959-1967

Source: U. S. Department of the Interior, Bureau of Commercial Fisheries, Market News Service

Table 11.--Seasonal indices[1] of catfish quantities landed and wholesale prices in the New Orleans area

Month	Catfish landings	Catfish wholesale prices
January	59.0	100.2
February	70.3	106.4
March	123.5	103.9
April	156.6	102.3
May	134.0	94.6
June	103.9	96.7
July	105.9	94.7
August	87.1	100.8
September	93.9	105.4
October	116.2	101.9
November	86.8	96.3
December	62.8	96.8

1/ Based on ratio to moving average 1957-1966

Source: U. S. Department of the Interior, Bureau of Commercial Fisheries, Market News Service

Table 12.--Average prices received for dressed catfish, 1966

City	Quantity distributed	Average wholesale prices: Primary market	Average wholesale prices: Secondary market	Average retail price	Retail value
	1,000 lbs. 1/	--------Dollars per pound--------			Dollars
Chicago	848	.62	.81	.94	791,120
Dallas/Ft. Worth	600	.53	.66	.86	516,000
Memphis	600	.59	.75	.92	552,000
New Orleans	500 2/	.54 2/	.75 2/	.90 2/	450,000 2/
St. Louis	500	.63	.80	.99	495,000
Little Rock	475	.55	.81	.94	446,500
Peoria	275	.64	.83	.95	261,250
Davenport	250	.64	.79	.95	237,500
Louisville	200	.52	.68	.88	176,000
Cincinnati	30	.52	.62	.83	24,900
Total	4,278	.584 3/	.765 3/	.923 3/	$3,950,270

1/ Dressed weight.

2/ Estimated dressed weight equivalent. Usual market form in New Orleans is in the round.

3/ Weighted average.

Source: John R. Donahue, Fishery Marketing Specialist, U. S. Department of the Interior, Bureau of Commercial Fisheries

Table 13.--Prices and price spreads between market levels

Market level	Price	Spread
Primary wholesale	$0.584	$0.181
Secondary wholesale	0.765	0.158
Retail	0.923	
Total spread		$0.339

I. Price Elasticities

As expected, the seasonal indices of supplies and prices in the Chicago and New Orleans markets indicate that prices react inversely to changes in quantities. To develop a more precise definition of quantity-price relationship in the various catfish markets, a series of regression analysis were made. Annual and monthly landings and price data were used to measure these relationships. Significant results were found for two areas: East Coast Florida, and Gulf Coast. In both areas, demand for catfish at the harvest level was observed as being price elastic; i.e., a given proportional change in landings was associated with a lesser proportional change in quantities. For example, the indications on the Gulf Coast were that a 1 percent change in landings was associated with an inverse price movement of 0.3 percent. On the east coast of Florida, prices were much less sensitive to changes in quantities.

To measure demand at the wholesale level, monthly price and quantity changes at Chicago were analyzed. It was found that prices in a given month responded inversely to that month's level of receipts, and were also effected by the level of receipts in the prior month--a lagged effect. Receipts during the period observed averaged 85,000 pounds per month which were sold at an average price of 53 cents per pound. The analysis showed that a 5,000 pound change in the level of receipts in 2 consecutive months would be associated with a 1 cent per pound change in price. A strong upward trend in prices was also shown by the analysis.

Demand for catfish in the Chicago market was shown to be price elastic. The elasticity coefficient for the association between prices and current month's receipts was 6.4. Thus, a 1 percent change in prices was associated with slightly more than a 6 percent change in the level of receipts. (See Appendix I, Technical Note (c).) Since the demand for catfish is elastic, the total returns to producers (i.e., price times quantity produced) would be increased if output were expanded. (See Appendix I, Technical Notes (a) and (b).)

III.--The Practice of Pond Culture and the Commercial Production and Marketing of Channel Catfish

A. Development

The harvesting of fish in public waters has long had an element of uncertainty, fostered by the mysteries of nature and the inability of man to cope judiciously with these mysteries. Management schemes have been employed in both marine and fresh water fisheries with varied degrees of success. A more highly controlled managerial environment has been achieved through aquiculture, the practice of rearing fish as a crop under controlled conditions. The practice has roots in antiquity. For example, carp were reared in ponds in China as long ago as 2000 B.C. Ancient Romans are known to have transported the techniques of pond raising carp from Asia Minor onto the European continent; and Egyptians as far back as 2500 B.C. were cultivating tilapia in artificial ponds. [12]

Fish farming was introduced into the United States during the late 1800's. At that time pressures on the natural resources began to be recognized, and the introduction of a European system of carp culture in the United States excited some interest. These early efforts were abandoned, however, with the discovery that carp was unsuited to the American palate.

Interest in fish ponds in the United States remained in limbo until Professor George C. Embody of Cornell published his classic work, "The Farm Fish Pond" in 1915. Embody urged reliance on native species such as black basses, sunfishes, and bowhead, among others. Significant advances were made in aquiculture in the 1930's through the work of Professors H. S. Swingle and E. V. Smith at Alabama Polytechnical Institute. These scientists experimented with chemical fertilizer, weed control, and balanced fish crops. [13] Large scale development of fish farming did not occur, however, until the 1950's. At that time primary emphasis was in raising minnows and goldfish, although there was some activity in the raising of foodfish, mostly buffalofish. Production was concentrated in Arkansas, Mississippi, Louisiana, and Texas.

In the Delta region of Arkansas attempts were also made, during the 1950's, to rotate fish with rice crops. The most popular species raised in this method was the bigmouth buffalo. Fish-rice crop rotation, however, was abandoned largely due to economic reasons. The markets for

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12/ A. Maar, et al., Fish Culture in Central East Africa, FAO, Rome, 1966.

13/ Frank C. Edminster, Fish Ponds for the Farm, Charles Scribner's Sons, New York, N. Y., 1947.

buffalofish was relatively poor, and economic returns were low. 14/

B. <u>Recent Trends in Fish Farming Acreage</u>

Technological and economic problems plagued early fish farming enterprises, but enough interest remained to encourage some of the early rice-fish farmers to try their hands at raising channel catfish. Their early experiences paved the way for the fish farming boom of the 1960's. 15/ By 1967, there were more than 40,000 acres of farmland devoted to the intensive farming of warm water fish in a 10-state area in central and southern U. S. Over 40 percent of this pond acreage was being used in the exclusive production of channel catfish. The remainder was used in the culture of bait fish for recreational fishing.

Table 14 indicates the growth trend in fish farm acreage in Arkansas. Farming buffalofish intensively, it may be seen, is nearly extinct, and has been replaced by the raising of catfish and minnows. Also, it is clear that catfish acreage is gaining rapidly on bait minnow acreage. In 1963, there were 8 acres in minnows for each in catfish in Arkansas. By 1966, this margin had dwindled to less than

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14/ Milton L. Bowman, Associate Professor, Department of Biology, Monmouth College, presentation made to the Nutrition Council, November 30, 1964.

15/ Roy Prewitt, "History of Fish Farming in Arkansas and Future Prospects," U. S. Department of the Interior, Bureau of Commercial Fisheries, Fishery Research and Services Newsletter, Ann Arbor, Michigan, August 1966.

four to one. 16/

Table 14.--Trend in intensive fish-farm acreage in Arkansas, by species, 1958, 1960, 1963 and 1966

Year	Buffalofish	Minnows	Catfish	Total
	-------Acres-------			
1958	3,446	4,000	--	7,446
1960	3,585	4,073	260	7,918
1963	743	8,249	1,070	10,062
1966	250	15,050	4,250	19,550

Source: J. Mayo Martin, Extension Biologist, U. S. Department of the Interior, Bureau of Sport Fisheries and Wildlife

Table 15 and Figure 7 show acreage devoted to intensive fish farming in 1967 by state. A total of 42,950 acres were being used in intensive fish farming of catfish and bait fish, nearly three-fourths of which were in Arkansas. The leaders in catfish acreage were Mississippi, Arkansas, and Texas, in that order, and they accounted respectively for 25 percent, 24 percent, and 17 percent of total acreage in catfish.

16/ The major sources for these estimates are:

(1) Fred P. Meyer, et al., Production and Returns from the Commercial Production of Fish in Arkansas during 1966. Agricultural Extension Service, University of Arkansas, Fayetteville, Arkansas, 1967.

(2) Correspondence with J. Mayo Martin, Extension Biologist, U. S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, Fish Farming Experimental Station, Stuttgart, Arkansas.

Table 15.--Estimated intensive fish farming acreage, by state, 1967 1/

State	Catfish	Minnow	Total
	------------	Acres	------------
Alabama	300	800	1,100
Arkansas	4,250	15,050	19,300
Florida	200	---	200
Georgia	300	---	300
Kansas	1,000	300	1,300
Louisiana	2,000	2,000	4,000
Mississippi	4,500	1,500	6,000
Missouri	1,400	4,000	5,400
Oklahoma	1,000	500	1,500
Texas	3,000	850	3,850
Total	17,950	25,000	42,950

1/ As yet, statistical reporting services do not cover fish farming enterprises on a regular basis. Acreage estimates, therefore, are based on several sources interested in and close to the industry.

Source: Estimates based on data supplied by J. Mayo Martin, Extension Biologist, U. S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, Fish Farming Experimental Station, Stuttgart, Arkansas.

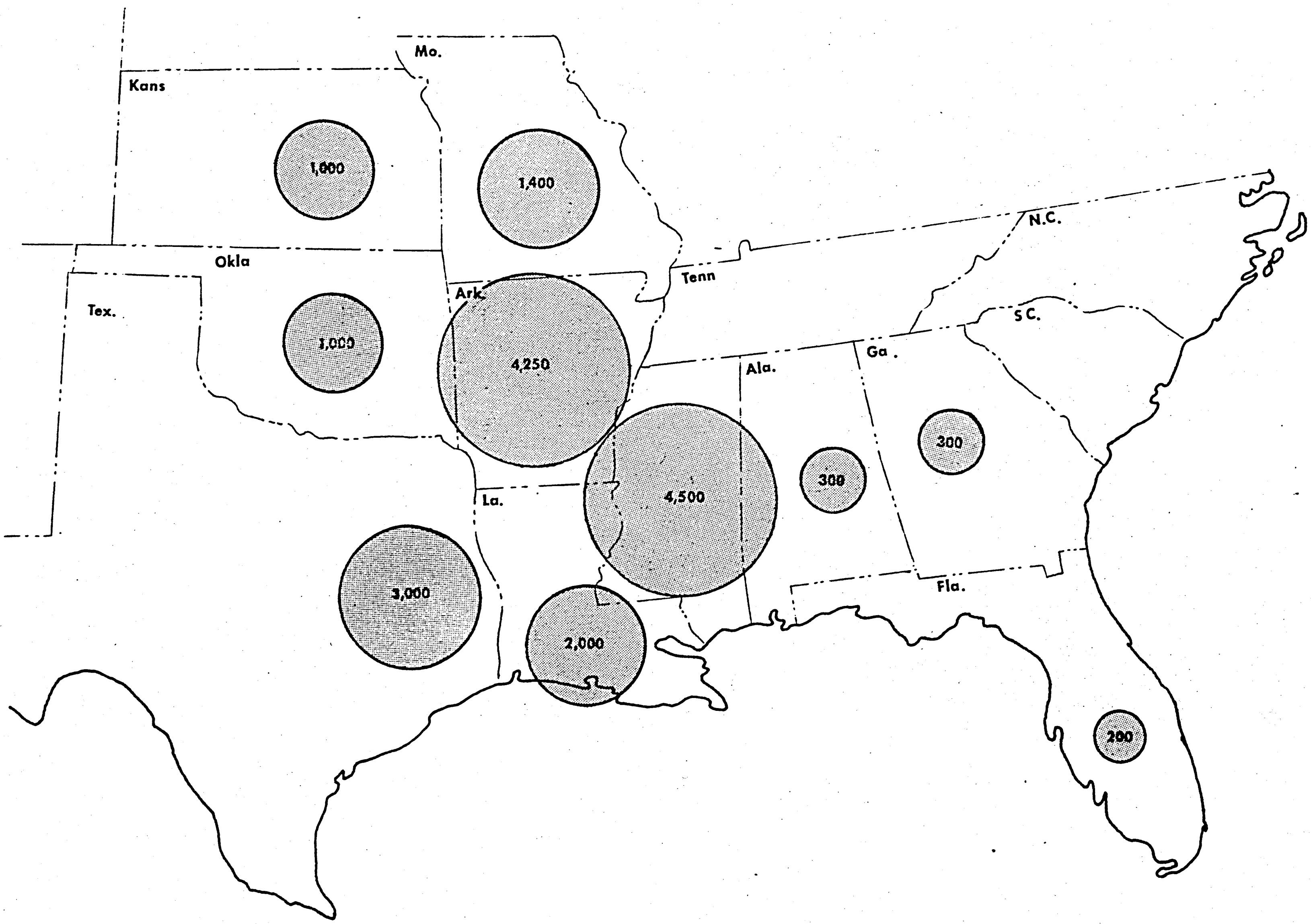

Figure 7.--Estimated channel catfish acreage - intensive culture, 1967

C. Production and Revenue Estimates

An estimated crop of more than 20 million pounds of catfish was produced in the 10-state area in 1967. Because exact crop figures are not known, it is necessary to estimate them by multiplying acreage times the average yield in poundage. Yields vary from farm to farm due to different levels of managerial expertise and experience associated with this relatively new crop industry. The average yield falls between 1,200 and 1,500 pounds per acre with some farmers attaining yields up to 2,000 pounds.

Of the total quantity of catfish produced in ponds, less than one-fourth was sold through conventional food marketing channels. The remainder was sold as live fish to stock recreational "fee" ponds, where anglers pay for the privilege of fishing and for the fish they land. Demand for pond raised catfish to stock "fee" ponds and for direct consumption is apparently strong, and farmers are able to sell current supplies at prices well above the prices paid commercial fishermen for natural water catfish. In Arkansas, for example, pond cultured catfish brought an average of 45 cents per pound in mid 1967, which was 10 cents per pound higher than prices paid for fresh caught catfish from natural waters. 17/ At the price prevailing in Arkansas, the total 1967 catfish crop would be worth well over $9 million.

D. Production Factors: Costs and Procedures

Geography as well as management affects production and harvesting

17/ W. P. Mathis, *et al.*, Arkansas Game and Fish Commission, unpublished report, 1967.

costs and there is a notable farm-to-farm spread in cost structures. In 1967, the approximate cost range of producing a pound of catfish was 25 cents to 35 cents. Yield is a key factor in the determination of unit costs. For example, total costs per pound drop from 36 cents to 28 cents over a yield range of 1,200 to 2,000 pounds per acre. Feed is the largest single entry in the cost schedule. Feed costs in an operation which yields 2,000 pounds per acre amount to nearly half of total costs. Fingerlings are next in importance as a cost item. The combined costs of stocking and feeding of a pond comprise nearly two-thirds of total operating costs. (Table 16)

Land in catfish farming areas may range, in price, from $200 per acre up to $1,000. A survey of fish farming enterprises in Arkansas in 1966, however, revealed that many ponds are constructed on land not well suited to the traditional area crops--rice, cotton, and soybeans, in Arkansas--and the average value of the pond site likely is closer to the $200 figure. Additional capital costs include levees, wells (the principal source of water supply), storage buildings and equipment (boats, seines, motors, etc.). The Arkansas survey found that, exclusive of the initial land value, investments in a foodfish pond average about $400 per acre. 18/

It has been shown that fish farming in Arkansas offers an attractive alternative land use. Net returns per acre from pond

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18/ Troy Mullins, "Producing Food Fish Requires High Capital," Arkansas Farm Research, University of Arkansas Agriculture Experimental Station, Fayetteville, Arkansas, January-February 1967.

Table 16.--Pond reared catfish production costs 1/

	Average costs 1/		Range of costs		
	Per pound of fish harvested	Per acre of pond	Per pound of fish harvested	Per acre of pond	Percent of total production costs
	Dollars				Percent
Fingerlings	.050	100	.03-.07	60-140	18
Feed	.125	250	.06-.20	117-596	45
Labor	.025	50	---	---	9
Harvesting	.030	60	.02-.04	40-80	11
Chemicals	.012	25	---	---	4
Other variables	.010	21	---	---	4
Total fixed	.024	47	---	---	9
Total costs	.276	553	.18-.38	359-760	100

1/ Assumes yield of 2,000 pounds per acre from an initial stock of 2,000 3 to 5 inch fingerlings.

Source: U. S. Department of the Interior, Fish and Wildlife Service, Fish Farming Research and Services Newsletter, May 1967

culture in that State have exceeded the returns realized from rice and soybean acreage. A catfish enterprise, for example, nets 39 percent more per acre than rice and nearly 5 times the return given by irrigated soybeans. Comparative returns are shown in Figure 8 and Table 17.

Catfish ponds vary in size and shape, depending on the layout of the land available, water sources, and other factors. Ponds from 5 to 20 acres, as a rule, characterize an efficient operation under present conditions, although many farmers tend to build bigger ponds--10 to 40 acres--as they gain knowledge and experience. Ponds from Arkansas south are constructed with a minimum depth of 3 to 4 feet. North of Arkansas a depth of 6 to 8 feet may be necessary to prevent winter kill. However, harvesting with seines is difficult in the deeper ponds. [19]

There is also a variance, among farmers, in the total acreage devoted to the pond culture of catfish. Under present cost and return conditions, 30 acres is the minimum scale that can return a significant income. [20]

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[19] Roy A. Grizell, Jr., Pond Construction and Economic Considerations in Catfish Farming, paper presented at 21st Southeastern Association of Game and Fish Commissioners, New Orleans, Louisiana, September 25-27, 1967.

[20] Otto W. Tiemeier and Charles W. Deyoe, Production of Channel Catfish, Agricultural Experiment Station, Kansas State University, Manhattan, Kansas, 1967.

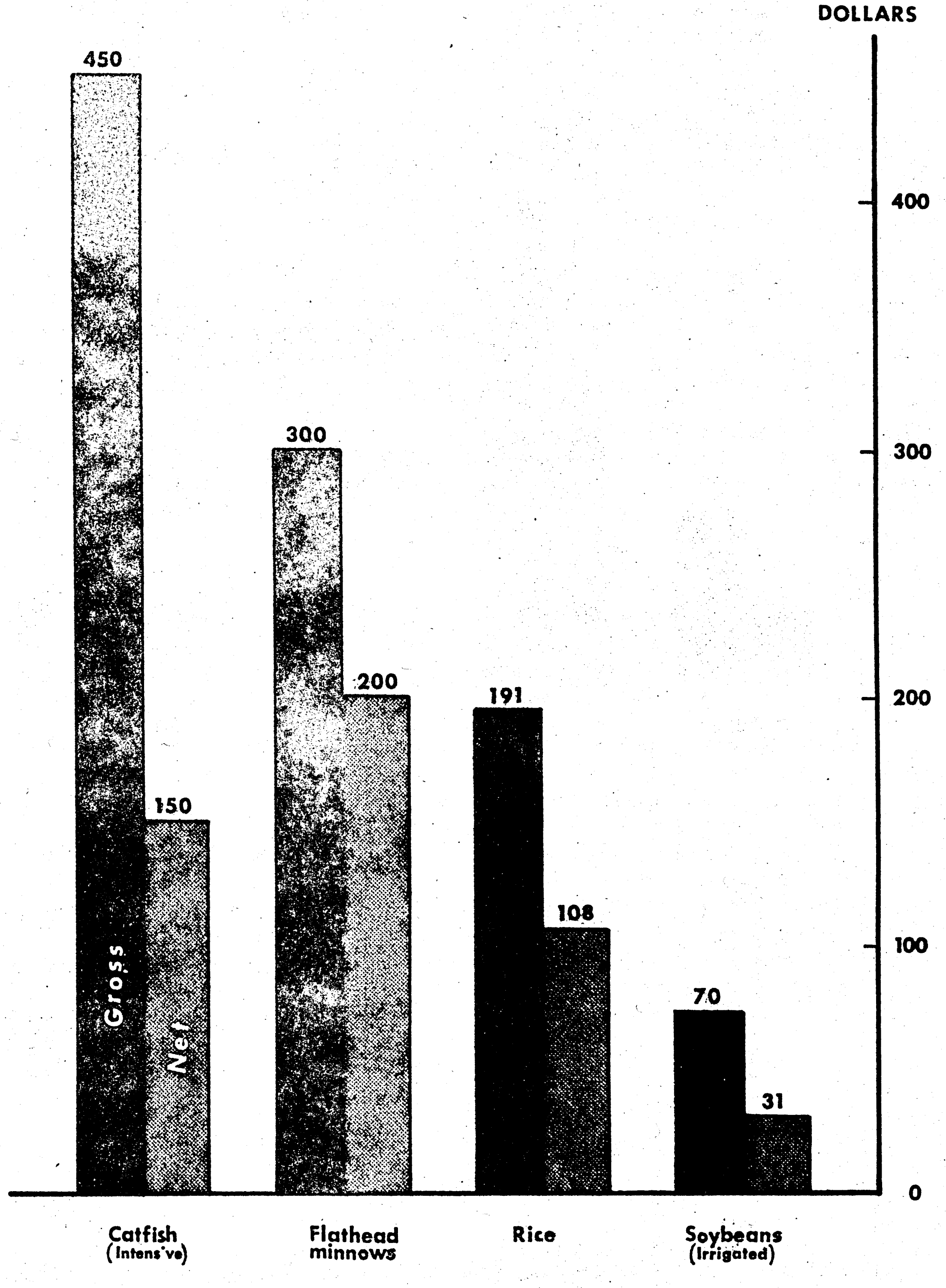

Figure 8.--Per acre returns from fish and agricultural crops in Arkansas

Table 17.--Per acre returns from fish and agricultural crops in Arkansas, 1966

Crop	Gross returns per acre	Net returns per acre
	-----------Dollars-----------	
Rice	191.25	107.70
Soybeans - irrigated	70.50	31.25
Soybeans - nonirrigated	56.40	26.50
Oats	35.00	17.50
Catfish - intensive	450.00	150.00
Catfish - fingerlings	1,000.00	500.00
Golden shiners	307.00	200.00
Fathead minnows	300.00	200.00
Goldfish	1,000.00	500.00
Fee fishing - catfish	1,000.00	350.00

Source: Meyer, Fred, et. al., Production and Returns from the Commercial Production of Fish in Arkansas During 1966, Agricultural Extension Service, University of Arkansas, and U. S. Department of Agriculture, 1967

A dependable supply of good quality water is essential for satisfactory catfish farming. The best source is a well or spring, in order to avoid problems such as trash fish, excessive flood waters, muddiness, diseases, and parasites. A 6 inch well flowing 1,200 gpm will furnish enough water for a catfish operation of about 40 acres. Well water usually has excessive carbon dioxide or nitrogen and is deficient in oxygen--a combination lethal to fish. The gases can be dispersed easily and quickly and the water oxygenated by splashing the flow over baffles or screens before it enters the pond. Streams or runoff water may also be suitable if the best known management precautions are understood and followed. However, water from springs, streams, and runoff may not be adequate during dry summer months.[21]

The current practice is to stock ponds in March or April with 4 to 6 inch fingerlings at the rate of about 2,000 per acre. Fingerlings from specialized growers generally cost about 5 cents each, although if a farmer gains the required proficiency, he may raise his own fingerlings at a fraction of this cost. The fish are put on a feeding program immediately and reach the desired market size--$1\frac{1}{4}$ - $1\frac{1}{2}$ pounds--in a single growing season of about 6 to 7 months. The length of a growing season depends on water temperature, as growth is retarded at temperatures below 60° F.

The current suggested rate of feeding is about 3 percent of body

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[21] Grizzell, op. cit.

weight per day. 22/ Under commercial operating conditions, the conversion ratio of feed into pounds of fish generally ranges from 2 to 1, to 2.5 to 1. Feed prices average about $100 per ton, and at a 2.5 to 1 conversion ratio, feed costs amount to about 12.5 cents per pound of fish. (Table 18 shows a feeding schedule which results in feed-fish conversion ratio of 2.4 to 1.)

Fish ponds also need chemical treatment to prevent disease outbreaks and to control vegetation. These chemical costs average about $25 per acre per season.

The harvest season for the March/April channel catfish fingerlings begins in October, when they have reached marketable size. The harvest may be full or partial, although under manual harvest systems, full harvests are usually much more efficient. 23/ Fish can be held over in the pond, however, as there are few physiological constraints against a harvest in any month of the year. The feed costs of holding fish beyond the growing season are negligible, in that it is recommended that fish be fed in winter on warm days only at a rate of one-half percent of body weight. 24/

Under present technology, a full harvest minimizes costs in both manual and mechanized systems. In a manual full harvest, the pond is

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22/ Milton L. Bowman, Director of Research, Ralph Wells & Co., The Commercial Production of Channel Catfish, unpublished paper.

23/ James T. Davis and Janice S. Hughes, Channel Catfish Farming in Louisiana, Louisiana Wildlife and Fisheries Commission, 1967.

24/ U. S. Department of Agriculture, Soil Conservation Service, Bulletin AK-44-50 (5-21-63), Little Rock, Arkansas.

Table 18.--A recommended feeding program for pond cultured channel catfish

Month	Estimated total weight of fish per acre 3/	Pounds of food per acre to feed per day	Pounds of food per acre to feed per month 2/	Estimated costs 1/ per month per acre
	Pounds			Dollars
March	20 - 80	3	81	4.05
April	200	6	156	7.80
May	300	9	243	12.15
June	550	18	468	23.40
July	850	25	675	33.75
August	1,000	30	810	40.50
September	1,500	35	910	45.50
October	1,800	35	945	47.25
Total			4,288	214.40

Note: Feed conversion rate, 2.4:1

1/ @ $100 per ton

2/ Normal practice is to feed 6 days per week.

3/ Based on stocking of 2,000 fingerlings (3 inch to 5 inch) channel catfish per acre.

Source: Milton L. Bowman, Director of Research, Ralph Wells and Co.

drained to a sump corner where the fish are seined, by hand and then transported in small lots by buckets to trucks. A team of eight men can harvest about 10,000 pounds of fish in a 10-hour day, at a cost of 2 to 3 cents per pound. The outfit needed for mechanized harvesting, includes a net (about 2,000 feet), a conveyor, line hauler, a barge and motor, and accessory equipment, all of which costs about $10,000. The mechanized system has important advantages over manual systems. It introduces flexibility into the harvesting operations by allowing a partial harvest (ponds are not drained); it is labor saving, and can be used in ponds of varied sizes.

Where mechanical systems are used, economic efficiency is enhanced by intensive use of the equipment. Tables 19 and 20 set forth estimated costs of mechanized harvesting operations, based on practices and equipment in current use for a given scale of operation. Also, economies are realized as the size of the operations is increased. For example, the costs of harvesting a 250,000 pound crop, at a rate of 10,000 pounds per day, have been estimated to average 2.2 cents per pound. A 500,000 pound crop harvested at the same daily rate, will average a cost of 1.6 cents per pound. 25/

Table 21 details costs and returns from the operation of a 5-acre pond in an established fish farming enterprise. Although it may be obvious that this is a more efficient overall operation than is typical,

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25/ U. S. Department of the Interior, Fish and Wildlife Service, Fish Farming Research and Services Newsletter, Ann Arbor, Michigan and Stuttgart, Arkansas, May 1967.

Table 19.--Estimated annual costs for theoretical producer-owned harvesting operations

Fixed costs:	Estimated original value	Estimated life in years	Estimated annual depreciation	Estimated annual costs
Haul seine net (2,060 ft. x 12 ft., nylon)	$ 3,000	5	$ 600	
Hauling line (5,000 ft. 3/4 in. manila rope)	400	5	80	
Net holding cribs (20 ft. x 10 ft. x 5 ft., nylon) 6 @ $75	450	5	90	
Seine barge (20 ft. x 8 ft. x 2½ ft., aluminum)	1,700	10	170	
Trailer (for seine barge)	1,200	10	120	
Line hauler (trailer mounted)	750	10	75	
Crane (to be mounted on truck)	2,500	10	250	
Blocks (8 in. sheave, steel, snatch type) 6 @ $20	120	10	12	
	$ 10,120		$1,397	$ 1,397
Rent and utilities (share of farm storage and work space)				650
Interest on investment @ 6% per annum				607
Miscellaneous fixed costs (including property taxes)				246
		Sub-total fixed costs		$ 2,900

Variable costs of operation and maintenance, assuming 30 operating days per year

For average daily harvesting rates of	5,000 lbs.	10,000 lbs.	20,000 lbs.
Supervisor	$ 750	$ 750	$ 750
Laborers (2 @ $15)	900	900	900
Fuel and lubrication	180	360	570
Mending twine and netting	30	60	120
Miscellaneous hardware and materials	120	240	480
Miscellaneous maintenance and repair	120	240	480
Truck use	600	600	600
Sub-total annual O & M costs	$2,700	$3,150	$3,900

Source: U. S. Department of the Interior, Fish and Wildlife Service, Fish Farming Research and Services Newsletter, May 1967

Table 20.--Estimated harvesting costs by harvesting rates and total pounds produced [1/]

No. of operating days	Ave. harvesting rate of 10,000 lbs. per day			Ave. harvesting rate of 20,000 lbs. per day		
	Average rate	Total cost	Cost	Average rate	Total cost	Cost
	1,000 lbs.	Dollars	$/lb.	1,000 lbs.	Dollars	$/lb.
5	50	3,425	.069	100	3,550	.036
10	100	3,950	.040	200	4,200	.021
15	150	4,475	.030	300	4,850	.016
20	200	5,000	.025	400	5,500	.014
25	250	5,525	.022	500	6,150	.012
30	300	6,050	.020	600	6,800	.011
35	350	6,575	.019	700	7,450	.011
40	400	7,100	.018	800	8,100	.010
45	450	7,625	.017	900	8,750	.010
50	500	8,150	.016	1,000	9,400	.009

1/ On the basis of the technology shown in Table 19.

Source: U. S. Department of the Interior, Fish and Wildlife Service, Fish Farming Research and Services Newsletter, May 1967

Table 21.-- Typical costs and returns from a five acre channel catfish pond operation

Initial Investment			
Construction of pond, 12,500 cu. yds. @ $0.19			$ 2,375.00
Drain pipe			168.00
Well $ 1,500.00)			
Pump 1,750.00) to serve 45 acres			
Motor 1,400.00)			4,650.00
Service buildings (prorated)			98.00
Annual costs			
Pond construction and pipe amortized @ 6% for 20 years ($2,543.00 x .08718)			221.68
Well amortized @ 6% for 20 yrs. ($1,500.00 x .08718 ÷ 9)			14.53
Pump amortized @ 6% for 15 yrs. ($1,750.00 x .10296 ÷ 9)			20.02
Motor amortized @ 6% for 10 yrs. ($1,400.00 x .13588 ÷ 9)			21.13
Service buildings amortized @ 6% for 20 yrs. ($98.00 x .08718)			8.54
Annual maintenance on well, pump, and motor (prorated)			72.00
Pond maintenance			75.00
Pumping costs, 31.8 acre-feet @ $12.00			381.60
Fingerlings, 7,500 @ $0.04 ea.			300.00
Feed, 7 tons @ $95.00			665.00
Taxes			3.00
Equipment purchases (prorated)			26.00
Labor costs - feeding and daily checking			90.00
harvesting			36.00
Transportation - feeding and hauling			108.50
Total costs of production			$ 2,043.00
Gross returns on 7,450 pounds at three assumed prices per pound	@ .35 lb.1/	@ .40 lb.1/	@ .50 lb.
	$ 2,607.50	$ 2,980.00	$ 3,725.00
Less costs of production	2,043.00	2,043.00	2,043.00
Net returns - to land and management	564.50	937.00	1,682.00
Average net returns per acre	112.90	187.40	336.40
Costs of producing fish (pound)	.27	.27	.27

Feed conversion: 1.87:1

1/ These estimates are additions to the original source.

Source: Roy A. Grizzell, Jr., *Pond Construction and Economic Considerations in Catfish Farming*, Soil Conservation Service, U. S. Department of Agriculture many of the costs listed are common to all operations, especially the capital costs. (Data in similar detail were not available from less efficient enterprises.) The actual returns in this example were based on an average selling price of 50 cents per pound. Returns based on fish prices of 35 cents and 40 cents per pound are also shown.

E. Processing Pond Raised Catfish

Under current marketing practices, most of the production of pond raised catfish is not being processed into a market form prior to wholesale distribution. As a rule, almost no processing is done at the farm level. The "live" fish market--for fee ponds--has been absorbing at least three-fourths of the total harvest and the remainder has been marketed mostly in the round (not dressed) by individual farmers directly to nearby institutional and retail outlets.

The development of large volume markets for pond raised channel catfish, however, presupposes the establishment of efficient processing facilities and orderly distribution channels. In 1967, there was only one catfish processing plant in operation, although various groups of investors were planning to construct at least an additional two plants (application for Federal loans for financial aid for plant construction and operation were pending).

The operational catfish processing plant was located in Mississippi, and was undergoing its trial period in 1967. Physical output problems, at this time, were mostly solved, but much remained to be done in the way of marketing. Hard decisions had not been reached as to the product form, packaging, or distribution channels.

The prototype processing operations was using a single production line capable of an output of approximately 1,000 pounds of product per hour. Approximately 1,500 pounds of fish are required to produce 1,000 pounds of product.

It has been estimated that a machine operation of the type installed in Mississippi can process fish for about 10 cents per pound, if it is operated at full capacity and a minimum production of 1 million pounds of product is reached during a production year. Hand processing the same quantity of fish would cost 12 to 13 cents per pound. 26/

Processors' margins are sensitive to differences in the yield of finished product from the whole fish. There is at least a 35 percent weight loss in processing the whole product. Assuming a price of 38 cents per pound for delivered, raw fish, and a 35 percent "dress-out" loss, the processors' raw material costs amount to $58\frac{1}{2}$ cents per pound. If the waste amounts to 40 percent of the original weight, the raw material costs are 63 1/3 cents per pound.

A simplified model of the marketing system for pond reared channel catfish likely will follow these lines: Producer to processor to wholesale distributor to institutional and/or retail trade to ultimate consumer. Starting with a production cost at the farm level of 28 cents per pound, and assuming 20 percent margins for processor and wholesale distributor, packaged catfish could <u>now</u> be offered to the institutional

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26/ Ibid.

and retail trade at a price of 96 cents per pound. Table 22 outlines the costs and margins in the various stages of the market flow. It should be understood that this model is patterned to fit the present "state-of-the-art." Expanded production and markets, and advancing technology can be expected to result in substantially reduced raw material costs, and lower selling prices.

F. Present Market Potential for Pond Raised Channel Catfish

There is widespread optimism in agricultural communities that successful markets can be developed for large quantities of pond raised catfish. The optimism centers on the potential for distributing catfish through the food marketing channels serving cities in south and central U. S.--the traditional "catfish belt"--as well as other areas. Urban populations in the so-called "catfish belt" total more than 15 million persons. In terms of total fish consumption the area now represents a market for about 160 million pounds of fish, based on total U. S. per capita consumption figures. As desirable river catfish and other fresh water species become less available it is not inconceivable that once consumers are educated to the consistent quality of pond raised catfish, the product could account for a substantial portion of total fish consumption in the "belt" area--perhaps as much as a fourth. Table 23 shows the major components of per capita fish consumption in the traditional catfish area along with estimates of how much of this consumption represents a potential diversion to pond raised catfish.

Table 22.--Costs and margins in market channels-for packaged dressed catfish Hypothetical example, 1967

	Dollars
1. Producer	
Production costs	.28
Margin	.07
	.35
2. Transportation costs	.02
3. Processor	
Raw fish costs	.37
Allowance for waste (@ 65% yield)	.20
Packaging	.02
Margin	.15
	.74
4. Transportation costs	.03
5. Wholesale distributor	
Cost of product	.77
Margin	.19
	.96 (price to retail or inst. trade)

Table 23.--Estimates of market potential for pond raised catfish in urban areas of South and Central United States, 1966

Item	Area consumption		Potential diversion to pond catfish	
	Per capita	Total		
	lbs.	1,000 lbs.2/	Percent	1,000 lbs.
1. Canned fish	4.20 1/	63,840	10	6,384
2. Convenience items (fish sticks, portions, frozen dinners)	2.00 1/	3,040	10	304
3. Shrimp and other shellfish	1.50 1/	2,280	10	228
4. Catfish	0.46 3/	6,940	--	--
5. All other	2.44 1/	85,020	33	28,057
6. Total	10.6 1/	161,120	21.7	34,973

1/ Based on national averages--edible weight

2/ Population of area in 1966 was 15.2 million

3/ Based on identified shipments of processed catfish into these areas--edible weight

Estimates are based on 1966 markets and show that about 35 million pounds of catfish (edible weight) could be marketed in the 10 urban areas, <u>assuming no change in total demand for fishery products</u>.

IV. Production and Processing Projections of Pond Reared Catfish

Catfish acreage has been increasing rapidly since 1960. Although this relatively short growth period rules out projections based on statistical time series analysis, sufficient information has been developed in regard to expected industry growth and characteristics to permit reasonable projections of future production and sales levels.

In the years ahead, the production and prices of pond-reared catfish will be influenced by several factors, which summarized include:

(1) A decline in supplies of fresh water fish from public waters. This will encourage the pond production of channel catfish.

(2) Increases in supplies of marine fish. As substitutes for catfish, growing supplies of marine species would exert a downward pressure on catfish prices.

(3) Increases in supplies of pond raised catfish. Heavier production will keep prices in check, probably lower wholesale prices somewhat from current levels.

(4) Improved feed conversion. This will lower production costs.

(5) Improved harvesting and processing efficiency. These are cost reducing factors, which in concert with better feed

conversion ratios will contribute to keeping net returns per acre at an attractively high level vis-a-vis other farm crops, despite any lowering of prices.

Consequently, it is expected that between 1975 and 1985 catfish acreage will increase from about 44,000 to 114,000 acres. This represents a rate of increase of about 15 percent per year through 1970 and 10 percent per year between 1970 and 1985.

With increased feeding efficiency, production per acre will increase by 1975. Moreover, genetic improvement in pond reared catfish is likely to occur. The combined effect of these aspects will improve average production per acre from the present level of 1200-1500 pounds to about 2,000 pounds. Total production in 1975 and 1985 is expected to reach 88 million and 229 million pounds, respectively. These projections are detailed in Table 24.

Not all of this production will be available to the developed food marketing system. Substantial quantities of channel catfish will continue to be sold for fee pond fishing. From an estimated sales of 16 million pounds in 1967, a projected increase per year was made using the increase in fresh water sport fishing, as reported in the National Survey of Fishing and Hunting. 27/ The number of fresh water fishermen increased about 10 percent between 1960 and 1965 and this rate of increase was assumed to apply to fee fishing up to

27/ U. S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, National Survey of Fishing and Hunting, 1965, Resource Publication 27, 1966.

1985. In addition, direct marketing by farmers to local restaurants and other direct purchase outlets, which presently amounts to about one-fourth of the catfish production, will continue to be of considerable importance to this industry. Marketing in these types of outlets will likely increase at about the same rate as population in the region but substantially less than catfish production increases.

Deducting the projected use in fee pond fishing together with that which is expected to be marketed directly by farmers, shows the projected supply expected to go into organized market channels. It is likely that this amount will be the supply for preservation methods such as irradiation or freezing.

Table 24.--Estimated pond reared catfish acreage and production, 1967, and projections for 1970, 1975, 1980, 1985

	Estimated	Projection			
	1967	1970	1975	1980	1985
	thousand acres				
Acres	18.0	27.4	44.1	71.0	114.4
	million pounds				
Total production	21.6	49.3	88.2	142.0	228.8
Marketed live	16.2	17.2	18.9	20.8	22.9
Marketed as food	5.4	32.1	69.3	121.2	205.9
Direct marketing	5.4	5.6	6.1	6.6	7.2
Available for processing	---	26.5	63.2	114.6	198.7
Dressed weight	---	17.2	41.4	74.5	129.2

V. The Benefits and Costs of Radiation Processing and Alternative Techniques

It was pointed out in a previous section of the report that the projected increases in pond reared catfish production presuppose the establishment of suitable processing facilities. Within the future market structure, various alternative methods of preservation may be utilized. For the purpose of comparative analysis, three specific preservation techniques are identified:

(1) fresh (iced)

(2) fresh (iced)-irradiated

(3) frozen

The benefits and costs of using each alternative method at a given product flow are analyzed. The economic feasibility, as applied to the management sector, is determined for each method, and the analysis is carried through to the development of a benefit-cost ratio in terms of public investment.

Price assumptions used in this analysis, as regards factors of production, are in terms of current price levels. It is thus assumed that changes in the general level of prices will not alter the relationships between per unit costs of the factors of production used in the catfish industry. However, the cost per unit of output in this industry will change in response to gains in productivity, and component costs will differ in percentage of total costs from those currently in effect.

A. Evaluation of Conditions for Industry Development

The lack of an organized industry structure for the production and marketing of pond raised channel catfish precluded an evaluation of industry attitudes toward commercialization of catfish irradiation. The development of an identifiable catfish industry structure, however, can be expected by 1975-1985, the time period under consideration in this analysis. The production of catfish through intensive farming methods will increase substantially and the marketing of this species will likely be carried out by organizations not presently engaged in such operations.

Present indications point toward an industry structure similar to the broiler industry. Both catfish and broiler production are adapted to large-scale production. Also, catfish farming is developing in those states with a high volume of broiler production, (see Appendix Table II-15). The broiler industry is characterized by large efficient growing operations which are vertically integrated, or at least coordinated by the feed dealers. [28] These dealers supply feed on one end of the production-processing chain and carry out certain marketing phases on the other. The major broiler contractors are now moving toward duplicating these operations in a restructured catfish industry. Thus, an evaluation of the potential of pond raised catfish production should take into account the evolution and current status of the broiler industry.

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[28] Bernard F. Tobin and Henry B. Arthur, Dynamics of Adjustment in the Broiler Industry, Harvard Business School, Division of Research, Boston, 1964, pp. 101-103.

B. Processing and Marketing Factors

1. Areas of irradiation plant sites. The likely areas of plant sites for catfish processing are those of concentrated production, similar to conditions in the broiler industry, where there is a concentration of slaughter plants in areas of heavy broiler production. 29/

The major concentrations of catfish production will be in Texas, Arkansas, Louisiana, and Mississippi. A single irradiation plant, located in each of these four states, could operate as a service facility for the processing plants.

Central markets also are possible locations for irradiation units. Current trends suggest that cities such as Chicago, Kansas City, Memphis, and Dallas, will be the major market outlets for processed catfish. However, a qualifying factor in locating irradiators at central markets is that these markets may be declining as a focal point for fish marketing. Hence, insufficient product concentration may make central market areas less favorable as alternative locations for irradiation processing plants. Moreover, the distance of these markets from the catfish growing areas would be an unfavorable factor in the maintenance of product quality prior to irradiation.

An alternative is for the installation of irradiation units in each of the processing plants. The feasibility of this will depend upon the size of the processing plant, as all indicators point toward

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29/ U. S. Department of Agriculture, The Broiler Industry, P&SA - 1, Packers and Stockyards Administration, Washington, D. C., August 1967, pp. 25-29.

considerable size economies for irradiation units. As developed later in this report, it is not likely that individual catfish processing plants would be of sufficient size to warrant installation of a radiation processing system.

2. Suitability for preservation techniques. Dressed and packaged catfish provide the most suitable market form for irradiation. The size at which pond reared catfish are harvested--$1\frac{1}{4}$ to $1\frac{1}{2}$ pounds live weight--makes dressing the desired form of processing. As pointed out in a preceding section, the majority of catfish marketed outside local production areas is sold in skinned and dressed form.

Fresh catfish can be stored for as long as two weeks at a temperature of 33° F. Research results have shown that by irradiating this product at a dose of 0.2 or 0.3 megarads, a two and threefold expansion of shelf-life respectively may be obtained. 30/ Other fresh water species, when irradiated, have been found to have roughly equivalent ranges of shelf-life. Yellow perch fillets were found to be storable for 40 to 61 days at an irradiation dosage of 0.3 to 0.6 megarads 31/, and whitefish indicate a shelf-life of 29 days after low dose gamma

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30/ J. A. Emerson, et al., Irradiation Preservation of Fresh-Water Fish and Inland Fruits and Vegetables, U. S. Atomic Energy Commission, Division of Isotopes Development, Report Number COO 1283-40, August 1966.

31/ U. S. Department of Commerce, Business and Defense Services Administration, Radiation Preservation of Food, (undated) irradiation. [32] These findings indicate that the shelf-life of fresh catfish may be extended sufficiently so that daily and perhaps weekly supplies can be evened out. Seasonal supplies, however, will not be greatly affected.

It has been estimated that frozen catfish can be successfully stored under commercial conditions for a period of 10 to 12 months. The product stored under laboratory conditions (-5° F.) has been found acceptable after 16 months. [33] Nonetheless, the present structure of the catfish industry, as well as present market conditions, have tended to discourage the production and marketing of frozen catfish products.

C. Comparative Costs and Benefits

The remainder of this analysis compares the three alternative preservation techniques for marketing pond reared, dressed catfish. Entrepreneur costs and returns at various levels are presented and discussed. These alternatives are compared in terms of costs and returns using conditions which are projected to exist during the 1975-1985 time period.

1. Production costs. The expected production costs of pond reared catfish during the period 1975-1985 are presented in Table 25. It is projected that the cost, per pound, of producing catfish will be below

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[32] Kurosh Ostovar, "Irradiation Extends Storage Life of Whitefish," Fisheries of Canada, June 1967, Vol. 19, p. 18.

[33] R. A. Grieg and J. R. Donahue, "Frozen Storage Capabilities of Channel Catfish," American Fisheries, September and October, 1967.

Table 25.--Farm costs and returns for pond reared catfish for production of 2,000 pounds per acre[1]

(1975-1985 conditions)

Item	Per acre	Per pound
	------------Dollars------------	
Fingerlings	100	.0500
Feed	130	.0650
Labor	50	.0250
Harvesting	40	.0200
Other variable costs	37	.0185
Fixed costs	56	.0280
Total	413	.2065
Transportation to processing plant		.010 [2]
Total cost of fish at plant		.2165
Price of fish at plant		.250
Farm margin		.0335

1/ A feed conversion rate of 1.3 is projected, compared to a current level of 2.5; harvesting costs are projected to decrease from a current level of $60 to a level of $40 per acre.

2/ Assumes a 50 mile shipment.

current levels due to changes in production efficiency. First, the feed conversion ratio will be reduced from the present level of 2.5 to a level of 1.3. Secondly, advancements in technology will lower harvesting costs from the current $60 per acre to $40. The derived production cost, then, is approximately $0.21 per pound of live weight. Transportation cost to the processing plant, given the most likely travel distance, will add $0.01 per pound to costs.

2. Processing costs. Projected processing costs are shown in Table 26, and are based on the following assumtions:

(a) The costs presented are for a plant handling 1,000 pounds of output per hour for a total of 1,200 hours of operation per year.

(b) Processing costs for the irradiated product are equal to the costs of processing fresh catfish, plus the specific costs related to irradiation. Irradiation costs were adapted from the most recent findings in this regard, published by a U. S. AEC contractor/investigator.[34/] These costs, on a unit basis, were found to be highly sensitive to product throughput. Fixed costs comprised a relatively high proportion of total costs, and their level was determined primarily by the amount of the initial investment in plant and equipment, which in turn was determined by the scale of the plant, that is, plant capacity.

Given a total throughput requirement, various combinations of plant capacity and utilization are possible to achieve the desired

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34/ U. S. Department of Commerce, (BDSA), The Commercial Prospects for Selected Irradiated Foods, TID-24058, Washington, D. C., March 1968.

Table 26.--Process costs for pond reared catfish

(dressed weight; 1975-1985 conditions)

Item	Fresh	Fresh irradiated	Frozen
	Dollars per pound dressed weight		
(1) Building and land	.005	.005	.005
(2) Equipment	.032	.032	.034
(3) Price of fish at plant	.385	.385	.385
(4) Labor	.046	.046	.053
(5) Packaging material	.022	.022	.022
(6) Other--administration, sales, etc. approx. 5 percent of sales value	.030	.030	.030
(7) Irradiation cost	---	.026	---
(8) Cost of processed fish	.520	.546	.529
(9) Processing margin	.100	.100	.100
(10) Price f.o.b. plant	.620	.646	.629

Source:

(1) and
(2) An Analysis of the Present Status and Future Potential of the Lake Superior Commercial Fishing Industry. U. S. Department of Commerce, Economic Development Administration, T.A.P., No. 722, page 45.

(3) Assumes 65 percent recovery from live weight.

(4) Dailey, Edward, U. S. Department of the Interior, Bureau of Commercial Fisheries (unpublished), studies on processing costs of fresh water fish, $0.03 per pound round weight of fish. Frozen includes .004 hours labor at $1.84 per hour.

Table 26. (continued)--Processing costs for pond reared catfish

(dressed weight; 1975-1985 conditions)

Sources:

(5) Same as line (1)

(6) Same as line (4)

(7) Includes $0.005 per pound handling and transportation.

(8) Sum of (1) through (7)

(9) (10) minus (8)

(10) Projected.

volume. An array of these possibilities is presented in Appendix Tables II-17, II-18, and II-19, which show the alternative capacity/utilization combinations for the required per plant throughput in the forecast years of 1975, 1980, and 1985. These tables detail the investment requirements, operating expenses, and unit production costs under the varying conditions.

A strong positive correlation exists between the plant capacity and unit costs at a given throughput. For example, it is estimated that in 1980 each of four projected irradiation processing plants will be required to process 18.63 million pounds of product. A minimum size plant under this condition would absorb a throughput of approximately 2,300 pounds per hour, at a cost of $0.0168 per pound. A plant of this capacity, however, would require full utilization, that is, operation on a three-shift, seven-day week basis. It is therefore obvious that a larger capacity plant would be needed to allow for expected increases in production requirements. Flexibility is gained however, at an addition in costs. A plant with enough capacity to process the 1980 throughput requirements, on the basis of a one-shift, five-day week operation, would irradiate catfish products at a cost of $0.0319 per pound.

For the time framework of this analysis, it was determined that the desired plant size would be a capacity sufficient to process the per plant requirement expected in 1985, at a plant utilization of approximately 90 percent. As shown in Appendix Table II-19, a minimum capacity for accommodating 1985 production would be a plant able to produce at a rate of 4,000 pounds per hour. On this basis, it was determined that each of the four irradiation processing plants contemplated in the 1975-1985 period should have a throughput capacity of 4,500 pounds per hour.

Table 27 summarizes the investment requirements and costs for operating a plant of the desired capacity during the forecast years 1975, 1980, and 1985.

Table 28 presents the total and unit costs of irradiation processing at the assumed plant size for each of the forecast years, over the period 1975-1985. The weighted average of these costs for the entire forecast period was used in the development of total processing costs for fresh-irradiated catfish. This cost of $0.021 per pound plus an allowance for transportation from the processing plant to the irradiation plant of $0.005 appears in Table 26 as the irradiation cost. The throughput requirements per plant are one-fourth of the projected crop of channel catfish available for processing, adjusted to a dressed, or processed, weight basis. The annual hours operated would be the number sufficient to reach the required throughput at the given capacity. Assuming eight-hour shifts, the number of shift days may be derived from the annual operating hours. From this figure it is possible to determine the point at which multiple shift operations become necessary. For example, a single shift operation five days per week for fifty weeks

Table 27.--Cost estimates per plant for irradiation of processed channel catfish, at projected levels of production, 1975, 1980, 1985 1/

Source	- cobalt - 60		
Dose	- 250,000 rads ("pasteurization")		
Process efficiency	- 30 percent		
Cobalt cost	- $0.45/curie		
Throughput capacity	- 4,500 lbs./hr.		
Plant investment	$ 860,625		
Source cost	143,438		
Total	$1,004,063		
Cost projections:	1975	1980	1985
Annual throughput (thousand pounds)	10,350	18,630	32,300
Plant utilization:			
Annual hours operated	2,300	4,140	7,178
Shift days (@ 8 hour shifts)	288	518	897
Expenses:			
Variable	$131,334	$137,334	$147,334
Fixed	203,536	203,536	203,536
Total	334,870	340,870	350,870
Allowance for return @ 8 percent	80,325	80,325	80,325
Total expenses and return allowance	415,195	421,195	431,195
Irradiation costs per pound	$ .0401	$ .0226	$ .0133

1/ These costs were developed from the basic data and procedures outlined in, U. S. Department of Commerce (BDSA), "The Commercial Prospects for Selected Irradiated Foods," Washington, D. C., March, 1968.

Table 28.--Projected throughput of catfish products for each of four irradiation plants with estimates of irradiation costs per pound, full forecast period, 1975-1985 1/

Years	Throughput	Cost per pound
	Thousand pounds	Dollars
1975	10,350	.0401
1976	11,640	.0357
1977	13,090	.0319
1978	14,720	.0284
1979	16,560	.0254
1980	18,630	.0226
1981	20,800	.0203
1982	23,220	.0183
1983	25,920	.0165
1984	28,930	.0148
1985	32,300	.0133
Total	216,160	.0215 (weighted average)

1/ Assumes the following:

Source:	cobalt - 60
Dose:	250,000 rads
Processing efficiency:	30 percent
Cobalt cost:	$.45/curie
Throughput capacity:	4,500 lbs./hr.

equals 250 shift days. Hence, it is obvious from the table that in 1975 it would be necessary to operate a plant on a six-day per week basis, or on a multiple shift schedule during parts of the year if a five-day per week operation were retained. The man-hour estimates given in the table are for production workers only, and do not include support or supervisory labor. Variable expenses are comprised chiefly of direct (production) and indirect labor expenses, maintenance expenses and supplies, and utilities. Fixed costs include amortization of plant and source, source replenishment costs, taxes, insurance, and third party liability. The amortization period for the plant was taken at ten years for three-fourths of the cost, and six years for the remaining one-fourth of the cost. The source is amortized on a ten year basis.

As may be seen, projected irradiation costs per pound will decline from about $0.04 in 1975 to $0.013 per pound in 1985. The cost per pound declines as output moves toward full utilization of capacity. It is very important to note however, that these costs imply that catfish will be the sole product processed in the irradiation plant. No allowance is made for unused capacity that could be used in the processing of other products, should these be made available to the plant.

3. Wholesale prices. The f.o.b. wholesale price for fresh catfish projected for the 1975-1985 time period is $0.62 per pound, which is

slightly below the current Chicago wholesale price for dressed catfish. Fresh-irradiated catfish, it is projected, would sell at $0.646 per pound, the difference over fresh being equal to the cost of irradiation. The availability of an irradiated product can be expected to result in an increase in demand for catfish (at wholesale), as the likelihood of spoilage losses, to be borne by retailers and institutional users, is reduced. Therefore, the quantity of irradiated sold would exceed the quantity of fresh that would be sold, at a price above the market price for fresh. A similar rationale was applied in building the assumption of a wholesale price for frozen catfish for the 1975-1985 period. Changes in supply and demand at wholesale that would accompany the marketing of frozen catfish products would result in a higher price per pound and increased marketings, due to expectations of diminished spoilage losses and the elimination of short-buying practices. The increase in price over a fresh product, in this instance is assumed to be the excess in cost of frozen over fresh. Frozen catfish products, therefore, would bring a wholesale price of $0.629 per pound. (See Appendix I, Technical Note (d).)

4. Marketing and distribution costs. The costs in this phase were developed from research reports in related food marketing as presented in Table 29. Under current practices, shipping costs of fresh fish are probably higher than those for frozen. The weight of the ice required for shipping fresh fish amounts to about 80 percent of the

Table 29.--Marketing and distribution costs of pond reared catfish [1/]

(dressed weight; 1975-1985 conditions)

Item	Fresh	Fresh irradiated	Frozen
	-----Dollars per pound-----		
(1) Price f.o.b. plant	.620	.646	.629
(2) Inter-city shipping costs	.015	.015	.015
(3) Wholesaling	.019	.018	.016
(4) Into store delivery costs	.040	.010	.010
(5) Costs of retailing	.150	.150	.075
(6) Total marketing and distribution cost	.844	.839	.745
(7) Retail price	.950	.934	.836
(8) Marketing and distribution margin	.106	.095	.091

Source:

(1) See Table 26.

(2) Cost Components of Farm-Retail Price Spread for Food, Technical Study No. 9, National Commission on Food Marketing, Washington, D. C., June 1966, Tables 12-17. This is approximately the mid-point of a given range for shipping meat and poultry products.

(3) Same source as line (2). Amounts to 3 percent of price at plant.

(4) Same as line (2); also Larry L. Snead, Research Study Concerning Potential Effects of Radiation Processing on Market Supplies and Structures of the Domestic Fishing Industry, (unpublished), U. S. Department of the Interior, Bureau of Commercial Fisheries, Washington, D. C., January 1966. Darrel A. Nash, Optimum Plans for Coordinated Egg Production and Marketing in Southwestern Illinois, (unpublished), University of Illinois, Urbana, Illinois, April 1964. Snead reports that the modal frequency of delivery is once a day for fresh fish and once a week for frozen fish. Using this information, it was derived from Nash that by reducing deliveries from daily to every five days reduces delivery costs

Table 29.(continued)--Marketing and distribution costs of pond-reared catfish

(dressed weight; 1975-1985 conditions)

Sources:

(4)--continued

per unit by one-third and that by reducing deliveries from daily to every seven days reduces delivery costs by nearly one-sixth. Thus, in this case, delivery costs of irradiated and frozen are reduced by one-fourth over fresh.

(5) Same as line (2).

(6) Sum of lines (1), (2), (3), (4), and (5).

(7) This is at the current level of highest valued marine fish.

product weight and thereby adds significantly to the shipping cost per pound of fish. 35/ An irradiated product would have to be maintained in the same way. However, improved containers and shipping techniques, now under development, will measurably reduce the shipping costs of fresh fish. It is expected that these improvements will be adopted commercially by 1975. Thus, projections assume no differential in the shipping costs of fresh and frozen products.

Per unit delivery costs vary according to the number of deliveries. A significant cost saving is possible for a given volume by changing from daily to weekly deliveries as detailed in Table 29.

Retailing cost estimates were obtained from agricultural food marketing reports. 36/ Considering the characteristics of catfish, it was decided that meat retailing costs would be the most representative of the situation for fresh and irradiated catfish. 37/ Retailing costs for frozen meat products were not available, and it was therefore necessary to base an estimate of the retailing cost of frozen catfish on the costs of retailing frozen dairy products.

35/ U. S. Department of the Interior, Bureau of Commercial Fisheries, A Study of the Feasibility of Improved Fresh Fish Marketing through Improved Packaging and Handling Practices and Procedures, 1967, (unpublished).

36/ National Commission on Food Marketing, Cost Components of Farm-Retail Price Spread for Foods, Technical Study No. 9, Tables 9, 12, 13, 14, 15, and 16, June 1966.

37/ Broiler retailing costs, which were much lower, are used in a later phase of this study to show the effects of reduced retailing costs on marketing margins, and thus the benefit-cost estimates developed in this study.

5. Retail prices. The projected retail price of fresh, dressed catfish is $0.95 per pound, which is somewhat below the current Chicago retail price. Widespread distribution would increase the exposure of catfish products to competing established fishery products, and the price is expected to adjust downward. Irradiated catfish, at the retail level, would sell at a price slightly below the assumed price for fresh. Consumer demand for irradiated catfish would not differ significantly from the consumer demand for "fresh"--nonirradiated catfish. The increase in supplies, as a result of the irradiation process, therefore, would result in a drop in price. The adjustment factor was taken from the demand analysis of fresh catfish sales in the Chicago wholesale market, which indicated that a one percent increase in quantities distributed is accompanied by a .157 percent decrease in price. (See Appendix I, Technical Note (c).) Applying this calculus to the estimated price for fresh catfish places the retail price of irradiated catfish at $0.934 per pound.

The assumed price of frozen catfish at the retail level takes into account the differences in demand that have been observed between fresh and frozen fishery products in general under present market conditions. Over a recent 18 month period, the percentage differences between prices paid at retail for fresh and for frozen haddock, in Boston, averaged 27.2 percent. As a reasonable assumption, one half of the fresh/frozen differential observed for haddock was applied to the projected catfish market. Thus, it was assumed that fresh catfish would bring 13.6 percent more, at retail, than frozen. Applying this percentage to the projected price for fresh--$0.95 per pound--results in an assumed retail price of $0.836. [38] (See Appendix I, Technical Note (e).)

6. Summary of costs and margins. The harvesting, processing, and marketing costs and margins together with the selling prices of each level are summarized in Tables 30, 31, and 32, which compare the costs for fresh, fresh-irradiated and frozen catfish. The tables may be conveniently read by starting in the upper left-hand corner and reading from left to right. By accumulating the values of the first two columns in this order, the costs, and the margins, can be determined at any point in the production-marketing chains. It will be observed that in strict terms of margin <u>per unit</u> of sale, fresh has an advantage over fresh-irradiated which, in turn, has an advantage over frozen. Nonetheless, as has been pointed out, sales of irradiated and of frozen products would exceed sales of fresh. Hence, in terms of total margins to be earned, the preference order would be irradiated, frozen, and fresh. This is more fully discussed below.

7. Effects of irradiation. There are several important advantages or benefits in radiation processing of fishery products. [39] A

38/ Price differentials on which this projection is based were computed from monthly retail price surveys made by the Division of Markets, State of Massachusetts. As a test of reasonableness for the wholesale and retail price projections, the "net" and "gross" margins at the two market levels, for the three preservation techniques, were compared. Processors' "net" margins are about 16 percent, and retailers' 10 to 11 percent. Gross margins for processors ranged from 38 percent for fresh to 40.5 percent for irradiated. Retailers' gross margins for fresh and irradiated were 27 and 26 percent, respectively, and 20 percent for frozen, Appendix Table II-20 lists these margins, with explanatory notes.

39/ Lawrence W. Van Meir, "The Economic Feasibility of Radiopasteurization of Fish," speech given at FAO Technical Conference on the Freezing and Irradiation of Fish, Madrid, Spain, September 2-9, 1967.

Table 30.--Costs, margins and selling prices of fresh processed pond reared catfish

(dressed weight; 1975-1985 conditions)

Level	Added cost	Margin	Selling price
	------Dollars per pound---		
Farm	.333	.052	.385
Processing	.135	.100	.620
Marketing and distribution	.224	.106	.950
Total	.692	.258	.950

Source: From Tables 25, 26, and 29

Table 31.--Costs, margins and selling prices of fresh irradiated processed pond reared channel catfish

(dressed weight; 1975-1985 conditions)

	Added cost	Margin	Selling price
	------Dollars per pound---		
Farm	.333	.052	.385
Processing	.161	.100	.646
Marketing and distribution	.193	.095	.934
Total	.687	.247	.934

Source: From Tables 25, 26, and 29

Table 32.--Pond reared catfish; costs, margins and selling prices, frozen process

(dressed weight; 1975-1985 conditions)

Level	Added cost	Margin	Selling price
	-----Dollars per pound-----		
Farm	.333	.052	.385
Processing	.142	.102	.629
Marketing and distribution	.116	.091	.836
Total	.591	.245	.836

Source: From Tables 25, 26, and 29

primary benefit is a reduction of spoilage losses. Results of one survey indicate a five percent spoilage loss by weight, in the marketing channel. 40/ Another report, summarized in Table 33, indicates that spoilage and shrinkage losses in the various production and marketing phases, and in different seasons, range between 1.3 percent and 4.8 percent, by weight.

It has been estimated that one-half of the spoilage loss could be eliminated by marketing the irradiated product. 41/ On that basis, this study assumes a sales increase in irradiated over fresh of 2.5 percent, which is equal to the reduction in spoilage.

Another benefit of irradiation derives from an increase in sales brought about by the elimination of the practice of "short-buying," that is, buying less fresh fish than expected sales. Irradiation is expected to open the possibility of carrying the product over for an additional 7 days or more, at retail. The retailer would thus have on hand the full amount of expected sales. An assumed sales increase of 7 percent by eliminating "short-buying," is used in this study, as derived from a survey. 42/

The net effect of the above measured benefits is to increase sales of either irradiated or frozen catfish 9.7 percent over fresh catfish sales. This results from the advantages that irradiated or frozen catfish would have over fresh in the amount of spoilage losses and in the elimination of short-buying.

40/ U. S. Atomic Energy Commission, Division of Technical Information, Cost-Benefit Study of Selected Products in Atomic Energy Commission's Low-Dose Food Irradiation Program, NYO-3666-1, December 1966, p. 77.

41/ Ibid.

42/ Ibid.

Table 33.--Weight losses in shrinkage and spoilage of fresh fishery products

	Winter	Summer
	-----Percent------	
Producer	1.3	1.8
Processor	1.3	1.8
Distributor	1.7	2.6
Wholesaler	2.4	3.2
Retailer	3.7	4.8

Source: Larry L. Snead, Research Study Concerning Potential Effects of Radiation Processing on Market Supplies and Structure of the Domestic Fishing Industry, (unpublished), U. S. Department of the Interior, Bureau of Commercial Fisheries, January 1966, pp. 24-30.

Demand may be increased by the expansion of the market area. This again is possible from the extension of shelf-life. However, no benefit is counted for this potential. The expenses that would be incurred in the immediate years ahead in developing catfish markets outside the traditional catfish consumption area are not determinable. Hence, in the interest of conservatism, it is assumed that the cost of further adding to the market area would be as great as any entrepreneurial returns from greater sales during the time period under analysis. Thus, a zero net benefit is given for market area expansion.

The possibility also exists for reducing short-term supply and price variations by lowering the time restrictions in marketing. This benefit may be quite significant, although no information is available on its magnitude. At this time, it must be counted as an unmeasured advantage.

8. Benefit-cost analysis. The objective of this benefit-cost analysis is to determine the feasibility of an investment of public funds in the development of commercial radiation processing for pond reared channel catfish. The procedure in this analysis is to measure the public benefits which may accrue from the investment and relate these benefits to the amount invested, i.e., to the development costs. At the outset, however, it is necessary to define "public benefits." This analysis proceeds from the position that public benefits are related to the value of the output of irradiated catfish at the final point of sale. This value may be considered as an increment to the gross national product or income stream. 43/ Irradiation processing,

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43/ In evaluating the techniques of benefit-cost analysis, Haveman states, "...there is no universal technique by which these streams (of costs and returns) can be evaluated and compared... Thus, for example, the corporation decision maker defines his goal to be...maximum profits, stipulates his constrained variable to be the capital budget,..." In regard to the application of benefit-cost analysis at the government level, Haveman states, "...because the government is a social institution, both the goal and the constrained variable relevant to the private sector lose their meaning. Consequently, in governmental investment analysis to secure economic efficiency, the goal of the program is taken to be the maximization of total national income and the constrained variable is defined as the social cost devoted to the support of the program..." Robert H. Haveman, Water Resource Investment and the Public Interest, Vanderbilt University Press, Nashville, Tennessee, 1965, p. 96.

however, is only one alternative of three major methods of processing channel catfish. Hence, a critical factor is to determine what differential, if any, exists between the alternative processes in their income producing potential. From the public view, the preferred process would be the one that created the largest increment to the national product. The measure of public benefits, then, may be taken as the difference between the total value of the output of the preferred process and its closest alternative. 44/

There is, however, a basic precondition to public investment in developing a commercial product. It must be commercially feasible to manufacture and distribute the product. The test of commercial feasibility is profitability. From a commercial viewpoint, then, the preferred catfish process would be the one that would maximize net revenues--the difference between total revenues and total costs in the marketing chain--at a percentage margin equal to or better than the next best alternative. (Margin, here, is defined as the percentage difference between total revenue and total costs.) In the context of a benefit-cost analysis there are two criteria to consider: a benefit (total revenue)-cost ratio, and the amount of net benefits (the difference between total revenue and total costs). In brief, comparisons are made first on the basis of expected returns per dollar spent, and secondly, on the basis of total net returns. In considering

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44/ This analysis concerns two alternatives for processing a new product, the assumption being that, under any circumstances, the product would be marketed. The concepts of this analysis apply equally to a new process as a replacement for an established product.

the alternative processes, the one with the highest benefit-cost ratio would be preferred. Where the benefit-cost ratios do not differ significantly between alternatives, the value of net benefits becomes the determining factor.

The above outlined principles of benefit-cost evaluation have been applied to the three alternative processes for channel catfish: fresh, fresh-irradiated, and frozen. The results of this analysis appear in Table 34, which is a simplified schedule of comparative benefits and costs as they apply to commercial feasibility. The analysis indicates that there are no significant differences in the commercial benefit-cost ratios of the three alternative processes; each would result in a benefit-cost ratio of approximately 1.4:1. Under these circumstances, the best alternative is chosen on the basis of maximized net returns. This forms the basis for adjudging radiation processing as the best alternative. In terms of net revenue to the commercial sector, irradiation processing has a 5 percent advantage over fresh, and close to a 1 percent advantage over frozen. The advantage of irradiated and frozen over fresh is the result of increased marketings due to increased demand (elimination of short buying) and decreased spoilage losses. Irradiated is favored over frozen on the basis of a slightly higher net margin (retail value less total costs).

Having identified irradiation processing as the preferred alternative process from a commercial viewpoint, it is then possible to measure the net public benefit of this alternative by measuring the difference

Table 34.--Benefit-cost analysis for the production and marketing of pond reared channel catfish

	Fresh	Fresh-irradiated	Frozen
(1) Benefits per pound (retail price)	$0.950	$0.934	$0.836
(2) Costs per pound (total production and marketing costs)	0.692	0.687	0.591
(3) Adjustment for difference [1/] in volume of total marketings	100%	109.7%	109.7%
(4) Adjusted benefits [2/]	$0.950	$1.025	$0.917
(5) Adjusted costs [3/]	0.692	0.754	0.648
(6) Benefit-cost ratio [4/]	1.373	1.359	1.415
(7) Net benefits [5/]	0.258	0.271	0.269

1/ Adjustment to account for increased demand and reduction of spoilage loss.

2/ Line (3) times line (1).

3/ Line (3) times line (2).

4/ Line (4) divided by line (5).

5/ Line (4) minus line (5).

in public benefits (as defined above) that would result from processing irradiated catfish products as against the next best alternative, which appears to be frozen. The basic measurement for this procedure can be derived from Table 34, line 1, which shows the unit retail value of the products under consideration. Thus, the public benefit per unit would be the difference in retail price between frozen and irradiated catfish, which is 9.8 cents per pound. Table 35 expands this unit differential to the projected total production for the years 1975-1985. This is the measured addition to the national product. The next step is to consider these public benefits in terms of their value at the time of expenditure of the public investment. Three discount rates are applied--6 percent, 8 percent, and 10 percent, and benefits are discounted to the base year 1970.[45/] The total benefits over the time period under consideration are then calculated and related to the expected public development costs

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45/ It is difficult to pinpoint an appropriate discount rate for the purposes of the benefit-cost analyses. A realistic approach suggests that future benefits should be discounted at a rate at least as high as the available borrowing rate in the money market. In addition, it is appropriate to consider the yield an investment may bring in alternative uses, i.e., to make allowances for opportunity costs of funds. With these principles in mind, this analysis presents calculations on three different discount rate bases that are compatible with current money markets and investment opportunities. In March, 1968 the money market rate for 3-5 year government bond or note issues was about 5.8 percent; the mortgage market rates were about 6.8 percent. (See Federal Reserve Bulletin, no. 4, vol. 54, April 1968).

Table 35.--Calculation of public benefits from the marketing of irradiated catfish products

Year	Projected output	Value of sales if: Irradiated[1]	Value of sales if: Frozen[1]	Excess in value of irradiated over frozen "real" benefits	Discounted benefits 6 percent	Discounted benefits 8 percent	Discounted benefits 10 percent
	Thousand lbs.	Thousand dollars					
1975	41,400	38,668	34,610	4,058	3,033	2,762	2,520
1976	46,560	43,487	38,924	4,563	3,217	2,876	2,576
1977	52,360	48,904	43,773	5,131	3,413	2,994	2,633
1978	58,880	54,994	49,224	5,768	3,619	3,116	2,691
1979	66,240	61,868	55,377	6,491	3,842	3,247	2,753
1980	74,520	69,602	62,299	7,303	4,078	3,383	2,815
1981	83,200	77,709	69,555	8,154	4,296	3,497	2,858
1982	92,880	86,750	77,648	9,102	4,524	3,614	2,900
1983	103,680	96,837	86,676	10,161	4,763	3,736	2,944
1984	115,720	108,082	96,742	11,340	5,016	3,861	2,986
1985	129,200	120,673	108,011	12,662	5,284	3,991	3,031
Total	864,640	807,574	722,839	84,733	45,085	37,077	30,707

1/ Based on average retail price of $0.934 per pound for irradiated, and $0.836 per pound for frozen.

in terms of a benefit-cost ratio.[46/] The 1970 value of cumulative public benefits deriving from the sales of irradiated catfish, over the period 1975-1985, amount to about $45 million at the lowest discount rate, and $31 million at the highest rate. These calculations are shown in Table 35. Benefit-cost ratios, of course, would vary with the magnitude of public investment. A schedule of ratios at various investment levels is shown in Table 36. This schedule, in effect, indicates the ceiling levels of public investment which can be devoted to develop a commercial radiation process for channel catfish, that is, the size of required investments within the range of acceptable benefit-cost ratios.

It is important to point out that the calculated benefits are based on the assumption that the total industry output will be irradiation-processed, hence the estimates are to be considered as maximum. Catfish, however, are likely to be sold in some combination of market forms. Thus, the calculated net benefits will decline to the extent that farm output of catfish will be processed in some form other than fresh-irradiated.

46/ The benefit-cost ratios computed in this analysis were developed from an adaptation of the techniques in use by the Corps of Engineers, which, Haveman cites, "...takes the following form:

$$Z = \frac{\Sigma \frac{B}{(1 + i)^t}}{K + \Sigma \frac{O}{(1 + i)^t}}$$

in which B is the expected annual benefit in the form of addition to national income from a project, i is the rate of interest used to discount the future streams of benefits and costs, t is the estimated life of the project, K is the fixed investment cost, and O is the estimated annual operation, maintenance and repair costs." Haveman, op. cit., pp. 96-97.

Table 36.--Benefit-cost ratios from public investment in developing commercial irradiation-processing for channel catfish, at various investment levels

	Discount rate		
	6 percent	8 percent	10 percent
	---------Thousand dollars-------		
Discounted public benefits 1/	$45,085	$37,077	$30,707
	Benefit-cost ratios		
AEC development cost levels:			
500	90.2	74.2	61.4
750	60.1	49.4	40.9
1,000	45.1	37.1	30.7
1,250	36.1	29.7	24.6
1,500	30.1	24.7	20.5
1,750	25.8	21.2	17.5
2,000	22.5	18.5	15.4
2,500	18.0	14.8	12.3
3,000	15.0	12.4	10.2
3,500	12.9	10.6	8.8
4,000	11.3	9.3	7.7
4,500	10.0	8.2	6.8
5,000	9.0	7.4	6.1
5,500	8.2	6.7	5.6
6,000	7.5	6.2	5.1
6,500	6.9	5.7	4.7
7,000	6.4	5.3	4.4
7,500	6.0	4.9	4.1
8,000	5.6	4.6	3.8
8,500	5.3	4.4	3.6
9,000	5.0	4.1	3.4
9,500	4.7	3.9	3.2
10,000	4.5	3.7	3.1

1/ From Table 35.

9. Effects of varying cost conditions on benefit-cost projections. The estimates given above are based on conditions we adjudge are most likely to exist during the period 1975-1985. Therefore, the benefit-cost ratios given are what we consider the best estimate.

It is useful, however, to explore what effect a deviation from projected costs would have on the benefit-cost ratios. For this purpose, we have made two assumptions in regard to retailing costs. Deviations from projected cost components other than retailing costs, of the same magnitude as those assumed below, would, of course, effect similar changes in benefit-cost ratios. The assumptions are:

(1) The cost of retailing fresh and irradiated fish would be $0.07 per pound instead of the adopted estimate of $0.15 per pound which is the current cost of retailing meat products. The lower figure is based on the cost of broiler retailing. (See Tables 37 and 38)

(2) The cost of retailing fresh and irradiated catfish is the simple average of meat and broiler retailing costs, or $0.11 per pound. (See Tables 39 and 40)

Under the assumption that retailing costs for fresh or irradiated catfish drop to $0.07 per pound, and all other costs, (including retailing frozen fish) remain constant, the advantages of irradiation processing over other techniques would be expanded. The net benefits of irradiation processing to the commercial sector, under this assumption, would exceed the net benefits from "fresh" processing by more than 6 percent, and those from frozen processing by more than 33 percent (Table 41). Similarly, irradiation processing would be the best commercial

Table 37.--Pond reared catfish; costs, margins, and selling prices, fresh--Assumption (1) 1/

(dressed weight; 1975-1985 conditions)

Level	Added cost	Margin	Selling price
	-----Dollars per pound------		
Farm	.333	.052	.385
Processing	.135	.100	.620
Marketing and distribution	.144	.186	.950
Total	.612	.338	.950

1/ Cost of retailing is reduced to the cost of broiler retailing at $0.07 per pound. National Commission on Food Marketing, Cost Components of Farm-Retail Price Spread for Foods, Technical Study 9, Table 16, June 1966.

Table 38.--Pond reared catfish; costs, margins and selling prices, fresh irradiated--Assumption (1) 1/

(dressed weight; 1975-1985 conditions)

Level	Added cost	Margin	Selling price
	-----Dollars per pound------		
Farm	.333	.052	.385
Processing	.161	.100	.646
Marketing and distribution	.113	.175	.934
Total	.607	.327	.934

1/ Cost of retailing is reduced to cost of broiler retailing.

Table 39.--Pond reared catfish; costs, margins and selling prices, fresh--Assumption (2) 1/

(dressed weight; 1975-1985 conditions)

Level	Added cost	Margin	Selling price
	--------Dollars per pound---		
Farm	.333	.052	.385
Processing	.135	.100	.620
Marketing and distribution	.184	.146	.950
Total	.652	.298	.950

1/ Cost of retailing is reduced to cost of retailing broilers plus one-half the difference between broiler and meat retailing costs, or $0.11 per pound. National Commission on Food Marketing, Cost Components of Farm Retail Price Spread for Foods, Technical Study 9, Tables 12, 13, 14, 16, June 1966.

Table 40.--Pond reared catfish; costs, margins and selling prices, fresh irradiated--Assumption (2) 1/

Level	Added cost	Margin	Selling price
	--------Dollars per pound---		
Farm	.333	.052	.385
Processing	.161	.100	.646
Marketing and distribution	.153	.135	.934
Total	.647	.287	.934

1/ Cost of retailing is reduced to broiler retailing plus one-half the difference between broiler and meat retailing costs.

Table 41.--Benefit-cost analysis; pond reared catfish--Assumption (1) (Assumes drop in retailing cost of fresh and irradiated catfish to $0.07 per pound and no change in retailing costs for frozen)

(dressed weight; 1975-1985 conditions)

	Fresh	Fresh-irradiated	Frozen
(1) Benefits per pound (retail price)	$0.950	$0.934	$0.836
(2) Costs per pound (total production and marketing costs)	0.612	0.607	0.591
(3) Adjustment for difference in volume of total marketing	100%	109.7%	109.7%
(4) Adjusted benefits	$0.950	$1.025	$0.917
(5) Adjusted costs	0.612	0.666	0.648
(6) Benefit-cost ratio	1.552	1.539	1.415
(7) Net benefits	0.338	0.359	0.269

alternative under the assumption that retailing costs for fresh and irradiated catfish would be $0.11 per pound. In terms of percentage differences in net benefits, the advantage of irradiated over fresh would measure close to 6 percent; and the advantage over frozen would exceed 17 percent (Table 42).

Table 42.--Benefit-cost analysis; pond reared catfish--Assumption (2) (Assumes drop in retailing cost of fresh and irradiated catfish to $0.11 per pound, and no change in retailing costs for frozen)

(dressed weight; 1975-1985 conditions)

	Fresh	Fresh-irradiated	Frozen
(1) Benefits per pound (retail price)	$0.950	$0.934	$0.836
(2) Costs per pound (total production and marketing costs)	0.652	0.647	0.591
(3) Adjustment for difference in volume of total marketings	100%	109.7%	109.7%
(4) Adjusted benefits	$0.950	$1.025	$0.917
(5) Adjusted costs	0.652	0.710	0.648
(6) Benefit-cost ratio	1.457	1.444	0.1415
(7) Net benefits	0.298	0.315	0.269

APPENDIX I

Technical Notes

(a) In the analysis of price determinants for catfish landings on the east coast of Florida, monthly data were used covering the period January 1965 through December 1967. Price was the dependent variable (X_1) and the independent variables were quantities landed (X_2) and time (X_3). The least squares linear regression yielded the following equation. Standard errors are in parentheses.

$$X_1 = 15.27 - \underset{(.0013)}{.0023X_2} + \underset{(.1015)}{1.0285X_3}$$

$r^2 = .79$
price flexibility = -.0215 [1]
price elasticity = 46.6 [1]

(b) Annual data were used for the price analysis of catfish landings on the Gulf Coast, covering the years 1955-1966. Graphs indicated measurable trends for both landings and prices. To minimize the effects of trend in correlation of landings and price, the trends were calculated by means of fitting least squares trend lines to the data, then calculating the percentage deviation from trend in each time period for both variables. Through simple regression analysis, it was found that the following relationships existed between deviations from price trend (X_1) and deviation from landing trends (X_2):

$$X_1 = 130.5 - \underset{(.019)}{.313\ (X_2)}$$

$$r^2 = .70$$

It should be noted that the values of the variables are in terms of percentage. The equation thus states that for each one percentage change in the deviation of landings from the trend, the deviation from price trend will be 0.3 percentage points in the opposite direction.

1/ The low price flexibility, and corresponding high demand elasticity both show that monthly changes in landings do not have pronounced effects upon current prices at the landing point. See notes (b) and (c) for estimates of longer term flexibilities and elasticities.

Technical Notes

(c) Price elasticity estimates for wholesale sales of dressed catfish in the Chicago market were developed from a least squares regression analysis of monthly receipts and price in this market. The time period used was January 1964 through August 1967. In this analysis, price (X_1) was the dependent variable, and its association with the following independent variables was tested:

(X_2) Receipts of catfish in the current month

(X_3) Receipts of catfish in the prior month

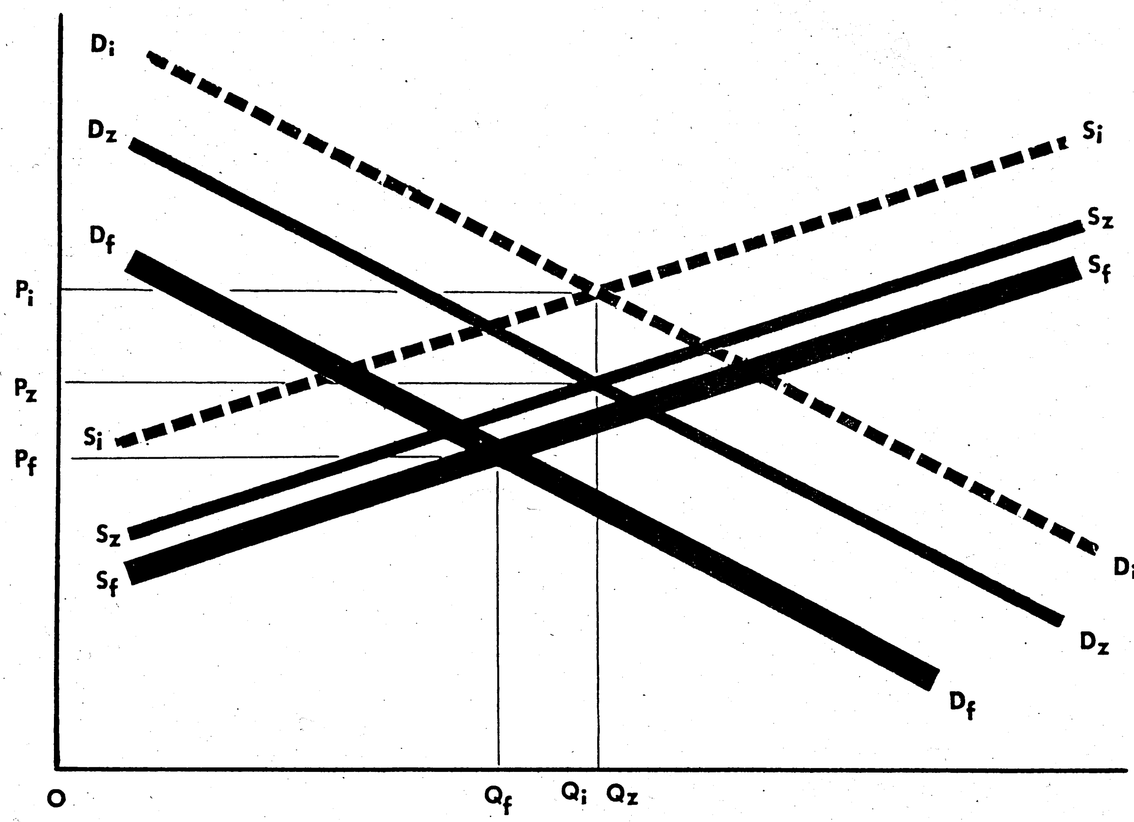
(X_4) A time variable

The regression equation with standard errors shown in parentheses, was:

$$X_1 = 62.4809 \text{ (cents)} - \underset{(.030600)}{.100446(X_2)} - \underset{(.031234)}{.077796(X_3)} + \underset{(.053490)}{.236498(X_4)}$$

$r^2 = .825$
price flexibility = .1566
price elasticity = 6.385

Supply and demand relationships, wholesale. 1/



1/ Explanation of graph appears on following page.

Technical Notes

(d) Explanation: Supply and demand relationships, wholesale.

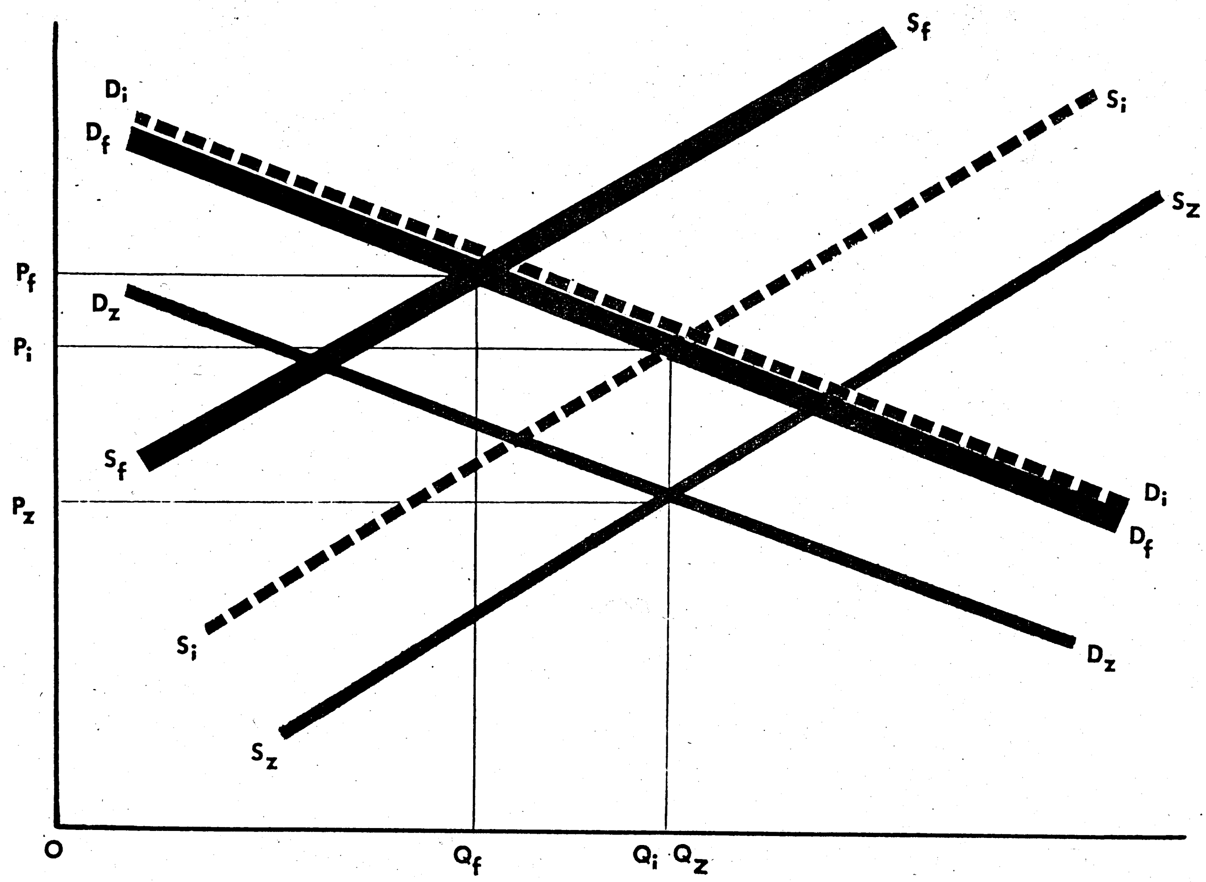
Fresh: The quantity and price of fresh processed catfish marketings, at the processor/wholesaler level is represented by the intersection of supply schedule S_fS_f and demand schedule D_fD_f. Quantity OQ_f would be sold at price OP_f.

Irradiated: The added cost of irradiation would affect the amount of catfish that processors would manufacture at all possible prices. With radiation-processing, they would be willing to manufacture the same quantity as they would fresh only at higher prices (or, at the same price, they would manufacture less). These new "decisions" are represented on the graph by supply schedule S_iS_i.

Retailers, on the other hand, would be cognizant of the cost advantages of stocking an irradiated product. These advantages are, basically, longer shelf life and reduced losses from lower markdowns and spoilage. Thus, the retailers would be willing to pay a premium for irradiated catfish. The higher prices they would be willing to pay for various quantities are represented by line D_iD_i on the graph, which is located to the right of the demand schedule for fresh catfish (D_fD_f). The market price (OP_i) would be established at the point of intersection of D_iD_i and S_iS_i, which is the point of "agreement" between suppliers and buyers--that is, where the amount processors would be willing to sell at price OP_i is equal to what would be purchased at price OP_i.

Frozen: The cost of freezing increases total processing costs and processors would offer the same quantities as fresh only at higher prices. The new supply schedule is represented by line S_zS_z on the graph. Substantially lower marketing costs for frozen, as against fresh, would induce retailers to purchase more frozen than they would fresh (despite the fact that they would have to sell the frozen at a lower price). Retailers' demand for frozen catfish is represented by line D_zD_z on the graph. In accordance with the assumptions of this study, the supply and demand schedules for frozen catfish intersect at a quantity equal to irradiated, but at a lower price than irradiated. Thus retailers would purchase OQ_z of frozen catfish at price OP_z.

Supply and demand relationships, retail 1/



1/ Explanation of graph appears on following page.

Technical Notes

(e) Explanation: Supply and demand relationships, retail.

Fresh: The demand at retail for fresh and for irradiated catfish is represented by line D_fD_f. The supply of fresh catfish is represented by the line S_fS_f. The intersection of these lines shows that at price OP_f, the quantity OQ_f of catfish would be sold.

Irradiated: The irradiation process would lower unit marketing costs, as explained in the text, and dealers would be willing to stock larger quantities of irradiated than fresh catfish at all possible prices, or the same quantities as fresh at lower prices. The shift of the supply schedule from fresh is represented by the line S_iS_i. There will be no significant shift from fresh to irradiated, in retail demand for catfish. Therefore, the increased supply would result in increased marketings at a price below the price paid for fresh. Quantity OQ_i would be marketed at price OP_i.

Frozen: The demand for frozen catfish products is represented by the line D_zD_z. Its location to the left of the demand curve for fresh or irradiated catfish, indicates that consumers will pay less for a given quantity of frozen than they would for fresh or irradiated, or would buy less at the same price. Dealers' marketing costs for frozen would be substantially below the costs of marketing either fresh or irradiated, and therefore the supply schedule at retail would show dealers' willingness to stock larger quantities of frozen than fresh or irradiated at any given price. This schedule is represented by line S_zS_z. As developed in the study, the quantity of frozen products marketed would be equal to irradiated but the equilibrium price would be lower--price OP_z in the diagram.

APPENDIX II

Tables

Table II-1.--Landings of catfish and bullheads, by States, 1955, 1960, 1965, and 1966; ranked in order of importance in 1966

State	1955	1960	1965	1966	Distribution in 1966
	----------Thousand	pounds	---------		percent
Florida	6,789	8,207	13,671	13,209	38.9
Louisiana	4,252	8,618	6,536	5,059	14.9
North Carolina	951	1,058	1,531	1,786	5.3
Minnesota	1,636	2,763	2,039	1,587	4.6
Tennessee	3,744	1,335	1,632	1,326	3.9
South Carolina	27	284	1,070	1,289	3.8
Virginia	2,749	2,992	940	1,191	3.5
Kentucky	795	605	507	1,174	3.4
Alabama	1,528	1,633	2,034	1,056	3.1
Illinois	960	902	849	846	2.5
Arkansas	883	933	343	839	2.5
South Dakota	40	81	889	780	2.3
Ohio	2,016	1,563	1,019	766	2.2
Mississippi	719	580	704	674	2.0
Wisconsin	498	634	650	567	1.6
Iowa	817	624	446	416	1.2
Maryland	696	566	389	362	1.1
North Dakota		410	72	324	1.0
Michigan	577	380	205	210	.6
Texas	22	135	104	160	.5
Oklahoma	93	55	89	81	.2
Georgia	86	141	74	80	.2
Missouri	55	49	40	33	.1
New York	114	112	46	32	.1
Nebraska	40	109	65	24	.07
New Jersey	33	20	21	15	.04
Indiana		36	12	14	.04
Kansas	39	5	4	4	.01
Other	13	2	15	11	.03
Total	30,172	34,832	35,996	33,906	100.0

Source: U. S. Department of the Interior, Bureau of Commercial Fisheries, Fishery Statistics of the United States

Table II-2.--U. S. Catch of fresh Water catfish, by type of gear used, 1950, 1955, 1960, and 1965

Type of gear	1950	1955	1960	1965
	---Thousand pounds---			
Haul seine	1,456.7	2,408.3	1,683.4	1,986.4
Fyke net	6,211.1	5,539.5	9,591.5	5,812.2 2/
Gill net	214.5	357.2	919.3	1,181.6
Pound net	530.0	1,182.8	529.7	584.7
Trammel nets	287.6	294.9	567.2	648.5
Lines	11,377.7	14,700.5	15,904.1	17,907.2
Pots	1,840.4	3,383.3	5,913.5 1/	7,320.2 1/
Trap nets	798.3	1,830.1	620.7	514.5
Traps	362.5	474.0	included in pots above	included in pots above
Dip nets	99.5	---	---	---
Stop nets	4.0	---	---	---
Miscellaneous	---	---	---	44.4
Total	23,182.6	30,170.6	34,829.4	35,999.7

1/ Includes traps
2/ Includes hoop nets

Source: U. S. Department of the Interior, Bureau of Commercial Fisheries, Fishery Statistics of the United States

Table II-3.--Catfish and bullheads catch - Mississippi River Drainage Basin - Northeast Sector, 1950 and 1955-1966

Year	Quantity landed: Illinois	Quantity landed: Indiana	Quantity landed: Wisconsin	Quantity landed: Total	Average price: Illinois/Indiana	Average price: Wisconsin	Average price: Total
	Thousand pounds				Cents per pound		
1950	631		443	1,074	21.9	21.4	21.7
1955	960		405	1,365	24.1	22.0	23.4
1956	1,014		312	1,326	25.0	22.1	24.4
1957	1,190	10	311	1,311	21.8	20.6	24.8
1958	1,316	8	457	1,781	23.0	19.5	22.1
1959	1,090	89	663	1,842	23.7	18.1	21.7
1960	903	36	618	1,557	25.0	17.8	22.2
1961	826	24	678	1,528	25.2	15.3	20.8
1962	787	11	854	1,652	24.6	13.2	18.7
1963	912	11	624	1,547	24.9	16.2	21.4
1964	1,051	13	781	1,845	24.9	20.6	23.1
1965	849	12	632	1,493	25.3	20.3	23.2
1966	846	14	567	1,427	28.4	22.8	26.1

Source: U. S. Department of the Interior, Bureau of Commercial Fisheries, Fishery Statistics of the United States

Table II-4.--Catfish and bullheads catch - Mississippi River Drainage Basin, Southeast Sector, 1950 and 1955-1966

Year	Quantity landed: Mississippi	Alabama	Tennessee	Kentucky	Total	Average price
	Thousand pounds					Cents per pound
1950	1,235	869	2,088	464	4,656	29.6
1955	719	1,458	3,745	978	6,900	25.0
1956	530	1,690	3,046	1,201	6,467	25.2
1957	629	1,041	1,708	1,629	5,007	25.3
1958	410	1,141	1,295	919	3,765	25.1
1959	373	1,317	1,014	761	3,465	24.5
1960	580	1,600	1,335	605	4,120	25.0
1961	590	1,080	1,902	623	4,195	24.7
1962	600	1,177	1,551	641	3,969	24.7
1963	535	2,313	2,093	1,189	6,130	24.8
1964	479	2,480	2,259	604	5,822	24.9
1965	704	1,996	1,633	507	4,840	26.7
1966	674	1,036	1,326	1,174	4,210	28.9

Source: U. S. Department of the Interior, Bureau of Commercial Fisheries, Fishery Statistics of the United States

Table II-5.--Catfish and bullheads catch, Mississippi River Drainage Basin, Northwest Sector, 1950 and 1955-1966

Year	Quantity landed							Average price			
	Minnesota	North Dakota	South Dakota	Iowa	Nebraska	Montana	Total	Minnesota	North Dakota/ South Dakota	Iowa/Neb./ Mont.	Total
	Thousand pounds							Cents per pound			
1950	3,309		134	170			3,613	14.4	15.7	21.8	14.8
1955	2,149		40	817	40		3,046	12.9	10.0	24.0	16.0
1956	2,167	864	719	620	52		4,422	14.5	6.8	22.3	12.9
1957	1,922	606	176	680	34		3,418	6.9	9.4	25.2	11.3
1958	2,330	635	320	912	28		4,225	6.8	10.5	24.7	11.6
1959	1,895	248	430	847	78		3,498	7.7	8.4	24.1	12.2
1960	2,753	410	81	604	109		3,957	7.3	5.5	23.3	9.9
1961	2,116			445		1	2,562	7.1		24.7	11.5
1962	1,384	122	88	332	40	13	1,979	7.9	8.6	21.6	10.6
1963	1,765	141	76	393	71	13	2,459	13.2	8.8	18.9	13.9
1964	2,228	309	202	741	41	4	3,525	6.1	7.2	21.1	9.6
1965	2,037	72	889	448	65	12	3,523	5.5	5.5	21.7	7.9
1966	1,582	324	780	416	24	7	3,133	7.9	7.0	23.5	9.8

Source: U. S. Department of the Interior, Bureau of Commercial Fisheries, Fishery Statistics of the United States

Table II-6.--Catfish and bullheads catch - Mississippi River Drainage Basin - Southwest Sector, 1950 and 1955-1966

Year	Quantity landed							Average price			
	Louisiana	Arkansas	Texas	Oklahoma	Missouri	Kansas	Total	Louisiana	Arkansas	All other	Total
	Thousand pounds							Cents per pound			
1950	3,529	1,275		254	91		5,149	17.7	24.9	31.0	20.4
1955	2,256	883	12	93	55	39	3,338	27.0	25.0	26.1	26.4
1956	2,381	871	26	153	43	3	3,477	25.0	24.9	27.1	25.1
1957	1,784	475	14	80	52	1	2,406	25.0	25.1	25.9	25.1
1958	3,387	906	93	52	60	2	4,500	21.1	25.1	24.6	22.0
1959	3,209	859	73	59	57	1	4,258	20.0	25.4	24.7	21.3
1960	2,670	99	99	55	49	5	3,811	18.9	24.9	26.0	20.7
1961	2,613	782	97	55	51	5	3,603	19.3	26.0	28.4	21.3
1962	2,641	630	95	54	47	6	3,473	20.0	28.0	28.7	21.9
1963	2,659	491	88	49	49	5	3,341	20.2	29.3	28.3	22.0
1964	1,738	424	95	70	49	6	2,382	21.7	30.0	30.9	24.1
1965	1,481	343	104	89	40	4	2,061	26.1	32.7	32.5	27.9
1966	854	839	150	81	33	4	1,961	27.8	35.0	31.7	31.4

Source: U. S. Department of the Interior, Bureau of Commercial Fisheries, Fishery Statistics of the United States

Table II-7.--Catfish and bullheads catch - Great Lakes, 1950 and 1955-1966

Year	Quantity landed				Average price			
	Ohio	Michigan	All other	Total	Ohio	Michigan	All other	Total
	--------Thousand pounds--------				--------Cents per pound--------			
1950	1,005	236	180	1,421	9.5	19.1	15.0	11.8
1955	2,016	577	184	2,777	16.7	19.4	16.3	17.2
1956	1,686	563	125	2,374	20.6	19.5	17.6	20.2
1957	1,549	401	147	2,097	20.3	20.9	21.8	20.5
1958	1,448	399	145	1,992	22.7	21.3	22.1	22.3
1959	1,385	434	114	1,933	21.4	21.4	24.6	21.6
1960	1,563	380	125	2,058	21.2	22.1	21.6	21.2
1961	1,618	347	122	2,087	21.7	24.5	21.3	22.1
1962	1,185	246	98	1,529	20.8	24.4	16.3	21.1
1963	1,179	224	103	1,506	22.5	26.3	18.4	22.8
1964	1,237	213	80	1,530	25.5	26.3	18.8	25.2
1965	1,019	205	61	1,285	28.2	28.8	24.6	28.1
1966	766	201	60	1,027	24.2	30.3	27.8	29.8

Source: U. S. Department of the Interior, Bureau of Commercial Fisheries, <u>Fishery Statistics of the United States</u>

Table II-8.--Catfish and bullheads catch - South Atlantic coast area, 1950 and 1955-1966

Year	Quantity landed					Average price			
	Florida (East Coast)	North Carolina	South Carolina	Georgia	Total	Florida (East Coast)	N. Carolina S. Carolina	Georgia	Total
	Thousand pounds					Cents per pound			
1950	559	671	18	149	1,397	15.0	8.3	13.4	11.5
1955	6,296	951	27	86	7,360	16.0	8.3	19.8	15.0
1956	7,841	1,088	67	59	9,055	12.0	8.6	11.9	11.6
1957	9,088	1,259	93	68	10,588	14.0	8.2	13.2	13.2
1958	7,102	1,534	74	66	8,776	14.0	8.1	13.6	12.9
1959	8,435	1,465	207	105	10,212	14.0	8.1	14.3	13.0
1960	8,178	1,058	284	141	9,661	13.0	8.2	14.2	12.4
1961	12,683	1,093	319	159	14,254	13.9	7.8	14.5	13.3
1962	14,344	1,061	352	128	15,885	13.7	8.3	14.1	13.2
1963	13,704	1,230	368	89	15,391	14.1	9.0	21.3	13.6
1964	12,069	1,274	1,434	58	14,835	14.6	12.5	29.3	14.2
1965	13,554	1,531	1,070	74	16,229	15.9	12.5	31.1	15.4
1966	13,185	1,786	1,289	80	16,340	17.3	14.5	26.3	16.8

Source: U. S. Department of the Interior, Bureau of Commercial Fisheries, <u>Fishery Statistics of the United States</u>

Table II-9.--Catfish and bullheads catch - Gulf Coast area, 1950 and 1955-1966

Year	Quantity landed						Average price			
	Louisiana	Florida (West coast)	Alabama	Mississippi	Texas	Total	Louisiana	Florida (West coast)	All Other	Total
	Thousand pounds						Cents per pound			
1950	3,602	1	102	-	20	3,725	21.9	-	23.0	22.0
1955	2,406	493	70	-	9	2,978	21.9	15.8	27.8	21.0
1956	3,463	713	61	6	10	4,253	22.0	12.1	26.0	20.4
1957	2,634	195	67	-	22	2,918	21.5	19.0	25.8	21.5
1958	3,349	104	48	-	28	3,529	20.9	13.5	23.7	20.7
1959	4,483	329	28	-	71	4,911	18.9	14.0	18.2	18.6
1960	5,947	29	33	-	36	6,045	19.4	13.8	21.7	19.4
1961	6,412	22	51	-	76	6,561	20.5	13.6	27.6	20.6
1962	6,185	60	50	-	69	6,364	20.6	15.0	25.2	20.6
1963	6,006	66	44	-	41	6,157	20.5	18.2	28.2	20.5
1964	6,070	81	45	-	27	6,223	23.5	18.5	29.2	23.5
1965	5,055	29	33	-	36	5,215	26.5	18.1	26.8	26.3
1966	4,205	24	20	-	10	4,259	27.8	16.7	25.0	27.7

Source: U. S. Department of the Interior, Bureau of Commercial Fisheries, Fishery Statistics of the United States

Table II-10.--Receipts - fresh and frozen catfish - Chicago, by state of origin, 1961-1966

State of Origin	1961	1962	1963	1964	1965	1966
	Thousand pounds					
Florida	601.9	722.2	736.2	605.9	501.2	540.3
North Carolina	176.2	106.5	116.2	93.5	64.0	72.8
Virginia	230.4	219.1	204.3	114.2	70.8	96.7
Wisconsin	205.9	128.2	91.1	158.9	89.7	64.0
Michigan	49.4	71.2	60.4	86.2	97.9	60.4
Iowa	43.7	43.1	41.2	106.9	76.9	30.0
Illinois	35.6	27.6	21.7	29.5	22.7	21.5
All others	271.2	174.1	137.5	188.8	175.7	106.3
Total	1,614.3	1,492.0	1,408.6	1,383.9	1,098.9	992.0

Source: U. S. Department of the Interior, Bureau of Commercial Fisheries, Market News Service

Table II-11.--Fresh catfish--monthly receipts--Chicago, 1961-1967

(dressed & skinned)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
	-----	-----	-----	-----	-----	-----	Thousand pounds	-----	-----	-----	-----	-----	-----
1961	110.7	91.3	130.7	120.1	169.8	143.2	126.4	150.8	121.5	155.4	135.3	96.1	1551.3
1962	110.9	105.6	114.2	125.1	154.0	116.3	107.7	129.9	112.7	144.5	106.4	97.1	1424.4
1963	122.2	71.6	111.6	131.6	117.8	115.3	96.9	128.7	98.3	150.4	96.5	89.0	1329.9
1964	98.9	79.1	89.2	97.7	117.9	114.0	134.5	114.7	109.2	137.6	108.4	93.0	1294.2
1965	78.4	67.4	70.4	84.4	99.1	114.5	112.1	80.4	67.1	84.0	85.2	66.0	1009.0
1966	61.0	70.1	97.2	65.2	52.7	91.7	61.6	73.0	71.2	70.2	72.5	61.7	848.1
1967	38.8	35.5	57.8	52.0	73.3	77.0	66.6	86.6	81.7	53.3	50.8	44.2	717.6

Source: U. S. Department of the Interior, Bureau of Commercial Fisheries, Market News Service

Table II-12.--Catfish shipments into Chicago related to total fish receipts, 1956-1967

	1956	1957	1958 1/	1959	1960	1961
	-----	-----	-----	Thousand pounds	-----	-----
Fresh receipts						
All fresh water species	42,607	35,461		36,044	34,251	29,749
Catfish	1,832	1,527		1,551	1,632	1,551
All salt water species	1,545	1,193		1,125	1,193	1,073
Total fresh receipts	44,152	36,654		37,169	35,444	30,822
Frozen receipts						
All fresh water species	3,624	3,646		3,264	2,762	2,921
Catfish	7	54		95	116	63
All salt water species	30,460	26,580		24,955	24,442	20,920
Total frozen receipts	34,084	30,226		28,219	27,204	23,841
Total fresh & frozen receipts						
All fresh water	46,231	39,107		39,308	37,013	32,670
Catfish	1,839	1,581		1,646	1,748	1,614
All salt water	32,005	27,773		26,080	25,635	21,993
Total receipts	78,236	66,880		65,388	62,648	54,663
Percentage relationships						
Fresh catfish as a % of						
All fresh water - fresh	4.30	4.31		4.30	4.76	5.21
Total fresh receipts	4.15	4.17		4.17	4.60	5.03
Total catfish as a % of						
All fresh water	3.98	4.04		4.19	4.72	4.94
All salt water	5.75	5.69		6.31	6.82	7.34
Total receipts	2.35	2.36		2.52	2.79	2.95

Table II-12.(continued)--Catfish shipments into Chicago related to total fish receipts, 1956-67

	1962	1963	1964	1965	1966	1967
	Thousand pounds					
Fresh receipts						
All fresh water species	28,054	23,913	22,718	23,311	18,145	18,563
Catfish	1,424	1,330	1,294	1,009	848	718
All salt water species	1,051	1,175	1,224	1,288	1,364	1,191
Total fresh receipts	29,105	25,088	23,942	24,599	19,509	19,754
Frozen receipts						
All fresh water species	2,552	2,439	1,943	2,622	3,686	3,368
Catfish	68	79	90	90	174	185
All salt water species	21,393	17,590	16,793	17,179	17,114	15,200
Total frozen receipts	23,945	20,029	18,736	19,801	20,800	18,568
Total fresh & frozen receipts						
All fresh water	30,606	26,352	24,661	25,933	21,831	21,931
Catfish	1,492	1,409	1,384	1,099	1,022	903
All salt water	22,444	18,765	18,017	18,467	18,478	16,391
Total receipts	53,050	45,117	42,678	44,400	40,309	38,322
Percentage relationships						
Fresh catfish as a % of						
All fresh water - fresh	5.08	5.56	5.70	4.33	4.67	3.87
Total fresh receipts	4.89	5.30	5.40	4.10	4.35	3.63
Total catfish as a % of						
All fresh water	4.87	5.35	5.61	4.24	4.68	4.12
All salt water	6.65	7.51	7.68	5.95	5.53	5.51
Total receipts	2.81	3.12	3.24	2.48	2.54	2.36

1/ 1958 - NA

Source: U. S. Department of the Interior, Bureau of Commercial Fisheries, Market News Service

Table II-13.--Average wholesale catfish prices in New Orleans areas, monthly, 1961-1967

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual average 1/
	Cents per pound												
1961	27.5	27.5	23.75	23.75	21.0	23.75	22.5	25.0	27.5	25.0	25.0	21.25	24.46
1962	25.0	27.5	27.5	27.5	25.0	27.6	27.5	27.5	30.0	27.5	25.0	25.0	26.88
1963	25.0	27.5	27.5	23.75	23.5	28.75	30.0	28.5	27.5	27.5	26.25	27.5	26.94
1964	27.5	30.0	27.5	27.5	25.0	25.0	25.0	27.5	27.5	30.0	28.75	27.5	27.40
1965	26.5	26.25	27.0	30.0	28.75	30.0	30.0	30.0	32.5	32.5	30.0	30.0	29.46
1966	30.0	30.0	32.5	32.5	32.5	30.0	30.0	30.0	37.5	37.5	35.0	35.0	32.71
1967	37.5	30.0	32.5	35.0	35.0	37.5	35.0	37.5	35.0	37.5	37.5	37.5	35.62

1/ Simple average

Source: U. S. Department of the Interior, Bureau of Commercial Fisheries, Market News Service

Table II-14.--Fresh catfish - average wholesale prices--Chicago, monthly, 1961-1967 1/

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual average 2/
	----------	----------	----------	----------	----------	Cents per pound	----------	----------	----------	----------	----------	----------	----------
1961	51.0	51.5	49.5	47.5	41.5	36.0	39.0	38.0	40.0	41.5	38.5	42.0	42.5
1962	47.5	50.0	50.5	45.0	33.0	37.5	38.5	42.5	46.0	44.5	44.0	44.5	43.3
1963	45.0	47.0	47.0	39.0	40.0	39.0	40.5	40.0	39.5	40.0	41.5	44.0	41.6
1964	42.5	48.0	47.5	44.5	41.5	40.0	42.0	41.5	44.0	45.5	47.5	49.0	43.0
1965	51.0	50.0	52.0	51.5	51.5	47.5	46.5	48.5	52.0	52.0	51.5	52.0	50.2
1966	55.0	59.0	61.5	61.0	62.5	58.0	57.0	58.5	59.0	59.0	59.0	61.0	59.2
1967	64.5	65.0	65.0	65.0	61.0	54.0	51.0	53.5	55.0	56.5	57.5	59.0	60.8

1/ Southern and eastern prices, represent the mid-point of the price range.

2/ Weighted average price.

Source: U. S. Department of the Interior, Bureau of Commercial Fisheries, Market News Service

Table II-15.--Changes in scale of production in broiler industry, South Central U. S., 1959-1964

State	Number of farms		Broilers sold	
	1959	1964	1959	1964
Alabama	3,684	4,658	141,018,054	214,461,267
Arkansas	4,039	4,083	149,642,925	267,771,498
Georgia	8,251	7,390	225,076,452	306,808,012
Kentucky	516	370	13,178,830	11,001,722
Louisiana	398	410	14,032,925	27,980,166
Mississippi	1,497	1,677	89,053,103	150,857,318
Oklahoma	208	249	6,634,368	13,218,885
Tennessee	1,008	874	28,961,895	36,220,128
Texas	2,196	1,913	80,472,220	124,197,718
Total	21,797	21,624	748,070,772	1,152,516,714

Source: U. S. Bureau of the Census, Census of Agriculture, 1964, Volume II, Chapter 2

Table II-16.--Changes in scale of production in broiler industry, South Central U. S. 1959-1964

State	% of farms selling 30,000 or more broilers		% of broilers sold on farms selling 30,000 or more		% of farms selling 100,000 or more broilers		% of broilers sold on farms selling 100,000 or more	
	1959	1964	1959	1964	1959	1964	1959	1964
Alabama	46.18	62.35	74.20	86.73	4.88	7.49	22.14	25.40
Arkansas	44.15	74.35	78.56	93.39	6.48	17.34	28.52	45.53
Georgia	42.94	52.67	64.25	82.92	2.69	6.58	16.51	25.22
Kentucky	20.91	29.17	49.80	60.17	3.29	2.70	18.00	16.47
Louisiana	40.69	72.18	75.62	93.04	8.52	19.75	23.92	51.71
Mississippi	59.78	80.66	90.22	96.44	13.66	27.78	50.77	62.20
Oklahoma	47.58	71.08	77.34	92.72	5.76	10.04	21.47	32.55
Tennessee	31.14	51.93	62.17	80.33	3.17	4.69	18.65	25.16
Texas	38.56	61.04	76.09	90.30	6.19	15.78	31.80	52.05
Total	43.30	61.89	73.33	88.68	4.96	11.41	25.99	44.19

Source: U. S. Bureau of Census, Census of Agriculture 1964, Volume II, Chapter 2

Table II-17.--Estimates of radiation-pasteurization costs for a single plant, in 1975, with a throughput of 10.35 million pounds, at a 250,000 rads dosage, 30 percent efficiency, under various assumptions of plant capacity and utilization

Plant capacity (lbs./hr.)	5,750	4,791	4,107	2,875	2,396
Operating days per week	5	6	7	5	6
Hours operated per day	8	8	8	16	16
Hours operated annually	1,800	2,160	2,520	3,600	4,320
Investment requirement					
Plant	$ 937,096	$ 848,583	$800,203	$672,266	$627,953
Source	183,345	152,745	130,942	91,673	76,373
Total	1,120,441	1,001,328	931,145	763,939	704,326
Operating expenses					
Labor - direct	42,000	42,000	42,000	42,000	42,000
Labor - indirect	42,000	42,000	42,000	42,000	42,000
Operating supplies	4,685	4,243	4,001	3,361	3,140
Maintenance	46,855	42,429	40,010	33,613	31,398
Source replenishment	25,668	21,384	18,332	12,834	10,692
Depreciation - source	18,335	15,274	13,094	9,167	7,637
Depreciation - plant	109,171	98,860	93,223	78,319	73,156
Utilities	9,371	8,486	8,002	6,723	6,280
Taxes and insurance	18,742	16,972	16,004	13,445	12,559
Third party liability	46,855	42,429	40,010	33,613	31,398
Total operating expenses	363,682	334,077	316,669	275,075	260,260
Allowance for return on investment of 8 percent	89,635	80,106	74,492	61,115	56,346
Total operating expenses and returns	453,317	414,183	391,161	336,190	316,606
Irradiation cost per pound	$ .0437	$ .0400	$ .0377	$ .0324	$ .0305

Table II-17.(continued)--Estimates of radiation-pasteurization costs for a single plant, in 1975, with a throughput of 10.35 million pounds, at a 250,000 rads dosage, 30 percent efficiency, under various assumptions of plant capacity and utilization

					Explanatory notes 1/
Plant capacity (lbs./hr.)	2,054	1,917	1,597	1,294	(1)
Operating days per week	7	5	6	7	
Hours operated per day	16	24	24	24	
Hours operated annually	5,040	5,400	6,480	8,000	(2)
Investment requirement					
Plant	$582,532	$570,011	$520,030	$486,540	(3)
Source	65,535	61,073	50,873	41,310	(4)
Total	648,067	631,084	570,903	527,850	
Operating expenses					
Labor - direct	42,000	42,000	42,000	42,000	(5)
Labor - indirect	42,000	42,000	42,000	42,000	(6)
Operating supplies	2,913	2,850	2,600	2,433	(7)
Maintenance	29,127	28,501	26,002	24,327	(8)
Source replenishment	9,175	8,550	7,122	5,783	(9)
Depreciation - source	6,554	6,107	5,087	4,131	(10)
Depreciation - plant	67,865	66,406	60,583	56,681	(11)
Utilities	5,825	5,700	5,200	4,865	(12)
Taxes and insurance	11,651	11,400	10,401	9,731	(13)
Third party liability	29,127	28,501	26,002	24,327	(14)
Total operating expenses	246,237	242,015	226,997	216,278	
Allowance for return on investment of 8 percent	51,845	50,487	45,672	42,228	
Total operating expenses and returns	298,082	292,502	272,669	258,506	
Irradiation cost per pound	$ .0288	$ .0282	$ .0263	$ .0249	

1/ See Explanatory Notes at end of appendix tables.

Table II-18.--Estimates of radiation-pasteurization cost for a single plant, in 1980, with a throughput of 18.63 million pounds, at a 250,000 rads dosage, 30 percent efficiency, under various assumptions of plant capacity and utilization

Plant capacity (lbs./hr.)	10,350	8,625	7,393	5,175	4,313
Operating days per week	5	6	7	5	6
Hours operated per day	8	8	8	16	16
Hours operated annually	1,800	2,160	2,520	3,600	4,320
Investment requirement					
Plant	$1,209,891	$1,099,561	$1,047,200	$ 898,251	$824,669
Source	329,970	274,890	235,620	164,985	137,445
Total	1,539,861	1,374,451	1,282,820	1,063,236	962,114
Operating expenses					
Labor - direct	45,000	45,000	45,000	45,000	45,000
Labor - indirect	45,000	45,000	45,000	45,000	45,000
Operating supplies	6,049	5,498	5,236	4,491	4,123
Maintenance	60,495	54,978	52,360	44,913	41,233
Source replenishment	46,196	38,485	32,987	23,098	19,242
Depreciation - source	32,997	27,489	23,562	16,498	13,744
Depreciation - plant	140,952	128,099	136,939	104,646	96,074
Utilities	12,099	10,996	10,472	8,983	8,247
Taxes and insurance	24,198	21,991	20,944	17,965	16,493
Third party liability	60,495	54,978	52,360	44,913	41,233
Total operating expenses	473,481	432,514	424,860	355,507	330,389
Allowance for return on investment of 8 percent	123,189	109,956	102,626	85,059	76,969
Total operating expenses and returns	596,670	542,470	527,486	440,566	407,358
Irradiation cost per pound	$ .0320	$ .0291	$ .0283	$ .0236	$ .0218

Table II- 18.(continued)--Estimates of radiation-pasteurization cost for a single plant, in 1980, with a throughput of 18.63 million pounds, at a 250,000 rads dosage, 30 percent efficiency, under various assumptions of plant capacity and utilization

					Explanatory notes 1/
Plant capacity (lbs./hr.)	3,696	3,450	2,875	2,329	(1)
Operating days per week	7	5	6	7	
Hours operated per day	16	24	24	24	
Hours operated annually	5,040	5,400	6,480	8,000	(2)
Investment requirement					
Plant	$759,220	$733,551	$672,266	$610,130	(3)
Source	117,810	110,033	91,673	74,205	(4)
Total	877,030	843,584	763,939	684,335	
Operating expenses					
Labor - direct	45,000	45,000	45,000	45,000	(5)
Labor - indirect	45,000	45,000	45,000	45,000	(6)
Operating supplies	3,796	3,668	3,361	3,051	(7)
Maintenance	37,961	36,678	33,613	30,506	(8)
Source replenishment	16,493	15,405	12,834	10,389	(9)
Depreciation - source	11,781	11,003	9,167	7,420	(10)
Depreciation - plant	88,450	85,458	78,319	71,080	(11)
Utilities	7,592	7,336	6,723	6,101	(12)
Taxes and insurance	15,184	114,671	13,445	12,203	(13)
Third party liability	37,961	36,678	33,613	30,506	(14)
Total operating expenses	309,218	300,897	281,075	261,256	
Allowance for return on investment of 8 percent	70,162	67,487	61,115	54,747	
Total operating expenses and returns	379,380	368,384	342,190	316,003	
Irradiation cost per pound	$ .0204	$ .0198	$ .0184	$ .0170	

1/ See Exlanatory Notes at end of appendix tables.

Table II-19.--Estimates of radiation-pasteurization cost for a single plant, in 1985, with a throughput of 32.30 million pounds, at 250,000 rads dosage, 30 percent efficiency, under various assumptions of plant capacity and utilization

Plant capacity (lbs./hr.)	17,944	14,954	12,817	8,972	7,477
Operating days per week	5	6	7	5	6
Hours operated per day	8	8	8	16	16
Hours operated annually	1,800	2,160	2,520	3,600	4,320
Investment requirement					
Plant	$1,525,240	$1,430,167	$1,316,310	$1,112,155	$1,059,100
Source	571,965	476,722	408,510	285,983	238,298
Total	2,097,205	1,906,889	1,724,820	1,398,138	1,297,398
Operating expenses					
Labor - direct	50,000	50,000	50,000	50,000	50,000
Labor - indirect	50,000	50,000	50,000	50,000	50,000
Operating supplies	7,626	7,151	6,582	5,561	5,296
Maintenance	76,262	71,508	65,816	55,608	52,955
Source replenishment	80,037	66,741	57,191	40,038	33,362
Depreciation - source	57,170	47,672	40,851	28,598	23,830
Depreciation - plant	177,690	166,614	153,350	129,566	123,386
Utilities	15,252	14,302	13,163	11,122	10,591
Taxes and insurance	30,505	28,603	26,326	22,243	21,182
Third party liability	76,262	71,508	65,816	55,608	52,955
Total operating expenses	620,804	574,099	529,095	448,344	423,557
Allowance for return on investment of 8 percent	167,776	152,551	137,986	111,851	103,792
Total operating expenses and returns	788,580	726,650	667,081	560,195	527,349
Irradiation cost per pound	$ .0244	$ .0224	$ .0206	$ .0173	$ .0163

Table II- 19.(continued)--Estimates of radiation-pasteurization cost for a single plant, in 1985, with a throughput of 32.30 million pounds, at 250,000 rads dosage, 30 percent efficiency, under various assumptions of plant capacity and utilization

					Explanatory notes 1/
Plant capacity (lbs./hr.)	6,409	5,981	4,985	4,038	(1)
Operating days per week	7	5	6	7	
Hours operated per day	16	24	24	24	
Hours operated annually	5,040	5,400	6,480	8,000	(2)
Investment requirement					
Plant	$ 975,885	$ 953,062	$ 864,931	$ 801,267	(3)
Source	204,255	190,612	158,865	128,775	(4)
Total	1,180,140	1,143,674	1,023,796	930,042	
Operating expenses					
Labor - direct	50,000	50,000	50,000	50,000	(5)
Labor - indirect	50,000	50,000	50,000	50,000	(6)
Operating supplies	4,879	4,765	4,325	4,006	(7)
Maintenance	48,794	47,653	43,247	40,063	(8)
Source replenishment	28,596	26,686	22,241	18,028	(9)
Depreciation - source	20,425	19,061	15,886	12,878	(10)
Depreciation - plant	113,690	111,031	100,764	93,348	(11)
Utilities	9,759	9,531	8,649	8,013	(12)
Taxes and insurance	19,518	19,062	17,298	16,025	(13)
Third party liability	48,794	47,653	43,247	40,063	(14)
Total operating expenses	394,455	385,442	355,657	332,424	
Allowance for return on investment of 8 percent	94,411	91,494	81,904	74,403	
Total operating expenses and returns	488,866	476,936	437,561	406,827	
Irradiation cost per pound	$ .0151	$ .0148	$ .0135	$ .0126	

1/ See Explanatory Notes at end of appendix tables.

Table II-20.--Estimated wholesale and retail "net" and "gross" margins for the marketing of fresh irradiated and frozen catfish products 1/

	Fresh	Irradiated	Frozen
	------------Percent------------		
"Net" margin as a percent of sales price:			
Processor/wholesaler	16.1	15.5	16.2
Retailer	11.2	10.2	10.9
"Gross" margin as a percent of sales price:			
Processor/wholesaler 2/	37.9	40.4	38.8
Retailer 3/	26.9	26.2	19.9

1/ "Net" margin is defined as sales price minus marketing and distribution costs; "Gross" margin is defined as sales price minus cost of raw material in the case of processors and minus the delivered cost of products to be sold in the case of retailers.

2/ The gross margin for processing plants would be reasonably comparable to "value-added" concepts as applied in the census of manufacturers. This census shows that in 1963 the value-added in the manufacture of fresh and frozen fishery products (SIC 2036) was 30.2 percent. (See U. S. Bureau of the Census, Census of Manufacturers, 1963, Industry Statistics: Canned and Frozen Foods.)

3/ It is reasonable to assume that retailers' gross margins for a frozen product would be lower than the margin for a similar product marketed in the more perishable fresh form. For example, the "typical" margin for frozen vegetables in independent supermarkets in 1967 averaged 27.1 percent, compared with a 30.1 percent margin for fresh produce. These same stores' average margin for all frozen foods was 25.2 percent; for fresh meats, 21.3 percent; fish (prepared), 21.6 percent; fish (uncooked), 25.7 percent. (Part I - 35th Annual Report of the Grocery Industry, Progressive Grocer, Vol. 47, Number 4, April 1968.)

EXPLANATORY NOTES for Tables II-17, II-18, and II-19

(1) Based on the assumed number of hours plant will operate annually.

(2) Hours of plant operation are the product of assumed operating days per week and hours operated per day, assuming annual operations for 50 weeks and 10 percent downtime.

(3) Based on relationship between size of source and plant cost per curie of source size, as developed in: U. S. Department of Commerce, The Commercial Prospects for Selected Irradiated Foods, TID-24058, March, 1968, p. 20.

(4) Computed according to procedure outlined in study cited in note 3, pp. 11-21. Briefly the steps are:

  (a) Determine desired throughput in terms of pounds per hour capacity.

  (b) Determine desired rads dosage.

  (c) Multiply throughput times dose to get rad pounds per hour.

  (d) Multiply rad pounds per hour by the conversion factor 0.000085 to obtain the required source size in curies. This yields the number of required curies at 100 percent efficiency level.

  (e) Determine percent efficiency level of the facility and divide into figure yielded in step (d). This will be the actual number of curies required.

  (f) Multiply actual number of required curies by assumed cost per curie, for source cost.

(5) Direct labor (production) costed at $2.00 per hour, per U. S. Department of Commerce, op cit., p. 21.

(6) Indirect labor costs include supervisory and support labor, and assumed to be 100 percent of direct labor. Ibid., p. 10.

(7) At 1/2 percent per year of plant costs. Ibid., p. 11.

(8) At 5 percent per year of plant cost. Ibid.

EXPLANATORY NOTES for Tables II-17, II-18, and II-19 (continued)

(9) At rate of 14 percent per year. _Ibid._, p. 10.

(10) At 10 percent per year. _Ibid._

(11) At 10 percent per year for 75 percent of plant cost, and 16.6 percent per year for remainder. _Ibid._

(12) At 1 percent per year of plant cost. _Ibid._, p. 11.

(13) At 2 percent per year of plant cost. _Ibid._

(14) At 5 percent per year of plant cost.

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14. A Price Incentive Plan for Distressed New England Fisheryes by A. Sokoloski and E. Carlson.

15. Demand and Prices for Shrimp by D. Cleary.

16. Industry Analysis of Gulf Area Frozen Processed Shrimp and an Estimation of Its Economic Adaptability to Radiation Processing by D. Nash and M. Miller.

17. An Economic Evaluation of Columbia River Anadromous Fish Programs by Jack Arthur Richards.

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