The Fresh Water Cultured Fish Industry of Japan

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CONTENTS

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INTRODUCTION

In the United States during the past 10 years there has been considerable interest in fresh water cultured fish production. Many people feel that fresh water fish culture can play a role in American agriculture by permitting a fuller utilization of farm water resources. Currently, domestic interest in fresh water fish culture has centered on the production of rainbow trout and channel catfish. Interest in cultured trout production occurred after World War II. Cultured catfish production has become prominent in the past 10 years particularly in the Southeastern states of Arkansas, Texas, and Mississippi as well as in adjoining states.

It was believed that a knowledge of Japan's fresh water cultured fish industry, which has been in operation on a commercial basis for at least 150 years, might add further interest and contribute some knowledge to the U. S. industry. For these reasons, the author, traveling under the auspices of the Agricultural Development Council, spent July and August of 1968 in Japan.

Mr. Shosaku Nishimura, Freshwater Fisheries Economist, located at the Fisheries Agency, Hino-shi, Tokyo played a major role in the author's research efforts. Under his direction, data were obtained from government

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sources, associations, feed companies, and private individuals engaged in various aspects of fresh water fish production and marketing. Travel covered three of the four main Japanese islands and 27 of Japan's 46 prefectures or states. Nearly all written data were in Japanese and the metric system was used exclusively for presenting numerical data. Because of the difficulty of translating data from Japanese to English and in transposing the metric data to American measurements some minor difficulties were encountered. However, inconsistencies were thought to be minor and were confined to metric system transpositions--an example would be grams into ounces which presents less refinement in data, since there can be a breakdown of 1000 grams per kilogram but only 16 ounces to a pound. In spite of these minor problems it is hoped that the reader will find the report informative and helpful.

THE ROLE OF THE JAPANESE FRESH WATER CULTURED FISH INDUSTRY

Fish have been raised by Japanese farmers for hundreds of years. However, production for commercial sale began about 150 years ago. The industry grew slowly until the 1930's when the government placed emphasis on marine harvest. During World War II, the government emphasized freshwater culture and production of fresh water fish expanded rapidly. After the war the cultured fish industry, though largely ignored by the Japanese government, continued to grow and in 1950 output was officially calculated at 6,000 tons of various species. From 1950 to 1966, the volume of output increased from 6,000 to 41,000 tons or by 583 percent (Table 1). The only other segment of the Japanese fish industry that grew as rapidly during

Table 1. Fish Production (Not Including Whales), Japan, 1950-1966.

Year	Marine Harvest	Shallow Sea Cultured Fish Harvest	Inland Fresh Water Harvest (Wild)	Inland Cultured Fresh Water Harvest	Totals
	000 (tons)	000 (tons)	000 (tons)	000 (tons)	000 (tons)
1950	3,588	53	69	6	3,716
1951	4,160	97	66	7	4,330
1952	5,121	125	58	10	5,314
1953	4,836	159	63	9	5,067
1954	4,744	160	90	10	5,004
1955	5,135	170	90	12	5,407
1956	4,947	198	99	14	5,258
1957	5,585	269	89	15	5,958
1958	5,730	236	86	17	6,069
1959	6,138	248	83	17	6,486
1960	6,412	313	82	17	6,824
1961	6,930[1/]	355	89	20	7,394
1962	7,051	399	93	22	7,565
1963	6,834	429	93	25	7,381
1964	6,468	399	98	32	6,997
1965	7,035	419	125	36	7,615
1966	7,229	446	114	41	7,830

SOURCES: Yearbook of Fishery Statistics, Department of Statistics, Fishery Statistics Section, Ministry of Agriculture and Forestry, Tokyo, Japan, 1950-1966.

1/ Between 1961-1965, 87 percent of the marine harvest came from domestic waters.

this period was shallow sea culture that increased by 742 percent. The catch from coastal waters increased 102 percent, and the wild inland freshwater fish catch increased 65 percent.

The 41,000 tons of freshwater cultured fish produced in 1966, represented only one-half of one percent of Japan's total fish catch (Table 2). However, because of the unique nature of demand for cultured fish the value of production was 2.6 percent of total wholesale sales. This means that each pound of cultured freshwater fish was valued at more than five times the average value of other fish. The total value of fish harvested

Table 2. Distribution and Value of the Various Types of Marine and Freshwater Fish Harvest, Japan, 1966.

Distribution of Harvest	Volume of Harvest		Value of Harvest	
	(000 tons)	(percent)	(million dollars)	(percent)
Marine harvest	7,229	92.3	1,390.3	79.9
Shallowsea culture	446	5.7	271.4	15.6
Inland freshwater	114	1.5	32.5	1.9
Inland cultured	41	.5	45.6	2.6
Totals	7,830	100.0	1,739.8	100.0

SOURCE: Yearbook of Fishery Statistics, Department of Statistics, Fishery Statistics Section, Ministry of Agriculture and Forestry, Tokyo, Japan, 1966.

by the Japanese places that country in a position second only to Peru. However, in value of catch, Japan ranks first, since most of its catch goes for higher priced human food rather than for processed fish meal as is the case in Peru.

In Japan there are four major species of freshwater fish produced by culturing methods, ie., in ponds, tanks, or running water enclosures: (1) rainbow trout (salmo irideus); (2) ayu or sweetfish (plecoglossus altivelis), which are not native to the United States; (3) eel (anguilla japonica); and (4) carp (cyprinus carpio). While some statistics show carp as divided between carp and Crucian carp, others may or may not distinguish between the two, and fish farmers rarely do. Japan has native catfish but regards them as trash fish and non-edible, as many people in the United States regard carp.

In 1965, the following percentages of fish produced were cultured: 100 percent of the trout; 85 percent of the eel; 72 percent of the carp;

Table 3. Varieties and Volumes of Fish Produced By Inland Fresh Water Fishing and From Cultured Impounded Water Areas, Japan, 1965.

Variety	Fresh Water Fishing	Cultured Fish	Percent Cultured
	(tons)	(tons)	
Eel	3,100	17,655	85
Carp	3,400	8,786	72
Crucian carp	10,300	1,675	14
Trout	-----	6,333	100
Ayu (Sweetfish)	9,000	1,455	10
Totals	25,800	35,886	---

SOURCES: Personal letter from Mr. Takeshi Nakamura, Chief, International Division, Japan Fisheries Association, Akasaka, Tokyo, March 8, 1968, except for figure of 1,455 tons for Ayu which came from Some Considerations on the Behavior of Freshwater Cultured Fish, Fishery Policy Department, Fishery Section, Ministry of Agriculture and Forestry, June 1968, p. 58.

14 percent of the Crucian carp; and 10 percent of the ayu (Table 3). The remaining volume of fresh water fish were harvested as wild fish caught in inland fresh waters, although many were produced in hatcheries before being released in native waters. Hence, to some extent these fish have been produced by artificial means even if they have not been fed to a finished weight.

In recent years the proportion of fresh water fish produced under cultured conditions has been increasing. Not only has the proportion been increasing but the absolute volume has increased also. For example, 8,934 tons of eel were cultured in 1961 and increased further to 18,756 tons in 1966. Similar results are shown for carp, trout, and ayu (Table 4). In 1961, a total of 19,874 tons of fish were cultured. By 1966, volume

Table 4. Volumes of Cultured Fresh Water Fish Production By Species, Japan, 1961-1966.

Variety	Years					
	1961	1962	1963	1964	1965	1966
	(tons)					
Eel	8,934	8,347	10,933	14,791	17,655	18,756
Carp	5,668	6,994	7,266	8,330	8,786	10,832
Crucian carp	1,670	1,707	1,690	1,690	1,657	1,588
Trout	3,332	3,866	4,339	5,966	6,333	6,868
Ayu (Sweetfish)	270	377	592	1,095	1,455[1/]	1,874[1/]
Totals	19,874	21,291	24,820	31,820	35,886	39,918[2/]

SOURCE: Fisheries Agency, Ministry of Agriculture and Forestry, Tokyo, Japan, 1961-1966.

1/ Official data were discontinued in 1964. Estimates for 1965 and 1966 were made by persons knowledgeable in the ayu industry.

2/ Some official figures indicate 41,000 tons of production.

had increased to 39,918 tons or by more than 100 percent. Unofficial estimates for 1967 and 1968 indicate further increases to 43,943 and 48,857 tons, respectively, for a total increase of 146 percent in seven years.

Further increases can be predicted as a result of a change in governmental policy concerning freshwater fish in 1966. In addition, interest has been stimulated in the cultured fish industry by articles such as one that appeared in Feed Research in 1964 (8). This article stated that the many fishing treaties signed by Japan in recent years have restricted fishing waters for the Japanese fishing fleet. The article points out that the only way to solve the dilemna of restricted waters is through freshwater fish culture.

PRODUCTION

There are four different methods of culture used in producing fresh water fish in Japan, namely: (1) pond, (2) running water, (3) circulating-filter system, and (4) net culture in lakes. The major difference between the first three of these is the volume of available water suitable for fish production.

Pond Culture

In Japan many of the cultured ponds have access to some running water as a result of their proximity to rice production. However, when the rice is mature and harvesting begins, the flow of water ceases and the ponds may have little or no running water available. In spite of this limitation, pond culture of fresh water fish is still used for several reasons: (1) investment is minimized compared to running water, circulating-filter systems, and net culture, (2) water temperatures are conducive to fast growth of warm water fish such as carp, and (3) feeding is relatively easy. Disadvantages include: (1) oxygen supply depends on plankton and it is difficult to manage water to maximize plankton growth, and (2) it is difficult to increase oxygen content at necessary times. Compared to running water culture, the number of fish and volume of output is low per unit of measurement.

To maximize production from ponds, the water supply during the summer must be at least one-half the flow of the other seasons. As water flow increases in the spring and fall it must be possible to control water flows so that the plankton content is not excessively decreased. Also, the mud layer at the bottom of the pond must not be excessive or harvesting becomes difficult, ie., unless complete draining can be practiced. Water

should be between six and 10 feet deep so that in hot weather some cooler water can be found at the bottom of the pond. Otherwise, feeding may have to be curtailed, thus decreasing the rate of gain. The pond should be subject to sunlight for a considerable part of the day so that plankton growth is encouraged. In Japan, desirable pond sizes range from 2.2 to 6.6 acres.

With pond culture, feeding should take place near the center of the pond. The water depth should be at least three feet even in extremely dry weather. The feeding area should be sunny and not subject to strong winds. When the pond is initially stocked the fish have a tendency to gather near the bank. Hence feeding should begin the day after stocking and in an area 6 to 10 feet from the bank. Over time the distance can be extended so that the fish are gradually moved to the center of the pond for feeding. The usual practice is to have a walkway extending into the pond with some provision made for stocking a minimum amount of feed at the end of the pier. Special care needs to be given to scattering the feed evenly over the feeding area. In Japan, the usual feeding practice is to feed about 10 times daily from 7 A.M. until 5 or 6 P.M. in running water culture and about 4 times in pond culture.

Most varieties of cultured fish will stay near the area where they are fed. If they are unable to secure feed at that spot they have a tendency to move to another part of the pond and may never return to the feeding area, but rely on natural foods such as plankton. When this situation occurs, growth of fish may be uneven and poor with 20 to 40 percent of the fish sometimes being produced without supplementary feeding. This can be a major problem to pond culturists and the greater the stocking

rate (such as in larger ponds) the greater the possibility of this problem arising and the rate of gain per pound of fish stocked may be decreased considerably.

Running Water Culture

Running water culture means that water is available throughout the production cycle. Heavy investment in wells, piping, pumps, and power may be required. Standby facilities are also necessary in case of a pump or power failure. However, the yield of fish is much higher than in pond culture principally because of the larger supply of available oxygen for fish. In contrast to circulating systems, the water is used only once and then is piped away or used for other purposes.

An important consideration in running water culture is to assure that the fish will not be swept away by the water current. Water flow should vary directly with the volume of fish being produced. For example, when the fish fry are first stocked and before intensive feeding begins the volume of water can be less than when the size of the fish have increased. In March, when fish are stocked, the water temperature is cooler and the oxygen content fairly high, thus the flow of water can be less than in July, August, and September when the fish are growing rapidly. As the end of the feeding season approaches, about October 15, and the water temperature again becomes cooler, the volume of water can then be decreased. (See page 29 for list of advantages and disadvantages of this method.)

Circulating Filter Systems

The circulating-filter system is comparable to running water culture, except running water is used more than once. The water is filtered at

various times and recirculated back to the areas of production. During circulation, the water is often aerated to increase its oxygen content. The major disadvantage of this method is that it has the tendency to encourage the spread of disease. If fish in one production unit are diseased, the system spreads the infection to the other production units.

Net Culture

Net culture is found in many lakes and some rivers. Fish are grown in net enclosures anchored in the larger body of water. No attempt is made to aerate the water. Instead water currents within the larger body of water are relied upon to bring a constant supply of fresh water to the net enclosures. Additional discussion of this method is found in a later section of this paper.

Production by Varieties

Eel - Shizuoka Prefecture[1/] is the main area of eel production in Japan. In 1968, it was estimated that this Prefecture produced 65 percent of the eel produced by cultured methods. Estimated value is about 10 billion yen per year or nearly $28,000,000. About 2,600 acres are in eel production in the Prefecture.

Eel production utilizes both pond and running water culture. Most types of fresh water culture enclosures in Japan have concrete or stone walls. Eel culture is no exception. A study of running water enclosures for eel in Shizuoka Prefecture revealed that all had permanent walls (Table 5). Of the pond type enclosures, more than 88 percent had permanent walls.

1/ A Prefecture in Japan corresponds to a state in the United States of America.

Table 5. Type of Construction by Types of Fresh Water Culture for Eel Production, Japan, 1964.

Type of Construction	Type of Water Culture			
	Running Water		Ponds	
	(No.)	(%)	(No.)	(%)
Concrete pools	5	4.5	112	72.3
Stone walls	106	95.5	25	16.1
Wooden walls	---	---	8	5.2
Earthern walls	---	---	10	6.4
Totals	111	100.0	155	100.0

SOURCE: Eel Culture Research Report, 1965, Fishery Section, Shizuoka Prefecture, Japan.

The running water enclosures for eel are relatively small. In 1964, 84 percent of 105 production units surveyed were less than 1.98 acres in size (Table 6). Pond enclosures were much larger with nearly one-half having water areas of 3.71 acres or more.

Production data secured for 1964 (Table 7) included 85 managements with running water culture and 56 managements with pond culture. The average water area of those with running water culture was 1.45 acres. The average water area for pond culture was 5.51 acres. Eel production from ponds was only 5,388 pounds per acre or 23 percent of the 23,195 pounds per acre produced from running water culture. Pond operators had much larger water areas than did running water culturists; however, the pond operators produced only 29,680 pounds of eel per management compared to 33,709 pounds for the running water operators.

1 acre = 0,4047 ha = 4.047 m²

1 pound = 0,454 kg

2446 kg pr. 4.047 m² ~ 0,6 kg / m²

10.530 kg pr. 4.047 m² ~ 2,6 kg / m²

Table 6. Size of Fresh Water Eel Culture Units, Japan, 1964.

Size	Type of Water Culture: Running Water	Ponds
Less than .74 acre	8	4
.75 - 1.98 acres	80	9
1.99 - 3.71 acres	14	23
3.72 - 7.41 acres	1	17
7.42 acres and over	2	15
Totals	105	68

SOURCE: Eel Culture Research Report, 1965, Fishery Section, Shizuoka Prefecture, Japan.

Table 7. Eel Production Data by Types of Fresh Water Culture, Japan, 1964.

Item	Type of Water Culture: Running Water	Ponds
Number of managements	85	56
Total water area (acres)	123.53	308.50
Average water area (acres)	1.45	5.51
Average sales per management (dol.)	15,654	20,428
Total eel production (lbs.)	2,865,292	1,662,107
Eel production per acre (lbs.)	23,195	5,388
Average production cost per management	13,541	18,286
Average net return to management (dol.)	2,113	2,142

SOURCE: Data was computed from Eel Culture Report, 1965, p. 13, Fishery Section, Shizuoka Prefecture, Japan.

The production cost per pound for pond operators was 61.6 cents. Production costs for running water operators averaged 40.2 cents. However, the pond operators received an average price of 68.8 cents per pound while the average price received by running water culturists was only 46.6 cents.[1/] Average net income per management was nearly identical at $2,113 for running water operators and $2,142 for pond operators. These returns may appear small by U. S. standards, but in Japan where a university graduate is paid $1,200 per year, these returns may be the equivalent of $12,000-$15,000 in the United States.

A complete breakdown of eel production costs for running water culture and pond culture are presented in Tables 8 and 9. Fish food is the highest cost item, averaging 51 percent of total costs in pond culture and nearly 55 percent in running water culture. Eel for stocking is the second largest expense item, averaging 16 percent for pond operators and 25 percent for those using running water culture. Wages paid ranked third as an expense item, with a much higher cost per management for pond operators ($2,015) than for running water operators ($644). Evidently, the larger water area used by pond operators increased the need for extra personnel to feed the eel.

Some small fish culturists feed small fish to the eel; however, the large operators use pelletized feed entirely. Whether the eel are fed fish or pelletized feed depends on the price relationship between small scrap fish and fish pellets. In general when the fish price is over 4 cents per pound even the smaller operators feed pellets. Fish pellets constitute about one-half of total production costs.

[1/] It is believed that the higher yield of eel per running water management at a given point in time temporarily depresses local prices.

Table 8. Eel Production Costs Using Running Water Culture, Japan, 1964.

Cost Item	Total Cost (dol.)	Average Cost Per Management (dol.)	Proportion of Total Cost (%)
Eel for stocking	286,736	3,373	24.9
Fish food	629,420	7,405	54.7
Office cost	28,967	341	2.5
Wages	54,752	644	4.8
Electricity			
Motors	19,611	231	1.7
Lights	5,703	67	.5
Oil, gasoline	10,306	121	.9
Maintenance and repairs	29,724	350	2.6
Interest payments	32,366	381	2.8
Insurance and land rent	28,905	340	2.5
Taxes	14,354	169	1.2
Miscellaneous	10,101	119	.9
Totals	1,150,945	13,541	100.0

SOURCE: Data were computed from Eel Culture Report, 1965, p. 13, Fishery Section, Shizuoka Prefecture, Japan.

Table 9. Eel Production Costs Using Pond Culture, Japan, 1964.

Cost Item	Total Cost (dol.)	Average Cost Per Management (dol.)	Proportion of All Cost (%)
Eel for stocking	164,441	2,936	16.1
Fish food	523,538	9,349	51.1
Office cost	36,752	656	3.6
Wages	112,856	2,015	11.0
Electricity			
Motors	27,464	490	2.7
Lights	1,896	34	.2
Oil, gasoline	8,603	154	.8
Maintenance and repairs	23,537	420	2.3
Interest payments	37,033	661	3.6
Insurance and land rent	47,560	849	4.6
Taxes	18,925	338	1.9
Miscellaneous	21,510	384	2.1
Totals	1,024,115	18,286	100.0

SOURCE: Data were computed from Eel Culture Report, 1965, p. 13, Fishery Section, Shizuoka Prefecture, Japan.

Carp - Gunma Prefecture accounted for 2,225 tons or 21 percent of the 10,800 tons of cultured carp produced in Japan in 1965 (5, p. 175). In 1966, it accounted for 57 percent of carp sales on the Tokyo wholesale market.

Carp is produced in Gunma Prefecture by three different methods: pond culture, running water culture, and circulating-filter systems. A report of these methods in 1963 indicated that a wide range in production per unit of water or per acre and differences in increases of fish weights over stocking rates could be expected. Pond culture yielded 3,569 to 7,138 pounds or 1.8 to 3.6 tons of carp per acre. The volume produced from circulating-filtering systems varied from 98,130 to 294,390 pounds or from 49.0 to 147.2 tons per acre. Production from running water culture was highest with yields of 535,350 - 1,697,000 pounds or 267.7 to 848.5 tons per acre (Table 10).

Table 10. Comparison of Carp Production Using Different Methods of Fresh Water Culture, Gunma Prefecture, Japan, 1963.

Type of Water Culture	Volume of Production in pounds per acre	Pounds of Production Per cubic yard of Water	Increase of fish weight at harvest time over stocking weight
Pond	3,569 - 7,138	4.8 - 9.6	7 - 10
Running water	535,350 - 1,697,060	720 - 2,280	10 - 15
Circulating filtering system	98,130 - 294,390	96 - 360	6

SOURCE: Fish Culture Seminar, Volume 1, Carp, Chapter III, Mr. Kenji Chiba, Green Book Company, Tokyo, Japan, 1967, p. 26.

Undoubtably the most intensive fish production rate in the world has been achieved by Mr. Kazuyoshi Tanaka, Annaka City, Gunma Prefecture, Japan. Mr. Tanaka has 16 different ponds and utilizes running water in each. Not all 16 ponds (races) are used to produce food carp, hence the following discussion is limited to the first pond (race) in the series of 16.

The first raceway has been in fish production for 70 years and is constructed of concrete and stone. The raceway measures 505 square feet of water surface and the average depth is 4.5 feet. The raceway is stocked with carp fry averaging 85 grams each or less than three ounces. Gross yield from the 8,500 carp stocked is about 22,738 pounds annually or 11.37 tons. On an acre basis, this amounts to a harvest of 980.0 tons. Deducting the initial stocking weight of 66.5 tons per acre equivalent the net gain in weight would by 913.5 tons. Feed conversion is 1.3 pounds of feed fed per pound of fish gain.

The flow of river water into this race varies from 0.1 to 0.5 tons (24-120 gallons) per second during the growing season. The raceway is stocked at the end of March and fed until early November. Harvesting is done by net which is drawn the length of the pool, entrapping the fish. Ten people are utilized for this operation which requires three hours.

During times of high water due to rain the flow of water entering the race is controlled so that the rapid flow does not suffocate the fish. The fish are fed a diet of silkworm pupae, a type of wheat, and fish pellets which contains about 50 percent fish meal. Feeding commences around April 15 when the water temperature is about 64 F. The first week the feed is boiled wheat. The second week, fish pellets are added to the

wheat ration. After the second week, silk pupae are fed along with fish pellets with a little boiled wheat fed in July, August, and September. Starting the end of September until the end of October, the feeding rate is gradually decreased. No feed is fed during the first two weeks of November until harvesting takes place.

Feeding commences at daybreak which may occur as early as 5 a.m. and is continued at intervals of 1½-2 hours until 11 p.m. Evening feeding is done under artificial lighting. If during the hottest part of the summer the water temperature reaches 91° F. feeding is discontinued. Feeding is done by tossing the feed in the water in handfuls near the site where the water enters but where the current is not rapid. The fish are trained to gather at the feeding area in response to someone hitting the side of the pond with a stick or stone. Feeding is discontinued while the fish are still actively feeding.

Mr. Chiba[1/] writes that the most important factors of running water culture are: (1) the quantity of running water which is directly related to the quantity of fish that can be produced, (2) the quality of water, essentially its oxygen content, (3) the need for constant running water, even if it must be circulated artifically, and (4) the temperature of water, which must be in a range where the species of fish will feed.

1/ The previous discussion of the case study of Mr. Tanaka has been based on three sources of information: Mr. Kenji Chiba's presentation in the book entitled Fish Culture Seminar, Volume 1, supplementary data furnished by Mr. S. Nishimura, Fishery Economist, Fresh-water Fisheries Agency, Hino City, Tokyo, and personal data obtained by the author from Mr. Tanaka in July, 1968.

Mr. Chiba in reporting his study of Mr. Tanaka's fish farming operation correlated the flow of water into nine different races with the volume of fish produced per raceway. His analysis is shown graphically in Figure 1. As stated previously, the volume of production is directly related to the quantity and quality of running water. The greater the volume of running water and the higher the oxygen content the greater the possibility of increasing production. Since in this case study the water flows from one raceway to another, the total volume produced is related to the volume of water at any one point times the number of points (races) where the water is used. More than 10 tons of fish are produced at the first raceway, while total production from all nine races is over 80 tons. Production declines after the water is used in the first raceway can be expected, due to oxygen depletion and lower stocking rates in subsequent races.

Survey data obtained during 1968 indicated that the cost of producing carp was about 23.0 cents per pound from both pond and running water culture. Net culture was found to be slightly more expensive, according to data furnished by the Fisheries Agency, Nagano Prefecture. These data indicated a carp production cost of 23.9 cents per pound using net culture in 1965. This figure presented an increase in cost of 12.7 percent over 1964. Undoubtably, costs have continued to increase since 1965.

Net culture is one of the more interesting methods used to produce carp. Since this type of culture can only be done in the larger lakes, which are limited in Japan, the presence of net culture is confined to a few prefectures having large lakes. Among these is Nagano Prefecture, which contains Lake Suwa. In 1965, Nagano Prefecture produced 2,144 tons

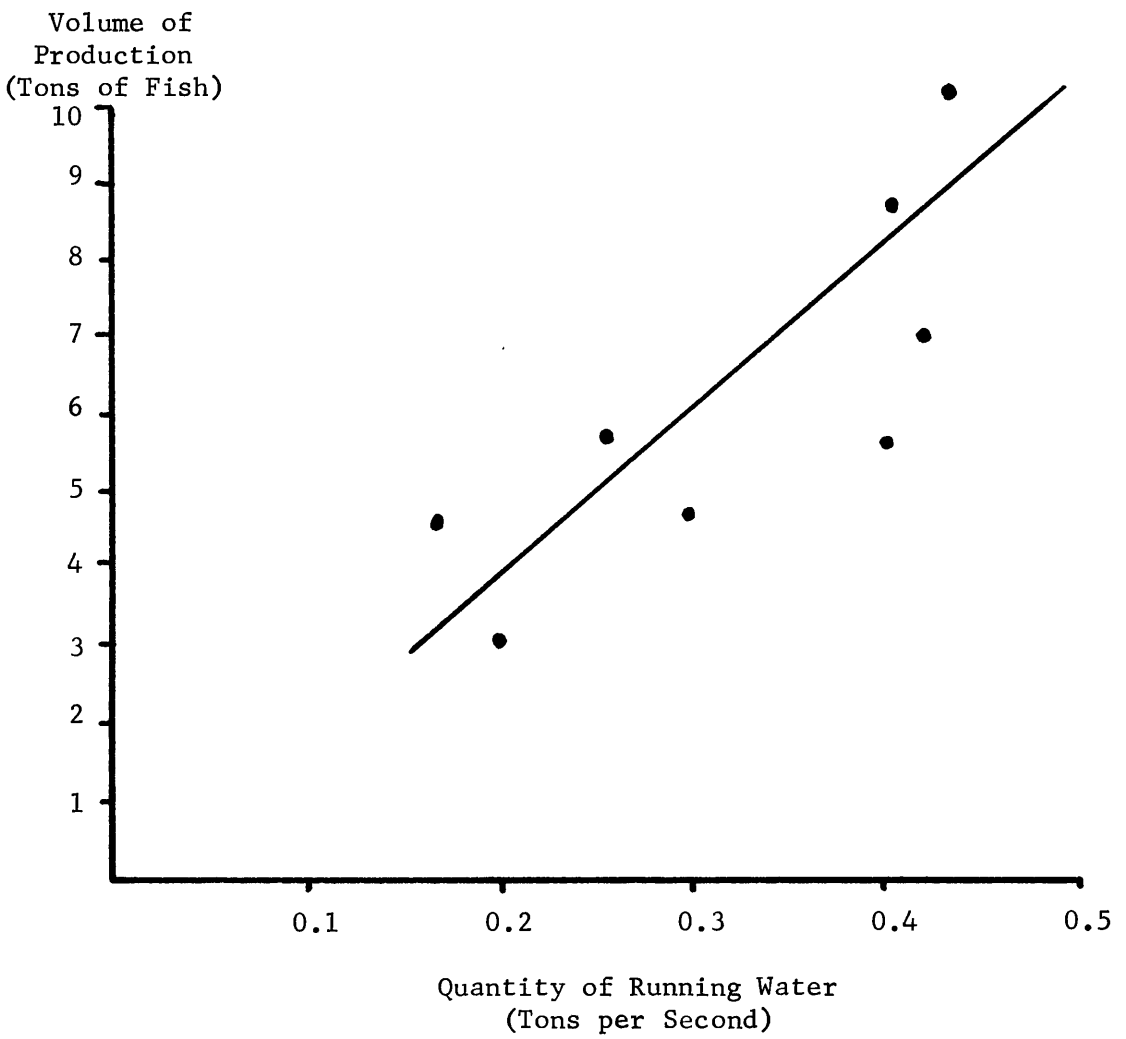

Figure 1. Relationship Between Running Volume of Water and Volume of Fresh Water Carp Production, Tanaka Fish Farm, Gunma Prefecture, Japan, 1966.

SOURCE: Fish Culture Seminar (1, p. 62).

or 20 percent of the cultured carp in Japan (5, p. 175). Fifteen percent of this volume was produced in Lake Suwa where net culture was initiated in 1958.

The culturing nets are in the form of a 29.5 foot square. The net is approximately 6.5 feet high, with approximately 5 feet of submerged net. On top of this net an additional three foot high net is attached to keep the fish from jumping out. A double net is used on the sides and bottom as a precaution to prevent fish from escaping in the event one net is broken or torn. The corners of the nets are anchored to the bottom of the lake and connected by a floating walkway. Nine 50-gallon drums are used to float the framework and each net. The usual depth of the lake where net culture is practiced averages about 10 feet.

The carp stocked are between 4-6 inches long and weigh 2½ to 3 ounces. The stocking rate is between 3,500 and 5,000 fingerlings per net set for an average of 772 pounds of fingerlings per net. Stocking usually takes place in April and feeding continues for six months. Fish are fed about four times daily for 10-20 minutes each time. Each net, which includes approximately 870 square feet of water area, yields about 7,718 pounds of fish, which is the equivalent of 193 tons per acre. The weight gain is 10 fold, a gain of nine pounds for each pound of fish stocked. Most producers feed only pelletized fish food, which has a 42 percent protein content. Feed pellets are composed of 50 percent fish meal, 39 percent wheat flour, 6 percent alfalfa, 3 percent yeast, 1 percent sodium chloride, and 1 percent vitamins.

A major finding by the Fishery Laboratory in Nagaro Prefecture was that the volume of fish harvested is directly related to the number of

fingerlings stocked. They found that a stocking rate of 70 fish per square yard of water is maximum.

A second finding reported by the Fishery Laboratory in Nagano Prefecture is the need to stock uniform size of fish. If the size of fingerlings stocked vary as much as 2-1, for example six inches and three inches, the ending weight may vary as much as 3-1. This implies that the larger fish stock acquires more than their proportional share of feed.

Net culture may be applicable in the United States and elsewhere, thus, a detailed illustration of this method is presented in Tables 11 and 12. Table 11 shows the average weight of fish stocked, number stocked, total weight stocked, total fish stocked and total fish weight stocked in three sets of four net ponds. Table 12 follows with additional information concerning the same 12 net ponds. Regardless of the size and number of fish stocked end results were nearly the same--about 11-12 tons of fish harvested for each group of four net ponds. Data is not available to show whether the same amount of feed was fed to each of the three groups of four net ponds, nor was an economic analysis made of the differences between stocking different weights and numbers of fish. However the average harvest of 143 tons per acre equivalent is very high by any standard of comparison.

The Fisheries Agency of Nagano Prefecture has done considerable research of net pond culture during recent years. One of their most interesting and perhaps most significant findings is the correlation between average water temperatures in Lake Suwa and growth of carp as measured by the increase in the body weight of fish per day (Figure 2).

Table 11. Illustration of Stocking 12 Net Ponds With Carp, Nagano Prefecture, Japan.

Item	Nets 1-4	Nets 5-8	Nets 9-12	Totals and Averages
Average weight of fish stocked	4.2 oz.	2.8 oz.	1.8 oz.	2.9 oz.
Number of fish stocked per net pond	3,500	3,500	4,000	---
Total weight stocked per net pond	919 lbs.	613 lbs.	450 lbs.	
Total fish stocked	14,000	14,000	16,000	44,000
Total fish weight stocked	3,676 lbs.	2,452 lbs.	1,800 lbs.	7,928 lbs.

SOURCE: Fish Culture Seminar, Volume 1, Carp, Chapter 5, p. 124, Green Book Publishing Co., Tokyo, Japan, 1967.

Rainbow Trout - In 1965, Shizuoka Prefecture accounted for 1,558 tons or 24.6 percent of the 6,333 tons of cultured trout produced in Japan. It also accounted for 71 percent of the trout sold on the Tokyo Wholesale Fish Market. Nagano Prefecture accounted for 1,556 tons or 24.6 percent of the 6,333 tons produced, and 14 percent of the sales on the Tokyo Wholesale Fish Market. These two prefectures accounted for 49.2 percent of trout production and 85 percent of the sales on the largest wholesale market in Japan.[1/]

1/ In 1966, the Tokyo wholesale market accounted for 47 percent of the value of all fish sold on the largest six markets in Japan.

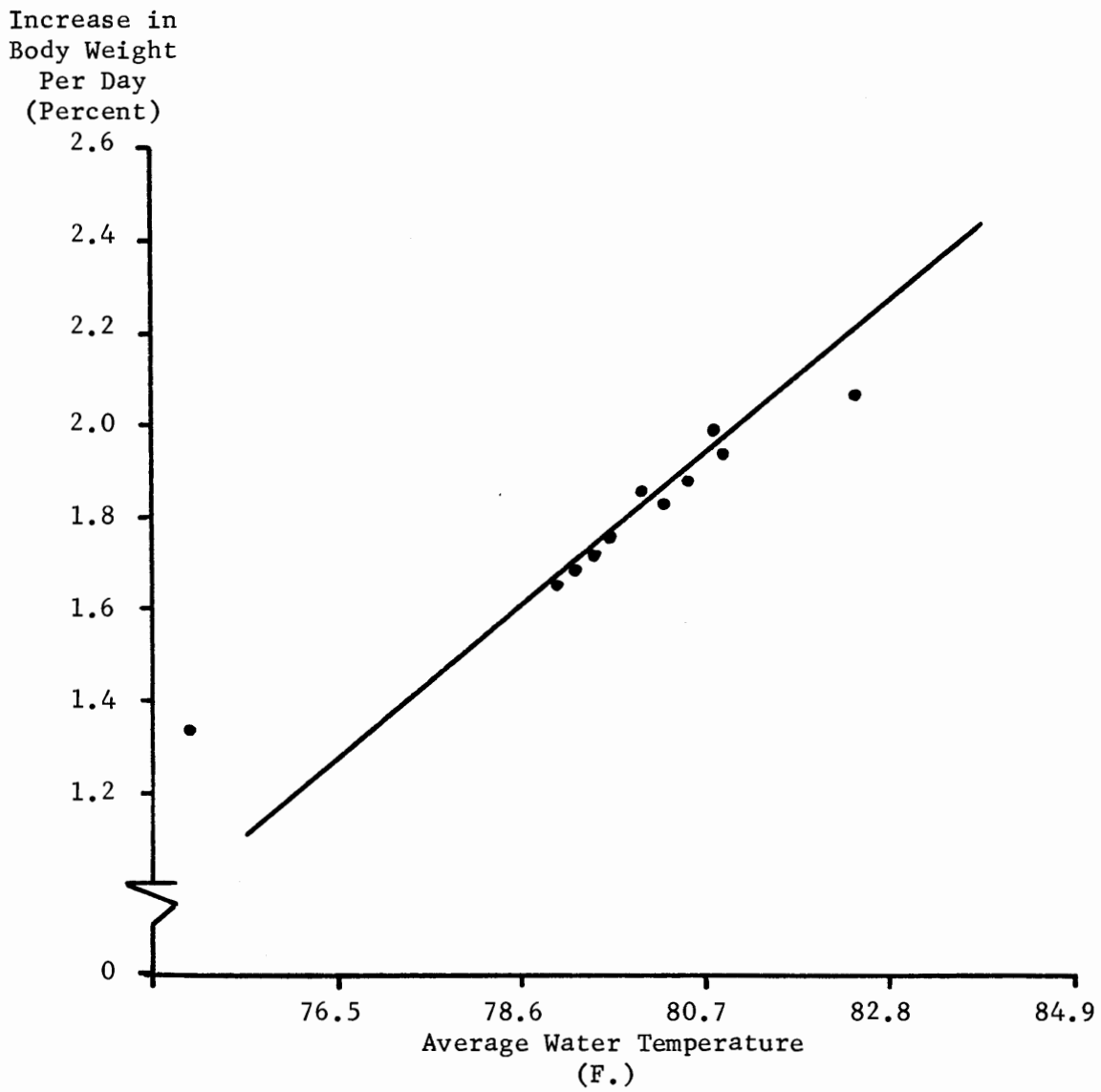

Figure 2. Relationship Between Average Water Temperature and Rate of Growth of Carp, Lake Suwa, Nagaro Prefecture, Japan.

Table 12. Illustration of Expected Harvest Volumes from Stocking 12 Net Ponds with Carp, Nagano Prefecture, Japan.

Item	Code or Formula	Net Ponds 1-4	Net Ponds 5-8	Net Ponds 9-12	Totals and Averages
Average weight of stocked fish	A	4.2 oz.	2.8 oz.	1.8 oz.	2.9 oz.
Average weight of fish harvested	B	28.1 oz.	28.0 oz.	28.8 oz.	28.4
Rate of growth	$\frac{B}{A}$	6.7	10	16	9.8
Survival rate	C	90%	90%	85%	---
Increased weight in group	$D = \frac{B}{A} \times C$	6	9	13.6	8.6
Total weight of fish stocked		3,676 lbs.	2,452 lbs.	1,800 lbs.	7,928 lbs.
Total volume of harvest (pounds)		22,056	22,068	24,480	68,604*

* Equal to 5,717 pounds per net pond or approximately 143 tons per acre equivalent.

SOURCE: Fish Culture Seminar, Volume 1, Carp, Chapter V, p. 124, Green Book Publishing Co., Tokyo, Japan.

Trout require a much higher oxygen content in the water than most other fish, as a result a plentiful supply of cold water of high oxygen content is essential. In general, production is carried out in small concrete lined units, sometimes called "races". When ponds are used, they have concrete sides and an abundance of cold water. Water is

secured from deep wells or from mountain streams. Rainbow trout producers utilize running water culture almost exclusively. The advantages and disadvantages of this type of culture are as follows:

1. The volume of fish produced is generally higher and more fish can be produced per given area of water surface.
2. Ponds or races are smaller, in contrast to pond culture, thus easier to manage.
3. Less people are required per unit of production.
4. Harvesting is easier compared with larger ponds.

Disadvantages:

1. A continuous volume of water flow is required during the growing season.
2. Essentially the same equivalent volume of water is required during each time period.
3. Care must be exercised at all times to insure that debri carried by the water does not interfere with the water flow.
4. The heavy flow of water requires the sides and bottom of the small ponds or races to be of durable material, such as concrete. Thus, construction costs are liable to be higher in comparison to other methods of culture.

Survey data obtained in 1968 from a major trout producing area in Shizuoka Prefecture near Mt. Fuji, revealed that the farm price for rainbow trout averaged 26.4 cents per pound, while production cost averaged 22.8 cents per pound. One producer (Mr. Watanabe) visited in this area was producing 220 tons of trout from one-half acre of water surface or the equivalent of 440 tons per acre. Water flow was 1.55 tons per second or approximately 22,400 gallons per minute.

Production costs of slightly less than 20 cents per pound were reported by Mr. Shosaku Nishimura for 1965 (Table 13). Between 1965 and 1968 it is reasonable to assume that production costs increased approximately one cent per pound per year or about five percent annually. Thus, the cost in 1968 would be about 23 cents per pound. The largest single component of trout production costs was feed, which accounted

for over two-thirds of total costs. Wages were the second highest cost item but accounted for only nine percent of total cost.

Japanese trout farmers were found to be extremely well informed on matters academic to their profession and made it a point to keep abreast of the literature and latest developments and findings released by the various trout laboratories. For example, practically all the farmers utilize up to date feeding tables to determine rates of feed application. Given their own conditions, they know how much to feed per given number of fish. A translated version of one of these tables is shown as Table 14 in this report.

Ayu - Ayu was introduced to Japan in 1846 by a Dutch scientist but did not become commercially important until about 1908. Ayu are a special breed of fish now found in Japan, Southern Korea, Okinawa and the mainland Chinese coast. Eggs are laid in September, October and November, usually in a water depth of 12-18 inches. Eggs number 10,000 to 100,000 per female. Suitable water temperature for hatching is 58-74° F. The number of days for hatching varies from 10 to 24. The warmer the water the more rapid the hatching. Ayu are produced most frequently by pond or running water culture. The fry are stocked when they are 2-2½ inches long. The fish are sold for consumption at about three ounces per fish, or 7-9 inches. About one-third of the total cultured production is produced in Tokushima Prefecture.

There is a definite relationship between water temperature and growth of ayu, (Figure 3). The fish can be produced for sale in about 90 days from the time the fry are stocked. The ideal method of feeding is in running water culture raceways.

Table 13. Rainbow Trout Production Costs, 1/ Japan, 1965.

Item	Cost	Cost Per Pound	Percent of Total
	(dol.)	(cents)	
Fingerling fish	733	.39	2.0
Fish food	25,050	13.34	67.6
Wages	3,325	1.77	9.0
Material	164	.09	.4
Electrical power	983	.52	2.6
Interest	2,097	1.12	5.7
Repayment	969	.52	2.6
Miscellaneous	3,747	1.99	10.1
Total and Average	$37,068	19.74	100.0

SOURCE: Fish Culture Seminar, Volume 3, Trout, Chapter 10, S. Nishimura, Green Book Company, Tokyo, Japan.

1/ Based on 187,803 pounds of trout production.

Table 14. Quantity of Feed to be Fed to Rainbow Trout in Relation to Water Temperature and Size of Fish, Japan.

Length of Fish	Water Temperature (F.)									
	36	40	45	49	53	57	63	68	71	74
(Inches)	(Percent of live weight)									
2 - 3*	1.4	1.7	1.9	2.3	2.7	3.1	3.6	4.3	4.8	5.5
4 - 5	0.8	1.0	1.1	1.4	1.6	1.8	2.1	2.5	2.8	3.2
5 - 6	0.7	0.8	0.9	1.1	1.4	1.5	1.7	2.0	2.2	2.6
6 - 7	0.6	0.7	0.8	0.9	1.1	1.3	1.4	1.6	1.8	2.0
7 - 8	0.5	0.6	0.7	0.8	1.0	1.1	1.2	1.4	1.5	1.7
8 - 9	0.5	0.6	0.6	0.7	0.9	1.0	1.1	1.3	1.4	1.7
9 - 10	0.4	0.5	0.6	0.6	0.8	0.9	1.0	1.1	1.3	1.6
10 and over	0.4	0.4	0.5	0.6	0.7	0.8	0.9	1.1	1.3	1.7

SOURCE: Fish Culture Seminar, Volume 2, Trout, Green Book Publishing Company, Tokyo, Japan, p. 145.

* Weight is also used in Japanese tables. However the difficulty of transferring grams into fractions of ounces made it impractical to do so here.

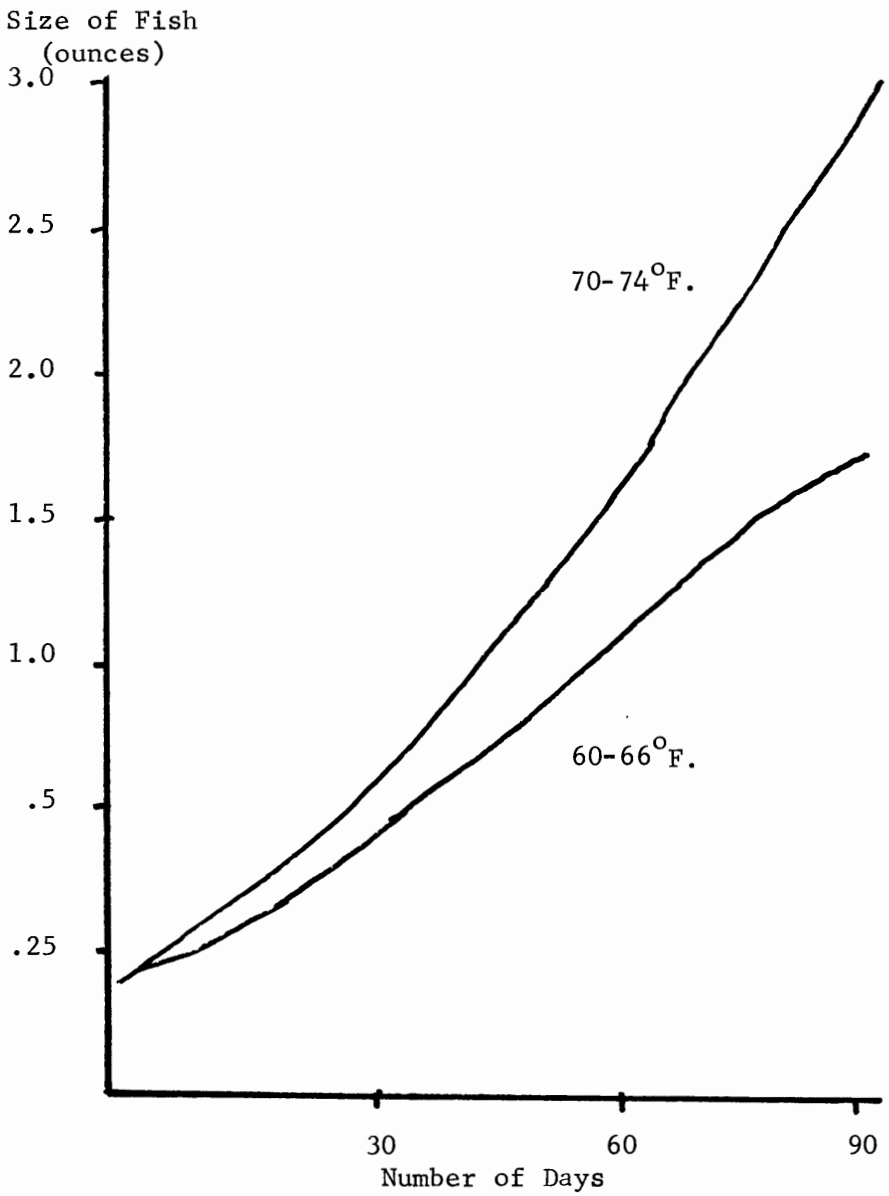

Figure 3. Relationship Between Growth Rates of Ayu Fish and Water Temperatures, Japan, 1967.

SOURCE: Fish Culture Seminar (12, p. 26).

Because of the light weights at which ayu are marketed the yield per person engaged in the ayu industry is smaller than for other marketable varieties. However since ayu are fed only about 90 days, sometimes two different ayu groups are fed. In other cases, after only one group of ayu are fed out, fish fry may be cultured or carp or trout may be fed out to lengthen the fish growing season. In any event, the productivity per person engaged in ayu production has been increasing, (Table 15). Between 1960 and 1964, production per worker increased from .91 tons to 1.77 tons or by 95 percent.

The cost of producing ayu is high. Research conducted in Shiga Prefecture in 1963 revealed production costs of 84.1 cents per pound of fish produced, (Table 16). Several reasons for this high cost were cited: (1) high cost of fish fry, (2) low gain per pound of feed fed, and (3) low productivity per person employed. The cost of production in 1967 and 1968 is not known. However the wholesale price for ayu at the Tokyo Wholesale Fish Market in 1967 was nearly identical to the 1963 price. This suggests that increased productivity may have offset increased costs of feed and higher wage rates. If production cost has increased,

Table 15. Shifts in the Productivity of Ayu, Japan, 1960-64.

Item	1960 (A) (Tons)	1964 (B) (Tons)	B ÷ A (Percent)
Per operator	1.90	4.40	132
Per acre pond	8.74	17.75	103
Per person	.91	1.77	95

SOURCE: Fish Culture Seminar, Volume 3, Ayu, Chapter 10, p. 117, Green Book Company, Tokyo, Japan, 1967.

this suggests that cultured ayu may be sold in the March-July period when ayu prices are very high. It appears logical to assume that this actually happens. Since the cultured fish are fed intensively compared to wild ayu, they should be ready for marketing sooner.

Table 16. Cost of Producing Ayu, Shiga Prefecture, Japan, 1963.

Item	Total Amount (dol.)	Cost per pound (cents)	Proportion of Total (percent)	Explanations
Ayu fry	1,111	10.5	12.5	1,102 pounds
Feed cost	5,000	47.1	56.1	88,184 pounds
Wages	833	7.8	9.3	$56 for 3 men for 5 months
Power cost	569	5.4	6.4	5 months
Fuel	139	1.3	1.6	Gasoline, oil
Telephone, transportation	139	1.3	1.6	-----
Interest	208	2.0	2.3	-----
Repayment	833	7.9	9.3	10 year loan
Miscellaneous	83	.8	.9	-----
Totals	8,915	84.1	100.0	-----

SOURCE: Fish Culture Seminar, Volume 3, Ayu, Chapter 10, p. 129, Green Book Company, Tokyo, Japan, 1967. Area of production is 3,000 square feet and production is 10,604 pounds or 76.9 tons to the acre. Gain was 9.6 pounds per each pound stocked. Nine pounds of feed were fed for each pound of gain. Feed cost was $114 per ton.

MARKETING

Data were obtained from the Food Marketing Research and Information Center, Tokyo, Japan concerning eel, carp, trout and ayu consumption. Information obtained, indicated that fish produced by cultured methods caters to a specialized, high quality market consisting of a small elite class of consumers which are not supplied sufficiently by salt water fish varieties.

In 1966, 361,022 tons of fish were sold on the Tokyo Wholesale Fish Market for an average price of 21.1 cents per pound. Fresh water fish, essentially from farm production units, accounted for only 1,733.2 tons or 0.48 percent of the volume handled by the market. However, fresh water fish sold for an average price of 62.7 cents per pound, accounting for 1.4 percent of the value of the market's total sales.[1/]

Marketing by Varieties

Eel - Eel consumption goes back about 150 years. Among the Japanese, this variety of cultured fish is considered highly nutritious and conducive to good health. Hence the demand is high. However, Japanese scientists have met with limited success in reproducing the eel fry or young by artificial means. The young fry are caught in nets at only a limited number of sites in Japan. The fry are then sold to culturists who raise them to market size. Catch of the eel fry are mainly from Chiba, Ibaragi and Shizuoka Prefectures, located between Tokyo and Nagoya. Since the young eels are caught there, most of the eel cultured are also produced there or nearby. Estimates place Shizuoka's production of cultured eel at 65 percent of Japan's estimated total production of 20,000 tons. The estimated farm value of this production is about 10 billion yen or nearly $28,000,000 in the one Prefecture alone. Shizuoka Prefecture has about 2,600 acres devoted to eel production. Only about 385 tons of eel are exported, largely to Western Europe, while about 98 percent of Japan's production is consumed domestically. Exports to the

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[1/] Supply and Demand of Food, Six Largest Cities of Japan, p. 428, and 1966 Tokyo Wholesale Fish Market Report, Fishery Statistics Section, Statistics and Survey Division, Ministry of Agriculture and Forestry, Tokyo, Japan.

U.S.A. are limited to a few tons yearly, as consumer acceptance in the States has been slow to develop in spite of the excellent qualities of this type of fish.

An economic study of the possibility of increasing exports to Western Europe, where eel production is declining, indicated that it is uneconomical for Japan to produce the larger eel desired by that market. Japanese producers have traditionally produced a smaller eel (18 - 24 inches) which is desired by the Japanese market.

Eel is very high priced in Japan and the price fluctuates widely from year to year, due to the unpredictable changes in the catch of the eel fry. When the Japanese catch is poor, some are imported from Taiwan. The catching season is from December to March. When caught, the eel weigh a fraction of an ounce and are about three inches long. As soon as they are caught, feeding is started. By the following October they are about one foot long and weigh a few ounces. By August of the next year they are about two feet long and weigh about one-third of a pound. Export demand is for eel approximately twice this size which means feeding them for an additional time period.

The Tokyo Wholesale Fish Market is the largest, sales outlet for eel. In 1966, this market accounted for about four percent of total sales. The Tokyo market prices are used as standards by the industry in pricing throughout the country. For this reason price data and volumes sold on the Tokyo Wholesale Fish Market are presented in Table 17. In 1966, 85 percent of the eel sold on the Tokyo Wholesale Market came from Shizuoka Prefecture. Of the other 14 Prefectures which contributed eel, Chiba Prefecture ranked second.

As shown in Tables 17 and 18, eel is a high priced item relative to other varieties of cultured fish and is viewed by most consumers as a luxury item. During part of the 1964-1966 period, the wholesale price was over one dollar per pound, which was quite high relative to the prices of salt water fish which averaged about 20 cents a pound during the same period.

An unknown, but significant share of eel are utilized by the better restaurants. Eel can be found in most large supermarkets and large retail fish shops. In very recent years, some eel has been sold as a precooked, frozen item. This has broadened the demand base for eel. In addition, some eel is canned. Of the four major types of fresh water fish cultured, only eel is processed as a convenience food.

The average monthly volume of eel sold and the weighted average monthly prices received by wholesalers at the Tokyo market for the 1964-66 period, are shown in Figure 4. During this three year period volume handled was at a peak during the months of July and August. Each year during July, one day is set aside as eel day by the Japanese and one of the traditional meals during the day is eel. Hence, the large volume sold in July is without a corresponding decline in prices.

Carp - The major market for carp is Chinese restaurants, which are widespread and popular in Japan, (Table 19). In general, carp producers sell to outlets in the local markets near the source of production. This has been the traditional method of distribution, based largely on poor transportation. As transportation has improved the local markets have broadened. Although some carp is sold at large centralized, wholesale

Table 17. Volume of Eel Sold and Prices By Months, Tokyo Wholesale Market, Japan, 1964-1966.

Months	Years					
	1964		1965		1966	
	Pounds	Price (Cents)	Pounds	Price (Cents)	Pounds	Price (Cents)
January	15,928	75.0	23,550	64.2	70,805	75.8
February	16,437	81.4	54,590	65.6	54,828	66.9
March	28,523	87.8	63,329	66.1	72,540	82.2
April	14,074	105.3	59,729	78.9	74,568	90.6
May	20,428	106.9	70,799	70.0	105,146	83.9
June	32,584	86.4	128,460	60.6	160,614	84.4
July	76,643	72.8	422,992	62.8	366,594	96.9
August	146,447	60.8	233,677	63.3	231,260	86.7
September	50,827	58.3	106,588	69.7	102,007	72.8
October	32,170	56.4	70,589	64.2	92,302	75.6
November	34,767	55.8	60,560	67.8	76,103	74.7
December	40,882	56.1	67,357	72.5	79,967	72.8
Totals and Averages	509,710	68.6	1,362,220	64.7	1,486,734	84.4

SOURCE: Ministry of Agriculture and Forestry, 1966 Tokyo Wholesale Fish Market Report, Fishery Statistics Section, Statistics and Survey Division, Tokyo, Japan, 1968.

fish markets, the major markets are not at these centers. In general, little carp is sold in very large cities. Hence, city people have not acquired a taste for carp nor are they accustomed to using it in the home. The custom of eating carp in the home is not widespread among the younger Japanese. Hence, available data suggests that demand will increase very slowly, principally in response to increases in population and rising incomes of those who have acquired the taste for carp. As in the U.S.A. the modern Japanese wife does not like to prepare carp because of the bony nature of the fish. Carp is not on sale at most retail markets in large cities. Hence, the possibilities of rapid expansion of this segment of the industry depends on a more efficient distribution system and stimulating consumer acceptance among the younger Japanese. Carp production

Table 18. Volume of Eel Sold By Type of Water Culture and Average Farm Prices by Months, Japan, 1964.

Month	Running Water Culture		Pond Culture	
	Monthly Sales (lbs.)	Average Price Per Pound (cents)	Monthly Sales (lbs.)	Average Price Per Pound (cents)
January	155,658	61	62,732	61
February	65,501	66	15,642	71
March	185,843	65	73,691	61
April	86,740	74	100,609	72
May	82,551	71	169,860	74
June	171,068	57	258,853	69
July	485,799	57	484,437	58
August	359,954	59	303,216	67
September	107,750	57	248,051	64
October	74,632	61	190,436	58
November	153,226	65	112,613	62
December	155,812	62	122,867	65
Totals and Averages	2,084,534	61	2,143,007	64

SOURCE: Computed from data presented in Eel Culture Research Report, 1965, Fishery Section, Shizuoka Prefecture, Japan.

Table 19. Distribution of Carp Food Fish for Consumption, Tokyo, Japan, 1966.

End User	Percentage
Chinese Restaurants	60
Japanese Restaurants	10
Home Use	10
Government Purchases	10
Other (Fishing ponds, etc.)	10
Total	100

SOURCE: Nozawaya Corporation resulting from a private letter by Mr. Nakazawa. Appeared in Fish Culture Seminar, Volume 1, Carp, Chapter 10, p. 211, Green Book Co., Tokyo, Japan, 1967.

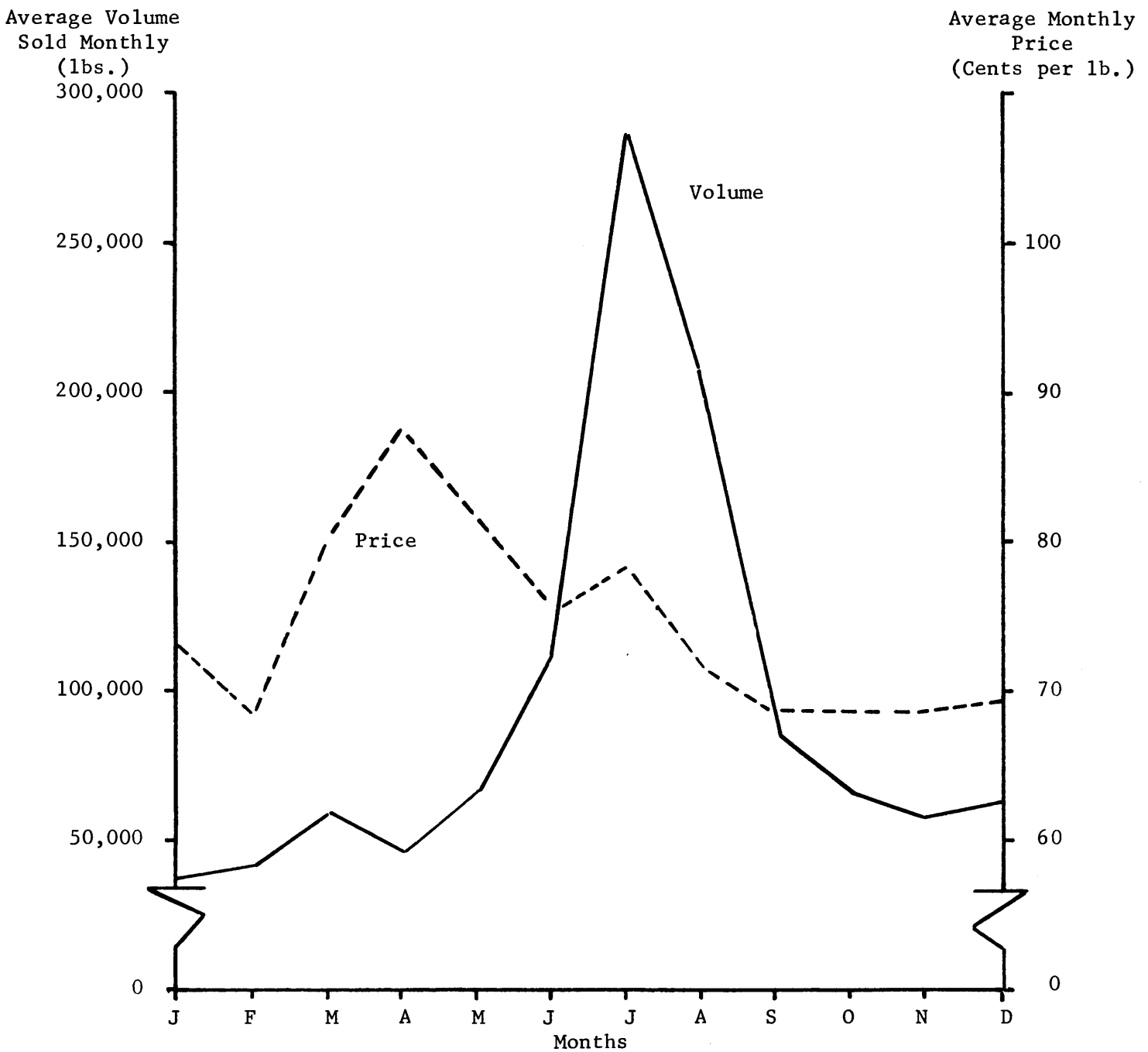

Figure 4. Volume of Eel Sold and Weighted Average Monthly Prices, Tokyo Wholesale Market, 1964-1966.

SOURCE: 1966 Tokyo Wholesale Fish Market Report, Fishery Statistics Section, Statistics and Survey Division, Ministry of Agriculture and Forestry, Tokyo, Japan, 1968.

is widespread throughout Japan and hence the availability of carp is good in most small cities, towns and villages.

In 1968, production cost averaged about 23 cents per pound, including harvesting. Transportation and marketing cost associated with shipping the fish to the Tokyo market cost an additional 9 cents per pound. Average 1968 prices on the Tokyo Fish Market for carp are not known, but in 1966 carp averaged 43.9 cents per pound at the wholesale level. Assuming the average wholesale price in 1968 was the same, 11.9 cents were spent for wholesaling activities (retail prices of course were higher). Volume of carp sold and prices received at the Tokyo Wholesale Market during the period 1964-1966 are presented in Table 20 and Figure 5. Wholesale prices reach their highest level during the period May to August. Lows occur during the months of October, November and December. An inverse relationship between quantities sold and price existed most of the time for carp.

One possible answer for the low October - December prices might be a shift in eating habits from restaurants to home cooking. During the fall months, either these restaurants shift from carp dishes or restaurant trade for these speciality items decrease.

Since there is a widespread market for carp in small cities, villages and towns, carp are not transported long distances for sale. Carp sold on the Tokyo Wholesale Market came from only eight Prefectures. Gunma Prefecture accounted for 57 percent of the market's total sales in 1966, and Ibaragi Prefecture accounted for 38 percent.

Rainbow Trout - Japan is a large producer of trout and the volume of production has been increasing rapidly. Between 1962 and 1966 production increased from 3,866 to 6,868 tons or by 78 percent. Japan is also a

Table 20. Volume of Carp Sold and Prices by Months, Tokyo Wholesale Market, Japan, 1964-1966.

Months	1964		1965		1966	
	Pounds	Price (cents)	Pounds	Price (cents)	Pounds	Price (cents)
January	5,093	38.6	4,810	34.2	10,260	44.2
February	4,903	43.1	11,751	32.8	5,732	45.6
March	4,934	47.8	6,870	34.7	5,095	48.3
April	4,806	46.1	8,854	35.6	5,990	53.1
May	5,331	45.6	7,873	42.8	5,201	56.1
June	6,243	51.4	8,486	66.4	3,957	58.1
July	7,185	49.7	10,044	56.9	4,266	57.5
August	5,692	48.6	5,465	56.4	3,880	51.9
September	4,663	42.5	4,938	53.1	4,901	42.5
October	3,770	38.9	4,306	44.4	6,466	31.9
November	5,348	33.9	5,187	39.2	5,803	30.0
December	6,695	36.9	7,379	40.3	10,038	30.3
Totals and Averages	64,663	43.9	85,963	44.7	71,588	43.9

SOURCE: 1966 Tokyo Wholesale Fish Market Report, Fishery Statistics Section, Statistics and Survey Division, Ministry of Agriculture and Forestry, Tokyo, Japan, 1968.

large exporter of trout. In 1962, 1,173 tons were exported, compared to 2,652 tons in 1966, for an increase of 126 percent (Table 21). During the period 1962 to 1966 exports accounted for 35.2 to 49.9 percent of domestic cultured production.

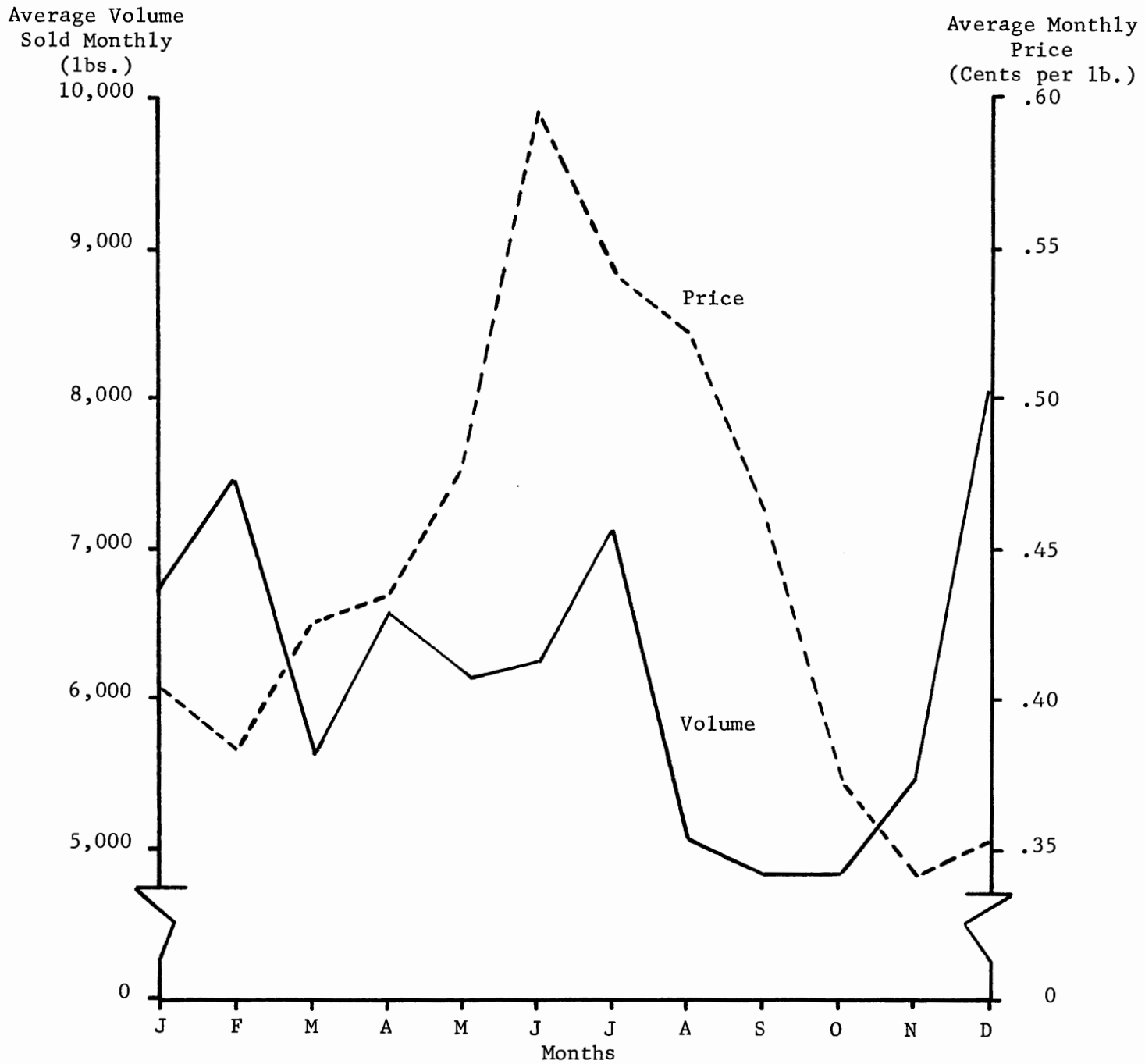

Figure 5. Volume of Carp Sold and Weighted Average Monthly Prices, Tokyo Wholesale Market, 1964-1966.

SOURCE: 1966 Tokyo Wholesale Fish Market Report, Fishery Statistics Section, Statistics and Survey Division, Ministry of Agriculture and Forestry, Tokyo, Japan, 1968.

Increasing quantities of trout are being sold domestically. The chief domestic markets in 1968 were restaurants and game fishing ponds. In 1966, only about 307 tons of the 4,216 tons sold domestically were sold on the Tokyo Wholesale Fish Market. Seventy percent or about 215 tons of the trout sold in the Tokyo market came from Shizuoka Prefecture. Most of the trout sold domestically (about 3,900 tons), were sold by direct sales between producers and restaurants, to managers of game fishing ponds, wholesaled to stores or sold at retail to housewives. Evidence suggests that the export price sets the farm price and the Tokyo Wholesale market reflects wholesale prices. In 1966, the wholesale price on the Tokyo market averaged 35.3 cents per pound.

Analysis of sales on the Tokyo Wholesale Fish Market reveals that volume and price movements follow a seasonal pattern. For the three year period 1964-66, volume reached a peak in March and declined to a low in December. In general, when volume was low for the month the average monthly price reacted inversely. For example, when volumes were highest in March, trout prices were near their seasonal lows. As volume declined from March through December, the average monthly wholesale price increased or stayed relatively high until October, November and December when price declined as volume declined, (Table 22 and Figure 6). In this respect, trout prices reacted similar to carp prices.

Ayu - Ayu production (often referred to as sweetfish) constitutes an important segment of Japan's fresh water cultured fish industry. In appearance they resemble the fresh water smelt found in the U. S. A. Statistics on ayu production were discontinued in 1964, however unofficial

Table 21. Volume of Rainbow Trout Exports in Tons and Importing Countries, Japan, 1962-1967.

Year	U.S.A.	England	Belgium	Australia	Others	Totals	Avg. Price Per lb. F.O.B. Tokyo
1962	910	125	---	29	109	1,173	41.7
1963	1,135	233	30	30	98	1,526	43.1
1964	1,408	419	139	23	177	2,166	38.9
1965	1,310	424	224	30	350	2,338	36.9
1966	1,085	476	204	32	431	2,228	39.7
1967	1,302	529	382	54	385	2,652	45.3

SOURCE: Some Considerations on the Behavior of Freshwater Cultured Fish, Fishery Section, Fishery Policy Department, Ministry of Agriculture and Forestry, June 1968, p. 84.

Table 22. Volume of Rainbow Trout Sold and Prices by Months, Tokyo Wholesale Market, Japan, 1964-1966.

Months	Years					
	1964		1965		1966	
	Pounds	Price (cents)	Pounds	Price (cents)	Pounds	Price (cents)
January	25,873	37.2	32,785	33.3	52,417	25.8
February	24,420	36.7	27,549	35.0	57,531	40.0
March	31,583	36.4	56,334	33.9	68,294	32.5
April	38,190	37.2	58,916	33.6	54,176	34.7
May	32,822	46.7	47,641	33.1	51,989	36.7
June	28,988	35.6	46,182	34.2	50,036	35.8
July	27,262	37.5	49,806	35.0	53,839	36.7
August	23,358	36.7	34,756	35.0	52,586	37.2
September	28,543	36.1	40,470	35.3	42,081	38.1
October	29,658	36.1	40,113	33.1	46,118	34.7
November	25,679	33.3	35,377	32.8	39,978	36.7
December	46,266	30.8	6,695	31.7	45,699	36.9
Totals and Averages	362,642	36.7	476,624	33.9	614,744	35.3

SOURCE: Ministry of Agriculture and Forestry, 1966 Tokyo Wholesale Fish Market Report, Fishery Statistics Section, Statistics and Survey Division, Tokyo, Japan, 1968.

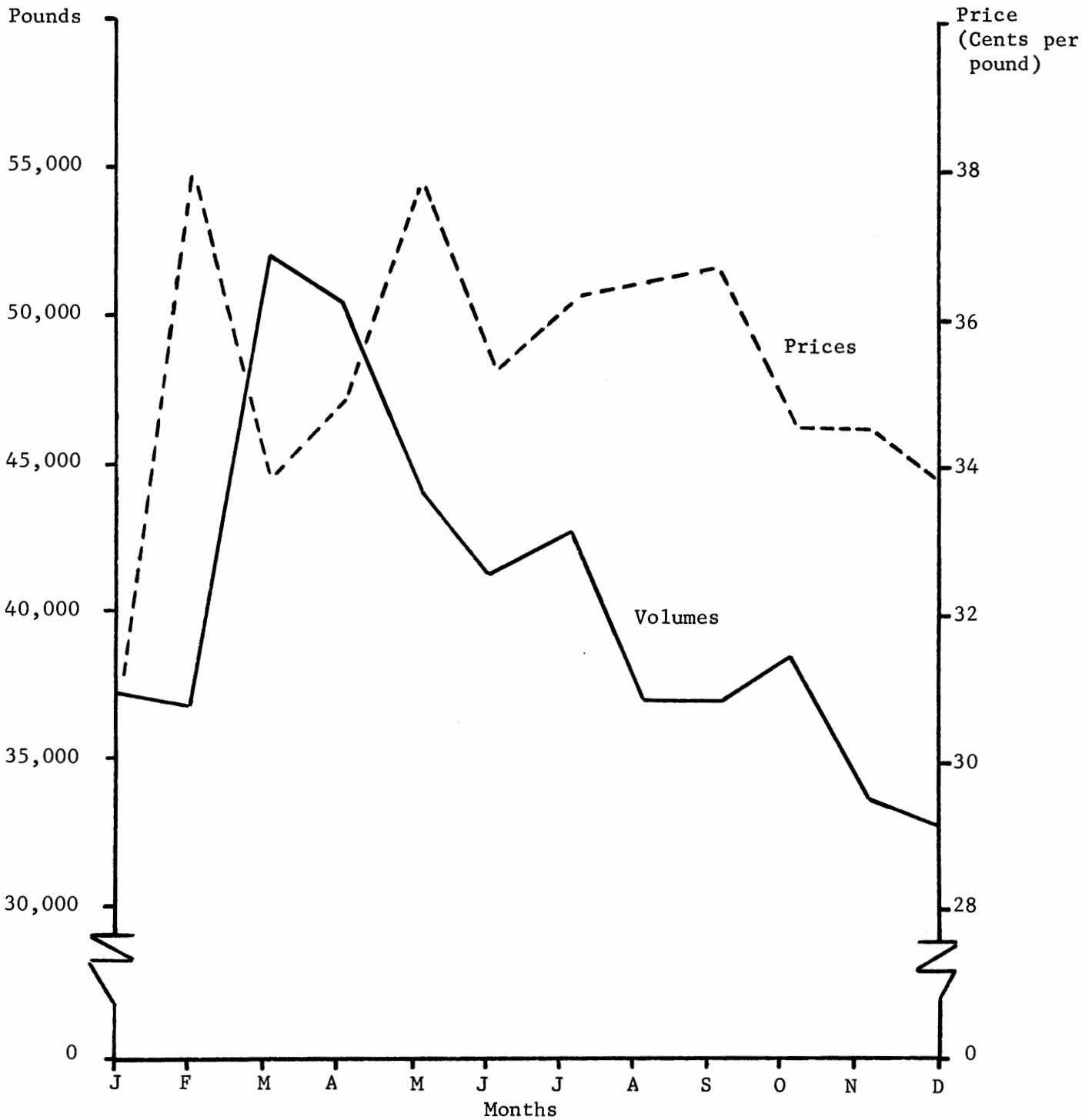

Figure 6. Comparison of Average Monthly Volumes of Rainbow Trout Sold and Prices Paid, Tokyo Wholesale Fish Market, Japan, 1964-1966.

estimates place production at about 1,650 tons in 1965. In 1967, estimated production was 2,200 tons. Compared to other varieties of cultured fish ayu stands second only to eel in demand expansion. Consumption is seasonal from April to September. If the wild ayu catch is small during this period the cultured pond price becomes quite high. Essentially they are sold as a 7-9 inch fish to high class restaurants. Home use increases in August and September when prices are lower.

Ayu are difficult to reproduce in captivity. Hence most ayu fry are caught in rivers, Lake Biwa and the sea shore. In 1968 an estimated 1,500 tons were captured. Two-thirds of this catch were caught in the rivers of Tokushima Prefecture as the ayu entered the streams from the Inland sea, (Tokushima Prefecture is on the island of Shikoku). However most of the cultured production is centered around the Nagoya, Kyoto, Kobe areas on the island of Honshu.

The major markets for ayu are located in the large cities where first class restaurants are to be found. Tokyo, the largest city in the world, with thousands of restaurants, is a major market for ayu. While some ayu producers sell directly to restaurants, in Tokyo, it is assumed that most of the ayu consumed are processed through the Tokyo Wholesale Market. In 1967, twenty-three percent or 495 tons of Japan's estimated total ayu production of 2,200 tons were handled by the Tokyo Wholesale Market (Table 23). How much of this volume was "wild" ayu as compared to "cultured" ayu is not known. But it is apparent that ayu prices reflect conditions in the Tokyo market. In 1966, ayu sold on the Tokyo Wholesale Fish Market came from 33 of Japan's 46 Prefectures. However, the four Prefectures of Tokushima, Shizuoka, Nagano and Shiga contributed 85 percent of the total.

The monthly volume of ayu sold is subject to wide variation. Prices paid by months also vary considerably (Table 24 and Figure 7). Ayu is one of the highest priced fish in Japan. For example, in 1966 the average wholesale price on the Tokyo market was $1.14 per pound. Prices ranged from a low of 63 cents to a high of $2.81 per pound. In general, prices start extremely high and then decline steadily as the market becomes saturated.

INSTITUTIONAL FACTORS

Fresh water fish production and marketing is strongly affected by social and economic conditions. Japan has industrialized rapidly and its population has become centered in large urban areas. Fresh water fish production areas in rivers and lakes have been affected by reclamation projects and filling in of water areas for additional land surface. Factory use of water and disposal of waste water has affected the quantity and quality of water available. Statistics show that in spite of these effects, the volume of fresh water production has steadily increased. This is because about one-half of the inland fresh water harvest has come from increased production of small, fresh water clams rather than fish.

Production from inland fresh waters such as lakes and rivers has been mainly a joint operation consisting of farming and fishing. After World War II, with increased industrialization many full-time fishermen converted to part-time fishing and another full or part-time job.

Government policies have placed a heavy reliance upon marine fishing. The total production of 140,000 tons from inland fresh waters and from cultured fish operations accounts for only about two percent of Japan's

Table 23. Volume of Ayu Sales on the Tokyo Wholesale Market, Japan, 1961-1967.

Year	Volume of Sales (tons)	Sales Price Per Pound (cents)
1961	137.8	92.2
1962	175.3	77.8
1963	190.7	88.9
1964	210.5	91.7
1965	321.9	71.4
1966	239.2	114.4
1967	494.9	88.3

SOURCE: Tokyo Wholesale Market Statistics, Department of Agriculture and Forestry.

Table 24. Volume of Ayu (Sweetfish) Sold and Prices by Months, Tokyo Wholesale Fish Market, Japan, 1964-1966.

Months	Years					
	1964		1965		1966	
	Pounds	Price (cents)	Pounds	Price (cents)	Pounds	Price (cents)
January	5,287	65.3	3,508	60.6	2,729	331.7
February	2,061	61.1	328	55.8	0	0
March	3,858	51.9	1,325	47.2	3,208	280.6
April	13,898	88.6	10,104	83.6	9,213	109.2
May	50,020	93.3	49,147	89.7	33,841	158.6
June	73,532	121.4	94,150	93.9	67,406	155.6
July	100,237	96.9	139,933	76.9	98,098	135.8
August	98,398	82.2	177,975	61.9	128,209	103.3
September	65,166	73.6	141,937	59.4	104,245	87.5
October	4,497	60.6	23,583	53.3	31,526	62.5
November	3,040	30.0	2,361	49.4	214	74.7
December	1,993	41.7	591	35.3	1,217	74.4
Totals and Averages	421,987	88.1	644,942	71.4	479,906	114.2

SOURCE: Ministry of Agriculture and Forestry, 1966 Tokyo Wholesale Fish Market Report, Fishery Statistics Section, Statistics and Survey Division, Tokyo, Japan, 1968.

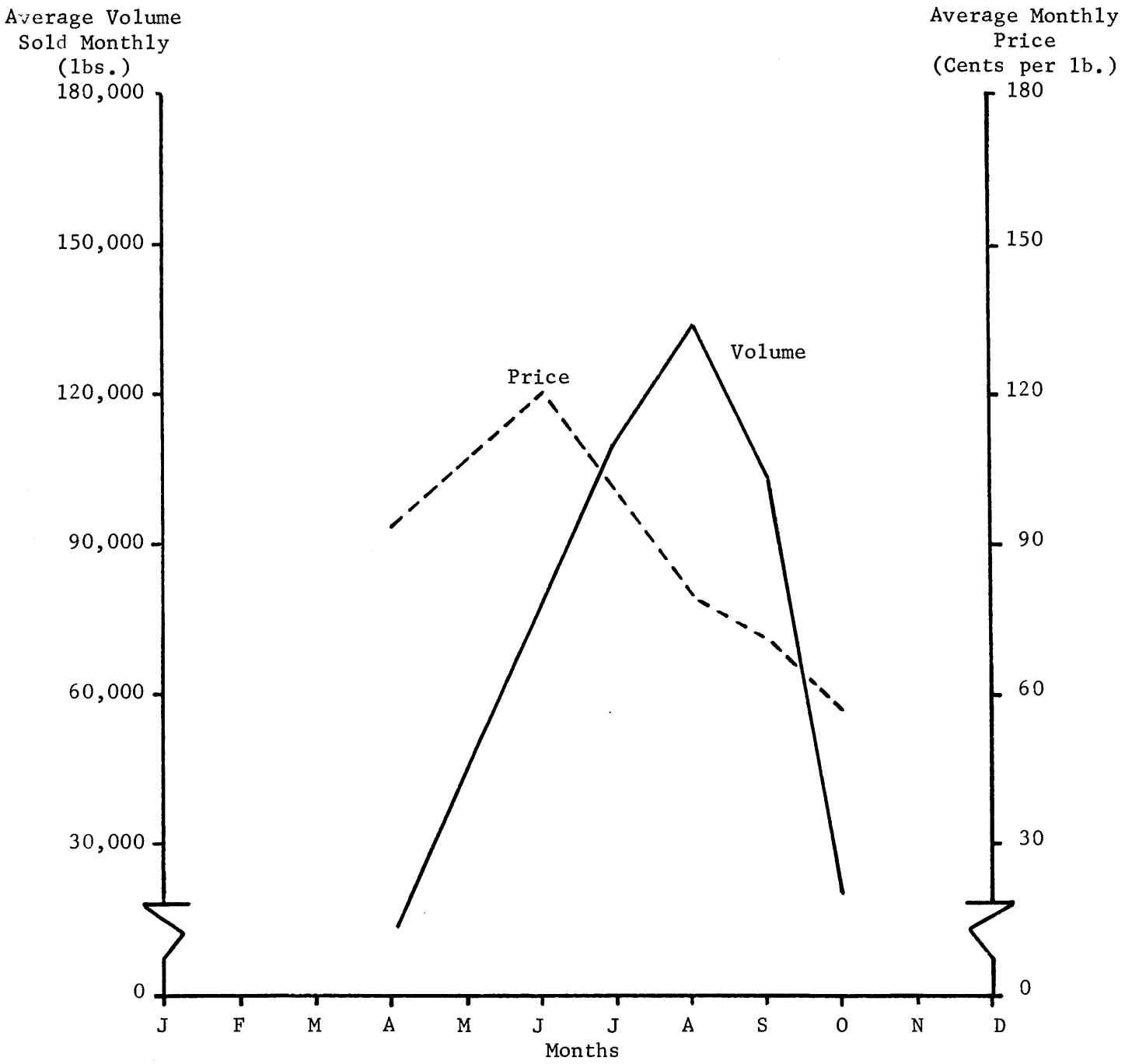

Figure 7. Volume of Ayu (Sweetfish) Sold and Weighted Average Monthly Prices, Tokyo Wholesale Market, 1964-1966.

SOURCE: 1966 Tokyo Wholesale Fish Market Report, Fishery Statistics Section, Statistics and Survey Division, Ministry of Agriculture and Forestry, Tokyo, Japan, 1968.

Note: Does not include data for some months when volumes were relatively small.

total fish production. By contrast, the annual catch of marine North sea cod alone is 1,200,000 tons. Production of fresh water cultured fish is expensive as compared to marine production. Not only is production small but consumption is limited, compared to marine fish. Hence, relatively few people have been concerned about this specialized area.

Government policies have been directed toward increasing the food supply. Low-priced protein from cod or bonito is a less expensive source of protein than from cultured fish. During the period of essentially coastal fishing, the fresh water fishing industry was relatively more important. As the fishing fleet became mechanized there was less emphasis on fresh water culture. Then during World War II overseas fishing was cut off, and fresh water culture was again encouraged and production increased. White and grass carp were imported from China for production as well as additional fish supplies. Production of fish from rice fields became more important. Now the industry is in a different period and there is no need for fish protein produced from rice fields.

Water resources are good in Japan. The average rainfall is 62 inches and total rainfall averages 600,000 million tons annually. About 67 percent of the rainfall is run-off water to the sea, although some is used in rice field irrigation before reaching the sea. In some areas, the demand for water for rice production is high and often creates a water scarcity problem, which is particularly evident on the Pacific side of the main island of Honshu. Demand for rice water in 1965 was 40,000 million tons. Demand for cities and factories was 15,000 million tons. City water needs are growing rapidly and by the year 2000, city water needs are expected to increase 8-10 times, possibly to 200,000 million tons annually, making it necessary perhaps to use sea water. The future water supply for cities

is important. The large fresh water rivers and lakes are near the cities and through the use of dams and reservoirs, surface water run off has been reduced and a fuller use made of water resources. Examples are Tokyo, Osaka, Nagoya and Kyoto. Because of the need for importing raw materials for manufacturing, industry has located on the Pacific side of Honshu island where the large population centers are located. An additional growth center is located near Fukuoka on Kyushu. In these areas that segment of the fresh water fishing industry which relies on rivers and lakes as sources of production are finding their water supply threatened by city needs, factory needs, pollution and rice field needs.

As natural fish foods have been destroyed the catch in rivers and lakes has had a tendency to shrink. Production could be higher if different river and lake techniques were permitted. For example, up until 1966 motor boats were not permitted on Lake Kasumiga (Northeast of Tokyo). Hence productivity per man hour was low and illegal use was made of motor boats. After motor boat use became widespread, it was permitted legally. With this change one man could harvest as much as two men did formerly. However, because of the higher harvests the number of fishing days permitted was cut to two days, with limited seasons. Boats were restricted to one hour per day. This indicates the potential of overfishing with modern techniques. As a result of these changes, the former full time fishermen have nearly disappeared and fishing is done on a part-time basis by farmers. Fishery statistics for 1963 show that the number of full-time commercial fishermen on Japan's lakes and rivers has declined as much as 50 percent in some areas. Some of these former fishermen have turned to raising fish under intensive cultural conditions. The conclusions is that if full-time freshwater fishermen are going to continue working they must give serious attention to the production of cultured fish.

Since 1966 the Japanese policy has been to rebuild the fresh water fish industry. The rebuilding policy is only one aspect of Japan's plans to expand its scale of operations to create a more efficient use of machinery and to equalize farm and city incomes. Fresh water fisheries are concentrating on rebuilding the industry on 16 lakes, including production of fish eggs and fry. In the case of agriculture, the policy is to consolidate land holdings--a program which may prove difficult. In the fish industry, cooperative fishing is being encouraged because there is no one single owner of the water resources.

In years past, the availability of fresh water fish was limited to points near the production area or areas due to poor transportation and distribution facilities. People close to producing areas became conditioned and accustomed to eating fresh fish. (Author's Note - In Japan fresh fish generally means that the fish has been killed only a few minutes or at most a few hours before eating.) The country price was cheap. As the people moved from the countryside into metropolitan areas, they retained their desire for fresh water fish. However, in the large cities were large supplies of low priced marine fish. Hence it was not long before the consumption of fresh water fish by rural migrants to the cities declined. Although some fresh water fish found its way to urban centers transportation and distribution facilities were archaic and inefficient. The need to convey the fish in tanks of water so they would reach the market in a live condition resulted in excessive marketing costs and only the better class restaurants could afford the prices. Home use declined and as a result many of the younger generation do not have the taste or custom of eating fresh water fish. To many Japanese fresh water fish has become a luxury.

In recent years, higher incomes have stimulated production and consumption. While mass consumption is still to come, existing markets are strong. Carp and trout production have increased rapidly, however, prices have not kept pace with increased costs of production. Many consumers prefer wild fresh water fish to cultured fish, claiming to be able to distinguish differences in taste, texture and quality. Since the production cost of wild fish is low this places cultured fish under some competitive pressure. Efforts are being made to improve the varieties of cultured fish and to lower the costs of production.

In 1968 Japan became the third leading industrial power in the world, ranked only behind the U.S.A., U.S.S.R. and slightly head of West Germany. In spite of this the country ranks only 23th in its standard of living. Social capital such as housing and roads needs to be increased. Demand for consumer goods is high, particularly for food and clothing. Home diets have been improved and dining out at restaurants is a national custom. With smaller families, eating traditions have changed since young couples no longer live with parents.

Japan is experiencing a boom in tourism and travel. Improved transportation systems and mass advertising is increasing domestic travel. Congested living demands relaxation and travel is one safety valve. Travel is good for the cultured fish industry since much of the travel is in the cultured fish producing areas.

The catch of wild fresh water fish cannot meet the demand for fresh-water fish; the cultured fish industry can. The markets for fresh water fish have traditionally been for non-processed fish. This situation is changing. Eel for example can be bought as a pre-cooked frozen, pre-wrapped item or can be purchased in cans. There are limited volumes of

prepackaged-polyethelene packs of carp. Gift packs of fish are also available in limited quantities. Dried fish in prepackaged form is increasing. All of these changes are developing a broader market for fresh water fish.

SUMMARY AND CONCLUSIONS

In 1966, approximately 41,000 tons of fresh water fish were cultured in Japan, accounting for one-half of one percent of the total fish volume and 2.6 percent of the value of total wholesale sales. Each pound of cultured fresh water fish produced in Japan in 1966 was valued at more than 5 times the average value of other fish.

Four major varieties of fresh water fish are cultured: (1) eel, (2) carp, (3) rainbow trout, and (4) ayu or sweetfish. In 1965, 85 percent of the eel, 72 percent of the common carp, 100 percent of the rainbow trout and 10 percent of the ayu were cultured; the remainder were caught as wild, fresh water fish. The proportion and absolute volume of cultured fish has been increasing rapidly. In 1961, a total of 19,874 tons of fish were cultured. Estimates for 1968 indicate an increase to 48,857 tons or a 146 percent increase in seven years.

There are four different methods of culture used: (1) pond, (2) running water, (3) circulating-filter systems, and (4) net culture in lakes. The major difference between the first three of these is the volume of available water used. Net culture means that fish are produced inside net enclosures anchored in large lakes.

Production costs vary widely between the different varieties of fish produced and between the four different methods of production. In general, the absolute volume of production was highest with running water culture,

followed by circulating-filtering systems, net culture and pond culture, respectively. Pelletized feeds comprised essentially of fish meal, wheat flour, alfalfa leaf meal, yeast, solium chloride and vitamins, were used extensively.

Examples of outstanding warm water fish culturists included one carp producer who has been able to attain an unprecedented production of 980 tons of fish per acre equivalent. Yields of rainbow trout in excess of 400 tons per acre equivalent were also found. Feed conversion rates were as low as 1.3 pounds of feed per pound of gain.

Major markets for eel, carp, trout and ayu are "high class" restaurants. With the possible exception of rainbow trout the cultured fish industry caters to the luxury food market while salt water fish is consumed more as a staple. In recent years, due to a rapid rise in Japan's standard of living, the market for cultured fresh water fish has expanded. Increased emphasis in Japan on tourism and travel has also stimulated the market- as the people living in large cities travel in and to the areas where most of the cultured fish are produced. These changes along with prepackaging is creating a broader market for fresh water cultured fish.

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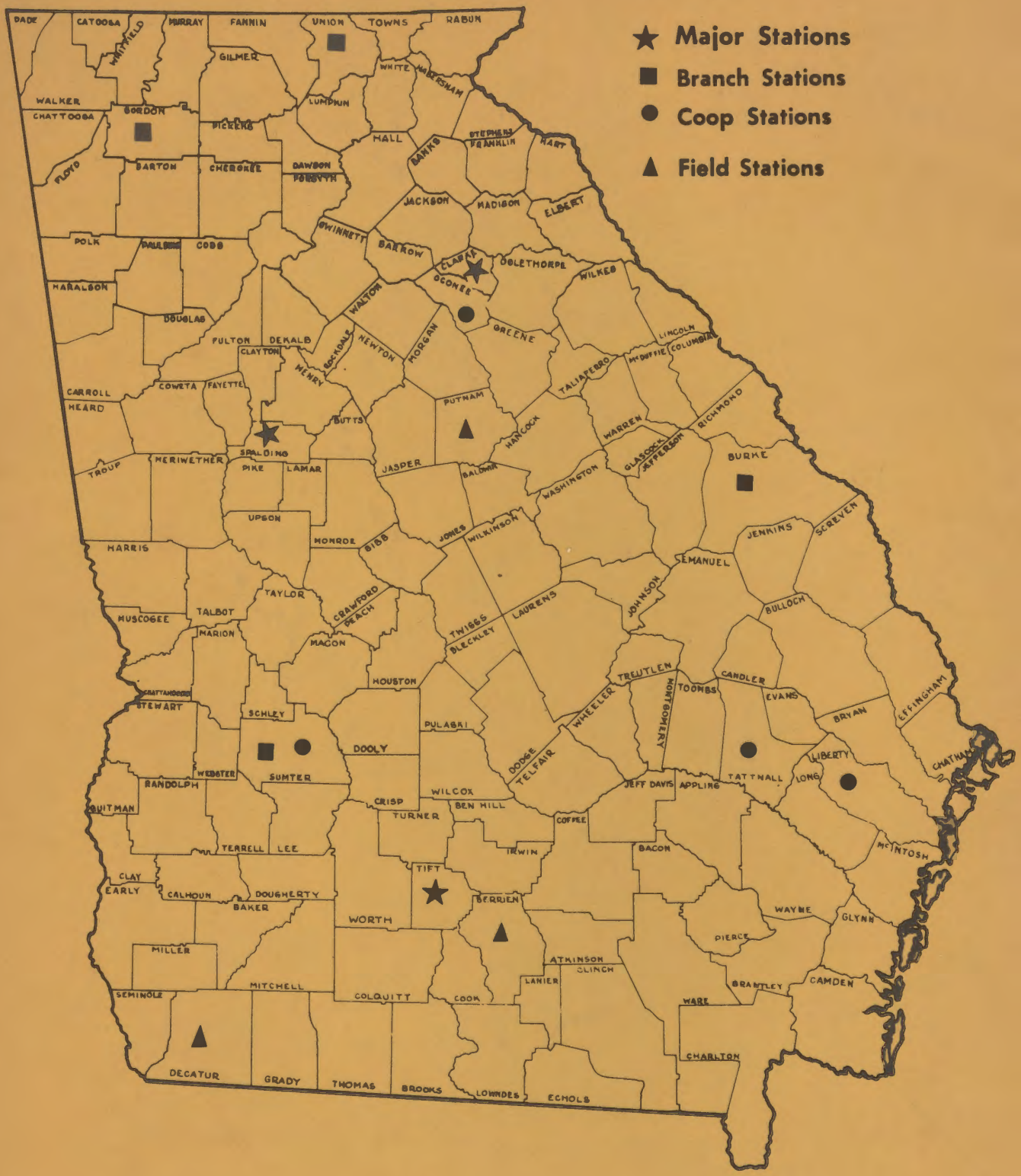
Major Stations
Branch Stations
Coop Stations
Field Stations
DADE
CATOOSA
WHITFIELD
MURRAY
FANNIN
UNION
TOWNS
RABUN
GILMER
WHITE
HABERSHAM
WALKER
CHATTOOGA
GORDON
LUMPKIN
PICKENS
HALL
STEPHENS
FRANKLIN
HART
BANKS
FLOYD
BARTOW
CHEROKEE
DAWSON
FORSYTH
JACKSON
MADISON
ELBERT
GWINNETT
POLK
PAULDING
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