

*Japan's culture of eels quadrupled in the 1960's; new sources of supply are sought.*

## Japan's Eel Fishery

WILLIAM B. FOLSOM



### INTRODUCTION

The Japanese have been eating eels (called "unagi" in Japanese) since pre-historic times. Eels are usually served as "kabayaki" (broiled strips of eel on skewers flavored in a mixture of soy sauce, sugar, and "mirin"—a sweet rice wine) and "unagi donburi" (kabayaki—without skewers—served in a bowl of hot rice). Traditionally the Japanese feast on eels during "Ushinohi" (the Day of the Ox) in mid-July. The Japanese believe that eels give them the energy to beat the hot summer weather.

In recent years the price for eels in Japan has reached astronomical heights; a few thin slices of broiled eel, served with a bowl of rice, costs several dollars in a Tokyo restaurant. In April 1971 the Japanese newspaper *Yomiuri* reported that live, Japanese-bred elvers (baby eels) could be sold for US\$147.27 (US\$1 = 360 yen) per pound at Hamamatsu in Shizuoka, Japan. Mr. Clinton E. Atkinson, U.S. Regional Fisheries Attaché in Tokyo, reports that a Japanese firm quoted a retail price for Japanese elvers as \$417 (US\$1 = 260 yen) per pound in February 1973. He

adds, however, that retail prices for eels are misleading since there is no true retail price; prices fluctuate greatly and are dependent upon a variety of conditions.

### CATCH

Japan's catch of eels between 1952 and 1970 (Table 1, Figure 1) has ranged between 1,700 and 3,400 metric tons and appears to be decreasing. One reason for the apparent decline in catch has been the growing pollution of Japan's coastal waters and rivers. In early January 1972, for example, fishermen along the coast of Shizuoka Prefecture complained that they caught only two tons of eels in an area which once saw catches of between 20 and 30 metric tons per year. The construction of hydroelectric dams in Japan has also adversely affected the eel fishery. Finally, overfishing, especially on the reduced stocks, has contributed to the decline in catch in recent years.

Japan's most important species of eel is *Anguilla japonica*, which spawns in the Pacific Ocean. The elvers are caught by Japanese fishermen for sale to eel culturists and restaurants as they enter Japan's rivers from December through May (February to March is the heaviest period). Those that survive the fishermen, pollution, dams, and natural predators, live in the waters between mouths and upper reaches of Japan's

rivers. They grow for a period of between 5 to 20 years until they reach sexual maturity; then they migrate downstream and enter the ocean to spawn. This migration of mature eels—or silver eels—usually occurs between August and October of each year. After spawning the adult eels are believed to die.

### CULTURE

The Japanese have cultured eels since 1879. However, eel culture did not begin to flourish until the early 1960's. Between 1962 and 1968-69, the harvest of cultured eels increased from 7,600 tons to slightly more than 23,000 tons. Then in 1970, production dropped to 16,700 tons, causing prices to soar.

The sharp drop in production in 1970 was caused by a mysterious disease which affected the gills and kidneys of the cultured eels. Many thousands died overnight. Losses ran into the millions of dollars. Many Japanese believe that the disease was introduced with the first imports of elvers from Europe in 1969. The eel, under culture conditions, is subject to 10 different types of disease which can easily wipe out an eel farm overnight. These problems, plus their

(Opposite.) Eel culture ponds at Yoshida-Machi (Shizuoka Prefecture). Photograph by Kazutami Nishio, Maruhai Yoshida Eel Research Laboratory, Yoshida-Machi, Haibara-Gun, Shizuoka Prefecture, Japan.

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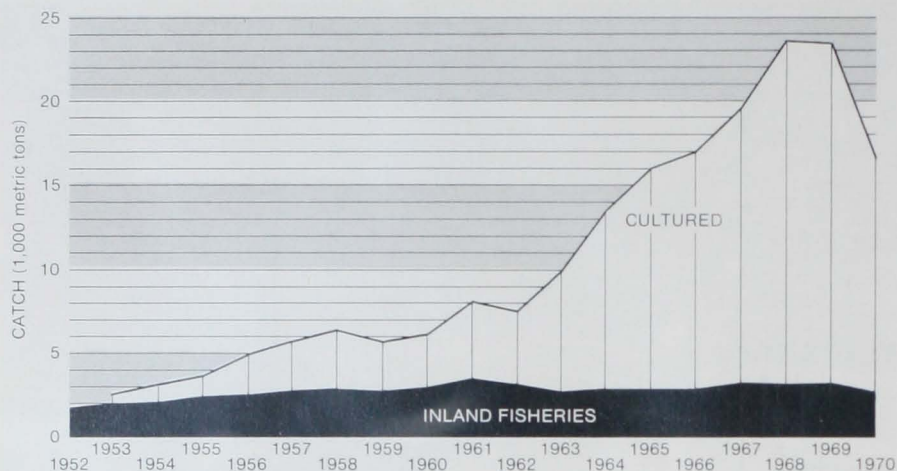


Figure 1.—Catch of inland eels and culture of inland eels, 1952-70.

sensitivity to pollution—in addition to problems of artificially breeding eels—have limited the propagation of eels in Japan.

In spite of these many difficulties, the culture of eels in Japan is an important and profitable business. Sanders (1971), in *Australian Fisheries*, reported on the methods used by the Japanese in culturing their eels:

Elvers are caught in the winter as they migrate upstream from the spawning grounds in the open sea, and are cultured in relatively small ponds of 150 to 350 square meters by 70 cm deep. This phase of culture lasts for about one year, during which time the young eels grow to about 20 gm in weight. The original stocking density is about 500 to 600 gm per square meter.

The growth of individual eels is tremendously variable and constant culling is required during all stages of culture to ensure approximately uniform sizes in each pond.

When elvers begin feeding they are given small oligochaete worms for about two to three days, then for seven to 10 days a paste of mixed oligochaete worms and fish flesh. Then they are weaned on to fish flesh or synthetic diets especially formulated for eels. They are fed twice a day and the quantity of feed given is about 30 percent of body weight.

Young eels prefer to eat in a darkened place and feeding is done in a shelter at one side of the pond. The food is placed in a wire basket sus-

pending just above the water to prevent undue contamination of the water. When young eels reach a weight of 20 gm they are ready for the next phase which takes them to adulthood.

The aim of adult culture is to produce 150 gm eels for market and this is achieved in about two years from the elver stage, which is double the growth rate of wild eels. The size of the adult ponds is about 3,000 to

10,000 square meters by 50 cm deep. The stocking rate is about 500 to 700 gm of seed eels per square meter of pond. Growth is most rapid during April to October and during the period the eels must be fed as much as possible. The quantity of food supplied is about 10 percent of body weight and is fresh or frozen fish flesh or synthetic diets. If fish flesh is used the feed coefficient is 6 to 7 while for synthetic diets it is less than two.

During culture care must be taken to maintain a satisfactory water quality. As all phases of culture are in still water and the density of stocking is high, the maintenance of water quality is relatively difficult. PH levels in the water should be about 8.0 to 9.2 during the daytime, and about 6.8 to 7.2 at night.

Ponds located on acid soils usually have a PH around 5.5 to 6.5 which is too low for satisfactory eel culture. A high dissolved oxygen level is absolutely necessary and the minimum desirable value for eels is 2.0 to 2.5 cc per litre. Water wheels which oxygenate and mix water layers are a common feature of eel ponds. Satisfactory levels of calcium nitrate and phosphate should be maintained and this can often be done by the addition of fertilisers.

Ponds are usually drained and the bottom mud turned and sprinkled with lime at the end of each year.

The species composition and abundance of micro-organisms is of considerable importance during eel culture. In general phytoplankton are beneficial to eel culture and zooplankton are not. Well managed eel ponds are a blue-green color, with a plankton composition of 0.3 to 2.9 percent zooplankton and 97.1 to 99.7 percent phytoplankton.

## MARKETING

The Japanese classify eels according to size and maturity. For culture purposes, the Japanese prefer the smaller sizes and will pay higher prices for them; the larger the eels, the lower the price. The so-called "glass eel" (an elver which has just entered fresh water and is still translucent or white in color—called "shirasu" in Japanese) commands premium prices. "Kuroko" (elvers usually over a week in fresh water and black in color) are the next most

Table 1.—JAPAN. Catch and culture of inland eels; 1952-1970.

YEAR	EEL CATCH AND PRODUCTION		TOTAL
	Inland fisheries catch	Eel Culture	
— 1,000 Metric Tons —			
1952	1.7	—	1.7
1953	1.9	2.5	4.4
1954	2.0	3.1	5.1
1955	2.3	3.6	5.9
1956	2.4	4.9	7.3
1957	2.7	5.7	8.4
1958	2.8	6.3	9.1
1959	2.7	5.7	8.4
1960	2.9	6.1	9.0
1961	3.4	8.1	11.5
1962	3.1	7.6	10.7
1963	2.7	9.9	12.6
1964	2.8	13.4	16.2
1965	2.8	16.0	18.8
1966	2.8	17.0	19.8
1967	3.2	19.6	22.8
1968	3.1	23.6	26.7
1969	3.2	23.3	26.5
1970	2.7	16.7	19.4

FAO, Yearbook of Fishery Statistics, Rome, various years.

popular. Other larger-sized elvers are also designated by special names.

The market price for the different size categories of eels is dependent on the season, supply conditions, their fat content, taste, and freshness (live eels are preferred).

In 1971, the Japanese wholesale price for elvers generally ranged between \$66 and \$83/lb; juveniles sold for between \$35 and \$50/lb, while adult eels sold for between \$2.50 and \$3.00/lb (US\$1 = 360 yen). These prices were generally paid for Asian eels, which normally command better prices on the Japanese market.

## IMPORTS

Faced with a growing demand and potentially lucrative profits, but plagued with supply difficulties, the Japanese have turned abroad to find new sources of elvers for their eel farms. In 1970 Japan imported 290,347 pounds of elvers valued at \$6.1 million (Table 2). In 1971, imports reached almost 700,000 pounds (Table 3), and in 1972 (Table 4) slightly over 450,000 pounds.

Prices published in Japanese fishery newspapers indicate that the Japanese are willing to pay more for eels of Asian origin. In October 1972, a trade journal reported the Japanese import price for live, adult eels from Taiwan was \$2.58 to \$2.72/lb compared with \$3.63 to \$4.09/lb during the summer months. In November 1972, that newspaper reported the sale to Japan of some 900 kilograms of elvers [CIF (cost, insurance, freight) Hong Kong] by Mainland China at the following prices:

Eels per kilogram	Dollars per pound (US\$1 = 308 yen)
300 - 500	20.56
500 - 1,000	30.85
1,000 - 1,200	41.13
2,000 - 3,000	61.70
3,000 - 4,000	82.27
4,000 - 6,500	113.12

In contrast, the prices quoted to potential U.S. exporters were considerably lower. On October 30, 1972, the Regional Fisheries Attaché cabled the

Table 2.—JAPAN—imports of elvers, by quantity, value (C&F (cost and freight) Tokyo), and by country, 1970.

COUNTRY	QUANTITY	VALUE	AVERAGE PRICE PER POUND
	Pounds	US Dollars (Dollar = 360 yen)	US\$1.00/lb.
Okinawa	4	208	52.00
South Korea	23,579	760,730	32.26
China, Taiwan	221,960	4,836,530	21.79
China, Mainland	44	930	21.13
Hong Kong	110	2,063	18.75
France	22,849	273,605	11.97
Great Britain	7,891	87,719	11.11
New Zealand	455	3,994	8.87
Italy	13,455	110,622	8.22
Total	290,347	6,076,401	20.93

Table 3.—JAPAN—imports of elvers, by quantity, value (C&F (cost and freight) Tokyo), and by country, 1971.

COUNTRY	QUANTITY	VALUE	AVERAGE PRICE PER POUND
	Pounds	US Dollars (Dollar = 360 yen)	US\$1.00/lb.
France	51,924	594,530	11.45
Italy	16,041	166,704	10.33
Great Britain	10,056	114,605	14.38
Taiwan	595,465	7,336,129	12.32
South Korea	21,342	909,383	42.61
China, Mainland	2,757	126,491	45.88
Hong Kong	387	14,249	36.82
Canada	326	2,927	8.96
United States	81	994	12.27
Total	696,379	9,265,012	13.32

Table 4.—JAPAN—imports of elvers, by quantity, value (C&F (cost and freight) Tokyo), and by country, 1972.

COUNTRY	QUANTITY	VALUE	AVERAGE PRICE PER POUND
	Pounds	US Dollars (Dollar = 308 Yen)	US\$1.00/lb.
France	145,418	1,701,391	11.70
Italy	5,082	73,841	14.53
Great Britain	17,688	247,101	13.97
Taiwan	250,983	5,057,307	20.15
South Korea	29,482	1,737,964	58.95
China, Mainland	3,269	n.a.	n.a.
Hong Kong	350	1,929	5.51
United States	891	3,395	3.81
Philippines	2,013	68,904	34.23
New Zealand	3,441	47,569	13.83
Total	456,617	7,939,421	19.63

\*Does not include Mainland China.

prevailing CIF-Japan prices for eels as follows: (US\$1 = 308 yen):

Live elvers (2,700 eels/lb) .....	\$15.91 to \$18.18/lb
Live elvers (1,400 to 1,800 eels/lb) .....	\$ 8.18 to \$ 9.09/lb
Live adult (150 to 200 grams per eel) .....	\$1.23 to \$1.36/lb
Frozen adult (150 to 200 grams per eel) .....	\$0.22 to \$0.27/lb

The Regional Fisheries Attaché discussed these price differences with Japanese importers. Their responses, with his comments, are:

*American/European eels are different species, and the quality of meat (oil, taste) differs.*

On the contrary, Dr. Isao Matsui,





(Above) Eels feeding in culture ponds, Yoshida-Machi (Shizuoka Prefecture). Photograph by Kazutami Nishio, Maruhai Yoshida Eel Research Laboratory, Yoshida-Machi, Haibara-Gun, Shizuoka Prefecture, Japan.

(Below) Sorting cultured eels, Yoshida-Machi (Shizuoka Prefecture). Photograph by Kazutami Nishio, Maruhai Yoshida Eel Research Laboratory, Yoshida-Machi, Haibara-Gun, Shizuoka Prefecture, Japan.



Japan's leading eel expert, told the Attaché that variations caused by differences in culture environment can be much greater than variations between species. This is borne out by recent reports from the industry that some Japanese dealers actually prefer Japanese-cultured European eels to Asian eels.

*Mortality is high on imported eels and prices must allow for this loss.*

Shipping of elvers and adult eels is an extremely complex operation. Eels exude slime when subject to stress and they can suffocate in transit unless shipped properly. Poor handling in shipment, delays en route, and other complications also contribute to mortality. These potential losses must be taken into consideration.

*American/European eels are received later in the growing season which affects their growth and early marketability.*

There is some truth to this, but the difference between Japan (March-April) and Maine (April-May) appears to be small.

*American/European eels are adapted to cooler water than Asian eels and grow slower.*

Recent studies show that temperature, along with a susceptibility to a *cyclochaete* parasite, to be the major problems in rearing European/American eels in Japan. Considerable research is now in progress in Japan in an attempt to develop more suitable methods to rear European/American eels.

*Asian eels are collected and sold at a younger age when they are smaller in size and the number per pound is greater.*

This is certainly true, but this problem could be overcome by concentrating on smaller eels and proper holding methods.

In addition to these factors there are additional barriers preventing the ex-



port of larger-sized eels to Japan. The Japanese charge an import duty on eels, as follows:

Description	Duty
Young eels for culture (Up to 13 grams/eel)	Free
Live or frozen eels (13 grams/eel or more)	5% ad valorem
Sliced & precooked eels	12% ad valorem

## U.S. EXPORT OPPORTUNITIES

Although American eels (*Anguilla rostrata*) have already been sold on the Japanese market (the initial reaction was good), the process is not a simple one. The Japanese—with centuries of eating eels behind them—are reluctant to try something new, even a similar product from a new source. Japanese importers will invariably ask for a

number of samples, analyze them from every angle, conduct taste tests, and then offer a price that allows for all kinds of possible contingencies. In view of this, the Regional Fisheries Attaché suggests that U.S. exporters try to keep their first orders near the break-even point, until a market has been firmly developed. Then, as the demand grows, competition between buyers will gradually force the price up.

Inquiries of those who wish to export eels to Japan can be addressed to:

Japan Marine Products Importers Association  
Sanshi Kaihan Bldg.  
1-7, Yuraku-cho, Chiyoda-ku  
Tokyo, Japan.

For a list of Japanese fishing and trad-

ing firms located in the United States, write to:

International Activities Staff, (Fx-41)  
National Marine Fisheries Service,  
NOAA  
U.S. Department of Commerce,  
Washington, D.C. 20235

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## Elver Investigations in the Southeast

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The true American eel, *Anguilla rostrata*, is widely distributed throughout states bordering the Gulf of Mexico and Atlantic Ocean. Several Atlantic states have historically utilized a small percentage of the adult eel for commercial purposes. However, only recently has the possibility for utilizing the juvenile eel (elver) emerged.

The present interest in commercial harvest of elvers stems from a combination of factors affecting the Japanese

adult eel market. Rising per capita incomes in Japan have strengthened the demand for adult eels, while the supply of Asian eels, *Anguilla japonica*, has declined owing to environmental factors and increased fishing pressure. During the 1960's the Japanese turned to mass culture of eels to supplement the wild and imported eels (see accompanying article, *Japan's Eel Fishery*, by William B. Folsom). Mass culture of eels in turn has been limited by

availability of fingerlings or elvers. Furthermore, eel breeding techniques have not been developed and probably will not be for the foreseeable future. Hence, the Japanese have begun rather serious investigations into the possibility of securing supplies of American elvers.

This Japanese interest resulted in a trip to the United States by an investigative team of Japanese eel experts. The team, composed of Dr. S. Nishimura, economist, Fisheries Agency, Hino-Shi, Tokyo, Japan and Mr. K. Nishio, head of eel culture, Maruhaiyoshida Fisheries Cooperative, Shizuoka, Japan, was hosted by Dr. Evan Brown, economist, University of Georgia. Actual elver investiga-

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