An Economic Analysis of Eel Farming in North Carolina

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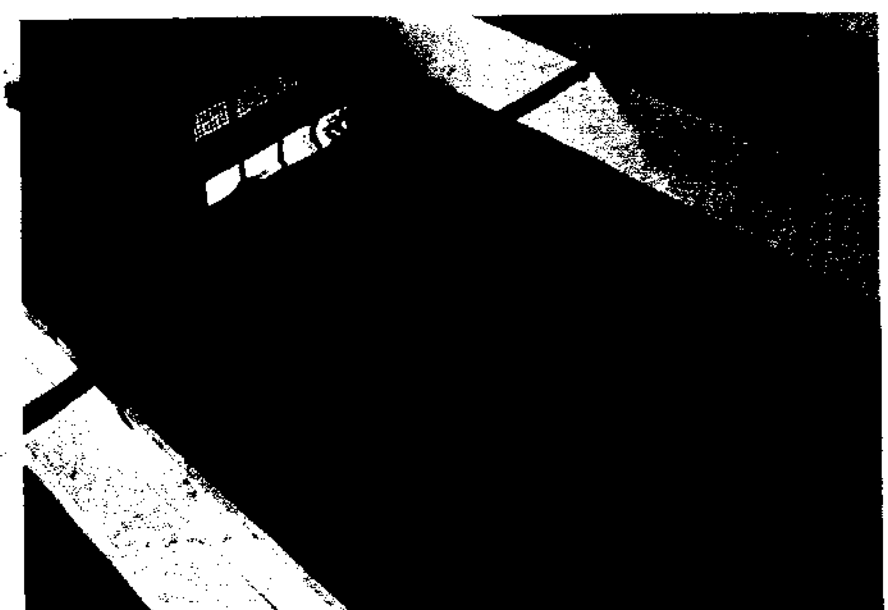

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AN ECONOMIC ANALYSIS OF EEL FARMING IN NORTH CAROLINA

by

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Introduction

The eel fishery of North Carolina is a relatively young one, composed primarily of potting for grown, wild eels in estuaries and streams. From 1960 through 1970, quantity landed per year averaged 39.3 thousand pounds, with receipts to fishermen of $1.9 thousand. Average price per pound during this period was $.05. Quantities landed in 1971 and 1972 increased considerably, with price averaging $.16 per pound during both years. Then for the years 1973-76, quantity landed averaged 333,307 pounds per year at an average price of $.42 per pound.[1]

Prior to the early 1970's, eels were not marketed for food, rather primarily as bait for various uses. But in recent years, eels have been exported for human consumption and have commanded higher prices.

During this period of growth in landings, the North Carolina Sea Grant program began studying eel potting and assisting fishermen with building pots.[2] Sea Grant's work with the eel fishery evolved into experimentation with the capture of small eels and growing them out to market size. This phase of research has followed some of the Japanese culture practices, which now produces some 20,000 tons per year.[3] With rising prices for adult eels and small eels for stocking culture operations, interest in domestic culture has intensified.

The purpose of this bulletin is to estimate costs associated with capturing small eels and growing them to marketable size. The costs

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[1] Data for the years 1960-73 are from Chestnut and Davis (1975), pp. 72-78; other years are from National Marine Fisheries Service, "North Carolina Landings," various monthly and yearly summary issues.

[2] See, for example, D. R. Berg, et al. (1975) and Abbas (1977).

[3] Forrest (1974), p. 29.

developed are best guestimates based on researchers' experience with the eel culture facility at New Bern, North Carolina, and information available in a fairly limited literature. A single scale commercial facility is hypothesized; hence, no information is available or implied as to the most profitable facility size. The facility examined in this bulletin is one with an assumed annual grow-out rate of 20 metric tons (44,092 pounds). This size was chosen based upon the views of Sea Grant personnel and available literature on eel culture operations.[4]

Before developing the projected investment and operating costs associated with the facility, a brief review of markets is presented. Little information is available domestically on the various markets and product forms; hence, one should investigate these carefully before attempting eel culturing.

Eel Markets

Foreign markets for mature eels exist for both frozen and live eels. The Japanese prefer eels of 6-8 ounces in weight, with the primary utilization being kabayaki, a barbecue-type product.[5] It is this product that utilizes a significant share of Japan's culture output.[6] For the period 1968-71, an average 24,000 metric tons of eels were cultured annually, while only 3,000 metric tons were harvested from the wild.[7]

Eels sold on the European markets are either frozen or live, with the primary utilization being the smoked eel.[8] Larger eels (1-3 pounds) are

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[4] A recognized reference to eel culture is Usui (1974).

[5] Canadian Department of Industry, Trade and Commerce (1975), pp. 38-40; Forrest (1974), p. 29; Usui (1974), p. 83.

[6] Canadian Department of Industry, Trade and Commerce (1975), p. 40; Usui (1974), p. 18.

[7] Usui (1974), pp. 110-111.

[8] Ibid., p. 29.

preferred for smoking, though there are variations in size preferences between European countries.[9] An additional product form, though utilizing smaller quantities, is the jellied eel.[10]

Most of the European smoked eel market is apparently supplied with wild-harvested adult eels, with some importing from the United States, New Zealand, and Japan.[11] This contrasts with the Japanese market, where the bulk of the supply is from eel culture.

There is also active trade in elvers, the juvenile eels used to stock culture operations. Japanese and Taiwanese growers have been unable in recent years to locally capture sufficient numbers of small eels. Hence, stocking supplies of small eels are now imported, largely from Western Europe.[12] Some small eels have recently been exported from the United States.

Little is known by U. S. researchers concerning the characteristics of the demand for eels in the various markets. Questions arise concerning the abilities of the markets to absorb additional supplies and the effect on market prices of increased supplies. Of perhaps more importance to the long run growth in demand is the effect of rising income on consumption. These issues are important to a potential eel grow-out industry, as are issues surrounding the quantities of small eels available for stocking and the fishing pressure that they could withstand.

Commercial Eel Culture

Having been spawned at sea, small eels - referred to as glass eels until pigmentation develops, then elvers - ride ocean currents to estuaries

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[9] Canadian Department of Industry, Trade and Commerce (1975), pp. 11-34.

[10] Usui (1974), pp. 29-30.

[11] Forrest (1974), p. 29.

[12] Ibid.

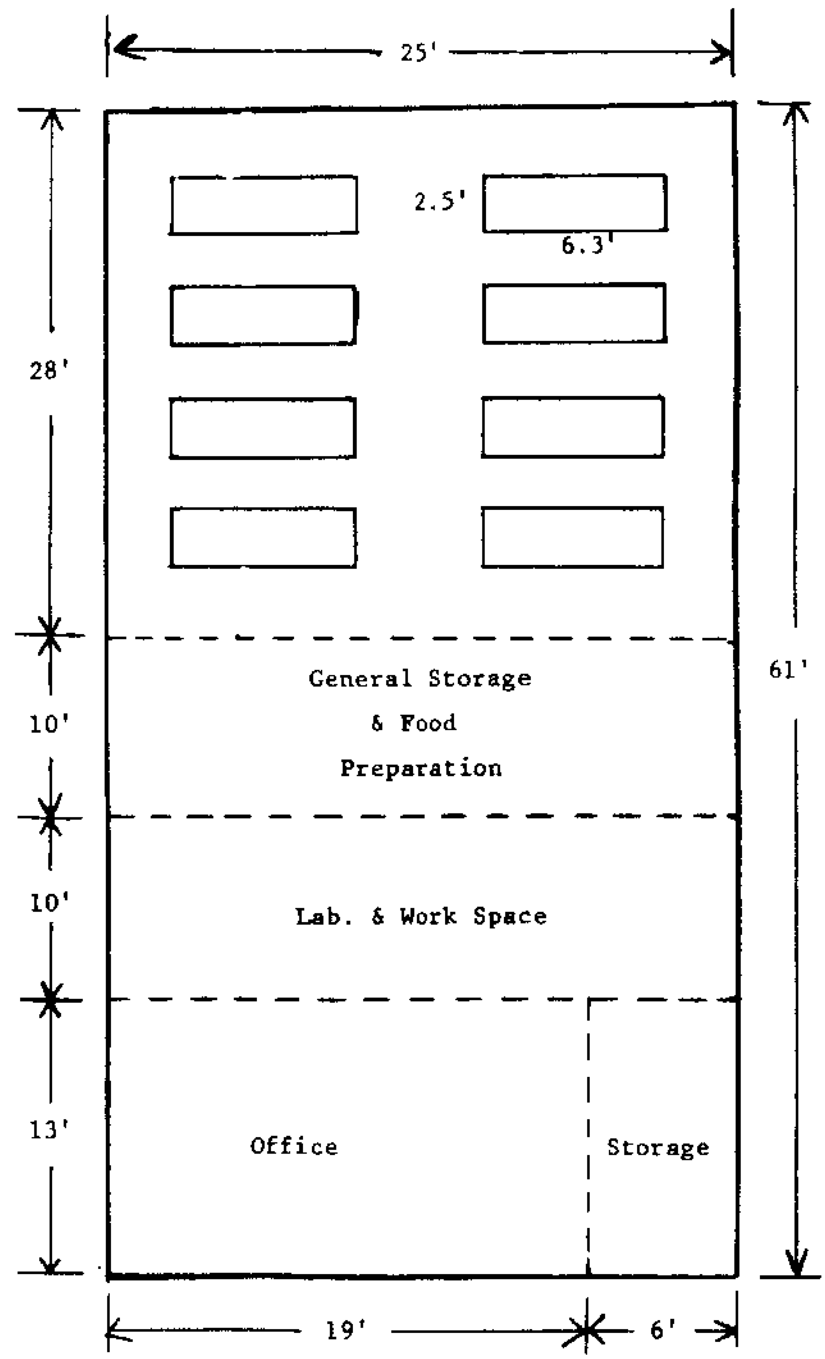
and coastal streams each year. They enter and remain in these streams for several years until sexual maturity. During this time they are trapped by pots and supplied to markets as wild-harvested eels. Those escaping capture migrate back to the ocean when the spawning instinct is triggered, which is generally thought to occur after 10-12 years in fresh water.

Commercial eel culture begins with the elver. These are captured in early spring with either traps or dip nets in the smaller coastal streams. To supply a facility with an assumed 44,092 pound capacity, Sea Grant personnel feel that 12 traps combined with 40 hours of labor should be sufficient to capture 40-50 pounds of elvers. This assumed initial stock is based upon an elver count of 3,000 per pound and an expected mortality rate of 35 percent (5 percent in the elver stage and 30 percent during grow-out). The mortality rate calculated from Usui (p. 118) is 66 percent, largely attributable to sorting and discarding the slow growers. The lower mortality assumed here is based upon less stress to the elvers captured and stocked locally. The Japanese industry imports a significant portion of elvers for stocking: long distance shipping increases disease and stress risks, hence increases mortality.

Once captured, elvers are transferred to tanks housed in a building which also includes some laboratory and storage space (Figure 1). Each tank has a 235 gallon capacity, constructed of plywood and fiberglass tape. Required water flow is estimated to be 4 gallons per minute. Eight tanks are believed necessary by the end of the elvers' 3-4 month stay in the elver facility, hence cost estimates reflect this.

Early experiments with a stream water source resulted in high mortality from changing and uncontrollable water temperatures. Water from wells negates this problem. The initial cost of wells and operating costs of pumping are included in the adult enterprise, as only a small proportion of water pumped flows through the elver facility.

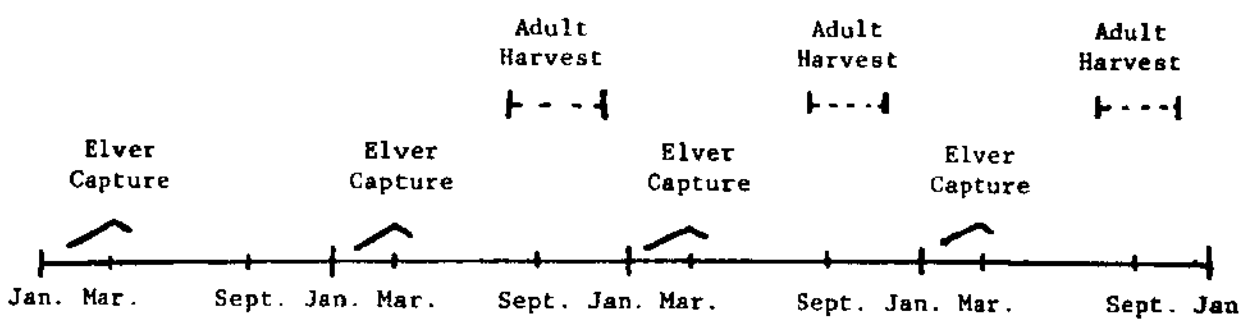
Figure 1
Suggested Building Layout



After the 3-4 month stay in the elver facility, the elvers are transferred outside to the fingerling ponds (Figure 2). After adaptation to the pond environment and grading, they are transferred to the grow-out ponds (Figure 2). Slow growers are discarded in the grading process.

The eels remain in the grow-out ponds until harvested, 18-24 months after the elver capture. The harvesting technique involves drawing down the ponds and collecting the eels in a catch basin. They are then removed with scoop nets and transferred to holding tanks or transport vehicle.

Tank trucks currently collect wild-harvested eels from individuals' holding tanks; hence, this assembly process would likely be employed by the culturist. We might illustrate the timetable from elver capture to harvest as follows:



Grow-out may require 18-24 months, thus the dotted lines during harvest. Eighteen months have been assumed in estimating costs.

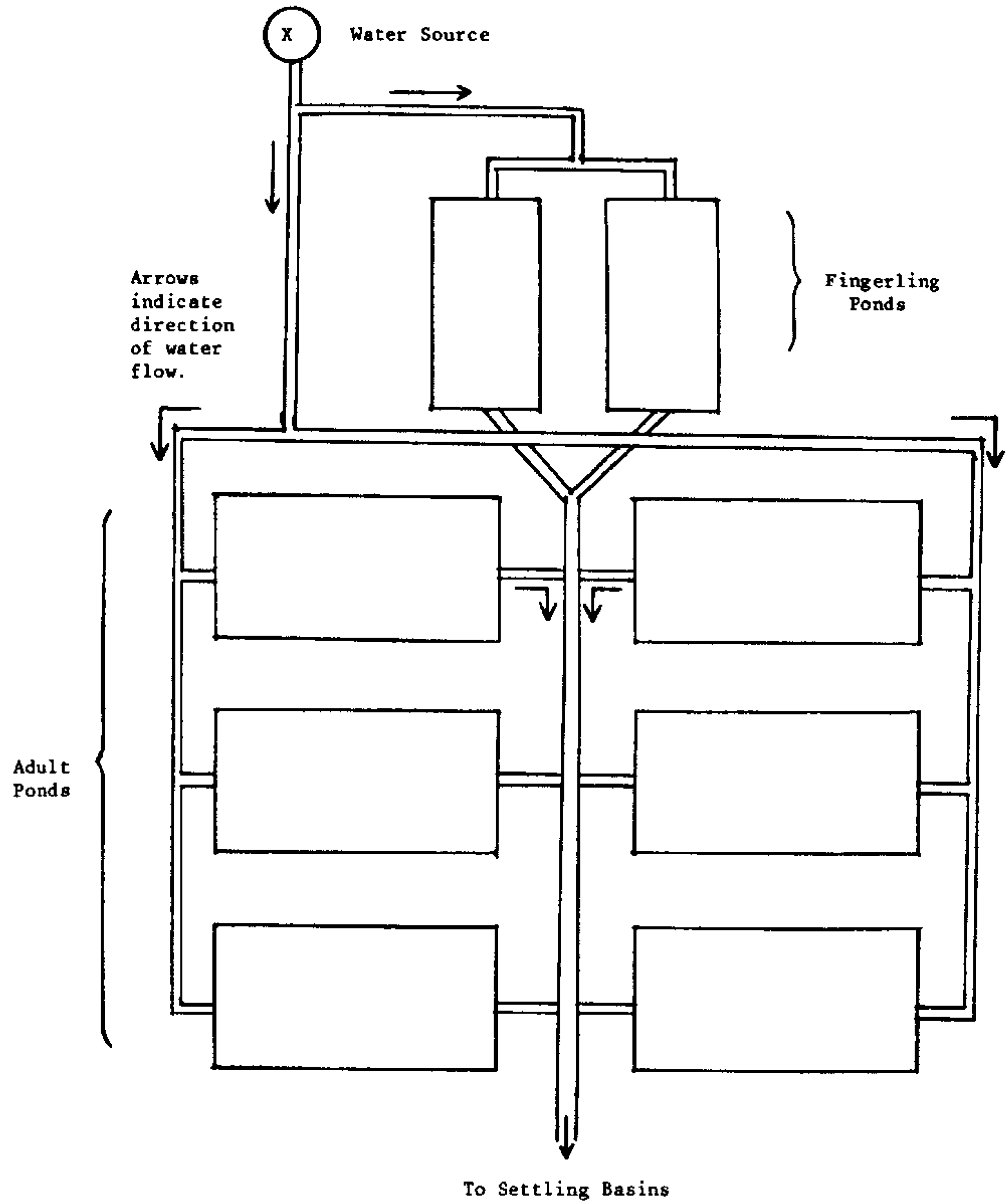
During each year after the first one, there are both elver captures and marketable eel harvests. Hence, both the elver facility and all grow-out ponds are in use during at least part of any given year. The costs estimated below reflect this.

Initial Investment

Following Japanese practices, two identifiable enterprises involved in eel grow-out are included in the facility: an elver holding operation and

Figure 2

Hypothetical Pond Layout



the adult eel ponds. The building and elver facility is developed first, followed by the grow-out facility.

Table 1 presents the initial outlays and descriptions of costs for the building that houses the elver tanks, feed storage, and office/laboratory space. Table 2 presents outlays for the ponds; Table 3, outlays for the water system, and Table 4, support facilities.

The estimates for the building, elver tanks, and equipment related to the elver facility in Table 1 are complementary to the suggested layout in Figure 1. Estimates are included in Table 1 for two feed mixers: one to mix dry feed ingredients (fishmeal, starch); and one to mix the dry ingredients with water and vitamins to form the dough-like final feed. The aeration system included in Table 1 represents a backup system in case dissolved oxygen in the water supply falls below safe levels in the elver tanks. Table 2, containing estimates for pond outlays, also includes a backup aeration system.

Table 3 contains estimates for two wells. The larger well serves as the primary water source; the smaller one as a backup. As use of the pump and motor on the smaller well would be less, the expected life is greater than for the larger pump. An estimate for a truck is included in Table 4 for hauling feed, etc.

Tables 1-4 present the estimated investment, excluding land, for a complete system capable of growing out 20 metric tons (harvest weight). Total outlays for building and included equipment, ponds, water system, and support facilities (Tables 1-4, respectively) are: $24,918; $19,604; $11,388; and $5,420. The combined total investment equals $61,330. This figure will vary, of course, as input prices vary, terrain differences affecting excavation, etc.

TABLE 1. Estimated Outlays Associated with Building and Elver Facility

Item	Description	Unit Cost (dollars)	Initial Investment (dollars)	Expected Life (years)
Building				
Elver tank area	996.8 sq. ft.	8/ft.	7,974	20
Feed preparation	250 sq. ft.	8/ft.	2,000	20
Office space	247 sq. ft.	12/ft.	2,964	20
Electrical				
Sockets & conduit	Est. for 12 outlets or fixtures (includes wiring)	20	240	20
Meter		100	100	20
Office heating unit		500	500	20
Elver tanks	8 @ 235 gal.capacity each	100	800	10
Aeration system				
Hoses & micro-pore tubes		100	100	20
Air compressor	3/4 h.p.	350	350	20
Installation			40	20
Freezer (fd. storage)	15 cu. ft.	250	250	15
Feed mixer, dry	9 cu. ft. Cement mixer, 7 h.p.	1,800	1,800	10
Feed mixer, wet	140 qt. dough mixer, 2 h.p.	6,900	6,900	20
Laboratory & misc. equip.			900	10
TOTAL			24,918	

TABLE 2. Estimated Outlays Associated with Ponds

Item	Description	Unit Cost (dollars)	Initial Investment (dollars)	Expected Life (years)
Ponds				
Fingerling	2 ponds, 5,026 sq.ft. each. $1/cu.yd. excavation; $100 each for 2 sluices; $50 each for 2 feeding piers	725	1,450	20
Adult	6 ponds, ½ acre each, 3 1/3 ft. deep; $1/cu. yd. excavation; 6 sluices @ $84 each.	1,414	8,484	20
Settling basins	2, 1600 sq. ft. each	310	620	20
Feeding stations	1 each adult pond (wood)	175	1,050	10
Aeration system	7½ h.p. air pump, micro-pore tubing, 750 ft. hose, fittings, install.		7,500	15
Misc. equip.	Oxygen meter, scales, etc.		500	10
TOTAL			19,604	

TABLE 3. Estimated Outlays Associated with Water System

Item	Description	Unit Cost (dollars)	Initial Investment (dollars)	Expected Life (years)
Water source				
Primary well	8 in. x 200 ft.	12/ft.	2,400	20
Pump, motor	7½ h.p. motor, incl. install.		3,300	6
Secondary well	4 in. x 200 ft.	4/ft.	800	20
Pump, motor	3 h.p. motor, incl. install.		2,000	10
Plumbing (ponds)				
Main lines	960 ft., 3 in. PVC	.75/ft.	720	20
Input lines	42 ft., 1½ in. PVC	.20/ft.	9	20
Fittings		15% of above	110	20
Valves	6	10	60	20
Installation	Main & input lines	.50/ft.	500	20
Main drain	8 in. x 375 ft. thinwall PVC	1.50/ft.	563	20
Branch drains	6 in. x 75 ft. thinwall PVC	1.25/ft.	95	20
Installation	Drains	1.25/ft.	565	20
Plumbing (elver facility)				
Main, feeders	175 ft., 2 in. PVC	.35/ft.	62	20
Tank input lines	33 ft., 1 in. PVC	.15	5	20
Fittings		15% of above	10	20
Valves	8	1	8	20
Main tank drains	80 ft., 4 in. PVC	1	80	20
Tank drains	25 ft., 1½ in. PVC	.30	8	20
Fittings (drain)		15% of above	13	20
Installation	8 hrs.	10	80	20
TOTAL			11,388	

TABLE 4. Estimated Outlays Associated with Support Facilities

Item	Description	Unit Cost (dollars)	Initial Investment (dollars)	Expected Life (years)
Elver traps	12, plastic coated wire	60	720	5
Scoop nets, misc.			500	3
Truck	½ ton	4,200	4,200	8
TOTAL			5,420	

Operating Costs

Costs associated with the hypothetical eel grow-out operation are presented in two categories: overhead costs and operating costs. Overhead costs are those incurred regardless of the quantity of eels being handled. These include yearly depreciation and interest charges on investment, yearly maintenance, taxes, and insurance. Operating costs, on the other hand, vary directly with the quantity of eels being handled. These include such items as feed, utilities, and labor. These two categories of costs are summarized in Table 5.

The costs shown in Table 5 actually represent those expected once the first year is past, as there are no harvests the first year. Grow-out should require around 18-20 months.

As noted in Table 5, the assumed feed conversion (pounds of feed per pound of net weight gained) is 2:1. In the literature available on eel culture, there is considerable variation in reported conversions.[13] Using the figures reported in Table 5, feed cost per harvested pound is about $.50. With a 4:1 feed conversion, this cost would double. Usui reports (1974, p. 55) that Japanese feed costs are approximately 30 percent of production costs. In contrast, feed costs in Table 5 are about 60 percent of operating costs and 46 percent of total overhead and operating costs. Brown (1969, pp. 19-20) reports that in the late 1960's, production costs in Japan were approximately $.62 per pound for pond-cultured eels. About half of production costs were feed costs for those operations using artificial feed. The feed cost shown in Table 5 on a per pound basis is $.50. This cost may not be as far afield as it appears. Nominal feed costs no doubt have risen considerably since the late 1960's.

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[13]For example, for artificial feed Usui (1974, p. 119) reports a conversion of 1.4:1; Bardach, et al. (1972, p. 391), a range of 3.03-4.36:1; Homma (1971, p. 118), 1.5:1; and Folsum (1973, p. 42), less than 2:1. Though too insignificant to affect the feed conversion, for approximately a week

TABLE 5. Estimated Yearly Eel Production Costs

Item	Cost (dollars)
Operating costs	
Feed[a]	21,952
Labor[b]	8,193
Utilities[c]	4,454
Chemicals[d]	200
Interest on operating capital[e]	2,088
Total operating costs	36,887
Overhead costs	
Amortization[f]	8,661
Taxes & insurance[g]	1,227
Maintenance[h]	920
Total overhead costs	10,808
Total operating and overhead costs	47,695

[a] Estimate based on 2 lbs. feed required per lb. of net weight gain. Over a typical 12-mon. period, a total of 44.052 tons of feed required, 25 percent of which is starch ($788/ton) and 75 percent fishmeal ($400/ton), plus 88.1 lbs. of vitamins at $.632 per lb.

[b] Estimate based on 1¼ full time employees (2,500 hrs. per yr.) plus an additional 80 hrs. for elver capture and adult harvesting, all at $3.00 per hr. plus .0585 FICA.

[c] Utilities include all yearly operating costs of equipment in Tables 1-4, plus $500 for misc. expendable items and lighting.

[d] Estimated total per year.

[e] Estimated at 12% of one-half the total operating costs.

[f] Items from Tables 1-4 amortized at 10% per year over respective lives, then aggregated.

[g] Estimated at 1% each (total of 2%) of total investment.

[h] Estimated at 1.5% per year of total investment.

An interesting computation to a potential grower is the break-even price - the price he would have to receive to just cover all costs. From Table 5 total overhead and operating costs are $47,695 per year, excluding land and management. Hence, the break-even price would be $1.08 per pound, assuming a 44,092 pound harvest. This price exceeds considerably that paid in recent years for wild eels noted earlier as in the upper $.40's per pound. Whether European markets will pay a sufficient premium, and in which product form, for cultured eels is unknown and should be examined.

One might ask questions of possible sources of cost reductions. One of the most likely candidates for potential cost reduction is feed. As more is learned of the production response to different feed formulations, costs could decline. Additionally, improved grading out of the slow growing eels will improve the overall feed conversion. Sea Grant researchers are currently exploring recreational bait markets as potential markets for the slow-growing and/or undersized eel.

Though small now, a second area where costs may be reduced is labor - a cost related to feed preparation in addition to actual feeding. Improvements in feed preparation and feeding techniques may reduce labor requirements over most of the culture cycle. A 25 percent reduction in daily labor required would reduce the labor bill by $1,985 - equivalent to $.05 per harvested pound savings. However, these improvements would not affect labor required to capture elvers or in harvesting.

Some Preliminary Derived Demand Analysis

The purpose of this section is to do a preliminary analysis of the potential profitability of marketing eels cultured in North Carolina on the European or Japanese markets. Little is known about price movements over a

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after capture elvers are fed raw fish; thereafter a mixture of fishmeal, vitamins and water. One pound of vitamins are mixed with 1,000 pounds of meal.

season on either market; hence, this analysis should not form the basis for investment decisions.

As noted in the review of markets, eels are sold frozen and live, with different size preferences dependent upon the market considered. For example, it was noted earlier that the Japanese prefer smaller eels, with most of their cultured eels domestically consumed.

Recently quoted prices for live-frozen eels (eels that are frozen while still alive) do not appear very favorable for cultured eels.[14] A recently quoted price (April 1977) for New Zealand live-frozen eels in Europe was $.76 per pound. Irish and English eels were selling at or below this price. In England, the New Zealand eel was selling at $.64 per pound. At a grow-out cost of $1.08 per pound, the cultured eel does not appear to be a candidate for the European live-frozen market. The grow-out cost might be reduced with more efficient feeding, etc., but keep in mind that we have added no cost for freezing, handling (beyond harvesting), transportation, and potential tariffs. These would add a significant amount to the $1.08 per pound. European prices without the potential dampening effect from frozen carry-over stocks might be sufficient to cover the grow-out cost and the processing/shipping costs, but we have no information allowing even a guestimate. However, the frozen market does not appear to be a viable one for the domestically cultured eel.

The markets for live eels appear more favorable for moving cultured eels, though again little is known concerning price sensitivities to quantities marketed, etc. Live eel prices in Europe this year are expected to range from $3 to $4 per pound, with the $3 price expected during peak harvests. In the Japanese markets, these ranges are from $4 to $6 per pound.

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[14] Two factors may be depressing these prices, though the size of the effect is unknown. One, our wild harvesting season coincides with that of Europe. Second, an abundant harvest last year has apparently resulted in

Air freight rates were obtained from one carrier as an approximation of upper limits of shipping charges. These are shown in Table 6 by weight class and destination.

Assuming the previous price ranges are accurate expectations, market quotes less freight rates leaves an amount to cover culture costs, handling and shipping between growers and port of departure, and possible tariffs. These margins are presented in Table 7.

The last column in Table 7 shows the margin available for the two weight classes. Most shipments would probably exceed 660 pounds; hence, the second net price in each row is of particular interest. This price represents a crude estimate of the margin available to cover culturing and domestic handling and transporting. With culture costs ranging from, say $1.00-$1.15 per pound, it would appear that the net price is more than sufficient to cover remaining handling and transporting costs. However, these prices are single predictions. If the peak harvest prices realized were lower than $3.00 and $4.00 on the two markets, then the margins would be of concern. For example, if the price on the European market were $2.50, the net price drops to $1.42, which might not be sufficient to cover the remaining costs. As little is known about the sensitivity of these prices, demand should be more thoroughly investigated before investing.

Concluding Comments and Suggestions for Future Work

Based on experimental work thus far, culture costs appear high compared to those often cited with fish.[15] However, one would expect improvements in diet formulations as research continues, with improved technical and economic

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large frozen inventories extending into this season, with a resulting price dampening effect. We might add that our wild harvested eels are entering these markets.

[15]For some recent cost estimates and literature citations for trout, see Easley (1976).

Table 6. Air Freight Rates for Two Weight Classes

Weight Class (pounds)	Quoted Rate (dollars per pound)	Effective Rate* (dollars per pound)
	Raleigh - Rotterdam	
220-660	$1.12	$1.49
over 660	.81	1.08
	Raleigh - Osaka	
220-660	$1.91	$2.55
over 660	1.52	2.03

*Effective rate applies to cost per pound of eel actually shipped. Live shipping requires holding tanks and water or misting system. It is assumed that the tanks, etc., account for 25 percent of weight shipped; hence, the effective rate is the quoted rate divided by 75 percent.

Table 7. Market Prices Less Air Freight Rates for Two Weight Classes.

Market	Price	Less Effective Freight Rate*	Net Price
	(dollars per pound)		
Europe (Rotterdam)	4.00	1.49	2.51
		1.08	2.92
	3.50	1.49	2.01
		1.08	2.42
	3.00	1.49	1.51
		1.08	1.92
Japan (Osaka)	6.00	2.55	3.45
		2.03	3.97
	5.00	2.55	2.45
		2.03	2.97
	4.00	2.55	1.45
		2.03	1.97

*See Table 5 for explanation of effective freight rate.

efficiency. We would expect the feed conversion to drop as improved diets are developed, which would reduce cost. We might also expect some improvements in diet production techniques that could also reduce costs. Improved grading (dispensing of slow-growing eels) may also aid in reducing costs.

In addition to the feed problem, a major consideration - and one perhaps increasing risk - is that elvers currently have to be captured in the wild. Looking ahead to potential commercial eel culture, an important question concerns the harvest pressure that elvers can withstand. This issue is important not only for the availability of elvers for culture purposes, but also for the availability of future adult eels for wild harvesting. However, from accounts of normal elver runs, it is likely that considerably larger effort in wild harvest and culture would be required before affecting stocks.[16]

From some admittedly crude price and air freight rate computations, it does not appear that cultured eels could profitably be marketed in Europe in frozen form. Wild harvested eels are, however, currently marketed in Europe in both live and frozen forms. These are also larger eels than those cultured. Live eel markets in both Europe and Japan appear to offer the most profitable options, with size-preferences favoring the Japanese market. Given higher prices and freight rates to Japan, an interesting question is whether net price (market less transoceanic freight rates) on the Japanese market would exceed that on the European market. Seasons and timing of harvests could affect which market is more profitable.

Before encouraging eel culture, we need to know more about the markets for the eels. One important question centers on the effects of seasonality. If cultured eels would be harvested during peak culture and/or wild harvests

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[16] One factor that could develop into much expanded effort on eel stocks is the potential for direct export of elvers.

in foreign markets, the price received could be considerably lower than those required for profitable culturing. How long is the foreign harvest season? How do prices respond seasonally? Are eels with higher fat contents bringing higher prices currently? If so, on which markets and for how long?

These are examples of some of the very basic questions one might ask concerning the marketing of eels. An additional set of questions deals with transportation and handling costs in getting eels to market.

Also importantly related to marketing and demand characteristics is the issue of what effect, if any, might an expanded eel export trade have on foreign prices. If our stocks are sufficient for supporting a significant quantity of wild harvest and cultured eels, what impact would these larger quantities have on prices? If there were price dampening effects, would these be large enough to adversely affect the wild-harvest industry as well as the potential culturing of eels?

These are examples of some of the important demand issues. Some are difficult questions to answer; however, perhaps less difficult than the questions one might ask if no markets currently existed, that is, if we were investigating the potential market for a new product.

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