UTILIZATION OF FINFISHES CAUGHT INCIDENTAL TO SHRIMP TRAWLING IN THE WESTERN GULF OF MEXICO

PART II: EVALUATION OF COSTS

by

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ABSTRACT

This report presents estimates of the cost of operating several alternative systems for holding and landing finfish caught incidental to shrimp trawling operations. Freezer units, brine immersion tanks, an on-board fish meal plant, an extra crew member and a mother-ship concept are the systems evaluated. Break-even prices are estimated that would be necessary to cover operating costs and a 10 percent return on investment. Additionally, problems in traditional work patterns, crew incentives and institutional arrangements are discussed.

Comparison of estimated break-even prices with recent market prices indicate that none of the proposed systems are viable except under very restrictive conditions. The mother-ship or tender vessel concept shows the most economic potential but is plagued with problems of coordinating a large number of vessels in an industry where independence of operation is valued highly. The analytical model presented may be used to evaluate other systems not considered directly in this study.

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INTRODUCTION

Background of Problem

Each year shrimp trawlers in the Western Gulf of Mexico capture millions of pounds of finfish incidental to trawling operations. To date, economic conditions have not warranted recovery of these species since the costs associated with recovery and processing have exceeded returns so most of the non-shrimp species are discarded at sea.

Expanding world demand for feed and food has created an increased awareness in the past two or three years of the potential value of the underutilized finfish species in the Western Gulf of Mexico including the incidental catch of shrimp trawlers. Although market instability is still apparent for feed and fish products, many observers feel that long-term pressures of rising incomes and populations will require utilization of food sources previously untapped.

Due to rapidly increasing costs of operating fishing vessels, alternative systems of operation are being evaluated which may lead to an assessment of methods designed to capitalize on the incidental catch. This report continues the economic evaluation of trawl-fish utilization. A previous report discussed potential market channels for this fish resource [2]. Based on the characteristics of each market, possible but as yet unrealized market volumes were also estimated. The emphasis of the previous report was on the demand for trawl-fish products. This report concentrates on the costs to shrimping firms of preserving and delivering trawl-fish.

Purpose and Objectives

The purpose of this report is to examine the set of ex-vessel prices which would be required for a viable system of collections and utilization of fish currently discarded in the shrimp trawling industry. In other words, several methods of delivering trawl-fish products are thought possible. Each method has its own cost structure and probably would deliver a product with some unique characteristics. For example, gutted foodfish and fish meal are two different, but possible, trawl-fish products. The costs of producing each product in conjunction with the existing shrimp trawling operations can be expected to differ. Consequently, the analysis presented here attempts to account for such differences. To be more specific, the objectives of this report are:

(1) To list and discuss preservation systems which could feasibly deliver ashore trawl-fish of marketable quality.

(2) To determine a set of break-even prices which would enable the owner of a shrimp trawler to recover the costs of equipment, financing, and labor in the preservation and delivery of trawl-fish.

(3) To estimate returns to crew members at the owner's break-even point under such a program, and

(4) To make a comparison of prices developed in objective (2) above, with current and historical prices paid at the processor level by processors in order to appraise the shrimp fleet as a trawl-fish supplier.

Scope of Research

The preservation and delivery systems analyzed in this report are connected only with the normal operations of shrimp trawlers in the Gulf of Mexico. In this respect, a basic assumption throughout this report is that shrimp vessels continue to operate primarily for shrimp. It is the purpose of this report to examine the question of whether or not the preservation and delivery of trawl-fish is profitable when performed as an activity secondary to shrimping. Therefore, trawl-fish may be regarded as a by-product of shrimping activity. Analysis of the trawl-fish systems considers only the costs of adding enough equipment to a shrimping project to recover trawl-fish.

For clarification regarding the use of the term "costs" in objective (2), cost information utilized is that which was available to the authors at the time of writing. However, firm owners may wish to specify different cost levels for their own decision-making. It is felt that the analysis is presented in enough detail to allow readers to do their own calculations if they wish. A framework for analyzing costs is presented, while the last word in price and cost figures is not presented. The dollar values used were "hypothesized" based upon currently available information.

METHODS OF ANALYSIS

In accordance with the first objective, five possible methods of recovering trawl-fish will be analyzed. Four systems involve preservation of fish on-board the shrimp trawlers while the fifth system consists of a "tender vessel" specialized to the recovery of discarded fish. Though these systems and the reasons for selecting them will be described more thoroughly later in this report, it is important to note that they exhibit different cost structures, and therefore, may be viable under different economic conditions.

Break-even analysis is used to determine the minimum product price which each system will require before it can produce trawl-fish products on a commercial basis.

The break-even approach is a method of calculating a price or set of prices which would enable the owner of an enterprise to at least recover the given total costs of a particular project. The term "break-even" refers to a method where a price is calculated which allows all costs of operating the system to be recovered, but which leaves no return to the owner of the system. Below this "break-even" price the owner can only partially recover installment and operation costs whereas above this price the owner receives some return for his efforts. At the price, the owner "breaks even." This method is used to examine each of the trawl-fish systems proposed.

A review of the scientific literature and interviews with shrimp fishermen revealed that the ratio of trawl-fish to shrimp varies both geographically and seasonally [2, pp. 17-18]. This variability limits the validity of a single break-even price. Different ratios of shrimp to trawl-fish can be expected to influence the level of the break-even price. The pounds of shrimp harvested are based on the average annual landings, in heads-off weight, of a vessel with a keel length between 66 and 72 feet. This category was selected because it was thought that this size vessel would be the one most likely to have room for additional equipment or storage of additional catch. The average annual landings of this category of vessel were 55,000 pounds based on 1971 landings [8, p. 12].

Break-even prices are calculated for different assumed trawl-fish to shrimp ratios. Table 1 shows the four ratios used and the annual harvest of trawl-fish at each ratio, given a yearly shrimp harvest of 55,000 pounds. Thus, if the ratio is 1:1, the annual trawl-fish harvest is 55,000 pounds, if it is 4:1, the annual trawl-fish catch is 220,000 pounds, etc. Though the quantities of trawl-fish appear rather large, only small fractions of the total may be marketed for human consumption. These fractions, however, would bring a higher price than the remainder of the catch. Thus, two

Table 1. Annual incidental trawl-fish harvest under different trawl-fish to shrimp ratios for a steel vessel in the 66-72 foot keel-length category catching 55,000 pounds of shrimp per year.

	Trawl-fish to shrimp ratios			
	1:1	4:1	7:1	15:1
Trawl-fish catch (pounds)	55,000	220,000	385,000	825,000
Shrimp catch (pounds)	55,000	55,000	55,000	55,000

Table 2. Annual harvest of foodfish for a steel trawler catching 55,000 pounds of shrimp per year assuming different trawl-fish to shrimp ratios and different percentages of foodfish in the trawl-fish harvest.

Percentage of foodfish in finfish catch	Ratio of finfish to shrimp[a]			
	1:1	4:1	7:1	15:1
.5	275	1,100	1,925	4,125
2.5	1,375	5,500	9,625	20,625
5.0	2,750	11,000	19,250	41,250

[a]Sample calculation: From Table 1, 55,000 pounds of trawl-fish are caught when the trawl-fish to shrimp ratio is 1:1. When .5 percent of the trawl-fish catch is foodfish, 275 pounds of foodfish (.005 x 55,000 = 275) are landed each year. All elements of Table 2 are calculated in this manner. These quantities are gross weight, before heading and gutting. These weights are used to allow comparison of related break-even prices with wholesale prices which are quoted "in the round." (See Table 18, p. 44).

types of systems are suggested. One type would be designed to utilize the entire finfish catch, the other to take only fish for human use. For this reason, it is desirable to have an estimate of the quantity of foodfish occurring in the trawl-fish catch. Accordingly, Table 2 shows the pounds of foodfish that will likely be harvested given different assumed percentages of foodfish for each trawl-fish to shrimp ratio.

A different break-even equation is used for each of the two types of recovery systems. If the total trawl-fish harvest is to be utilized, the formula is

$$P_{tf} = \frac{AFC + AVC}{\alpha Q_{tf}} \qquad (1)$$

where

P_{tf} = Break-even price per pound of the trawl-fish, in either raw or a finished product form.

AFC = Annual fixed costs of the trawl-fish system.

AVC = Annual variable costs of the trawl-fish system.

α = Percentage of dockside value accruing to the shrimp trawler owner.

Q_{tf} = Pounds of trawl-fish harvested annually by a shrimp trawler.

When only foodfish are to be retained by the system, the equation utilized is

$$P_{ff} = \frac{AFC + AVC}{\alpha Q_{ff}} \qquad (2)$$

where

P_{ff} = Break-even price per unit of foodfish.

Q_{ff} = Pounds of foodfish harvested annually by a shrimp trawler,

and the other variables remain as defined for Equation (1). By comparing (1) and (2) it can be seen that the right-hand portion of the two equations differs by only the terms Q_{tf} and Q_{ff}. Values for Q_{tf} and Q_{ff} are given in Tables 1 and 2, respectively, which makes the use of the two formulas quite convenient.

Present institutional arrangements require the captain and crew's payment to be approximately 35 percent of the gross value of the catch.[1/] Since it is possible that trawl-fish recovery could interfere with shrimping activity, it can be assumed that the crew will take an avid interest in any decisions concerning the implementation of a trawl-fish system. Consequently, the third objective calls for an estimate of potential gains to crew members under the trawl-fish systems discussed. The estimates are made at the vessel owner's calculated break-even point under the assumption that trawl-fish recovery does not interfere with shrimp harvesting. This assumption was made because of the difficulty in determining potential interference levels.

The first step in this analysis is to calculate the rate of return per fishing hour for a shrimp fisherman assuming a 55,000 pound annual vessel catch, a $1.73 price per pound of shrimp, a 35 percent crew share, and 2,700 hours fishing per year. Generally, there is a captain and two crew members on the large shrimp trawlers. Arrangements concerning the division of the crew's share may vary, but in general the captain receives the largest portion of the crew's share, with the rigsman and the header receiving the next largest shares, respectively. The captain determines how the crew's share will be split, and if he has crew members that are better than average, he will probably offer them correspondingly larger shares. A typical split might be 45 percent of the crew's share for the captain, 35 percent for the rigsman, and 20 percent for the header. These are the percentages assumed for this analysis. Details are shown in Table 3. Under the assumptions used, a captain would make $5.55 per hour of fishing, a rigsman $4.32, and a header $2.47 in the production of shrimp.

The next step is to calculate the potential hourly return for each shrimper under a given trawl-fish system. This potential hourly return maybe calculated as follows:

$$P_{HR} = \frac{\beta \frac{(1-\alpha)}{\alpha} (AVC + AFC)}{hr.} \qquad (3)$$

where

P_{HR} = The potential hourly returns for each crew member under a given trawl-fish system.

[1/] Actually this arrangement varies somewhat. For example, the captain and crew might receive 35 percent of the gross catch value with the vessel owner paying all vessel expenses, or they might receive 40 percent and bear part of the variable vessel expenses. The actual arrangement will change to suit the situation.

Table 3. Calculation of hourly "wage" of shrimp fishermen.

Fishing days per year[a]	225
Hours of fishing per day	12
Hours of fishing per year per vessel	2,700
Pounds of shrimp caught per year	55,000
Price per pound	$ 1.73[b]
Value of catch	95,150.00
	.35
Crew's share (35 % of total)	$33,303.00
Captain's share (45% of crew's share)	14,986.00
Captain's return per hour of fishing	5.55
Rigsman's share (35% of crew's share)	11,656.00
Rigsman's return per hour of fishing	4.32
Header's share (20% of crew's share)	6,661.00
Header's return per hour of fishing	2.47

[a]This assumes either that no fishing related labor is done while in port or that such labor receives no remuneration.

[b]Estimated ex-vessel price per pound of heads-off Gulf shrimp for 1973 for vessels of this size, (Wade L. Griffin, March, 1974, Gulf States Marine Fisheries Meeting). It should be noted that this is a much higher price than that recently given by the NMFS ($.705 in 1971) as an index for all sizes and species [13, p. 24].

hr = Annual hours spent fishing by each crew member.

β = Percent of crew share received by each member.

By definition, at the break-even point, the vessel owner must receive AVC + AFC. Thus, the total returns for the incidental catch must be $(AVC + AFC)/\alpha$. The total crew share is $(1-\alpha)$ times the total return. Each crewman's annual share then would be β times the total crew share. Thus, each crewman's potential hourly returns would be his individual annual share divided by the annual hours he spent fishing.

The last objective calls for the comparison of the above break-even prices and the current (at the time of this writing) and historical dockside fish prices paid by processors and dealers. What is compared then, is the maximum price processors can or have paid for fish and a set of minimum prices shrimpers can accept for landing trawl-fish. If the maximum price paid by processors is below the minimum price acceptable to shrimpers, then in all probability the fish will continue to be discarded at sea. However, if the maximum price is above the minimum price, or if a range of both prices overlap, then there is at least the possibility that the trawl-fish will be landed. Consequently, the shrimp fleet can be appraised as a potential supplier of trawl-fish.

DESCRIPTION OF SYSTEMS AND CALCULATION OF BREAK-EVEN PRICES

This section will list and analyze selected trawl-fish systems which could feasibly be used with a shrimping vessel. Physical and operating characteristics of each system are discussed in light of how each would affect the normal operating procedures aboard a shrimp trawler. Break-even analysis is presented for each system.

Several constraints are imposed on each system by the nature of the trawl-fish and fishing operations. First, most Gulf-shrimp trawlers use ice to preserve their catch, though a few have freezing equipment. Shrimp prices are more lucrative than trawl-fish so shrimpers would not wish to divert any cooled storage from shrimp to trawl-fish. Hence, it is assumed that trawl-fish would utilize only excess storage capacity and would not displace shrimp. Second, the time spent in gutting individual fish to prevent spoilage would reduce the time available for the activities of handling shrimp and setting the nets for more trawling. Third, unprocessed finfish lose quality rapidly after several days in the hold, yet many shrimp trawlers average trips of 10 to 14 days in length, depending on fuel supplies and shrimp catch rates. There are other constraints on trawl-fish systems, but the above three are the most important in designing adequate methods of handling trawl-fish.

An examination of present technology and discussions with fishermen were used to decide upon the systems which appeared most promising with respect to the recovery of trawl-fish and, at the same time, seemed the least likely to interfere with shrimping activity. Of the five systems discussed, three--the brine immersion system, the on-board meal plant, and the tender-vessel system--are designed to recover the entire incidental trawl-fish catch. The freezing unit and the addition of another crew member would retain only fish suitable for human consumption. A comparison of Tables 1 and 2 suggests that use of the last two methods would not substantially reduce the volume of discarded fish but they may offer the possibility of an additional market channel for seafood products and improving returns to owners and crew. None of these systems has been used except on a limited basis, suggesting that trawl-fish prices are still too low to warrant recovery of incidental finfish catches. The break-even analysis is intended to shed more light on this. In addition, the examination of each system includes a discussion of expected effects on activities aboard the trawler and of crew-vessel owner arrangements concerning division of returns from trawl-fish.

Freezing Unit

The freezing unit discussed is a mechanical hatch type designed to blow chilled air (to -5°F) into the storage hold.2/ Only foodfish would be recovered with this system. The unit would replace the hatch on the storage hold, yet would allow passage of one crewman at a time into the hold. An electrical generator powered by either the ship's engine or by an independent diesel engine would provide energy to operate the unit. Either source would use about one gallon of diesel fuel per hour. Installation of a freezing unit would not reduce the capacity of the trawler's hold (approximately 100 boxes or 10,000 pounds of shrimp).

With the operation of a freezing unit the activities of the crew would undergo little change. They would continue to sort shrimp from the rest of the catch and to discard most of the trawl-fish, saving only the large-sized ones. The shrimp would be headed as before, but in addition, large-sized finfish would also be gutted and cleaned. The latter operation would lengthen the amount of time spent by a crewman on these activities, though the freezing unit could conceivably produce an offsetting reduction in time spent icing the catch.

There are several disadvantages regarding use of the freezer unit. First, even though frozen shrimp have lower bacterial counts and suffer less breakage, there is no compensating price differential. Thus, increased shrimp revenues would not be forthcoming, and all freezing unit costs would have to be borne by trawl-fish. Second, frozen shrimp is more difficult to process than is iced shrimp. Finally, without a back-up system or insurance, the risk of mechanical breakdown of the freezing unit at sea introduces the risk of losing an entire trip's catch.

A hypothetical cost structure for a freezing unit is presented in Table 4. Annual fixed cost is the sum of depreciation, refrigerant, spare parts, and interest costs.3/ Annual variable cost is the sum of

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2/ Unless otherwise referenced, technical and economic information about each of the trawl-fish systems was obtained by the authors through personal interviews, telephone interviews, or correspondence. The mention of a particular design or brand name does not imply endorsement by the authors, The Texas Agricultural Experiment Station or the Sea Grant program of Texas A&M University.

3/ An interest rate of 10 percent is used in the calculations. This may not be the relevant opportunity cost even though that rate of return could be earned by investing through a financial institution. If 20 percent could be earned by investing in additional shrimping equipment instead of trawl-fish systems, that would be the appropriate interest rate to use, provided it was the maximum alternative return available to the vessel owner.

Table 4. Hypothetical cost structure of a freezing unit on board a steel shrimp trawler of the 66-72 foot keel-length category.

Annual depreciation			
Cost of unit	$ 8,000.00		
(5 year life, straight line method, no salvage value)	$ 1,600.00		
Refrigerant		$ 40.00	
Spare parts		$ 550.00	
Opportunity interest cost [(Initial investment + salvage value) ÷ 2] x Interest rate = [($8,000 + 0) ÷ 2] x .10[a]		$ 400.00	
Annual Fixed Cost (AFC)			$ 2,590.00
Fuel cost (annual)		$ 2,352.00	
Trips per year	28		
Days per trip[b]	10		
Hours of operation per day	24		
Fuel consumption--gal./hr.	1		
Annual hours of operation	6,720		
Price per gallon (diesel)	$ .35		
Repair and maintenance (.15 x $8,000)		$ 1,200.00	
Annual Variable Costs (AVC)			$ 3,552.00
Total Annual Costs			$ 6,142.00

[a]For comments on the 10 percent interest rate see p. 10, n. 3.

[b]It is assumed that the refrigeration unit would be operating during the entire time at sea. The hold would be empty during the day of travel to the grounds, but some operation would be necessary prior to fishing in order to achieve a suitably low temperature before stowing the catch. Also, an assumption of eight fishing days per trip, 12 fishing hours per day and 28 trips per year gives approximately 2700 fishing hours per year (actual value = 2688 hours). This is consistent with the calculations in Table 3.

fuel expenditures and repair and maintenance costs. By substituting the values for AFC and AVC calculated in Table 4 into Equation (2) and letting α = .65, the break-even formula becomes:

$$P_{ff} = \frac{\$2,590 + \$3,552}{.65Q_{ff}} \qquad (4)$$

If it is also assumed that 2.5 percent of the finfish are suitable for human consumption and that the fish to shrimp ratio is 7:1, 9,625 pounds of foodfish would be landed (Table 2). The break-even price for 9,625 pounds of foodfish landed would be $.98 per pound as shown in Table 5. All the break-even prices in Table 5 are calculated in the same fashion. The management and crew's share will be the dollar values of 6,256 and 3,369 pounds, respectively (65 and 35 percent, respectively). Management's share would be used to offset the costs of the system and to improve profits; the crew's share would be available as extra income.

From this, calculations can also be done to determine the potential hourly returns for crew members. The total annual costs (AVC + AFC) of a freezer system were calculated as $6,142 (Table 4). Since the vessel owners receive 65 percent of the gross value of the catch, the gross value must be $9,449.23 (i.e. $6,142 ÷ .65) in order for the system to break even under the assumed conditions. Thirty-five percent of this gross catch value goes to crew members. Table 6 shows the calculation of returns [using Equation (3)] to the individual crew members under break-even conditions for the freezing unit. The captain would receive an additional $.55 per hour of fishing, the rigsman $.43, and the header $.24. It is important to remember that these figures are calculated under break-even conditions for a specifically assumed cost structure. It should also be noted that for the values in Table 6 to be considered net increases for the crew, it has to be assumed that foodfish harvesting will not interfere with shrimp production.

Brine Immersion Tank

The brine immersion system consists of a large tank holding seawater which is used to preserve the fish. The entire trawl-fish catch is preserved. In warm climates, such as that of the Gulf of Mexico, the tanks are cooled close to freezing termperatures in order to retard spoilage. This method is used by the industrial fishing fleet of the Gulf. Boats in this fleet fish for menhaden or bottomfish used in pet food. The capacities of their tanks range from 75 to 300 tons of fish.

Table 5. Break-even prices for foodfish landed by a steel shrimp trawler of the 66-72 foot keel-length category using a freezing unit.[a]

Percentage of foodfish in trawl-fish catch	Ratio of trawl-fish caught relative to shrimp			
	1:1	4:1	7:1	15:1
	--------------------dollars/lb.--------------------			
.5	34.36	8.59	4.91	2.29
2.5	6.87	1.72	.98	.46
5.0	3.44	.86	.49	.23

[a]These break-even prices are calculated on an "in the round" weight basis. This is done to permit comparison with available quoted wholesale prices. The product would actually be headed and gutted when unloaded at the dock.

Table 6. Potential returns to crew members from harvesting foodfish using a freezing system at the owner's break-even point.

Hours of fishing per year per vessel[a]	2,700	
Total annual cost of the freezing system[b]	$6,142.00	
Break-even catch value ($6142 ÷ .65)	$9,449.00	
Crew's share as fraction of total	.35	
Value of crew's share	$3,307.00	
Captain's share (45% of crew's share)		$ 1,488.00
Approximate percentage increase in annual return		10%
Captain's additional return per hour of fishing		$ .55
Rigsman's share (35% of crew's share)		$ 1,158.00
Approximate percentage increase in annual return		10%
Rigsman's additional return per hour of fishing		.43
Header's share (20% of crew's share)		$ 661.00
Approximate percentage increase in annual return		10%
Header's return per hour of fishing		$ .24

[a]Calculated in Table 3, p. 7.

[b]Calculated in Table 4, p. 11.

Fish which are landed by vessels of the industrial fleet usually arrive in good quality, but during the peak fishing season these vessels stay out an average of only five to six days. Gulf shrimp trawlers usually average twice the trip time of the industrial fishing boats. Experience has shown that after three days in a brine immersion tank, bacterial counts become high enough to make the fish unsafe for human consumption. After ten days, bacterial growth stemming from the digestive tract makes even pet food use questionable.4/ Given these considerations, it would probably be impossible for a shrimp trawler to stay out for the length of a normal trip and use brine immersion to store the entire catch. Shrimp would have to be preserved by the methods now used, and the trawl-fish separated for brine storage. Because of this, a vessel could not carry a tank designed for 75 to 300 tons of fish and retain shrimping as the primary activity. Accordingly, the tank proposed for shrimp trawlers is much smaller and would displace only 3,000 gallons of water (400 cubic feet) giving it a capacity of 2,000 pounds of fish. Given a uniform catch rate, this unit would probably be used only during the second half of the trip. The alternatives to this would be either a technological improvement allowing longer brine storage or shorter shrimping trips. In either of these cases, both shrimp and trawl-fish could be stored unsorted in cooled brine. Sorting would then occur at the dock.

With the addition of this system, the crew's activities would change very little. As before, the trawl would be dropped onto the deck and the shrimp and large foodfish desired by the crew would be sorted out. With this system, however, instead of shoveling the trawl-fish overboard, the crew would place them in the tank. There would be some additional sorting of debris and undesirable elements (crabs, starfish, stingray) from a catch.

Table 7 presents the hypothetical cost structure for the brine immersion system. Table 8 presents the break-even price given the hypothesized cost structure, an annual shrimp catch of 55,000 pounds, a 35 percent crew share, and a 1:1 trawl-fish to shrimp ratio. It should be noted that with 28 trips per year (as assumed) and a 2,000 pound tank, the maximum annual trawl-fish catch is limited by capacity to 56,000 pounds. Since all trawl-fish are kept with this system, Equation (1) is used for break-even calculations. The break-even formula is thus:

$$P_{tf} = \frac{AFC + AVC}{\alpha Q_{tf}} = \frac{1,450 + 2,514}{.65(55,000)} = .11$$

4/ Pet foods involved in interstate commerce are inspected by the USDA.

Table 7. Hypothetical cost structure of a 3000 gallon brine immersion system on board a steel shrimp trawler of the 66-72 foot keel-length category.

Annual depreciation				
Cost of unit (5 year life, straight line method, no salvage value)		$ 5,000.00		$ 1,000.00
Spare parts				$ 200.00
Opportunity interest cost $\left(\frac{\text{initial investment - salvage value}}{2}\right) \times \text{interest rate} =$				
$\left(\frac{\$5,000 + 0}{2}\right) \times .10^{a} =$				$ 250.00
Annual Fixed Cost (AFC)				$ 1,450.00
Fuel Cost				
Trips per year		28		
Days per trip	10			
Days fishing 8				
Days running 2				
Days unit operates during trip (10 ÷ 2)		5		
Hours operating per day of operation		24		
Annual hours of operation		3360		
Fuel consumption--gal./hr.		1.5		
Annual fuel consumption			5040	
Price per gallon			$ .35	
Annual fuel expenditures				$ 1,764.00
Repair and maintenance (.15 x $5,000)				$ 750.00
Annual Variable Cost (AVC)				$ 2,514.00
Total Annual Costs				$ 3,964.00

[a]For comments on the 10 percent interest rate, see above p. 10, n. 3.

Table 8. Break-even price for trawl-fish landed by a steel trawler of the 66-72 foot keel-length category using a 3000 gallon brine immersion tank.

Ratio of trawl-fish caught relative to shrimp	Break-even price
	dollars/ton
1:1[a]	$222.00

[a]Under the assumptions of a 2,000 pound capacity tank and 28 trips per year, the maximum possible annual trawl-fish harvest is 56,000 pounds. The actual ratio used in the break-even calculations is 1:1.

Thus, the approximate break-even price per pound of fish landed is $.11 or $222.00 per ton of fish landed.

Table 9 shows the calculation of the potential returns to crew members assuming the break-even conditions exist and the crew gets 35 percent of the value of the catch. It also should be noted that it is assumed that trawl-fish are handled during only half the time spent shrimping. The return per hour is really the return per hour for time when trawl-fish are on board. The figures obtained are $.71, $.55, and $.32 per hour for the captain, rigsman, and header, respectively.

Fish-Meal Plant

This system proposes the installation of a small, on-board fish-meal plant. This plant would reduce virtually the entire trawl-fish catch to a meal product. Driving power and heat for cooking and drying purposes would be supplied by the vessel's engine and exhaust gases. The unit would be installed between the ship's engine and ice hold; it would provide forward compartment storage for 6 tons of fish-meal and would displace about 25 percent of the ice hold.5/

Such a system would have several advantages. An on-board fish-meal plant would make it possible to utilize most of the trawl-fish. Unlike the freezing unit system, it would not be necessary to discard everything except foodfish. Furthermore, the brine immersion system constraint of operating during only half the trip would be removed. The plant would reduce the fish to a product weighing roughly 20 percent as much as raw fish. Storage capacity would thus be 80 percent less than that required by an equivalent quantity of raw fish. It would be unnecessary to store raw fish, and the handling of them would be reduced. The unit would be small enough not to interfere with shrimping operations; if conflicts of this sort arise, they would probably stem from factors other than the size of the unit. Relative to a land-based system, the initial costs would be rather low; operating costs would also be low.

There are also disadvantages with this system, most of which are serious. Technical problems arise because of the presence of fish oil in the meal. This oil introduces both quality control problems and the risk of oxidation, which causes rancidity and spontaneous heating. Since almost all animal fats and oils are susceptible to rancidity caused by oxidation, the problem certainly is not unique to fish and fish products. However, susceptibility to this

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5/ From the information available, the 6 ton storage capacity figure is thought to be an upper limit.

Table 9. Potential hourly returns to crew members from harvesting trawl-fish using a 3000 gallon brine immersion system at the owner's break-even point.

Hours of fishing time per year per vessel[a]	2,700	
Hours of fishing time during which trawl-fish are handled and maintained on board (2700 ÷ 2)[b]	1,350	
Total annual cost of the brine immersion system[c]	$ 3,964.00	
Break-even catch value ($3,964 ÷ .65)	$ 6,098.00	
Crew's share as fraction of total	.35	
Value of crew's share	$ 2,134.00	
Captain's share (45% of crew's share)		$ 960.00
Approximate percentage increase in annual returns		5%
Captain's return per hour of trawl-fish handling		$ .71
Rigsman's share (35% of crew's share)		$ 747.00
Approximate percentage increase in annual returns		5%
Rigsman's return per hour of trawl-fish handling		$ .55
Header's share (20% of crew's share)		$ 427.00
Approximate percentage increase in annual returns		5%
Header's return per hour of trawl-fish handling		$ .32

[a]Calculated in Table 6, p. 14.

[b]Because of the maximum storage time that can be achieved with the brine immersion system, it is assumed the unit operates only during the second half of the trip, and therefore, fishing time is divided by 2. See above, p. 15.

[c]Calculated in Table 7.

complicated process varies positively with the presence of polyunsaturated carbon chains in the oil [3, p. 175]. Since fish oils are highly polyunsaturated, oxidation caused by exposure to the air is the most general cause of fish oil flavor and odor deterioration [9, p. 141].

In relation to fish-meal production, the oil oxidation problem occurs because the meal will contain oil in varying amounts, depending on the raw material from which the meal is produced and the production process used. The oil content of Gulf trawl species may vary from approximately 2 percent to 13 percent [2, Table 2, p. 25], causing one to expect wide variation in the oil value of meal produced from different batches of fish. The oilier the fish, the greater the problem of oxidation during production and storage. Meinke [11, p. 6] has suggested that the oil content of meals produced aboard shrimp trawlers could be excessive by current standards. An earlier reference suggests that for commercial classification purposes, non-oily meal may contain up to 2 percent oil while oily meal may contain up to 6 percent oil [3, p. 428]. On an 8 percent moisture basis, Meinke considers a 4 to 8 percent oil component to be excessive [11, p. 6]. In any case, the conditions for preservation of oil in fish meal are poor because of the large surface exposed to the air. Problems of acidity and oil hydrolysis may occur as storage time accumulates [3, p. 429].

On board the shrimp trawler, oxidation of improperly stored meal may result in spontaneous heating and fire hazard. If the forward hold tends to be hot and humid, the problem could be aggravated; under such conditions bacterial counts could also become troublesome. Of course, marketing would be a problem as well. Oxidation causes the meal to have a scorched taste and to be darkened. The value may also be unfavorably altered. Finally, potential purchasers would need to know the composition and properties of the meal they were obtaining, and they would want some assurance of a continuing supply of uniform meal. Even if the oxidation problem could be solved, quality control problems could still be expected if the oil content varied from one batch of fish to the next.

Though the above problems are severe, they should by no means be considered insurmountable. Curing processes and antioxidants exist--obviously onshore plants have dealt satisfactorily with the technical problems [1, pp. 158-59; 12]. The question is whether or not they can be overcome for on-board trawl processing at an economically feasible cost.

Unfortunately, problems other than those associated with the technological nature of the process exist. The meal itself is in bulk form which is rather inconvenient and necessitates either packaging by the crew or shore facilities to remove it from the vessel's hold.

The crew could be expected to object to any additional work as well as to the odor emitted by a reduction unit. Also, the addition of a shrimp meal plant would significantly alter the activities of the crew during shrimp trawling. After the trawl fish were separated from a catch, they would have to either be fed continuously into the reduction unit or accumulated into appropriately sized batches and fed intermittently into the unit. This means not only that fish would be on deck during and probably after trawling, but also more work for the crew. It also raises the question of just how much such a system would interfere with the shrimping operation. The sorting of the shrimp catch is in itself a production bottleneck. The handling of trawl-fish would aggravate this problem, though mechanical sorting might provide relief. If mechanical sorting was employed, the salvaging of trawl-fish could provide an additional source of revenue with which to offset the expense of a unit. However, even though such a machine has been designed, the use of sorters apparently has occurred only on a very limited scale.6/

The hypothetical cost structure for the reduction unit is shown in Table 10. Annual fixed cost (AFC) and annual variable cost (AVC) for the meal plant are computed as $9,191 and $5,214, respectively. The assumptions of a 65 percent management share and a 55,000 pound annual shrimp catch are continued. It is also assumed that the trawl-fish catch reduces to a quantity of meal weighing 20 percent of the raw fish poundage. The break-even formula for the reduction unit then becomes [from Equation (1)]:

$$P_{tf} = \frac{AFC + AVC}{\gamma \alpha Q_{TF}} \qquad (5)$$

where

γ = Weight of the meal product as a fraction of the raw trawl-fish weight = .20

The break-even prices for a reduction system are given in Table 11 and range from $4,029 per ton to $269 per ton for a 1:1 and 15:1 ratio, respectively.

In Table 12 we give the potential hourly returns to crew members under break-even conditions. The potential hourly returns to crew members are $1.29, $1.01 and $.57, for captain, rigsman and header, respectively.

6/ For an article on the sorter, see [5]. In this article, the manufacturer claims substantial increases in the amount of shrimp recovered and in vessel operating time would result from use of the sorter. However, information available indicates these devices have been used only on a very limited basis.

Table 10. Hypothetical cost structure of a fish-meal reduction unit on board a steel shrimp trawler of the 66-72 foot keel-length category.

Annual depreciation (meal plant)			
Cost of unit	$34,763.00		
(5 year life, straight line method, no salvage value)		$6,953.00	
Renovation of forward compartment			
(5 year life, $2,500 initial outlay)		$ 500.00	
Opportunity interest cost [(Initial invest + salvage value) ÷ 2] x Interest rate = [($34,763 + 0) ÷ 2] x .10[a]		$1,738.00	
Annual Fixed Cost (AFC)			$9,191.00
Repair and maintenance (.15 x $34,763)	$ 5,214.00		
Annual Variable Costs (AVC)			$5,214.00

[a]For comments on the 10 percent interest rate, see above p. 10, n.3.

Table 11. Break-even prices for fish-meal produced by a steel trawler of the 66-72 foot keel-length category with an on-board reduction unit.

Ratio of trawl-fish caught relative to shrimp	Break-even price
	dollars/ton
1:1	$4,029
4:1	$1,007
7:1	$ 583
15:1	$ 269

Table 12. Potential returns to crew members from harvesting trawl-fish using an on-board reduction unit at the owner's break-even point.

Hours of fishing time per vessel per year[a]	2,700	
Total annual cost of the meal plant system	$14,405.00	
Break-even catch value ($14,405 ÷ .65)	$22,162.00	
Crew's share as fraction of total	.35	
Value of crew's share	$ 7,756.00	
Captain's share (45% of crew's share)		$3,490.00
Approximate percentage increase in annual returns		23%
Captain's return per fishing hours		$ 1.29
Rigsman's share (35% of crew's share)		$2,715.00
Approximate percentage increase in annual returns		23%
Rigsman's return per fishing hour		$ 1.01
Header's share (20% of crew's share)		$1,551.00
Approximate percentage increase in annual returns		23%
Header's return per fishing hour		$ .57

[a]Calculated in Table 3.

Extra Crewman

The next system hypothesized involves the addition of a crewman whose function it would be to recover only the large foodfish brought aboard an ice shrimp boat. No equipment would be added. The crewman would be expected to clean and gut the fish and possibly fillet them, too. Most of the large shrimp boats have four or more bunks, and with a regular crew of three there would be room for another crewman. The additional crewman could be paid an hourly wage, a percentage of receipts from the sale of foodfish, or a combination of both.

Such a system has several advantages, most of them dealing with the required investment level and the ease with which such a system could be inaugurated. There would be no need for additional equipment and hence, no additional investment costs would be incurred. Furthermore, it would not be necessary to temporarily withdraw the vessel from service for equipment installation purposes. In fact, if an average shrimp catch could be expected and the usual amount of excess capacity maintained without additional icing, the only cost this system would incur would be that of an additional crew member. Even if additional icing was necessary, the costs involved would be only that of the extra crew member and the additional ice.

Unfortunately, this system, like the others, is not free of disadvantages. There is, of course, the problem of devising an incentive system which induces the crewman to maximize the value of the foodfish catch, net of costs. It would be difficult to find men willing to work exclusively with trawl-fish under any conditions where shrimping employment appeared more lucrative though this is a simple opportunity cost problem. Conflicts could arise if options of taking either foodfish or shrimp arose. That is to say, under present institutional arrangements, the captain and crew get 35 percent of the value of the catch. If one crew member receives 35 percent of the value of the trawl-fish catch while the rest of the crew receives 35 percent of the shrimp catch, a situation allowing a choice between shrimp and fish is bound to cause a conflict of interest. Furthermore, the system must be devised in a way such that the additional crewman can handle and ice down fish without disrupting shrimping activities.

The hypothetical cost and returns structure resulting from an additional crew member is presented in Table 13. The assumptions of a 55,000 pound annual shrimp harvest and a 65 percent management share are still employed. Additionally a 10,000-pound hold capacity is assumed. The fishing time of 2,700 hours per year is assumed (as calculated in Table 3) and also the extra crew member would be paid \$2.00 an hour in addition to receiving 35 percent of the gross value of the trawl-fish catch. It is also assumed that two pounds of ice would be required to preserve each pound of foodfish stowed and that the price of ice is 1/2 cent per pound.

Table 13. Hypothetical costs and returns to an additional crew member recovering edible trawl-fish on board a shrimp trawler of the 66-72 foot keel-length category.[a]

Trawl-fish to Shrimp Ratio	Percentage of Foodfish in Catch	Pounds of Foodfish	Ice Expenditure	Annual Variable Cost	P_{ff}[b]	Value of Crewman's Share	Extra Crewman's Annual Income
1:1	.5	275	$ 3.75	$5,403.75	$30.23	$2,909.71	$8,309.71
	2.5	1,375	18.75	5,418.75	6.06	2,917.79	8,317.79
	5.0	2,750	37.50	5,437.50	3.04	2,927.88	8,327.88
4:1	.5	1,100	15.00	5,415.00	7.57	2,915.77	8,315.77
	2.5	5,500	75.00	5,475.00	1.53	2,948.08	8,348.08
	5.0	11,000	150.00	5,550.00	.78	2,988.46	8,388.46
7:1	.5	1,925	26.75	5,426.75	4.34	2,922.10	8,322.10
	2.5	9,625	133.75	5,533.75	.89	2,979.71	8,379.71
	5.0	19,250	267.50	5,667.50	.45	3,051.73	8,451.73
15:1	.5	4,125	56.25	5,456.25	2.04	2,937.98	8,337.98
	2.5	20,625	281.25	5,681.25	.42	3,059.14	8,459.14
	5.0	41,250	562.50	5,962.50	.22	3,210.58	8,610.58

[a]Assumptions: The vessel lands 55,000 pounds of shrimp per year, two pounds ice required per pound of foodfish, price of ice is .5 cents per pound, 2700 hours of fishing time per year, additional crewman paid $2 per hour of fishing plus 35 percent of gross value of trawl-fish catch. Also, crewman's share = [(AVC + AFC) ÷ .65] .35 under break-even conditions; AFC = 0.

[b]These prices are calculated on an "in the round" weight basis to allow comparison with available quoted wholesale prices.

The break-even prices are displayed in Table 13 and range from a high of $30.23 per pound to a low of $.22 per pound depending on assumptions. Since it is assumed that working time remains at 2,700 fishing hours per year, annual variable cost (AVC) changes only as the outlay on ice changes. As can be seen, this outlay is not very large when compared to the $5,400 yearly outlay on labor. Accordingly, total revenues required to break-even on this type of operation do not vary widely--the revenues required to break-even under conditions which produce the minimum harvest of foodfish in Table 13 will be roughly 90 percent of those required to break-even when the maximum harvest shown in Table 13 is taken. Because the crewman's share is 35 percent of the gross catch value, the minimum value of the crewman's share will be roughly 90 percent of the maximum value. This can be calculated from the information in Table 13. It can also be shown that the additional man's share value of foodfish per hour of fishing ranges from a minimum of $1.07 to a maximum of $1.19, given the different hypothesized break-even conditions. It should be recognized that these calculations are made at the break-even level of operation. As landings of foodfish exceeded this level, returns to both crewman and management would increase. As with all systems discussed earlier, the assumed rates of pay and other factors could be varied as appropriate. It is important to recognize that this system includes no provision for enhancing the returns to other crew members.

Tender Vessel

A tender vessel, or mother ship, is the last system to be described. The purpose of this vessel would be to gather trawl-fish from the shrimp boats working the grounds and deliver these fish to demand points. The type of boat envisioned is similar to those used in the industrial fish fleet; that is, one equipped with a 150-ton capacity brine immersion tank. This vessel would not do any trawling of its own but rather would simply pump aboard the trawl-fish discarded by the shrimp boats. This task would be facilitated by the tendency of the shrimp vessels to congregate while trawling during the peak shrimping season. Thus, the mother ship would fill its hold by staying close to one or several groups of trawlers.

The mother ship concept offers several advantages. The individual shrimp vessels would need no alteration in equipment or crew size, since a vessel specialized in trawl-fish recovery would be used to load them. Also, since discarding is practiced by all shrimpers, operation of the mother vessel could be handled in several ways. A large fleet owner might operate it for the sole use of his vessels. A group of owners could organize through partnership or cooperative to operate the vessel. It would also be possible for a firm or firms specialized in the recovery of trawl-fish to operate such a vessel.

Disadvantages could also be expected, however. It would be necessary to coordinate the operations of the tender vessel and the shrimp fleet in such a way that they could operate simultaneously without interfering with each other's activities. There might also have to be a trial period during which the operations of the mother vessel would be perfected. Furthermore, there would have to be some kind of organizational structure developed for the purpose of carrying out the operations of a tender vessel. Finally, there would be the problem of financing such a vessel. The degree of difficulty presented by this last problem would be inversely related to the viability of the project. If the financing problem proved to be intractable, it would reflect a lack of confidence in the project. This problem would become less difficult if the project became obviously more profitable.

The hypothetical cost structure of a tender vessel is reported in Table 14. The treatment is summarized, with some modification, from Juhl's development of costs for an industrial fish vessel [7]. We retain Juhl's assumptions of a vessel with a 150-ton capacity which makes 40 trips per year during which it operates 4,040 hours and fishes 2,600 hours. His figures for lubrication, administrative, contingency, and insurance, hull and P&I expenses are accepted. The supplies and repair and maintenance figures are summarized from his work, and it is assumed the annual expense of pumps and associated equipment designed to bring the trawl-fish on board would be about the same as that for nets and gear. However, the price per gallon of fuel has been revised upward to 35 cents. Also, opportunity interest cost and annual depreciation expenses are used instead of Juhl's repayment of principal, amortization, and interest costs. This modification keeps the analysis of the system within the framework used for the other recovery methods.

Since this system requires labor input in addition to the crew of the shrimp trawler, another change was also made in Juhl's budget. Since the tender vessel is not actually catching the fish, it is assumed that the crew would be paid a wage rather than a share of landings. For convenience, this payment was assumed to be equal to the share value for the average shrimp trawler crew as shown in Table 3. Alternative assumptions could be used which might include some form of share basis incentive for the tender vessel crew. The shrimp trawler crew would receive 35 percent of the value of landings as under the other systems but the additional labor input must also be covered.

From Table 14, it can be seen that the calculated annual fixed cost (AFC) is $60,450 and the annual variable cost (AVC) is $88,116. The break-even prices range from $346 per ton for a 1:1 ratio to $38 per ton for a 9.09:1 ratio. It should be noted that Q_{tf} in Equation (1) may be any value taken from Table 1. However, it is assumed that the tender vessel has a 150-ton capacity and at any one time it is supplied by 24 shrimp trawlers. Assuming that the tender vessel makes 40 trips per year, it can harvest up to 12,000,000 pounds of trawl-fish annually.

Table 14. Hypothetical cost structure of a tender vessel outfitted for recovering discarded trawl-fish.[a]

Annual depreciation			
Cost of unit (10 year life, straight line method, no salvage value)	$250,000.00	$25,000.00	
Opportunity interest cost $\left(\frac{\text{initial investment + salvage value}}{2}\right)$ x interest rate =			
$\left(\frac{250,000 + 0}{2}\right) \times .10$[b]		$12,500.00	
Administrative		$ 600.00	
General repair and maintenance		$ 3,850.00	
Pumps repair and maintenance		$ 7,000.00	
Insurance, hull, and P&I		$ 8,500.00	
Contingency		$ 3,000.00	
Annual Fixed Cost (AFC)			$ 60,450.00
Labor[c]		$33,303.00	
Fuel		$49,490.00	
Annual hours of operation	4,040		
Gallons consumed/hour	35		
Price/gallon	$ .35		
Lubricants		$ 688.00	
Annual gallons consumed	550		
Price/gallon	$ 1.25		
Supplies		$ 4,635.00	
Annual Variable Cost (AVC)			$ 88,116.00
Total Annual Costs			$148,566.00

[a] See [7].
[b] For comments on the 10 percent interest rate, see above p. 10.
[c] Straight salary assured for crew of tender vessel. Charge at the rate of payment for a crew of three on a typical shrimp trawler (Table 3).

Twenty-four shrimp vessels, each landing 55,000 pounds of shrimp yearly will supply 12,000,000 pounds of trawl-fish annually when the ratio of trawl-fish to shrimp harvest is approximately 9.09:1. Accordingly, the full capacity of the vessel is utilized when this ratio is reached. This is the "full capacity ratio" cited in footnote a of Table 15. Table 15 gives the calculated break-even prices.

It should be noted that the relevant break-even price would need the "full capacity" level. The tender vessel could be operated at this level with 24 trawlers under the assumptions discussed above. If, however, the catch ratio was lower, the logical adjustment would be to have the tender vessel service more shrimpers. This could probably be done without much effect on the cost structure so it would be logical to expect that the system would operate near "full capacity" even if a few additional shrimpers were required to supply the fish.

Estimates for potential additional returns to shrimp trawler crew members for this system are shown in Table 16. At the owner's break-even point, the increase in returns to the crew would be about 10 percent. Again it should be noted that these returns would increase if the system operated at a profit position exceeding the break-even level.

Table 15. Break-even prices for trawl-fish landed by a 150-ton tender vessel.

Ratio of trawl-fish caught relative to shrimp	Break-even price
	dollars/ton
1:1	$346
4:1	$ 87
7:1	$ 49
9.09:1[a]	$ 38

[a]Capacity of the tender vessel is reached at a 9.09:1 ratio based on 55,000 pounds of trawl-fish supplied from each of 24 shrimp trawlers and the 150-ton capacity of a tender vessel making 40 trips per year.

Table 16. Potential returns to crew members from harvesting trawl-fish using a tender vessel calculated at the owner's break-even point.

Hours of fishing time per vessel per year[a]	2,700	
Total annual cost of operating tender vessel system	$148,566.00	
Cost per trawler serviced ($148,566.00 ÷ 24)[b]	$ 6,190.00	
Break-even catch value ($6,190.00 ÷ .65)	$ 9,523.00	
Crew share	$ .35	
Value of crew's share (annual)		$3,333.00
percentage increase[c]		10%
Captain's share (45%)		
Annual		$1,500.00
Captain's additional return/hour fished		.56
Rigsman's share (35%)		
Annual		$1,167.00
Rigsman's additional return/hour fished		.43
Header's share (20%)		
Annual		$ 666.00
Header's additional return/hour fished		.25

[a]See Table 3.

[b]Calculation based on 24 trawlers being serviced by tender vessel.

[c]Calculation based on average returns as shown in Table 3.

COMPARISON OF BREAK-EVEN PRICES WITH AVAILABLE MARKET PRICES

Once the break-even prices have been calculated, a comparison with available market prices will provide further information on the economic feasibility of the proposed systems. A glance at Table 17, which presents fish price indices as reported by the NMFS [10], indicates that fish prices have indeed risen. The most recent prices quoted are roughly three times as great as those occurring in the base year 1967. Species included in these indices are not those that occur widely in the Gulf. However, such price information should lead to the increased utilization of species previously not within the margin of harvest. Dramatic increases in prices intensify incentives to find substitute goods. Nevertheless, relative increases in prices do not tell the whole story. In order to determine whether break-even prices can be met, information on absolute prices must be evaluated.

A simple spot check of prices provides most of the information needed. Table 18 displays NMFS information on several Gulf foodfish species, and on menhaden, an industrial fish [10]. The lowest quoted foodfish price is 15 cents per pound, the highest 55 cents. The lowest break-even prices for foodfish retained by a freezing unit are 49 cents, 46 cents, and 23 cents (Table 5). The lowest break-even prices for foodfish recovered by an additional crew member are 45 cents, 42 cents, and 22 cents (Table 13). Somewhat less favorable prices of 78 cents and 89 cents are also calculated. Provided that the incidental foodfish catches are comparable with those sold on the New Orleans market (prices listed in Table 18) and that ex-vessel and wholesale fresh-fish prices are roughly comparable, the lowest break-even prices do compare favorably with available prices. However, it certainly cannot be assumed that the incidental trawl catches produce foodfish comparable to those now on the market. Furthermore, the lowest break-even prices are based upon the most favorable assumptions made about foodfish availability. Though these availability levels may hold occasionally, it is certainly questionable to assume that they exist throughout the year--yet the break-even calculations assumed this. For these two reasons and the institutional limitations discussed in earlier sections describing these systems, potential economic viability of the two foodfish recovery systems (extra crewman and freezing) must be regarded as very tenuous.

The tender vessel and the brine immersion systems are designed to recover industrial fish. Recent ex-vessel menhaden prices are included in Table 18, the highest of which converts to $82 per ton. This fish is a high quality industrial species, and its price must be regarded as the upper limit on the price of incidental trawl-fish--in fact, it is unlikely that the incidental catch can meet menhaden quality standards. The pet food market may be a more logical basis

Table 17. Ex-vessel price indices of various types of marine fishes at selected dates (1967 price = 100).[a]

Date	Type of Fish		
	Edible Fish[b]	Edible Finfish[c]	Industrial Fish (Menhaden)
1-73	190.4	211.4	217.7
3-73	203.7	220.1	203.1
11-73	258.7	292.3	291.3
12-73	261.8	298.4	345.5
1-74	254.9	291.2	321.2
2-74	256.6	305.5	321.2
3-74	255.5	307.7	321.2
4-74	256.7	302.3	334.2

[a]Indices are as reported in [10]. Dates of the Market Report used for this table are 3-13-74, 5-13-74, and 5-31-74.

[b]Based on approximately 3 dozen types of finfish and shellfish.

[c]Based on approximately 2 dozen types of finfish.

Table 18. Spot check of wholesale fish prices in cents per pound at the New Orleans fresh fish market.[a]

Type of Fish	Date of Report 3-6-74	3-18-74	4-1-74	5-13-74
Med. Drum, Blk.	20	15-20	20-25	20
Med. Drum, Red	25-30	25-35	30-35	40-45
Lge. King Whiting (Blk. Mullet)	20	15-20	15-20	15-20
Lge. Sea Trout, Sptd.	40-45	45-50	45-50	45-55
Sea Trout, Wht.			20-30	
Lge. Croaker		20-25		

Dates	1-73	11-73	1-74	2-74	3-74	4-74
Menhaden[b]	2.7	3.6	4.0	4.0	4.0	4.1

[a]As reported in [10]. Date of report refers to the date of that particular issue of Market Report in which this price information is found. All prices are "in the round."

[b]Menhaden prices are not quoted in the fresh fish price summary of the Market Report, but appear with the ex-vessel price indices of the Market Report. Menhaden prices are thus not quoted wholesale, but ex-vessel. Menhaden price information comes from Market Report dates 3-13-74, 5-13-74, and 5-31-74. Dates listed in the table are the dates on which the individual menhaden prices were effective.

for obtaining comparative prices. Prices for this market are not officially quoted, but checks with the industry indicate that recent prices average less than the menhaden price quoted above (35 to 50 dollars per ton). At a break-even price of $222 per ton (Table 8), the brine immersion system should be regarded as untenable.

Break-even prices for the tender vessel system are in the approximate range of values in the pet food market under the best conditions. The questionable quality of trawl-fish and the technical problems of joint tender vessel-shrimp trawler operations are major limitations to the viability of this system.

A spot-check of Peruvian and menhaden meal prices, as they have existed since the beginning of 1972, is presented in Table 19 [4]. Maximum prices quoted are around $600 per ton, but the most recent prices are $200 or $300 below this. The lowest break-even point ($269, Table 11) for the meal plant is within the range of available prices, but if these fall to early 1972 levels, the system is clearly untenable. Since the quality of the meal produced by on-board plants is questionable, and since difficult technical problems are involved, this system must also be regarded as tenuous. Furthermore, the lowest meal-plant, break-even price is based on the best finfish availability assumption used. Inasmuch as this level of availability may not be present, the prospect of economic success is very low.

Crew Incentives

The adoption of some system of utilizing trawl-fish discards from shrimpers will depend on more than an analysis of measurable returns to owners. The incentives for the crew are important also as a significant change in work arrangements and attitudes will be necessary to make any proposed system successful. The analyses discussed above indicate that earnings of crew members could be enhanced more under some systems than others when evaluated at the owner's break-even point. They ranged from zero for the extra crewman (foodfish system) to a 25 percent increase for the on-board fish-meal plant. The others were in the 5 to 10 percent range.

The adoption of some system of saving trawl-fish may occur first on owner-operated vessels as the incentives are more significant when both management return and captain's share are combined. Even under this situation, however, most of the systems examined in this report could be considered tenuous, at best, given the obvious technical and institutional problems inherent in their adoption.

Table 19. Spot check of fish meal prices (dollars per ton).[a]

Date	Market: Atlanta		Fort Worth		Memphis	
	Menhaden	Peruvian	Menhaden	Peruvian	Menhaden	Peruvian
1- 3-72	175.00n	170.00	175.60	172.60	160.00s	160.00s
7- 3-72	183.00	183.00	186.40	186.57	177.00	177.00
1- 1-73	275.00n	300.00n	275.00n	339.00	325.00	325.00
3- 5-73	420.00n	420.00n	451.35	451.35n	400.00	400.00
6- 2-73	470.00n	550.00n	605.67n		600.00	
11- 5-73	400.00	450.00	444.00		425.00	
1- 7-74	550.00n	550.00n	550.00		575.00	
3- 4-74	425.00	425.00	449.40		400.00	
4- 1-74	375.00	425.00n	350.00		410.00	
5-20-74	275.00	400.00	274.40		280.00	

[a]Prices are as quoted in [4], vols. 44, 45, 46. Dates listed are the dates of Feedstuffs issues in which the prices quoted appeared (n = nominal, s = sacked). Feedstuffs offers quotations from 11 markets, but only three, selected because they are relatively close to the Gulf, are quoted here.

SUMMARY AND CONCLUSIONS

Summary

The economic potential of utilizing finfish caught incidental to shrimp trawling depends both on market demand and the cost structure of systems of utilization. Market considerations were evaluated in a separate report while the cost structure considerations were examined in this research report.

A framework of analysis was developed to derive estimates of break-even costs for operating alternative systems of utilizing the incidental catch. The factors included are fixed and variable costs, shares accruing to owner of vessel and the quantity of trawl-fish harvested annually. Five utilization systems were hypothesized: on-board freezer units, brine-tank installation, on-board fish-meal plant, extra crewman to clean and ice down food-grade fish, and a tender vessel concept. Break-even costs are estimated for each system and presented in matrix form showing changes as levels of catch change.

Two systems hypothesized to recover fish of edible grade require returns generally higher than market prices available. Only under the most favorable conditions could costs of recovering these fish be held below 50 cents per pound. Wholesale market prices for anticipated species landed do not average high enough to cover these costs. This, plus associated institutional problems, make the extensive adoption of such systems highly improbable.

The on-board fish-meal plant would produce a product at a cost in excess of $250 per ton under the best conditions. Current market prices approximate this level but the quality of the product produced through this system would likely be lower than fish-meal produced in a conventional manner. Even if meal prices increased to levels reached in late 1973, substantial technical and distribution problems would have to be overcome to allow significant adoption of such a system.

The installation of a brine immersion tank system on shrimp trawlers for recovering incidental finfish catch is shown to be economically untenable. A cost of $222 per ton was budgeted against a value of $50 per ton or less.

The development and operation of a system of shrimp trawlers with a larger vessel acting as a tender for the purpose of handling incidental catch generally would require a gross value of landings in excess of $40 per ton. At this level, recent prices could

permit operation of the system under the best conditions. The most important limitation would be the organizational and logistical problems of coordinating such a system in an industry where the independence of the individual vessel captain has traditionally been highly valued.

Returns to captain and crew are important, as incentives will be necessary to encourage changes in operating patterns. The estimates of additional returns associated with the adoption of the systems discussed above range from zero for the foodfish extra-crewman system to 25 percent for the on-board fish-meal plant. Other systems increased returns to the crew by 5 to 10 percent.

Conclusions

The economic viability of systems for utilizing the incidental finfish catch associated with shrimp trawling must be considered very tenuous. This observation has been made by many in the industry but the full extent of the analysis is presented here and the reasons for this conclusion are now clear. It is evident that in any analysis of this type, where hypothetical systems must be evaluated, many assumptions must be made and these influence the outcome of the research. But the important result is that a method of analysis is laid out in detail which can be followed by others wishing to evaluate other systems under other assumptions.

The limitation in utilization of the incidental catch is not in the basic market demand from the quantity point-of-view. It was shown that anticipated quantities could be absorbed in most markets without a great deal of negative effect on price. The major problem on the market side of the analysis is a limitation in the market channels available in the Western Gulf of Mexico to handle the anticipated finfish landings. The problem is one of facilities and institutions capable of handling landings of this magnitude.

On the cost side of the analysis, it is evident from the break-even analysis that the profit potential is not great enough to encourage the adoption of utilization systems. In an industry where many small operators are found to be operating in a pattern narrowly confined by tradition, such as the fishing industry, the economic incentives must be very clear to encourage change. The signal from the marketplace is not that clear to those members of the industry who must initiate the change.

The scope of this study was limited to the examination of the economic feasibility of utilizing finfish caught incidental to shrimp trawling. Its conclusions are limited to systems hypothesized to operate as by-product systems where the fishing effort is still directed at the landing of shrimp. It is quite likely that the full utilization of finfish from the Western Gulf will depend on development of a fishing industry separate from current shrimp trawling operations. The evaluation of such a development is beyond the objectives of the report presented here although many of the market limitations discussed would be relevant.

Economic pressures on the shrimp industry will continue to mount. As this occurs and market channels for finfish develop in the Western Gulf, interest will increase in finding ways of utilizing the incidental catch. The framework of analysis presented here will be of value in assessing those opportunities.

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