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

PART I: EVALUATION OF MARKETS

by

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ABSTRACT

As long as fishermen specialize their efforts in trying to harvest only a few select species, there will almost always be the problem of unwanted fish in a catch. Such is the case in the shrimp fishery, where the amount of fish caught incidental to trawling often exceeds by three or four times the amount of shrimp caught. In the past, and today, these fish are simply thrown back into the sea. However, because of growing national and international demands for protein and a slow expansion of current protein sources, the prospect of utilizing the incidental fish caught during trawling operations is being investigated.

This study evaluates the nature of the markets potentially available for trawl fish and estimates potential volumes which could be marketed through these channels. Identification of potential markets was accomplished by determining the magnitude and composition of trawl fish. Through interviews and a review of biological studies it was found that most trawl fish were less than one pound live weight and the majority of them belonged to the sciaenid family (black drum, croaker, and seatrouts); longspine porgy was the most numerous species. As yet there is no precise estimate on the amount of fish discarded in the Western Gulf of Mexico, but it lies somewhere between 52 and 368 million pounds.

Discarded trawl fish can be processed into fish meal, fish solubles, fish oil, an ingredient in pet food, and various forms of seafood (fresh and frozen fillets, fish sticks and portions, and whole fresh fish). Factors which hinder the utilization of trawl fish, however, were identified and discussed as they affect the markets for and supply of fishery products and their interaction. Among these, consumer identification of underutilized species is a significant problem. The common fishing concept of harvesting only prime species currently in demand and discarding the rest is a firmly established institutional pattern which hinders the development and utilization of other available species.

Price flexibilities were estimated for each market to evaluate impact of increased supplies on price. Based on these estimated relationships, current market conditions and the availability of trawl fish in the Western Gulf of Mexico, potential volumes which could move through each market were determined. The total catch of trawl fish by shrimpers of 368 million pounds could move through the reduction market (fish meal-and oil) with only a negligible effect on price. The pet food market could absorb 20 million pounds with no more than a 10 percent decline in price. Eighty million pounds could move through the seafood market in various forms, mainly fillets, portions, and sticks. The fresh whole fish market in Texas is the most limited and could only expand by about 1 million pounds without depressing prices more than 10 percent.

The lack of viable marketing facilities along the Texas Coast for many product forms is an important limitation on flow of trawl fish into market channels. Recent shifts in demand and relative supplies of some fish species may tend to make many of the markets studied less sensitive to increased landings of trawl fish than the flexibility estimates from historical data suggest. Estimated cost of handling trawl fish through alternative hypothesized systems is currently under study and will be reported in a subsequent publication.

Key words: fisheries, trawl fish, economics, markets, price flexibility, potential volume.

ACKNOWLEDMENTS

The research reported in this publication was initiated as part of a broad research project in the Sea Grant program at Texas A&M designed to evaluate the potential of utilizing finfish caught incidental to shrimp trawling in the Western Gulf of Mexico. It was developed under the direction of Dr. James Teer, Head, Department of Wildlife and Fisheries Science. Coordination during the project was provided by Dr. Richard Noble of the same department. Their guidance and assistance is greatly appreciated. The results of the economic and marketing segments of this study are reported in two phases, the first of which is presented here.

The authors would like to thank the members of the many firms in the fishing related industries both along the Gulf Coast and other areas of the United States for their contributions in the form of responses to interviews conducted with them. Many research personnel associated with Universities and various government agencies contributed valuable information and insights which have contributed to the report. As always, however, errors and limitations of the report remain the responsibility of the authors.

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INTRODUCTION

Background of Problem

Shrimp constitutes the most valuable fishery in the United States, accounting for approximately $600 million in retail sales in 1971 (321.3 million pounds consumed). Some 15,000 people are directly employed in the fishery, while thousands more are involved in processing, distribution, and marketing [4, p.i]. There are nearly 4,000 vessels (boats which are five net tons and over) and 10,000 boat numbers in all in the South Atlantic and Gulf of Mexico waters, which account for most of the domestic landings.

In shrimping operations, the vessel typically drags two otter trawls on the ocean bottom, side by side, which are rigged each to a boom extending from the middle of the vessel (Figure 1). When a trawl is brought up, the entire catch is dropped onto the rear deck area. As the trawl is dragged along the bottom for several hours and captured fish are packed into the cone of the trawl, most are dead upon delivery to the vessel deck. Further, since shrimp is the most valuable of the species caught (other fish on the average are valued far less), shrimp fishermen separate shrimp from the catch and shovel almost everything else overboard. In most cases the amount of shrimp caught (by weight) is a small fraction of the total trawl catch.

The central problem addressed in the research effort is whether the fish shoveled back represent an "economic" waste. The physical quantities of fish being discarded justify an investigation into alternate means of disposal. In addition, the technology is available to bring this trawl fish, as well as shrimp, ashore. What the fisherman and society must ask themselves is whether the resources used (labor, equipment, and financial) in preserving and marketing trawl fish are economically utilized when compared to all the other activities in which the same resources can be used. Simply put, will it pay off to preserve and market this fish or should the industry continue to discard them at sea?

Objectives and Scope of Research

To examine this question, analyses of two distinct types are needed. First, the nature of the markets for these species must be studied with the view toward determining their current viability and potential for utilizing this additional supply. Second, alternative systems for recovering and delivering these fish to a processor or handler have to be delineated and appropriate costs estimated. Only in this way can both the potential revenues and costs be evaluated.

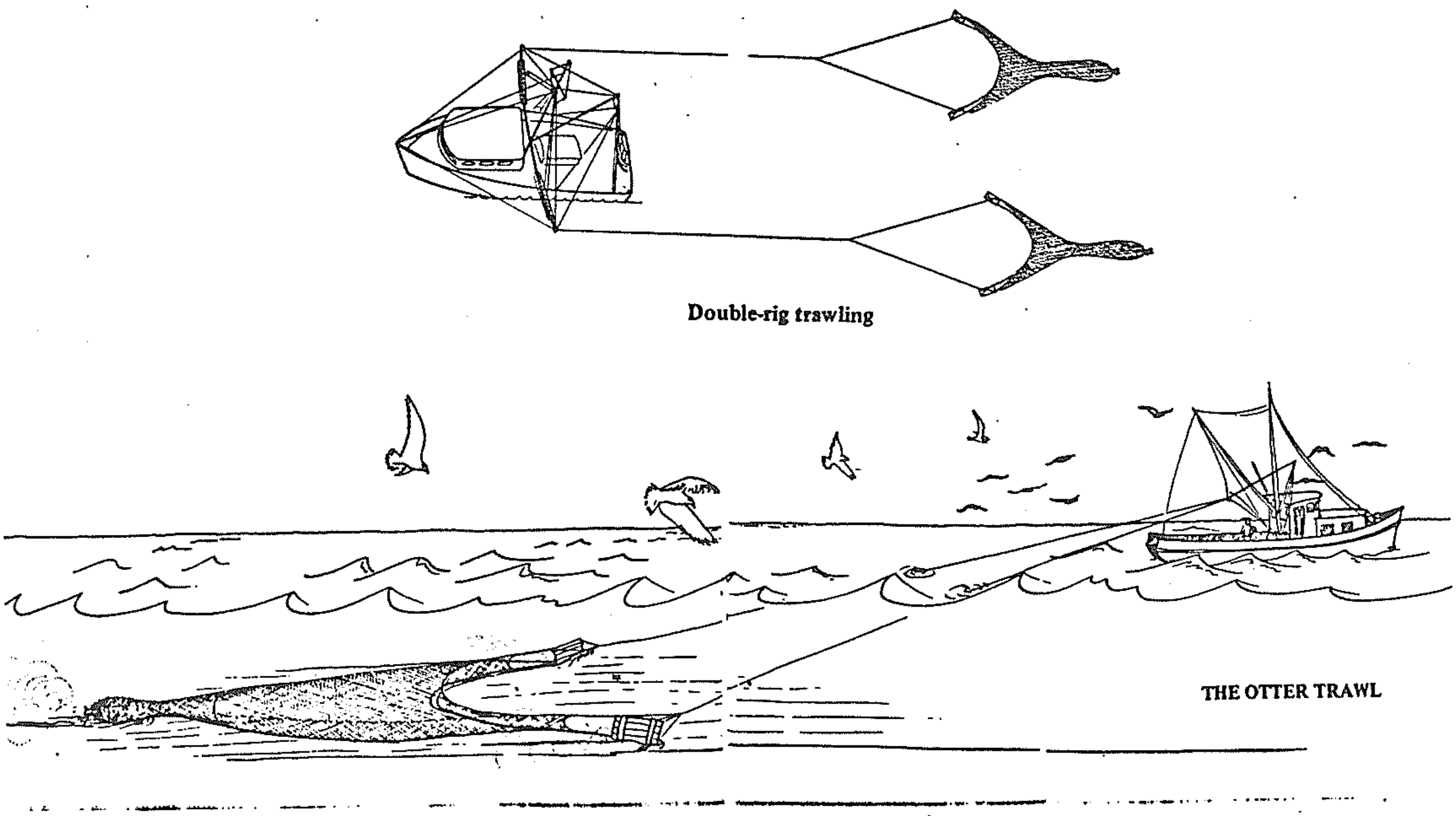

Figure 1. Off-shore Gulf of Mexico Shrimping Operations.

The research reported herein has as its objective the evaluation of the nature of the markets potentially available for trawl fish. The study of alternative recovery and delivery systems and their costs is currently underway and will be reported in a subsequent publication.

This report examines the character of markets and potential for economical utilization of trawl fish species. More specifically, the objectives are:

(1) To estimate the magnitude of supply and the composition of fish caught incidental to shrimp trawling,

(2) To identify and quantify important characteristics of selected product markets for trawl fish including sources and magnitude of supply and nature of organizations comprising the market channels,

(3) To evaluate the price structure in these product markets and estimate the price responsiveness of these markets to changes in quantities produced. Further, to evaluate the potential volume of trawl fish which could be marketed through these product market channels.

Although the incidence of discarding trawl fish is high among most Gulf of Mexico shrimpers, this study is concerned specifically with the problems of those in the Western Gulf areas. This phase does not presume to determine the feasibility of a commercial trawl fishery but rather relates to the fish caught incident to shrimping operations. There is, however, much information in this first report relating to marketing economics which should provide a basis for research in the general area of the economics of trawl fishing in the Gulf of Mexico. Finally, while the trawl fish being examined are those found in the Western Gulf, the organizations, market channels and end-products examined range from state to national and international in character.

METHOD OF ANALYSIS

Several qualitative and quantitative techniques were used to achieve the objectives. Following is a description of the various techniques applied to each objective.

The first, estimating the magnitude of supply and composition of trawl fish, provides the foundation of the analysis. Information for this first objective was obtained through personal interviews with shrimp and fish industry members and active research personnel such as biologists, and a survey of scientific literature relating to the availability and composition of trawl fish in the Western Gulf of Mexico. Information obtained through trawling operations conducted by biologists working on associated research programs was also utilized.

By ascertaining the number and kinds of markets which can or would utilize trawl fish, individual markets can be identified as being possible outlets for trawl fish. The actual number and kinds of markets for trawl fish depend on its availability and species composition. With the markets identified, their characteristics can then be described, including existing sources of supply and operating methods. Firms in the respective markets were interviewed and surveyed with regard to structure of the industry, trends, problems, potentials, and collection of data on amount of fish used, competing commodities, and pricing of end-products.

Secondary data, from such sources as government reports, provide industry-wide information on important variables (price, quantity, income, etc.) which determine how a market behaves. Depending on the availability and comprehensiveness of the data, behavioral relationships among important variables in each market can be estimated by linear regression equations.

Typically, when quantities of a product flowing into a market are increased substantially, prices may decline. The magnitude of this relationship is a measure of "price responsiveness" to supply. The relationships quantified above will aid in evaluating the price structure and determining the price responsiveness in each market. Along with quantifying the relationships between price and other variables, examining the data with regard to trends, fluctuations, and patterns and analyzing the performance in each market should help to evaluate the price structure in each market. The results from the quantification process and the average price and quantity produced in each market are used to calculate the price responsiveness. An alternative method to calculate price responsiveness is to use different sets of actual price and quantities produced. By varying these sets of prices and quantities produced, the sensitivity of price responsiveness of these changes can be gauged.

To evaluate the potential volume of trawl fish to be handled in each market, an assumed quantity of fish (or range of quantities) and the price responsiveness in each market are used to estimate how much price in each market is depressed by the additional trawl fish. The constraint on a potential volume (or range of quantities) is that the additional trawl fish does not depress price to or below producer costs.

Finally, the interrelationships among economic units (people, firms, etc.) and among all three objectives should be noted. The structure and conduct of each industry will determine market performance and price structure. The structure and conduct of each industry are themselves influenced by the number and kinds of firms and people in each market. The desires and interests of participants in the industry helps determine the rate of inflow of fish and in turn depends on availability of various species. Also, price responsiveness is a function of the rate of flow (quantity produced) of fish through a market. These interrelationships are very important in the functioning of a market and the study should describe them in detail and point out how they influence one another.

MAGNITUDE AND COMPOSITION OF TRAWL FISH

The problem of catching unwanted fish in commercial harvest operations, such as shrimping, has been with the fishing industry since at least 1907. In that year a U.S. Bureau of Fisheries report suggested that resources be used to develop the utilization of those species having no market [5]. The purpose of this section is to develop estimates of the magnitude and composition of "unwanted" trawl fish [1/] in the Western Gulf of Mexico.

The magnitude and composition parameters are estimated through observations from three sources: personal interviews, survey of scientific literature, and results from trawling by Texas Department of Parks and Wildlife and the Department of Wildlife and Fisheries Sciences, Texas A&M, as they become available. As a preface, it should be noted that it is very difficult to estimate accurately the total weight (biomass) of one or several fish species. The reason for this is the little-known population dynamics among the forms of life in the sea. Water salinity and temperature are easily recorded, but the added effects of natural death-loss, predator relationships with other species, fishing effort by man, and pollution confront physical scientists with a host of unknowns. The supply of trawl fish to be estimated is the market supply for plant, animal, and human use, that is, potential fish for capture and marketing.

Interviews

Personal interviews were conducted with basically two types of fish industry members--shrimp fishermen and industrial fishermen.[2/] All shrimp fishermen interviewed were located in Texas while all industrial fishermen interviewed were located in Louisiana and Mississippi. Identical questionnaires were used for members of each fishery.

Among Texas shrimpers there was no unanimity regarding the ratio of shrimp caught to trawl fish. Estimates ranged from 1:1 (shrimp to trawl fish) to 1:7. One interviewee ventured an estimate of 1:10 for the whole Gulf of Mexico but stated that Texas definitely had less of an abundance of bottomfish. This latter point was confirmed by interviews with biologists

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[1/] Since the trawl is dragged along the ocean bottom, trawl fish can also be called bottomfish. Bottomfish are comprised of finfish and shellfish, i.e., vertebrate and invertebrate species.

[2/] Industrial fish are used in reduction processes for animal feedstuffings and industrial/manufacturing inputs, in animal food, and for animal bait.

of Texas Department of Parks and Wildlife at Rockport, Texas. The biologists stated that Texas has a lower volume of trawl fish compared to other Gulf states. Furthermore, because of the sandy ocean bottom (instead of a muddy one) and differing currents, fish west of Freeport, Texas, are believed more tropical in nature than those fish near the Mississippi River Delta. The one characteristic of trawl fish upon which there was universal agreement was the seasonality in catch-rate. Most trawl fish are captured in the summer months (May-September).

Using the range of ratios of shrimp to trawl fish and the 1968 annual catch of shrimp in Texas (as an example), the amount of trawl fish that could have been landed by Texas shrimpers in 1968 varies between 40,000 and 280,000 tons (based on heads-on weight).

The composition of trawl fish, from interview data, included red snapper, redfish, flounder, black drum, catfish, seatrout, croaker, porgy, gaff sail, silver eels, crabs, starfish, and jellyfish. The first six fish mentioned are food fish, large croaker is a food fish while small ones are used in pet food and for animal bait, and the remainder, except for crabs, have little commercial value. It was not possible to estimate precise amounts and percentages of each species in the trawl catches because of the large geographical range of shrimp trawling, seasonal factors, and the number of trips, made by shrimp fishermen. For the case of species acceptable for food fish, it appeared that their catch-rates for Texas shrimpers varied between a few pounds per day most often to occasionally a hundred pounds per day.

Interviews conducted with industrial fishermen in Louisiana and Mississippi again confirmed that Texas may have less bottomfish and a less favorable environment for large finfish populations than other Gulf states. Menhaden fishery members stated that their fishing grounds extended from the Mississippi River Delta to the Louisiana-Texas border (Sabine Pass), beyond which relatively fewer menhaden migrate inshore from deeper water. Menhaden are caught in schools at the surface and the species is the largest fishery in the U.S. in terms of quantity caught. Bottomtrawl fishermen stated that their fishing grounds extend as far east as Mississippi and as far west as Aransas Pass, Texas. However, most fishing was done in the area between the Mississippi River Delta and Morgan City, Louisisna. Also, the catch-rate drastically dropped west of Sabine Pass. Half the bottomfish catch was comprised of croaker.

Scientific Literature

Research on bottomfish in the Northern and Western Gulf of Mexico has been going on since the 1920's with investigations of the life histories of individual species. It was not until 1945 that research was published on the ecology of marine life in general along the Louisiana-Texas coast [11], and 1954 that research was published on marine life in the brown shrimp grounds of the Western Gulf of Mexico [14]. With the introduction of an industrial fishery along the Louisiana-Florida coast in the early 1950's, research was begun to specifically investigate marine life in this fishery.

A review of the above scientific literature, and other published research, reiterates two points mentioned from the interviews--1) spring through fall account for at least two-thirds of the bottomfish catch and 2) Texas waters may have lower populations of bottomfish than other Gulf states. The following discussion and summary of research on bottomfish establishes these two points and others such as species composition.

Gunter's studies on marine fishes of Texas found one hundred and nineteen species in the catch, of which "seventy-two species made up less than 1.5 percent of the catch" [11, p. 89]. Gunter estimated that four species--the Atlantic croaker, anchovies, mullet, and menhaden--had the greatest species biomass relative to any other fishes in the Northern Gulf of Mexico and are the most abundant of fish in Texas bays and offshore. Gunter also found that the white trout, which belongs in the same family as croaker (sciaenid), was the most numerous fish in offshore Texas waters. As a rough comparison in Gunter's study, the trawls taken in Louisiana contained four times as many fish as trawls taken in Texas [11, p. 173].

Hildebrand's research dealt specifically on the distribution and relative abundance of fish taken by shrimp trawlers. The area investigated ranged from the mouth of the Mississippi River, along the Louisiana-Texas coast, and down to the Campeche Banks off Mexico. Because of the night trawling required in the brown shrimp fishery, the results in Hildebrand's research may be different from daytime trawling. It was found that "[at] no time were the croakers really abundant on the offshore brown shrimp grounds...," especially so in Texas [14, p. 310]. Small shoal flounders were the most abundant species in Texas offshore waters during the year, with no apparent seasonal movements [14, p. 342]. Other fish in the Texas offshore trawls, in order of abundance, were butterfish, Mexican flounder, porgy, white trout, and lizardfish [14, p. 341].

Three studies stand out for research into the industrial (bottomfish) fishery along the Louisiana-Florida coast. By sampling the fish caught by boats in this fishery, Haskell, Roithmayr, and Thompson report that croaker, spot, and silver trout accounted for 75 percent of the industrial fish catch in 1958-62 [12, p. 1; 22, p. 2; 23, p. 34]. All three species belong to the same family, sciaenid. The three researchers also found significant seasonal factors in the characteristics of the fish themselves and landings of fish. Figure 2 demonstrates the effect of seasonality on annual catches. The catch-rate climbs during the spring and reaches a peak in the summer and fall. During these seasons the catch per unit of fishing effort (catch divided by average length of tow) increased because of fish abundance.

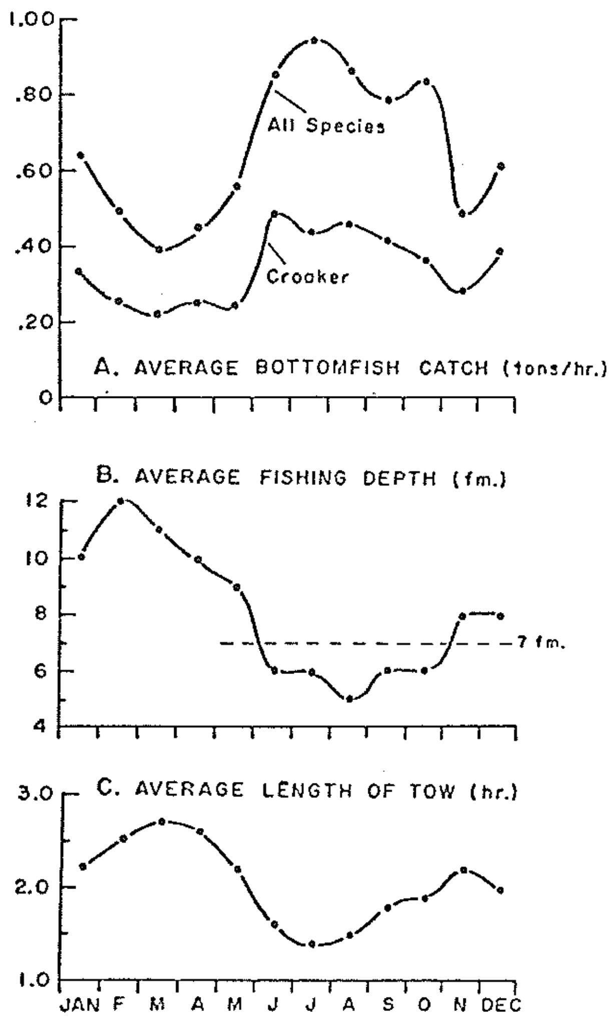

Figure 2. Catch and Effort Statistics, 1959-62, in the Industrial Bottomfish Fishery.

Source: Roithmayr, Charles M., "Review of Industrial Bottomfish Fishery in Northern Gulf of Mexico, 1959-62," Commercial Fisheries Review, January 1965.

Haskell mentions two important points concerning the geography of the industrial fishery and its species composition: 1) "[if] the fishery continues to expand, it will likely be extended [further] offshore" and 2) [species] generally termed 'sport fish' or 'food fish' are rarely caught, comprising one-half of one percent of the total catch" [12, pp. 3-4]. Haskell also cites studies by Morrow and Gunter which contend that a trawl fishery may have beneficial effects on all fishing in a region [20, 10].

Returning to Texas waters, Compton has documented trawl fish availability from the Mississippi River Delta to Port Aransas, Texas. Trawls made by the Texas Department of Parks and Wildlife exploratory vessels found that scrap fish production from Sabine Pass to Port Aransas averaged an annual catch-rate of 75 pounds per hour during 1960-65. Results of the Texas Parks and Wildlife trawls are listed in Table 1, indicating seasonal catch-rates and species composition. Again there is a significant seasonality in catch-rates, highest during the summer and fall when average water temperatures are above 68 degrees Fahrenheit. Croaker and seatrout made up almost 70 percent of the total catch [2, p. 2]. Compton did not state whether trawling was done during the day or at night.

Miller conducted daytime trawl surveys of Gulf fishes near Port Aransas, reporting that members of the sciaenid family (sand seatrout, silver seatrout, croaker, and star drum) comprised nearly 57 percent of the total catch [17, p. 104]. The time period investigated was February-July, 1964, at depths from 3-15 fathoms. Miller states that "as the water temperature increased the catch was marked by a general increase in the numbers caught"; however, "the species diversity of the bottomfishes appeared to decrease" [17, p. 105].

One of the most recent investigations on bottomfish in the Northern and Western Gulf of Mexico is that by Moore, Brusher, and Trent [19]. This study collected bottomfish with a shrimp trawl in 4-60 fathom water between the Mississippi River Delta and United States-México border from 1962 through 1964. Trawling was done both during the day and at night. Moore et al. reported that catches "were generally two to five times greater off Louisiana than off Texas..." [19, p. 45]. Winter catches were reported to be very low off the Texas coast, while those in the summer and fall were the highest [19, pp. 63 & 69]. Figure 3 indicated area differences for the whole year along the Louisiana-Texas coast. An annual catch-rate of 77 pounds per hour for the Texas coast was estimated, and Moore et al. hypothesized that commercial catch-rates may be three times as great because of increased efforts. For the whole year, the four species that dominated the catches off Texas, in order of abundance, were longspine porgy, Atlantic croaker, inshore lizardfish, and silver seatrout.

Summary of Availability

Based on observations from personal interviews and a survey of scientific literature, a summary of the availability of trawl fish can now be made.

Table 1. Texas Trawl Fish Availability, Galveston, Texas, to Port Aransas, Texas, 1960-65.

A. Catch-Rates[a]

Depth	Winter Jan.-Mar.	Spring Apr.-June	Summer July-Sept.	Fall Oct.-Dec.
	pounds/hr.			
3-10 Fathoms	30	100	250	40
10-20 Fathoms	40	80	75	40

B. Species Composition

	Percentage Species Caught
Atlantic Croaker	30%
Seatrout	30%
Spot Croaker and Shoal Flounder	10%
Longspine Porgy and Star Drum	10%

[a]Annual production from Sabine, Texas, to Port Aransas, Texas, is 75 pounds per hour.

Source: Compton, Henry W., "Trawl Fish Availability," unpublished report, Texas Parks and Wildlife Department, Austin, April 1969, pp. 2-3.

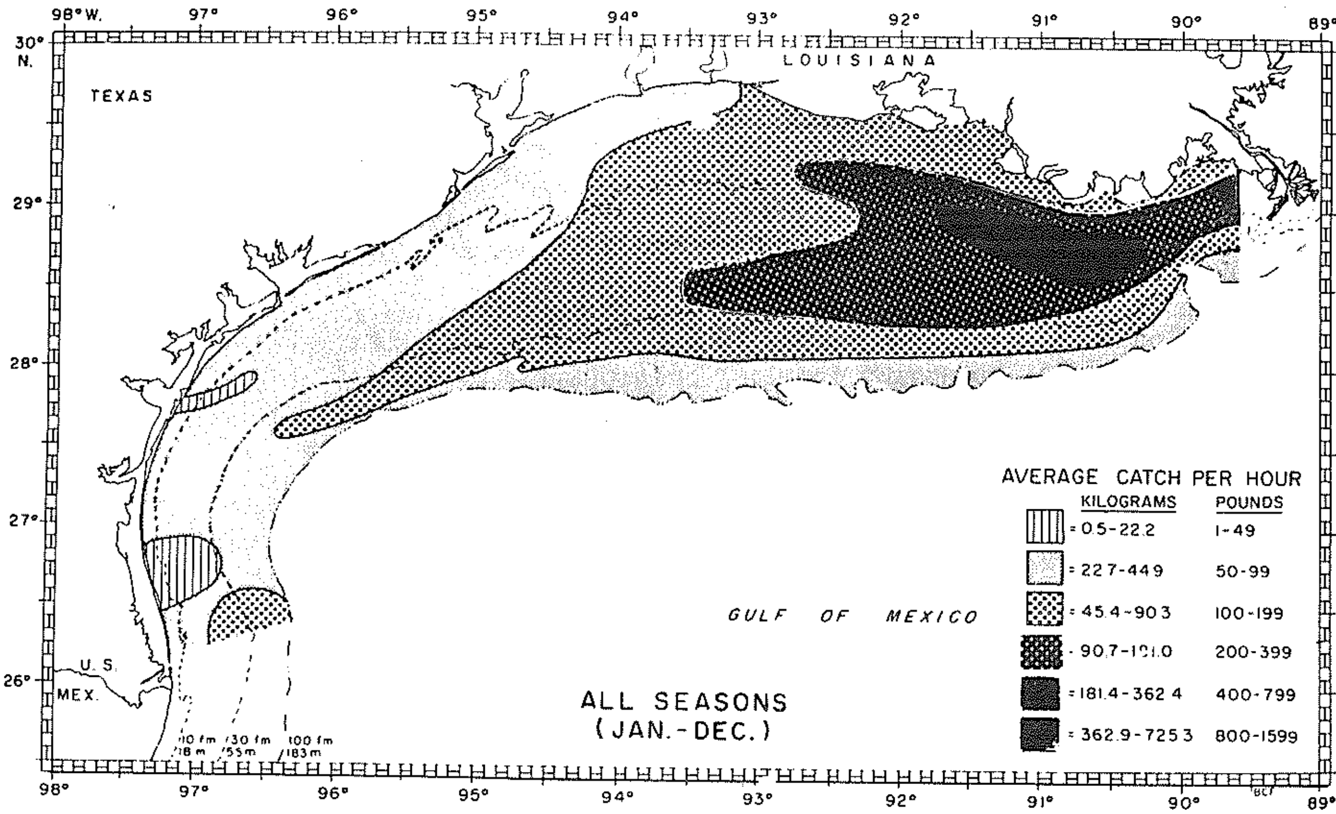

Figure 3. Relative Abundance (by Weight) of Demersal Fishes from 1962-1964, Estimated from the Average Catch of all Fish at Each Station.

Source: Moore, Donald, and Harold A. Brusher and Lee Trant, "Relative Abundance, Seasonal Distribution, and Species Composition of Demersal Fishes Off Louisiana and Texas, 1962-64," Marine Science, Vol. 15, 1970.

With regard to the ratio of trawl fish to shrimp, a realistic range would be from 1:1 to 7:1. The latter ratio may be applicable to summer months and the smaller ratio to winter months; a ratio of 4:1 may be appropriate year-round. The seasons of heaviest absolute catches of trawl fish correspond to the seasons of largest shrimp catches--summer and fall (July-December).

Most trawl fish caught by either fishermen or scientific personnel were smaller than food fish size, that is, less than one pound round weight. Approximately 75 percent of the trawl fish belonged to the sciaenid family, whose members include black drum, croaker, and seatrouts. Species currently marketed as food fish comprised a small fraction of the total trawl catch--somewhere between .5 percent and 5 percent. The absolute amount of all trawl fish caught and discarded also varies considerably, depending on a ratio of trawl fish to shrimp, between 52 and 368 million pounds annually. Additional estimates of the magnitude and distribution of species of finfish caught incident to shrimp trawling operations will be available when biological assessment studies currently underway in the Western Gulf are completed.

MARKET IDENTIFICATION

The composition of trawl fish, from interview data and scientific literature, was such that the following product markets were intially identified as appropriate for the utilization of trawl fish. They are 1) the reduction market (fish oil and meal), 2) fish protein concentrate (hereafter abbreviated to FPC), 3) the pet food market, 4) the fish fillet/portion market, and 5) the fresh whole fish market. These five product markets will be discussed with regard to structure, trends, problems, potentials, operating methods, and sources of supply. Such a discussion is necessary in order to appraise the potential for utilizing trawl fish in each market.

Reduction Market

The reduction industry has its roots in the whaling era of the 1800's. Whale oil provided the means to light millions of lamps in the North Atlantic community, but when the whale population declined in the late 1800's, more abundant fish stocks were harvested closer to the Eastern seaboard.[3/] Today these fish stocks include menhaden (Atlantic and Gulf coasts), an unclassified category consisting mostly of Atlantic bottomfish, and tuna, mackerel, and anchovy scraps from canning operations on the Pacific coast.

Menhaden operations in the reduction industry will be discussed primarily because 1) it represents 70 percent of the harvested fish stocks utilized in this product and 2) it is the primary species for reduction in the Gulf. Menhaden are processed at onshore facilities, where they are essentially dehydrated by reduction equipment. Estimates of the capital costs for the physical plant alone are $ 2-10 million, with the basic equipment costing over $870,000 [21]. Plants on the Gulf coast are located in Louisiana and Mississippi. Plants on the Atlantic range from Point Judith, Rhode Island, to Fernandina Beach, Florida, with the heaviest concentrations between Chesapeake Bay and Beaufort, North Carolina.

At sea, menhaden are caught by circular nets (called purse seines, see Appendix Figure 7) and brought aboard the vessel by means of a low-vacuum pump. Fish are stored en masse in the hold, immersed in sea water that is cooled close to freezing temperatures. The vessels are 180-250 feet in length, have a capacity of 900 tons and a crew of 17, and cost approximately $750,000. There is an unwritten yet established season among firms for menhaden in the Gulf from mid-April to mid-October.

[3/] In 1970 former Secretary of Interior Walter Hickel placed whales on the endangered species list and banned the importation of whale products.

Products of the reduction industry include fish oil, fish meal, and fish solubles. Uses for fish oil on a world-wide basis are in the food and non-food markets. Food use consists of margarine and industrial shortening. (Fish oil has not been used in food products domestically because of poor handling characteristics.) Non-food uses include drying oils, paints, lubricants, greases, soaps, fatty acids, and vitamins. Fish meal is used as an animal feedstuff, primarily for chickens, highly-valued fur animals, and young feeder pig. Fish solubles are also used as an animal feedstuff for the above group of animals.[4/]

The market for fish oil in the United States is a relatively stable one--domestic use has varied between 30-50 million pounds annually with a slight downward trend. Fish oil price, the prices and availability of competing vegetable oils, and the substitution of synthetics are factors in fish oil use. The export market for U.S. fish oil is considerably larger than the domestic one, as up to 90 percent of the fish oil is exported, most of it to the Low Countries in Europe.[5/] There is a relatively high degree of buyer concentration for fish oil, domestically and internationally, with such firms as Lever Brothers and Du Pont.

The market for animal feedstuffs is at an all-time high currently. The combination of heavy exports of soybeans, unusally bad winter and spring weather conditions, the failure of the Peruvian fish meal industry, and rising demands for meat products led to price increases in the past year of more than 100 percent for feedstuffs. The situation is critical because the U.S. imports 50 percent of its fish meal and the failure of Peruvian production has cut back imports drastically recently to a few million pounds monthly.[6/] Also, because the Peruvian fishing season is active when the domestic one is dormant, broiler producers must now wait until the start of the menhaden season to receive large quanitites of fish meal. Again buyer concentration is relatively high, in view of the highly integrated broiler industry made up of private firms and cooperative buying agents, such as the National Broiler Marketing Association.

Four firms dominate the supply side of the reduction market in the U.S., producing approximately 90 percent of the fish meal, oil, and solubles. They are Zapata Protein, Sea Coast Products, Wallace Menhaden, and Standard

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4/ Although soybean meal is the primary ingredient in broiler and swine rations, the use of fish meal and solubles is favored because they contain unidentified growth factors which cause faster than normal growth.

5/ The Low Countries include the Federal Republic of Germany, the Netherlands, Belgium, and Luxembourg.

6/ Peru is the world's largest producer, and exporter, of fish meal and oil. However, its government banned all fishing since October 1972 to late 1973 for fear of over-fishing its anchovy stocks. The anchovy has almost "disappeared" from the coast recently due to a change in the Humboldt Current.

Products. The latter three firms are family-owned. All four firms have plants and administrative offices on one or both of the Atlantic and Gulf coasts. Firms are vertically integrated from the capturing of fish to the marketing and transportation of the end-products. All suppliers use three methods of selling their products. In order of importance they are brokers, direct selling, and jobbers. When there is an above-normal supply, the latter two methods are more frequently used.

Problems in the domestic reduction market include the importance of imports (approximately 80 percent from Peru) and managing the fish stocks. Peru's large production and year-round stocks have a strong effect on domestic and international pricing. To conserve Gulf menhaden stocks, there is a trend towards a more formal fishing season when menhaden migrate inshore from deeper water. Many fish meal plants on the Atlantic coast are inoperative due to overfishing--in this case menhaden migrate parallel to the coast instead of at a right angle, thereby giving fishermen all along the coast a chance to harvest them. To its credit, the reduction industry through present technology utilizes the whole fish except for moisture. Tightening standards on the disposal of the moisture content as waste and smoke from the cooking process are being dealt with.

The byword in this industry is volume, as it takes roughly five pounds of raw fish to produce a pound of fish meal and one half pound of fish oil. In addition, fish must be processed quickly else they lose some quality, so a plant is built with an expected peak volume in mind. (A billion pounds of raw menhaden per year was processed along the Gulf coast during 1967-71.) Therefore, there is more than ample capacity for processing a potential volume of trawl fish.

The potential for trawl fish in the reduction market seems quite good under current conditions. The tight supply in the feed market is expected to last for several years before high-protein grain producers can adjust to the higher level of prices. Several cautionary notes should be made, however, regarding the production and marketing of fish meal made from trawl fish. They are 1) the volume of trawl fish landed must surpass a minimum amount to economically operate the plant, 2) trawl fish have little oil content thereby yielding less oil revenues, and 3) the processed fish meal must contain at least 60 percent protein (manufacturer's guarantee) or else the trawl fish must be blended with menhaden or a penalty be paid to the buyer. The latter objection may be unwarranted based on the data presented in Table 2.

Fish Protein Concentrate

There is currently no viable market for FPC and present indications for market development are bleak. FPC is the name given to fish protein

Table 2. Proximate Composition of Samples of Industrial Fish on a Wet Basis, Gulf of Mexico, 1959-62.[a]

Species	Protein[b] Content	Oil[b] Content	Ash[c] Content	Moisture[c] Content
	------- percent -------			
Croaker	16.6	2.9	4.75	75.20
Menhaden	14.7	13.3	3.60	70.33
Porgy	17.6	2.3	6.39	73.31
Silver Eel	16.8	3.4	2.44	76.58
White Trout	17.1	4.7	2.97	75.41

[a]For example, on the basis of 100 pounds of croaker which may be processed for meal and oil, there would be 24.8 pounds of dry matter for the meal containing 16.6 pounds of protein (63.58 percent of bulk with 1.305 pounds of added moisture), 4.75 pounds of ash, and 2.9 pounds of oil processed.

[b]Median level for year.

[c]Simple average.

Source: Thompson, Mary H., "Proximate Composition of Gulf of Mexico Industrial Fish," Fishery Industrial Research, U.S. Department of Interior, Vol. 3 No. 2, November 1964.

when it is extracted by solvent method from either whole fish or fish fillet. In its final form FPC contains approximately 80 percent protein, is claimed to be odorless and tasteless, and is completely insoluble and inert, that is, like sand. In spite of ingrained consumer taste habits, FPC is nutritious once it is digested. Further, the insoluble and inert properties of FPC prevent its use with other ingredients in food products. Because the above characteristics of FPC do not conform to a product demanded by the food or protein supplement markets, efforts in the development of FPC have been generally unsuccessful.

FPC was first developed in Canada. It was called "fish flour" and there were hopes, when a United Nations committee met in 1961 to discuss it, that it would help provide nutrition to an increasing world population. There began its problems. What is known as fish meal in the United States is called fish flour in Spanish. So naturally, when Spanish-speaking, less-developed countries learned that "fish flour" was intended for human consumption, they became indignant. Thereafter, FPC as a name was used.

Refining processes for FPC were developed by the Bureau of Commercial Fisheries. The Federal Food and Drug Administration approved FPC for human use with some serious restrictions. The only fish species approved for FPC production is hake (found in sufficient quantity in the Pacific Northwest), which is the only species accepted thus far by the FDA because of certain toxins in fishes. Hake are migratory in nature, going from shallow to deeper water and back, and are heavily fished by the Soviets. In addition, FPC is to be sold only for direct household consumption in bags not more than one-pound net weight,and cannot be pre-mixed with any foods. The reasonings in the latter restrictions have been characterized as either totally irrational or political in nature (stemming from the opposition of competing sources of protein).

The Bureau of Commercial Fisheries tried to develop an international market for FPC, with an experimental program in Chile [7]. However "... some industry spokesmen felt it will be difficult, for psychological reasons, to develop foreign markets until or unless FPC is first accepted by American consumers" [6, p. 169].7/ The pilot plant which was intended to produce FPC now stands idle and the FPC program has been officially terminated by the federal government. One remaining research project on an FPC-like substance is at Texas A&M University, where it is processed with more functional properties8/ for possible use in the protein supplement market [1]. Cost

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7/ A small-scale program of adding FPC to school lunches in Jamaica by a U.S. supplier has been recently reported by the National Marine Fisheries Service.

8/ Functional refers to characteristics enabling an ingredient to mix with, adhere to, or absorb other ingredients.

per pound or per unit protein is an important factor in this market and typically soybeans are the main, and most inexpensive, input. Therefore, there does not appear to be a potential for trawl fish in FPC as this market is not currently viable.

Pet Food Market

The pet food market is a billion dollar industry, with $1.4 billion in retail sales in 1971-72 [15, p. 14]. The pet food industry emerged after World War II with the growing affluence of American pet owners. The Northeast, Chicago, and Southern California areas became and remain centers of production and of consumption. As stated previously, plants were also built along the Gulf coast in the 1950's because of fish abundance. There are also several small, private companies in each region of the country packing their own or another's label.

Ingredients in pet foods include cereal grains, beef, veal, lamb, and pork parts, poultry (and parts), horsemeat, milk, eggs, and fish. Dry maintenance food for dogs and cats leads in pounds sold; it is made of cereals mostly. Animal protein is used mainly in the canned and semi-moist products where cooking of the ingredients is a requirement. However, almost all fish is used in cat food. Fish itself accounts for only 4 percent of all ingre

Most pet food canneries purchase cereals, livestock, and poultry locally or from centers of production (Kansas City or Omaha for beef) if prices are competitive. Brokers are often used as intermediaries between the canneries and suppliers of ingredients. Fish come from the Atlantic, Gulf, Pacific, and fresh-water sources. The forms in which it is used include whole, chopped-up, scraps, in a solution ("gurry"), or fresh if they are landed at a cannery. In terms of price, cereals are the most inexpensive input, followed by chicken and fish, and then by livestock.

Fish used for pet food are either caught for that purpose or are the by-products of filleting and canning operations. The fillet-less fish (called "racks") and scrap fish are the forms most often used in Northeast and Pacific pet food canneries. It is mainly along the Gulf coast where there is a fishery supplying primarily pet food canneries. This fishery was defined earlier as an industrial one, since its end-products are not intended for human consumption. The predominant species in the fishery is croaker. Boats used are large trawlers, with double-rigged nets which have larger net doors to open the mouth of the trawl more in height. Fish are stored in the hold much as they are in menhaden vessels, in circulating water kept close to freezing temperatures.

At the wholesale level, the concentration of buyers of pet food is fairly diffused. Buyers include national grocery chains, regional grocery chains, independent grocery stores (and their cooperative buying arrangements), specialty pet stores, and kennels. Pet food manufacturers either have their own sales force or use brokers to distribute their product.

In the supermarket nationally-known pet food brands dominate shelf space and sales. They include Ralston Purina, Lipton, Kal Kan, Quaker Oats, Carnation, and General Foods. Their pet food operations are but a small part of their general program in the food industry. Competing with the national brands are several private canneries in each region of the country. Besides pet food, they also pack other food and non-food products for a more diversified operation. Some of these regional canneries in and near Texas are located in San Antonio and Highlands (Texas), Biloxi and Pascagoula (Mississippi), Rush Springs (Oklahoma), and Clovis (New Mexico).

Problems in the pet food industry are concerned mainly with the prices of ingredients, a continuous and consistent supply of ingredients (especially fish which can be seasonal and has limited storage life), and the economic status of pet owners. There is a potential for increased automation in the manufacture of pet food and possibly new product forms. However, a study by the A.C. Nielsen Company warns manufacturers of creating too many flavors and varieties of pet food [15, p. 19].

Recent trends in the pet food market point towards increased sales but at a much slower rate than that which occurred in the 1960's (Figure 4). In a cost-conscious or inflationary economy it is usually the pet's diet which is the first to suffer. Another development, in relation to the use of fish, is that the increasing popularity of gourmet or specialty cat foods emphasize livestock and poultry ingredients instead of fish.

Most suppliers of fish to the pet food industry also serve the animal bait market. This bait is intended to help entrap marine and game animals. Along the Gulf, the crab and sport fisheries are the two largest buyers in this market, receiving bait in frozen and fresh forms, respectively. The animal bait market has used an average of eight million pounds of fish annually during 1965-72, which is approximately one-tenth the amount of fish used by the pet food industry along the Gulf. Like the pet food market, the animal bait market has experienced growth and should continue to do so. Therefore, the potential for trawl fish in these two markets appears good but the size of market is not great.

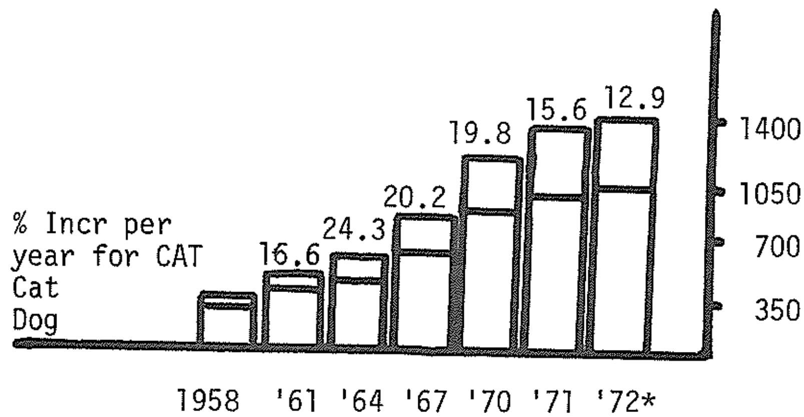
Fish Fillet/Portion Market

The fish fillet/portion market utilizes both fish fillets and minced fish flesh made into products of various sizes and shapes with or without other ingredients (such as breading). A fillet usually refers to the intact piece of fish, while a portion may be made from cut-up fillets and minced fish flesh processed into small items (less than a pound), often with a breaded exterior

Frozen fish fillets were introduced in the 1920's and processed products like fish portions in the 1950's with the major center of production

Dog and cat food consumer dollar sales through total U.S. grocery stores - at consumer prices

(Millions)



Dog and cat food consumer pound sales through total U.S. grocery stores

(Millions)

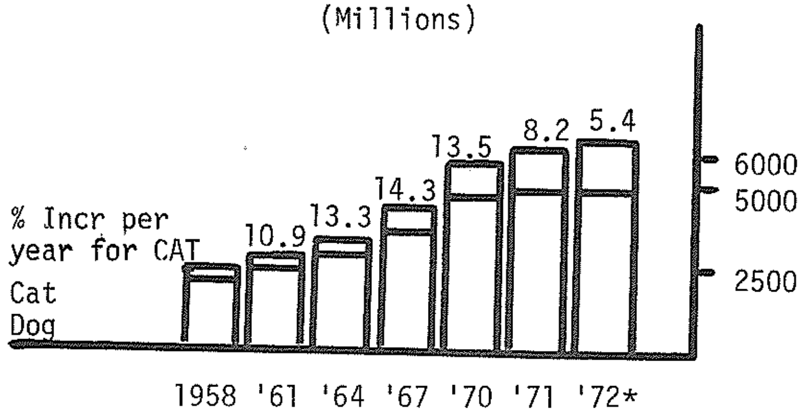


Figure 4. Consumer Dollar Sales and Consumer Pound Sales for Dog and Cat Food, 1958-72.

* 1972 Data: 12 mos. ended June 1, 1972.

Source: "Putting Pet Food Sales in Perspective," Petfood Industry, Nov. - Dec. 1972.

in the New England Area. This area became the center of production because of fish abundance off-shore and experimentation with marketing fish other than in the whole form. Today New England remains the major producing area due to its proximity to nations exporting fish to the U.S. for use in this market. Major exporting nations include Canada, Iceland, Norway, and Denmark. It was estimated that during 1971 over 90 percent of all groundfish fillets and steaks were imported. The fish fillet/portion market itself made up over 290 million pounds of the 441 million pounds of frozen fish and seafood shipped to retail stores in 1971 [3, p. 187]. In addition to retail stores, there is also the important institutional trade[9/] which prefers low-cost, easy-to-prepare food items.

Fish species used from North Atlantic waters include cod, haddock, flounder, ocean perch, pollock, whiting, sole, and turbot. Boats fishing in these waters are either side or stern trawlers with gross registered tons from 50 to 150 tons and have 15 to 17-man crews. Foreign vessels usually fish in groups of boats and often there is a mother ship nearby to freeze and possibly process the fish. Imported fish arrive as 10-25 pound blocks of frozen fish fillets for portion processing. Separate fish fillets are those of individual fish processed in exporting countries or domestically. Most domestic fillets are sold fresh on the retail market to restaurants and stores.

Buyer concentration in the fillet/portion market is very diffused. Buyers include the grocery chains and independents, restaurants, schools, the military, and other retail establishments. There is also a small degree of seller concentration which is composed of domestic and foreign processors. Many retail grocery stores place their own private labels on items which they have bought from processors.

The main problem in this market is guaranteeing an adequate supply of either domestic or foreign fish for processing. In recent years there has been grave concern over the stocks of popularly-demanded fish from the North Atlantic. These stocks are heavily fished by several foreign nations with too much fishing effort in the area. One result has been a large decline in total haddock landings following very intensive fishing by the Soviets in 1967 [24, p. 89]. This problem is increasing and many countries have already extended their off-shore boundaries to guard nearby ocean resources. The recent action by Iceland is but one example. Consequently, with the stocks of popularly-demanded fishes exploited at the highest levels, the prices for these species, and their associated end-products, have risen as demand for them increases.

One important development in this market is the interest in and utilization of the fish flesh separator by domestic processors. This device

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[9/] This trade includes restaurants, quick-snack establishments, schools, hospitals, the military, and in-plant facilities.

separates the flesh from the skin and bones of fish which are either too small to fillet or are in the form of fish "racks" described above in the pet food market. The flesh separator has been used in the manufacture of fish cakes and pastes by the Japanese during the past 20 years [16, p. 12]. Such a machine seems ideal for processing the edible portions of trawl fish, most of which are small according to the scientific literature. The resulting minced meat can then be frozen into blocks and later be cut up and processed into fish portions. An alternative method is to "reconstruct" the fish flesh and arrange it in a layering effect so that the product resembles the original fish flesh.

The potential for trawl fish in the fillet/portion market appears quite good provided the products made from trawl fish can overcome market resistance to new species. The fillets from large foodfish can be channeled into the fillet side of this market and the edible meat from small trawl fish and from the "racks" of food fish can be channeled into the portion side of this market. Both fillet and portion items have experienced growth in per capita consumption since their introduction and presently account for 25 percent of total fish consumption (Figure 5).

Fresh Whole Fish Market

The fresh whole fish market refers to whole finfish for human consumption and is concerned here only with the Texas market. Another term for this fish is food fish, and it is usually sold fresh in retail stores and in specialty fish stores and sold as part of a meal in restuarants. Many observations on this industry will be drawn from "A Study of the Marketing Channels for Fresh Finfish in the Texas Fishing Industry" by Gillespie and Gregory [8].

The history of the whole, fresh fish market in Texas is as old as the history of commercial fishing in Texas. Today many characteristics of an earlier era in harvesting and marketing remain with the industry. For example, there are little if any efficiencies in harvesting activities; many fishermen cannot earn an adequate living fishing and are forced to "moonlight" at other work [8, p. 41]. Another example, for some valid reasons, is the larger number of levels in the marketing system between harvesting and consuming fish--more levels than in marketing systems for other food products.

The dominant species in the whole, fresh fish market include red snapper, flounder, redfish, seatrout, black drum, and sheepshead. All of these species are bottomfish. Their relative share in total Texas finfish landings in 1968 was redfish 32 percent, seatrout 23 percent, red snapper 18 percent, black drum 16 percent, flounder 6 percent, and sheepshead 4 percent [8, p. 28]. Seventy percent of all finfish were landed in the Corpus Christi-Brownsville area, which also accounts for the largest share of Texas shrimp landings. Fish are caught either in the Gulf of Mexico or in the bays.

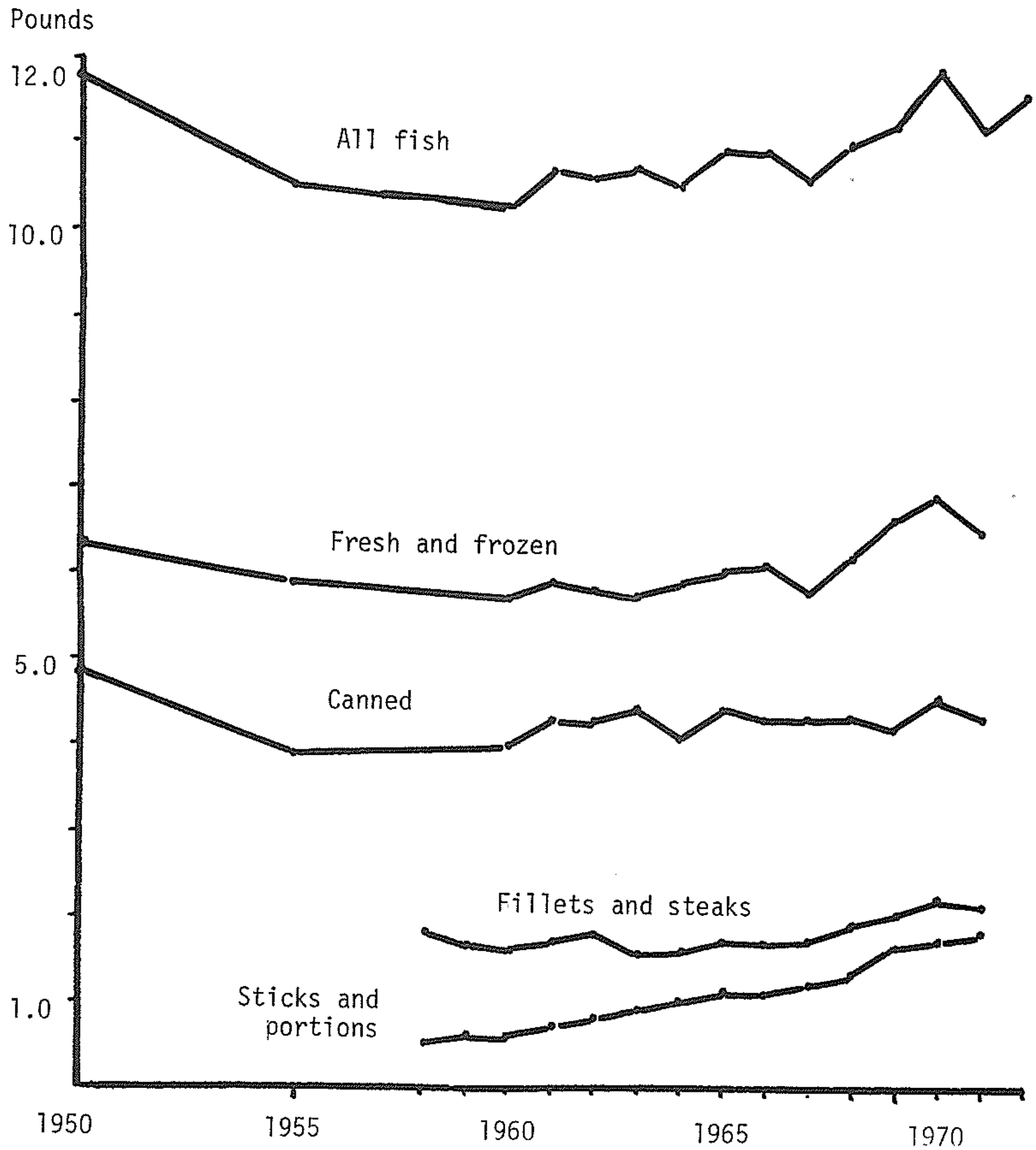

Figure 5. Per Capita U.S. Fish Consumption, in Total Edible Weight and Other Selected Categories, 1950-1972.

Source: U. S. Department of Commerce, "Fisheries of the United States, 1971," National Oceanic and Atmospheric Administration, National Marine Fisheries Service, NOAA NMFS CFS-5900, March 1972.

They are caught from boats and from shore; fishermen use either nets or bait and tackle.

Gillespie and Gregory estimated approximately 7,000 harvesters, many of whom own their own boats. Such a large group tends to disperse market power evenly. However, among wholesale there exists some degree of monopsony (buying) power. In several counties, some wholesale dealers bought from 20-70 percent of the total finfish landed in their respective counties [8, p.44]. At the retail level buyers include grocery chains and independents, small fish markets, restaurants, schools, and other institutional facilities.

The most striking feature of the whole, fresh fish market in Texas is the concentration of consumption along the coast. Because fresh fish is a very delicate product and great care is required to preserve its quality, dealers and retailers first satisfy the fresh fish demand in coastal areas at competitive prices. The increased effort to market fresh fish at consistently good quality in inland areas would make its price significantly higher. Present methods of marketing fresh fish in inland areas present the consumer with a product of mixed quality. From these trends, and with the advent of common household freezing facilities and frozen seafood products, it seems clear that there has been a decline in fresh fish consumption in inland areas.

Problems in this market are outlined by Gillespie and Layne: 1) there is at times an inconsistent supply of finfish, 2) the effects of pollution (oily taste in Galveston fish) on fish quality, 3) laws governing the capture of finfish (especially in the bays), and 4) inertia among firms regarding the marketing of fresh fish [8, p. 101]. In spite of these problem areas, there appears to be a good potential in this market for large finfish in the trawl fish catch, especially in restaurants specializing in seafood meals.

Summary

All but one of the markets discussed could readily absorb additional quantities of fish. The rising demand for high-protein foods may provide an incentive for the utilization of trawl fish. Most observers would agree that new sources of high-protein foods will be needed as present sources are only slowly expanding or are fully exploited. It should be noted that the higher a use a raw product can be put to, the higher will be the price for that raw product.[10/] For trawl fish, its possible uses extend from fish meal to pet food to seafood for human consumption.

[10/] The fertilizer market for fish was ignored for this reason because of the predominance of inorganic materials in fertilizer and their per unit costs put fish at a competitive disadvantage.

In the following sections institutional problems are examined and estimates of the price responsiveness of these markets are developed. From this the potential size of each market and its ability to absorb additional supplies is evaluated.

INSTITUTIONAL ARRANGEMENTS IN MARKET SYSTEMS

A very important feature in the utilization of trawl fish is the institutional arrangement in each market. "Institutional arrangements" refer to the underlying relationships (social, economic, political, etc.) among the economic units in a market. The economic units are made up of the people, firms, governmental agencies, and commodities (with their respective demands and supplies) in a market. The point is that institutional market arrangements can either help or hinder the development of markets for trawl fish.

The purpose of this section is to list and to discuss the institutional arrangements which have hindered the development of the five markets mentioned earlier. Although the institutional market arrangements are a part of the market identification process, these arrangements are important enough in themselves to be discussed separately here.

One of the fundamental attitudes fostered by the markets for fish products is what Walter Hickel calls fishing for the "fillet of the sea," that is, harvesting only the prime species demanded and discarding all else from a catch [13, p. 128]. This practice by fishermen is in contrast to those of the fishing fleets of some foreign nations--they process the entire catch into appropriate end-products, much like the total utilization of a steer, pig, or chicken at a packing plant. Fishermen and fish processors, however, cite uneconomical, short-run costs associated with the use of trawl fish and the comparative advantages of other animal and vegetable sources of protein. Nevertheless, if the utilization of trawl fish should be profitable, then the "fillet of the sea" attitude must be overcome first.

In reviewing the individual markets, the reduction industry exhibits a preference for one species--menhaden--which results from historical use. Reliance on menhaden has channeled harvesting and processing operations into the most efficient methods of handling very large quantitites of menhaden at a time. The boats used are specialized purse seine vessels, operating profitably only when tons of menhaden are captured. Onshore plants have capacities for these large quantities of fish and also profitably operate only with large inputs of menhaden. As a result of the menhaden's migratory habits, boats and plants remain idle half of the year in the Gulf, and because of intensive fishing efforts in the Atlantic, boats and plants have been idle for several years on end. The marketing of menhaden fish meal has also defined domestic fish meal with certain characteristics, i.e., the amounts of protein, moisture, ash, calcium, and other elements in the meal. (The same is true for menhaden fish oil.) Fish meal processors are hesitant to process under-utilized trawl fish because the resulting fish meal may have "inferior" characteristics, thus endangering their market. In addition, if fish is brought in by shrimpers, landings must conform to the established menhaden season and/or meet a minumum quantity level for the plant.

In the pet food industry, the use of fish has decreased relatively and in some cases absolutely, despite its low price compared to sources of protein from other animals. The reason for this is the increasing demand for canned, dry, and semi-moist gourmet meals which emphasize livestock and poultry ingredients. The use of these ingredients was encouraged by favorable input prices and by consumer acceptance. All major pet food makers have shifted production to meet this trend in pet food consumption. At the present time, however, pet food makers are caught in a cost-price squeeze--the costs for livestocks, poultry, and cereal ingredients are rising and manufacturers are unable to pass on all these costs. Nevertheless, the gourmet meals will continue to be processed if it is profitable to do so and the demand for them remains strong. Advertising and promotion has played a large role in the demad for gourmet meals, in effect selling them to the pet owner. Advertising and promotion techniques for fish (and its staid image) apparently have not been tried.

The seafood industry (for human consumption) maintains strong market resistance to the introduction of new species. This resistance stems from lack of consumer acceptance (which is in part affected by industry advertising and promotion), unfavorable past experience with fish by the consumer, and little contact with less popular species by the industry. At the present time, the demand for the more popular species is so strong a price differential of one-third or more would be necessary to move less popular species through the market--in spite of serious shortages at times for cod, haddock, and flounder. Fish handlers who do buy less popular species from shrimp crews exploit this demand situation (by offering a lower price than that prevailing in the market) besides being sometimes the only buyers shrimp crews can go to.

The seafood industry also depends on one product form (the fillet[11/]) which accounts for over half of total fish consumption [9, p. 229]. These two factors, species preferences and the fillet product form, is akin to the marketing of Angus T-bone steaks. Certainly there is a market for specific fillets, but the introduction of new product forms from the fish flesh separator will, in the words of Miyauchi and Steinberg, "shed the identity of the species and ... appeal to the consumer on the basis of their attributes alone" [18, p. 166]. Thus, less popular species can become a nutritious item instead of remaining unwanted or unused. With fillet and ground fish markets established, seafood can compete with livestock and poultry not only in the home and in restaurants, but also in the mass and quick-snack food categories [16, p. 21].

As indicated, institutional arrangements are often at the heart of decisions made in the individual markets for fishery products. These underlying relationships affect markets for fishery products, the level of supply, consumer acceptance, advertising and promotion, and governmental

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[11/] In fresh and in frozen forms.

policies. In addition, there are linkages between the markets, the institutional arrangements, and the supply of fishery products. Such a representation of these three factors and their linkages are illustrated for any one fishery product in Figure 6.

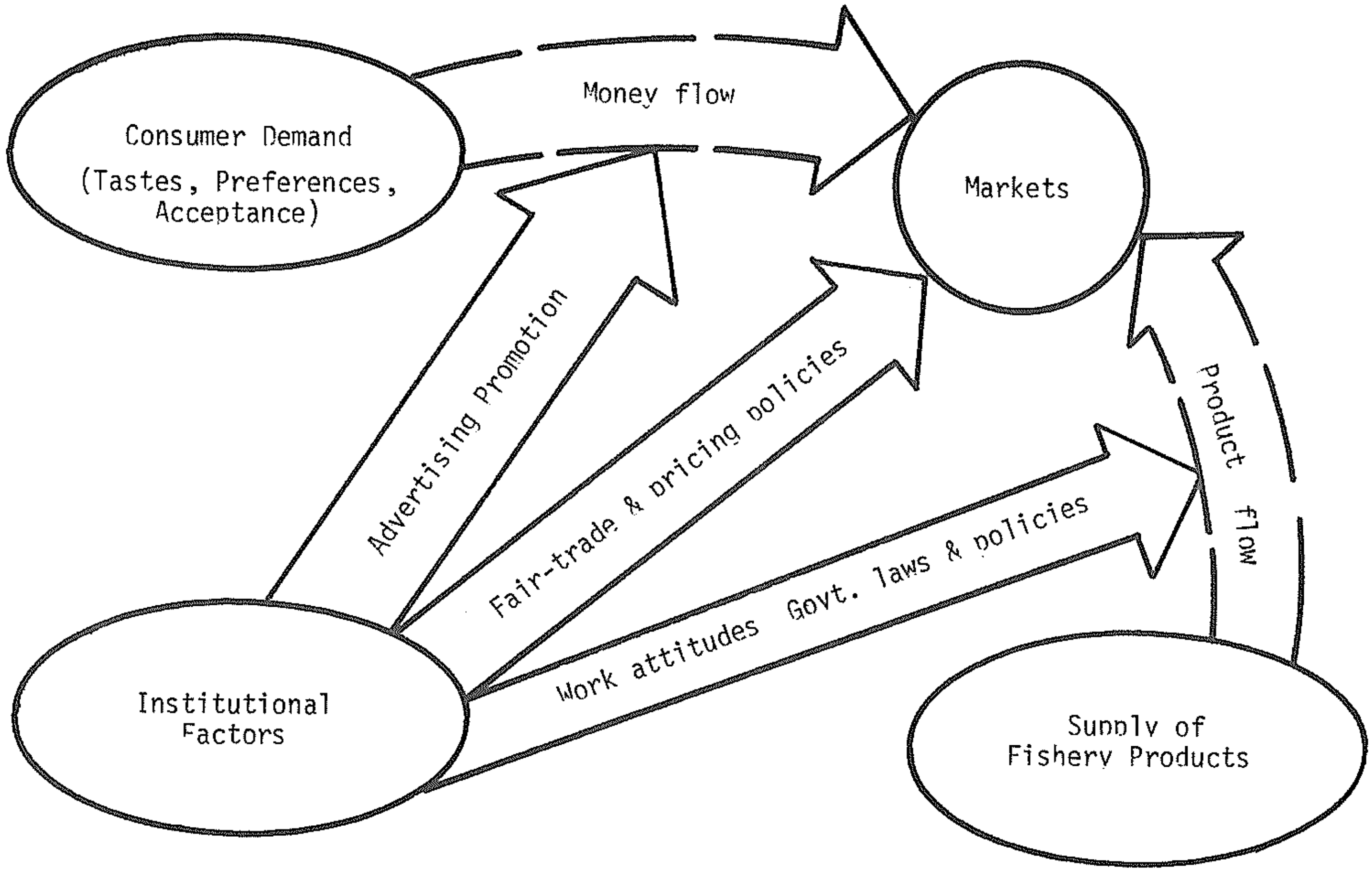

Figure 6. Institutional Arrangements in a Fishery and Its Market.

MARKET QUANTIFICATION

In this section we summarize the quantification of relationships among important variables in the relevant markets for trawl fish. The quantification process will enable us to state more precisely the direction and magnitude of change in the price of fish portions, for example, if trawl fish are processed into this end-product. In addition, this process provides measures of the response of a commodity's price to a percent change in its supply, that is, how "flexible" [12/] a commodity's price may be to a change in its supply. Finally an evaluation will be made of the potential volume of trawl fish that could be handled through each market. "Potential volume" in this case refers to an amount that would not depress market price to or below producer costs.

An entire publication could be written to describe and discuss the detail of both estimating procedures and findings relating to this section of the report. In the interest of space limitations and the needs of the general reader, these estimating procedures are not included here. A brief summary appears in the Appendix along with tables of data and findings which will be referred to in the paragraphs which follow (see Appendix Notes). The discussion which follows is therefore generally limited to the results of the analyses conducted on each of the relevant markets.

Relationships Within Markets

Reduction Market

The results from analyzing both fish meal and fish oil demonstrate that their prices were affected more by the prices of substitute products than their own supplies. For fish oil, its domestic demand was affected more by the prices of soybean oil and inedible tallow than monthly production of fish oil; its export demand was affected more by the price of tallow in Europe than the price of fish oil. For fish meal, its price was more affected by the price of soybean meal than U.S. production or imports of fish meal. (The impact of imports on fish meal price was twice as much as production.) However, the most important determinant of fish meal consumption (production plus imports) was fish meal price, followed by soybean meal price.

Fish oil. Analysis of fish oil markets revealed several important points. First, preliminary analysis indicated that there was no relationship between the fish oil market and the fish meal market. Second, there

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[12/] Flexibility, as used here, refers to the positive or negative percent change in a commodity's price brought about by a one percent change in either its own supply or another important related variable.

was also little or no relationship between the price of domestic fish oil and fish oil exports; that is, the domestic price depends largely on the U.S. fats and oils market while exports depend largely on the European fats and oils market.

In the U.S. market, the prices of soybean oil and inedible tallow both exerted the strongest effects on domestic price, while monthly production had little effect. In Europe the price of tallow, one of several important fats and oils,[13/] exerted a large effect on fish oil exports followed by the price of Peruvian fish oil, the world leader in reduction products. The negative effect a change in margarine production had on fish oil exports was not as expected (Appendix Table 1)--one would expect fish oil exports to increase if margarine production increased. The negative effect may be due to a changing composition of margarine ingredients over the period investigated, in addition to lack of data on industrial shortening production.

Fish meal. The U.S. fish meal market is influenced by both the domestic animal feedstuffs market and the world fish meal market. The domestic animal feedstuffs market, for high protein feeds, is reflected by the price of soybean meal, while the Peruvian fish meal price reflects the world fish meal market. Therefore, the U.S. price of fish meal (menhaden) reacts quickly to changes in both markets, especially to changes in the Peruvian price. In fact, early analyses indicated that 96 percent of the monthly variation in U.S. price was explained by the movement of the Peruvian price. These results suggest that the Peruvian price may be a good proxy for the U.S. price.

Important variables which affected the monthly price of fish meal and the quantity of fish meal demanded are listed in Table 3 (equations are in Appendix Table 3). Almost all the variables affected the price and the quantity of fish meal demanded in expected directions. For example, an increase in broiler placements or in the price of soybean meal increased the price of fish meal. Also an increase in the price of fish meal decreased the amount of fish meal demanded.

For equal amounts of U.S. production and imports of fish meal, the latter variable had twice as much effect on fish meal price than the first--even though one would expect price to be affected by total supplies, no matter where the source. This result may be due to the slightly different characteristics of imported fish meal (anchovies and herring versus menhaden) and the heavy dependence on imports. Analysis of the fish meal market also indicated that demand for fish meal was highest in the second and third quarters of the year, a time when broiler and feeder pig placements are at their highest levels (see Appendix Table 3).

[13/] Groundnut (peanut) oils, palm oils, and soybean oil are some substitutes for fish oil.

Table 3. Effect on U.S. Fish Meal Price and Quantity of Fish Meal Demanded[a] with a One Unit Change in Important Market Variables, 1967-72.

A. U.S. Price of Fish Meal (Dollars/Ton)[b]

Variable	Unit	Effect
Monthly Production	1,000 T	- .22
Monthly Imports	1,000 T	- .50
Soybean Meal Price	$/T	+ .80
Broiler Placements	Mil.	+ .19

B. Fish Meal Demanded (1,000 Tons)

Variable	Unit	Effect
Broiler Placements	Mil.	+ .16
Peruvian Fish Meal Price	$/T	-6.10
Soybean Meal Price	$/T	+ .58

[a]U.S. monthly production plus monthly imports in the following month of fish meal, in thousands of tons.

[b]For example, an increase of a thousand tons of monthly fish meal production would decrease U.S. fish meal price by $.22 per ton.

Source: Appendix Table 3.

Fish solubles. The fish solubles system was investigated as well and its results are reported in Appendix Table 5. Fish solubles are a by-product of the process which separates oil and meal and consequently its quantity and importance are limited. Therefore, the discussion of solubles shall be brief. The analysis indicated that price of fish solubles was most affected by its own supply--if supply increased by 1,000 tons price decreased by $.5/ton. The quantity of fish solubles demanded (the actual amount supplied) was most affected by the price of soybean meal, the dominant high protein feed. The sparse relationships reported here are due in part to the limited feeding of fish solubles by producers and the unique form in which it must be fed (semi-liquid).

Pet Food Market

For fish used as animal food (in canned, fresh, and frozen forms), the results indicated that fish landings had practically no effect on fish prices along the Gulf and for the U.S. as a whole. Fish prices were stable over 1965-72 (see Appendix Table 6) and this may have been due to the institutional setting of the industry--the small number of buyers and suppliers who have strong contractual ties, causing in turn "sticky" prices.

In the analysis fish price was related to fish landings and a variable which corresponded to all the other ingredients in pet food. This variable was the wholesale price index of farm products--wholesale because the farm products (cereal grains and meats) are bought by pet food manufacturers. For fish used in canned animal food only, the price of Gulf fish increased, but at a slower rate, when the wholesale price index of farm products also increased (Appendix Table 7). These results suggest that fish should be in a good competitive position as an ingredient in canned animal food during a time of rising prices. Again, changes in the annual amount of fish landed did not have an effect on the price of fish used in canned animal food. Despite the negligible effect landings have on fish prices, we believe something can be said about the nature of demand and the response of price to a change in fish landings. These points will be discussed in the subsection dealing with price responsiveness.

Fish Fillet/Portion Market

The price of Atlantic groundfish, at both the ex-vessel and wholesale levels, was affected by domestic landings, imports of fillets, and the consumer price index of red meats (Appendix Table 9,10). These three factors had approximately equal effects on both the ex-vessel and wholesale prices for groundfish (in fillet weight); per unit increases in landings and imports decreased the ex-vessel and wholesale prices a fraction of their per unit value, an increase in the red meat price index also increased prices fractionally. In addition to the above market variables, the stocks of fillets and national disposable income were also important variables affecting the demand for Atlantic groundfish, although to a lesser degree. The important difference between the two levels of demand for groundfish is that the ex-vessel demand reflects the fresh market, into which most domestic landings go, and the wholesale demand reflects the frozen market, which is dominated by the imports of frozen fillets. Both markets have evolved in this manner during the past 15 years.

The demand for fish portions, fish sticks, and a combination of the two was affected, in order of magnitude, by the stocks of fish sticks and portions, production of the respective products, the consumer price index of red meats, and national disposable income (see Appendix Table 10,12). For either fish portions, or sticks, or a combination of both, an increase of one million pounds of stocks is associated with a decrease of about 0.5 cents per pound. For per unit increases in the other variables, the price per pound decreased by a smaller amount (except for the red meat price index, which increased these prices). This was especially evident for increases in the consumer price index of red meats, thereby putting fish sticks and portions in a good competitive position.

The effects of per unit changes in important variables are listed in Table 4. As in Table 3, the effects on the prices of fish sticks, fish portions, and a combination of the two can be positive or negative. For example, a ten billion dollar increase in national disposable income would increase the price of fish sticks by 0.5 cents per pound (Table 4).

Fresh Fish

The analysis for fresh fish landed in Texas indicated that the demand for seven popular species (reflected by an aggregated price) and the supply of the same seven species have remained relatively stable over 1966-71. Graphs of this price series and the landings made of the seven species[14/] are shown in Appendix Figure 1. Individual species, such as red snapper, have experienced a relative decline in landings coupled with increasing prices, while landings of redfish have increased and corresponding prices have remained relatively stable (see Appendix Figures 2, 4).

The above results suggest that per capita fresh fish consumption in Texas has been decreasing with increases in the state population. (This conclusion is based on the assumption that Texas has negligible amounts of exports and imports of fresh fish.) For individual species, however, there have been changes in the postions of their respective demands and supplies, causing changes in market price and consumption. For example,

[14/] Includes redfish, seatrout, red snapper, black drum, flounder, sheepshead, and croaker.

Table 4. Effect on the Price[a] of Fish Sticks and Fish Portions with a One Unit Change in Important Market Variables, 1960-72.

Variable[b]	Unit	Effect on Price of Fish Sticks	Fish Portions	Both
Stocks of Sticks and portions	Mil. lbs.	-.499	-.483	-.456
Production of Sticks	Mil. lbs.	-.272		
Production of Portions	Mil. lbs.		-.152	
Production of Both	Mil. lbs.			-.131
Nat'l disp. income	Bil. dols.	.056	.129	.103
Index of red meat prices	1967=100	.414		.334

[a]In cents per pound.

[b]For example, an increase of one million pounds in the stocks of fish sticks and portions would decrease fish stick price by about 0.5 cents per pound.

Source: Appendix Tables 12-14.

the demand for red snapper has increased and per capita consumption has decreased, evidenced by higher prices and a relative decline in landings.

The investigation of the fresh fish species, including the aggregate category, indicated that there were definite seasonal (12-month or yearly) patterns and cycles lasting several years. The results were probably due not only to the biological cycles of fish, but also to seasonal demand factors such as Lent and other man-made factors. Almost all the landings and prices of every species exhibited not only seasonal patterns but also cyclical patterns of varying lengths (see Appendix Table 15, part B). Landings for some species peaked in summer, like croaker, with a simultaneous trough in price during the summer; this situation was just the opposite for other species, such as seatrout.

Price Responsiveness

Now that the basic relationships within the markets have been investigated and reported, the results from each market can be used to calculate the price responsiveness. As defined, price responsiveness measures the positive or negative percent change in price caused by a one percent change in supply (or another variable). This concept is commonly called a commodity's flexibility. If a commodity's flexibility is less than one, it implies that price changes disproportionately less than a change in the other variable; if the flexibility is greater than one, price changes at a greater rate than the other variable. The price flexibilities in the relevant markets for trawl fish, with respect to product supplies, are listed in Table 5.[15/]

The price flexibilities for fish meal, fish oil, and fish solubles are all less than one. These estimates suggest that meal, oil, and solubles had very stable price structures during 1965-72, where changes in important market variables did not affect their prices greatly. The price of fish oil is affected so little by its own production because fish oil is such a small segment of the fats and oils market. The same is true for fish meal, where it is a small segment of the high-protein feed market. Therefore, fish meal could be in a good competitive position with increases in soybean meal price; however, the use of fish meal relative to broilers is limited by the increase of "fishy" taste in chicken meat.

The price flexibility for pet food-type fish is estimated to be less than one. This estimate is based on interviews with firms and suppliers due to the limited amount of data available for adequate statistical analysis. We believe this estimate to be accurate within the range of fish used (see Appendix Table 6). One of the reasons for this price-quantity relationship is the availability of other protein and filler substances as ingredients--cereal grains, and beef, pork, and chicken parts--and the small

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[15/] Economists do not usually report signs for flexibilities unless they do not conform to theoretical expectations. However, for the convenience of the lay reader, signs of flexibilities are reported in this study.

Table 5. Price Flexibilities[a] in Selected Markets for Fish Products.

Price of[b]	Production	Imports
Fish Meal	-.03	-.12
Fish Oil	-.31	
Fish Solubles	-.07	
Pet Food	> -1.00[c]	
Fish Fillets		
Ex-vessel	-.78[d]	-.80
Wholesale	-1.36[d]	-1.21
Fish Sticks	-.40	
Fish Portions	-.53	
Fish Sticks & Portions	-.63	
Whole Fresh Fish	-.53[c]	

[a]Calculated at the means of the variables. Economists do not usually report signs for flexibilities unless they do not conform to theoretical expectations. However, for the convenience of the lay reader, signs of flexibilities are reported in this study.

[b]For example, a one percent increase in fish meal production would decrease monthly fish meal price by .03 percent.

[c]Landings.

[c]Landings, in fillet weight.

Source: Appendix Tables 1-16.

numbers of buyers and sellers which tends to make the price "sticky." However, it should be noted that marketing and production plans are made in advance by pet food firms. Therefore, if the amount of fish landed was either too much or too little for a firm to use, we could expect fish price to respond more flexibly at the extremes of the range.

The demand for fish used in pet food, keeping in mind the price-quantity relationships stated above, may be best illustrated by Figure 7. Between the quantities Q_1 and Q_4 demand for pet food-type fish is relatively inflexible, that is, movement along the demand curve in either direction will not change price very much. (For example, a decrease from Q_3 to Q_2 will increase price from P_2 to only P_1.) But to the left of Q_1 or to the right of Q_4, movement along the demand curve will cause price to rise or fall more rapidly.

The flexibility estimates for Atlantic groundfish at ex-vessel level also indicate that the price structure in this market was also relatively stable. A one percent increase in landings would decrease price by .78 percent. Although the flexibility with respect to imports is essentially identical (-.8), it is useful to separate them, especially when they reflect different markets. At the wholesale level, price was flexible with respect to both landings (-1.36) and imports (-1.21). This result stems mainly from the marketing margins operating at the wholesale level which amplifies the effect of changes in supply.

For fish sticks, fish portions, and a combination of the two, price flexibilities were all less than one, indicating that an increase in supplies would decrease price at a slower rate. The same was true for increases in the amount of stocks (flexibilities averaged -.15). Price flexibility for fish sticks with respect to income was also less than one (.75); that is, as income increased during 1960-72 the prices of fish sticks increased at a slower rate. This suggests that consumers' buying power for this item increased.

The price responsiveness of fresh fish indicates that individual species' prices are relatively inflexible to changes in landings. All the individual species have flexibilities less than one (see Appendix Table 16). This suggests that an increase in landings would increase revenue to a seller, as price received decreased less than proportional to the increase in landings. The price flexibility for the aggregate category indicates that percent changes in price are approximately half (-.53) of the percent changes in landings for the fresh fish market as a whole.

In summarizing the price flexibilities with respect to the utilization of trawl fish, it appears that every market could absorb additional quantities of fish without greatly affecting the price in respective markets. It is only for fillet (wholesale level) that there appear to be limitations on utilizing trawl fish (flexibility greater than one). In the case of fillet price at the wholesale level the relative flexibility appears to be related to the marketing margins.

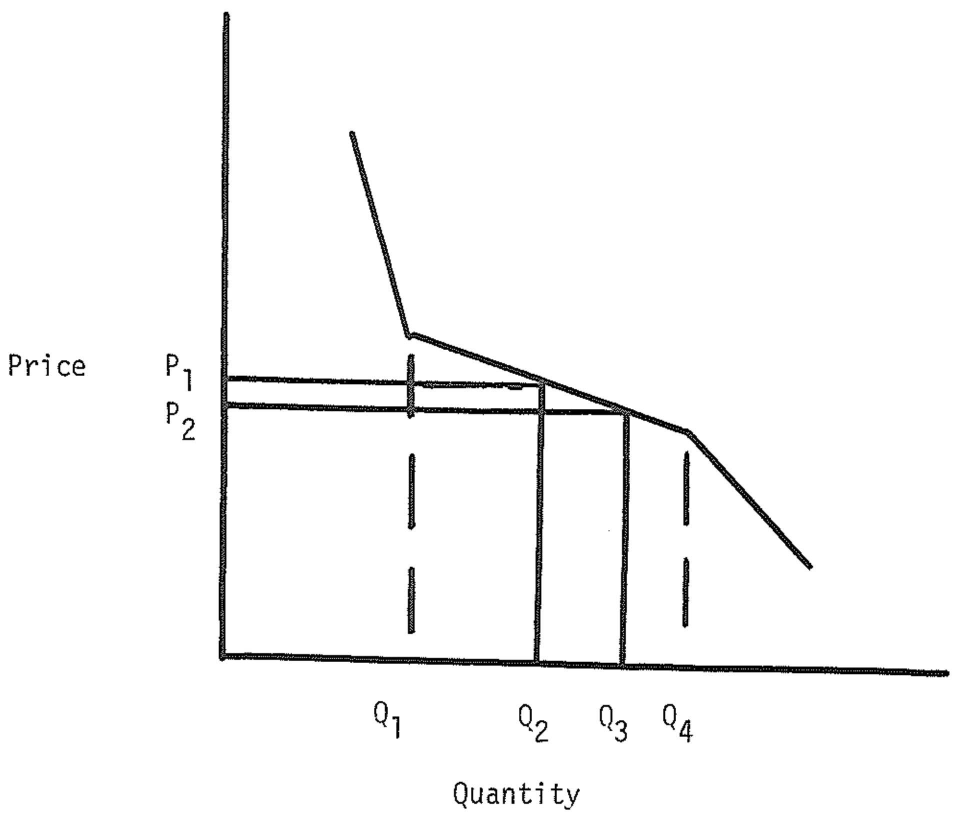

Figure 7. Hypothetical Demand for Fish Used in Pet Food.

Potential Volume

Estimates of the potential volume of trawl fish which could reasonably be handled through the various relevant markets depends on the observations and findings discussed above regarding both available supplies and the nature of the markets. The estimated quantities of trawl fish available for landing along the coast of Texas are summarized in Appendix Table 18. These quantities are then converted into end-products for each market by appropriate conversion factors. The percentage change in volume of end-product represented by each is then multiplied by the price-production flexibility for each market to obtain an estimate of the impact on (decrease in) price which would result from increasing the volume through the market. The limit on the potential volume of trawl fish in each market is set, by assumption, at an amount such that price would not decrease more than 10 percent from current levels (see Appendix Table 17 for indices on the data).

Using a conversion factor of 20 percent and the highest ratio of trawl fish caught relative to shrimp (7:1), it is estimated that average monthly production of fish meal, in each quarter, beginning with the first, would be 1.15, 1.79, 5.81, and 3.51 thousand tons. These monthly increases in production are increases of, by quarter, 27 percent, 7 percent, 16 percent, and 26 percent compared with the average 1965-72 monthly production. Monthly prices of fish meal would be expected to decrease, from this added production, by .8 percent in the first quarter, .2 percent in the second quarter, .5 percent in the third quarter, and .8 percent in the fourth quarter.[16/] These percentage decreases indicate that the effect on price of utilizing trawl fish as fish meal should be very negligible.

For fish oil, an annual increase in production may be expected at 12.33 million pounds, using the highest ratio of hypothetical trawl fish landings and a conversion rate of 3.325 percent.[17/] This quantity is a 7 percent increase from the average 1965-72 annual fish oil production. Annual fish oil price would be expected to decrease by 2.1 percent using an annual estimated price-production flexibility of -0.31 (Appendix Table 2). This result indicates that the effect on price of utilizing trawl fish as fish oil would also be negligible.

The potential amount of trawl fish which could move through the pet food market is estimated to be about 20 million pounds annually, which is approximately 25 percent of the average annual landings for this market along the Gulf. Since statistical analysis of the limited available data

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[16/] A 27 percent increase in monthly production in the first quarter multiplied by the price-production flexibility of -.03 (from Table 5) gives a decrease in price of .8 percent. Decreases in monthly prices for each quarter can be calculated similarly.

[17/] The average of oil percentages in Table 2 except for menhaden.

did not determine a significant flexibility, this estimate is based on a general analysis of the operations of the pet food industry and the nature of its demand for fish. It is felt that under current conditions the pet food industry along the Gulf could handle an increase of this magnitude without depressing prices by more than 10 percent.

The potential volume of trawl fish which could be marketed through the fresh Atlantic groundfish market is estimated to be approximately 17 million pounds (fillet weight). With this amount, prices would be reduced by about 10 percent. However, there is a physical limitation on the amount of large sized finfish available among trawl fish. We estimate this limit to be 9 million pounds round weight, or 3 million pounds fillet weight for both the fresh and frozen markets. This is based on the potential of 368 million pounds of trawl fish landed of which 2.5 percent would be acceptable for this market (Appendix Table 18). This quantity of fish would depress price in either market by only 2 percent.

In the fish portion market, we estimate the potential volume of trawl fish to be approximately 40 million pounds for fish sticks, 54 million pounds for fish portions, and 70 million pounds for a combined product category. These quantities were calculated by dividing the 10 percent decrease in price, assumed earlier, by the flexibilities for fish sticks, fish portions, and the combined product category (Table 5). This operation gives the percentage increases in the above products that would result in a 10 percent decrease in their prices. The actual amount of fish in these items is equal to 75 percent of the weight of the increased amounts (calculated from the average production during 1960-72). This amount of cooked fish can be converted to live weight, i.e., potential volume of trawl fish, by dividing by 40 percent [18, p. 169].

The potential volume of trawl fish which could be marketed through the whole fresh fish market in Texas is estimated to be approximately one million pounds. This quantity of finfish, if marketed, would be expected to decrease the whole fresh fish price dockside by 10 percent. While a greater quantity may be available it may result in depressing prices by more than 10 percent.

The various estimated potential volumes of trawl fish are summarized by product market in Table 6. Generally, the higher the input price is for fish in a specific market, the lower the potential volume which could be marketed. The pet food market seems to be an exception to this rule.

The reduction market (fish meal and oil) could absorb all of the estimated landings of trawl fish from Texas based shrimpers with only a negligible decrease in price. The pet food market is more limited but could handle approximately 20 million pounds annually with prices being forced down about 10 percent. The fish fillet market could absorb the increased supply of appropriate species from this source with prices being affected by about 2 percent. Fish sticks and portions can absorb 40 million and 54 million pounds, respectively. The fresh fish market is the most limited and could absorb only approximately one million pounds with an associated price reduction of about 10 percent.

Table 6. Potential Volumes of Trawl Fish[a] for Selected Product Markets, Live Weight.

Market	Maximum Volume
	Million Pounds
Fish meal and Fish Oil	368
Pet Food	22
Fish Fillets[b]	
Fresh	3
Frozen	3
Fish Sticks	40
Fish Portions	54
Both	70
Whole Fresh Fish	1

[a]From the Western Gulf of Mexico.

[b]Fillet weight.

Source: Appendix Tables 1-16.

SUMMARY AND CONCLUSIONS

The problem inherent in the use of trawl fish caught incidental to shrimp trawling operations is as much economic and social as it is physical or biological. It is the broad purpose of the research project, of which this report forms a part, to examine the economic questions involved in this issue. For the purpose of analysis these economic questions can be divided into two general areas. First is the need to determine the nature and viability of the markets through which the trawl fish might move, including a consideration of the potential volume which could move through each market without seriously disrupting the market through depressed prices.

The second area of economic analysis is the study of the costs incurred in the preservation, collection and delivery of these trawl fish to the appropriate markets or demand points. This includes both the development of model systems for performing the necessary tasks (since practically no system now operates) as well as estimating costs associated with each. Simply stated, the first area is analysis of the demand for the trawl fish, the second a study of the costs of making these fish available. The research reported herein deals only with the first of these two areas, that is, the nature of market demand for these trawl fish.

The objectives dealt with in this report were to estimate the magnitude and composition of trawl fish, thereby determine appropriate product markets currently available for trawl fish, and identifying characteristics in each market. The major findings are summarized in this section and related to the utilization of trawl fish. Also discussed are the limitations of the analysis and areas where additional research is needed.

Conclusions

Based on interview data and a review of scientific literature, it was found that most trawl fish were less than one pound live weight and the majority belonged to the sciaenid family, whose members include the croaker, the seatrouts (sand, silver, and white), and the black drum. Porgy was the single most numerous species. It was also found that large-sized finfish are rarely caught, comprising not more than 2.5 percent of an average trawl. The actual amount of trawl fish caught will vary by location trawled, the time of day or night, water temperature and salinity, and the season in the year. Although no precise quantity can be estimated, the number of trawl fish discarded in the Western Gulf of Mexico ranges from 52 to 368 million pounds; the most likely amount lies in the middle of that range.

Most current product markets for fish were identified as appropriate for the utilization of trawl fish. The market identification was based on the magnitude as well as the composition of types and sizes of trawl fish.

The products into which trawl fish can be processed include fish meal, oil, and solubles, pet food ingredients, fresh and frozen fillets, fish sticks and portions, and whole fresh fish. Generally, it was found that the higher a use trawl fish can be put to (i.e., from fish meal to pet food to seafood), the higher will be the price offered for trawl fish.

All of the above fish products were affected by competing products in the larger markets of which they are a part. Fish meal and solubles are part of the high-protein feed market which is largely dominated by domestic and export market conditions for soybeans and soybean meal. Fish oil belongs in the fats and oils market which, for fish oil, reflects domestic industrial use and foreign food use; soybean oil and tallow are its major competitors in this market. In the pet food market, cereal grains, livestock and poultry parts, and contractual ties between buyers and suppliers affected prices for fish. Finally, the chief competitor to seafood was red meat in the U.S. food market. For every one of the above fish products, the trend in price increases of competing products was associated with smaller price increases in the fish products, thereby putting them in a good competitive position.

Many of the above product markets will easily absorb products processed from trawl fish. This conclusion was based on the response of price to increasing supplies in each market and on current conditions in each market.

The high-protein feed market can utilize the highest estimated volume discarded trawl fish available in the Western Gulf of Mexico---368 million pounds---with very little decrease in the price of fish meal. The oil produced from this same quantity of trawl fish can easily be absorbed as fish oil in the fats and oils market, with only a small associated price decrease; however, individual fats and oils are usually blended at fixed rates and overall market growth has been stable. Based on current market condition, an estimated 20 million pounds of trawl fish could be utilized by the pet food industry. For seafood products as a whole, a potential 80 million pounds of trawl fish could be absorbed in the U.S. food market mostly in the form of fillets, portions and sticks. This estimate was based on the price responsiveness of various seafood products to increased supplies and on the current level of prices and short supplies of high-protein foods.

Limitations and Additional Research Areas

This analysis has dealt only with the ability of product markets to absorb potential quantities of trawl fish. The question of economic feasibility of utilization of the trawl fish has not been answered and depends on the specification of potential delivery and utilization systems, estimation of associated costs and evaluation of these costs relative to present market prices. This latter part of the analysis is currently under study and will be part of a future publication.

Two important limitations must be recognized regarding the conclusions on markets for trawl fish. First, the estimated relationships among important variables in each market are only valid within the range of the data used. Both the high-protein feed market and the U.S. food market are presently experiencing their highest price levels ever. In a few cases conditions have changed such that prices and quantities are beyond the data used in developing coefficients so that interpretations must be made with some caution. The exact magnitude of the coefficients estimated here are not as important as the relationships among variables which have been determined. An example of this exists in the examination of the market for fresh fish landed in Texas. The aggregate flexibility estimated was -.53 based on 1966 to 1971 data. Currently it appears that demand has shifted so that the flexibility is lower and an increase in landings of 20 percent would have a much smaller effect on market price.

A second limitation important particularly in Texas is the location of markets for various fish products along the Western Gulf of Mexico. Except for whole fresh fish, there are currently no facilities for handling the potential supply of trawl fish along the Texas coast. This necessitates consideration of transhipment to other areas or the construction of facilities in the development of a system for utilization of trawl fish.

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APPENDIX

TECHNICAL NOTES, TABLES AND DATA SOURCES

TECHNICAL NOTES

The following Appendix Tables 1-16 form the heart of the market quantification section. The object in analyzing each market was to estimate the coefficients of the independent variables. The coefficients reflect the direction and magnitude of change in the dependent variable for a unit change in an independent variable (holding all the other variables constant). The estimating procedure was accomplished through the least squares linear regression technique, which has the model

$$\mu_y = a + b_1 x_1 + \ldots + b_n x_n + e$$

wherein the expected value of y is related to a set of x's by linear functions (b's) and deviations from the expected value are relegated to the error term. Usual assumptions in this model are y is a normally distributed random variable with a fixed standard deviation of σ; σ^2_y is independent of x; and the e's are distributed randomly with $e_i^2 = 0$.

Where two or more of the important variables are determined by the working of models depicting a market, some form of simultaneous (equation) regression technique is recommended. The fish meal market is a good example of this "identification" problem. In Appendix Table 3 the price of fish meal is partly a function of the imports of fish meal and in Appendix Table 4, imports of fish meal is partly a function of the price of fish meal. In this case, the price and imports of fish meal are determined not only by each of their own models but also by the determination of the other variable by its own model; thus, the need for a simultaneous technique.

Fish oil and meal. Both the fish meal and fish oil markets lend themselves to simultaneous regression techniques. However, the reader will note that both markets were analyzed using ordinary least squares (OLS). Preliminary analyses indicated no relationship between the domestic price of fish oil and exports of fish oil; hence, including each of the variables in the other's equation would not significantly alter OLS coefficient estimates from simultaneous coefficient estimates.

The problem encountered with the fish meal market was that the variables simultaneously determined--price of fish meal, imports of fish meal, price of fish solubles--had most of the explanatory power of all the variables. The result was that the reduced form equations in a two-stage least squares analysis were often not significant statistically. A multivariate analysis of variance and a cononical correlation were run with all the endogenous variables on one side of the equation regressed against all the exogenous variables. The results in the analyses were not much different from analyzing each individual table in the fish meal and solubles market; the cononical r^2 (.69) for the whole system was slightly higher than the highest R^2 for any one equation.

Pet food. All of the equations in the pet food market were run by OLS. It was felt that the wholesale price index of farm products and landings of pet food-type fish were not themselves a function of the price of pet food fish. Landings are generally influenced by the effect of weather on fishing, availability of fish, and profits earned or expected by the fishermen. The equations in Appendix Table 7 are in logarithmic form, showing the percentage effect on price caused by a one percent change in the price index.

Fillets/portions. The fish fillet/portion market also lends itself to simultaneous regression techniques. Variables determined in the system could be price, imports, and stocks. Again, the reader will note that all the models except the wholesale demand for Atlantic groundfish were run by OLS. The first problem encountered in a complete simultaneous system (three endogenous variables, three equations) was that one of the equations was underidentified. This problem can be "solved" by respecifying one of the endogenous variables as exogenous. Then the problem of multicollinearity between independent variables emerged, resulting in very biased estimates for the fish block market. For this market the only acceptable models were those for the imports of fish blocks. The continuous upward trend in all the variables also biased estimates of the stock demand for blocks, groundfish, and sticks and portions--here stocks for all these items were positively related to the prices of respective products. The model of ex-vessel demand for Atlantic groundfish was run by two-stage least squares. The reduced form equation was imports as a function of the variables in Appendix Table 11, plus the other independent variables in Appendix Table 10; the estimated import values were then substituted into the model of wholesale demand.

Flexibilities. After the coefficients of the independent variables have been estimated, they can be used to form part of the calculations to derive price responsiveness (flexibility) in each market. The operation to derive a flexibility is as follows: the coefficient of the independent variable is multiplied by the average value of the independent variable and this term is divided by the average value of price.[1/] The resulting flexibility is then an average one with respect to the data. Another set of observations other than averages, i.e., the most recent observation, can be used in similar manner with the same coefficient to calculate a flexibility at a certain point. The flexibility estimates discussed in this report and

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[1/] This calculation for flexibility is valid when all the variables are in natural numbers. When the equation is in logarithmic form (all the variables are transformed into logs), the coefficient itself is the flexibility. In a semi-logarithmic equation, flexibility is the coefficient divided by the mean of price (when the independent variable is in logs) or is the coefficient multiplied by the mean of the independent variable (when the dependent variable is in logs).

listed in Appendix Table 5 were all calculated at the means of the data. Indices of the data, including means, high and low points, are reported in Appendix Table 17.

Fresh fish. A harmonic analysis was used to investigate the movement of landings and prices for selected Texas finfish and an aggregated finfish category. Harmonic analysis is simply a method used to best fit the cycles apparent in landings and prices (see Appendix Figures 2-6). In this study the cycles were fitted using sine and cosine functions. The basic form of each equation was y = a cos xt + b sin xt where y represents landings or price, a and b are coefficients, x is the number of months in a cycle (12 months in a one-year cycle), and t is 360 degrees divided by the number of months in a cycle.[2/] For every separate cycle, a set of sine-cosine functions is needed in an equation (see Part B of Appendix Table 15).

Each set of sine and cosine functions can be combined into a single cosine function, as listed in Part A of Appendix Table 15. At this point the price cosine coefficient for a particular cycle can be divided by the landings cosine coefficient for the same cycle to obtain a flexibility estimate for that cycle. For a good example and more detail concerning harmonic analysis, see Waugh and Miller's "Fish Cycles: A Harmonic Analysis"[3/] and Tintner.[4/]

In the last part of the Appendix is included a table which indicates sources of data for each relevant market (Appendix Table 19).

[2/] When running this equation on an electronic computer, the programmer should determine whether t should be expressed in degrees or radians.

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Appendix Table 1. Estimated Demand for U.S. Fish Oil.

A. **Monthly Domestic Demand, 1965-72**

Variable	Unit	Coefficient	t - value
Dependent			
Menhaden oil price	¢/lb.		
Independent			
Intercept		-2.236	
Total monthly production	Million lbs.	-0.011†	-1.905
Soybean oil price	¢/lb.	0.498***	6.217
Inedible tallow price	¢/lb.	0.771***	6.888

R^2 = .754 S.E. = 0.946
N =96 d' = 0.463 positive serial correlation

B. **Annual Export Demand, 1965-72**

Variable	Unit	Coefficient	t - value
Dependent			
Total exports	Million lbs.		
Independent			
Intercept		6106.173	
Tallow price[a]	$/MT	5.732***	4.620
Fish oil price[b]	$/MT	- 2.750**	-3.925
Margarine production[c]	1,000 MT	- 3.896*	-2.929

R^2 = .891 S.E. = 28.271
N = 8 d' = 2.279 no serial correlation

[a]U.S., bulk, c.i.f. Rotterdam.

[b]Peruvian, semi-refined, c.i.f. N.W. Europe.

[c]For Belgium, Denmark, France, Italy, Netherlands, Sweden, West Germany, United Kingdom.

†10 percent level of significance.

*5 percent level of significance.

**2.5 percent level of significance.

***1 percent level of significance.

Appendix Table 2. Estimated Annual U.S. Demand for Fish Oil, 1965-72.

Variable	Unit	Coeffiecient	t - value
Dependent			
Menhaden oil price	¢/lb.		
Independent			
Intercept		-4.994	
Annual Production	Million lbs.	-0.013†	-1.740
Soybean oil price	¢/lb.	1.058**	3.633
Inedible tallow price	¢/lb.	.584†	1.621

R^2 = .903 S.E.=0.613

N = 8 d'=2.539 inconclusive

Price-Quantity flexibility=

$$\frac{-.013\ (184)}{7.7} = -0.31$$

†10 percent level of significance, one-tailed test.

**2.5 percent level of significance.

Appendix Table 3. Estimated Monthly U.S. Demand for Fish Meal, 1967-72.

Variable	Unit	Coefficient	t - value
Dependent			
Menhadem meal price	$/T		
Independent			
Intercept		78.089	
U.S. monthly meal prod.	1,000 T	- 0.219[†]	-1.827
Total monthly imports$_{t+1}$	1,000 T	- 0.500***	-6.591
Soybean meal price[a]	$/T	0.798***	4.459
Broiler placements[b]	Million	0.188***	2.839
Menhaden solubles price	$/T	- 0.085	-0.359
R^2 = .617		S.E.=14.871	
N = 71 , where t=current month		d'= .930 pos. serial correlation	
Dependent			
Fish meal demanded[c]	1,000 T		
Independent			
Intercept		57.319	
Second quarter	1,000 T	24.604***	3.579
Third quarter	1,000 T	30.236***	4.324
Fourth quarter	1,000 T	12.319[†]	1.707
Broiler placements[b]	Million	0.156	1.446
Peruvian fish meal price	$/T	- 0.688***	-6.098
Soybean meal price[a]	$/T	0.581**	2.170
Menhaden solubles price	$/T	0.152	0.477
R^2 = .536		S.E.=19.886	
N = 71		d'= 1.645 inconclusive	

[a] 49-50 percent protein, bulk, at Decatur, Illinois.

[b] In 22 states, USDA statistic.

[c] U.S. monthly production plus total monthly imports in the following month.

[†] 10 percent level of significance.

** 5 percent level of significance.

*** 1 percent level of significance.

Appendix Table 4. Estimated Monthly U.S. Demand for Fish Meal, 1965-72.

Variable	Unit	Coefficient	t - value
Dependent			
Total monthly imports$_{t+1}$	1,000 T		
Independent			
Intercept		126.254	
Broiler placements[a]	Million	0.033*	2.006
Menhaden fish meal price	$/T	- 0.790***	-8.338
Soybean meal price	$/T	0.395*	2.037
R^2 = .450		S.E.=17.288	
N = 95 , where t=current month		d'= 1.375 pos. serial correlation	

[a]In 22 states, USDA statistic.

*5 percent level of significance.

***1 percent level of significance.

Appendix Table 5. Estimated Monthly U.S. Demand for Fish Solubles, 1967-72.

Variable	Unit	Coefficient	t - value
Dependent			
Quantity demanded[a]	1,000 T		
Independent			
Intercept		- 6.562	
Second quarter	1,000 T	6.713***	5.122
Third quarter	1,000 T	9.810***	7.800
Broiler placements[b]	Million	- 0.005	-0.229
Menhaden solubles price	$/T	- 0.073	-1.148
Menhaden meal price	$/T	0.015	0.555
Soybean meal price	$/T	0.147***	2.682
R^2 = .629		S.E.= 4.061	
N = 71		d'= 1.629 inconclusive	
Dependent			
Menhaden solubles price	$/T		
Independent			
Intercept		66.996	
Total monthly supplies	1,000 T	- 0.479*	-2.453
Fish meal demanded[c]	1,000 T	0.078†	1.935
Soybean meal price	$/T	- 0.044	-0.397
Broiler price[d]	¢/lb.	- 0.823	-0.927
R^2 = .147		S.E.= 8.402	
N = 71		d'= 0.207 pos. serial correlation	

[a]Monthly production plus imports

[b]In 22 states, USDA statistic.

[c]Monthly production plus imports in the following month.

[d]For two months ahead.

†10 percent level of significance.

*5 percent level of significance.

***1 percent level of significance.

Appendix Table 6. Landings and Value of Fish Used in Animal Foods [Canned, Fresh and Frozen] in the Gulf and U.S., 1965-72.

Year	Landings		Value		Price[a]	
	Gulf	U.S.	Gulf	U.S.	Gulf	U.S.
	--Million lbs.--		--Million dol.--		-- cents/lb. --	
1965	84.3	171.5	1.4	3.4	1.7	2.0
1966	76.4	148.2	1.4	3.0	1.8	2.0
1967	99.5	201.5	1.8	3.8	1.8	1.9
1968	93.5	192.7	1.7	3.6	1.8	1.9
1969	90.2	180.3	1.6	3.5	1.8	2.0
1970	96.5	179.1	1.8	4.2	1.9	2.3
1971	85.9	145.4	1.7	3.3	1.9	2.3
1972	78.5	135.3	1.6	3.3	2.0	2.4

[a]Weighted average of canned, fresh, and frozen.

Source: "Fishery Statistics of the U.S.," 1965-69, and "Fisheries of the United States," 1970-72, National Marine Fisheries Service-Bureau of Commercial Fisheries, U.S. Department of Commerce of Interior.

Appendix Table 7. Estimated Annual Demand for Fish Used in Canned Animal (Pet) Food, for the U.S. and Gulf, 1965-72.

A. Gulf (in logarithms)

Variable	Unit	Coefficient	t - value
Dependent			
Price of fish	¢/lb.		
Independent			
Intercept		-6.650	
Fish landed	1,000 lbs.	0.017	0.246
Wholesale price index of farm products	1967=100	0.532***	5.127

R^2 = .842
N = 8

S.E.= .724
d'=1.653 no serial correlation

B. U.S. (in logarithms)

Variable	Unit	Coefficient	t - value
Dependent			
Price of fish	¢/lb.		
Independent			
Intercept		-10.066	
Fish landed	1,000 lbs.	0.081	0.467
Wholesale price index of farm products	1967=100	1.113***	3.442

R^2 = .709
N = 8

S.E.=1.268
d'=1.685 no serial correlation

***1 percent level of significance.

Appendix Table 8. Estimated Annual U.S. Import Demand for Fish Block, 1960-72.

A. Direct demand

Variable	Unit	Coefficient	t - value
Dependent			
Imports	Million lbs.		
Independent			
Intercept		-4.690	
Price of cod block [a]	¢/lb.	7.639***	3.733
r^2 = .559		S.E.=5.075	
N = 13		d'= .370 pos. serial correlation	

B. Derived demand

Variable	Unit	Coefficient	t - value
Dependent			
Imports	Million lbs.		
Independent			
Intercept		-232.854	
Price of fish sticks and portions[b]	¢/lb.	9.065***	4.059
r^2 = .600		S.E.=4.953	
N = 13		d'=0.494 pos. serial correlation	

[a]Wholesale price.

[b]Weighted average price.

***1 percent level of significance.

Appendix Table 9. Estimated Annual Ex-vessel Demand for Atlantic Groundfish[a], in Fillet Weight, 1960-72.

Variable	Unit	Coefficient	t - value
Dependent			
Ex-vessel price[b]	¢/lb.		
Independent			
Intercept		150.928	
Stocks of groundfish[bc]	Million lbs.	- 51.683	-1.147
Landings[bc]	Million lbs.	- 95.451†	-1.580
Imports[bc]	Million lbs.	- 97.155*	-2.166
Nat'l disp. income	Billion dol.	0.026***	3.400
Index of red meat prices	1967=100	0.172***	3.381
R^2 = .980		S.E.=2.550	
N = 13		d'=1.754 inconclusive	

[a]Includes cod, flounder, haddock, ocean perch, pollock, and cusk.

[b]In fillet weight.

[c]In logarithms.

†10 percent level of significance, one-tailed test.

*5 percent level of significance.

***1 percent level of significance.

Appendix Table 10. Estimated Annual Wholesale Demand for Atlantic Groundfish[a] (in Fillet Weight), 1960-72, in Logarithms.[b]

Variable	Unit	Coefficient	t - value
Dependent			
Wholesale price[c]	¢/lb.		
Independent			
Intercept		3.874	
Stocks[c]	Million lbs.	-0.917†	-1.893
Landings[c]	Million lbs.	-1.362†	-2.001
Imports[c]	Million lbs.	-1.206†	-2.262
Nat'l. disp. income	Billion dol.	0.897*	2.505
Index of red meat prices	1967=100	1.121*	2.431

R^2 = .907 S.E.=0.031
N = 13 d'=1.653 inconclusive

[a]Includes cod, flounder, haddock, ocean perch, pollock, and cusk.

[b]Estimated by two-stage least squares with imports as an endogenous variable and ad valorem customs tax as an added exogenous variable.

[c]In fillet weight.

†10 percent level of significance.

*5 percent level of significance.

Appendix Table 11. Estimated Annual U.S. Import Demand for Groundfish Fillets, 1960-72.

Variable	Unit	Coefficient	t - value
Dependent			
Imports of fillets	Million lbs.		
Independent			
Intercept		577.223	
Stocks of groundfish[a]	Million lbs.	- 2.880***	-5.428
Landings of groundfish[a]	Million lbs.	- 1.925***	-9.900
Ad valorem customs tax	percent	- 14.557*	-2.254
R^2 = .984		S.E.=2.403	
N = 13		d'=2.169	

[a]Atlantic groundfish (cod, haddock, flounder, ocean perch, pollock, cusk), in fillet weight.

***1 percent level of significance.

*5 percent level of significance.

Appendix Table 12. Estimated Annual U.S. Demand for Fish Portions, 1960-72.

Variable	Unit	Coefficient	t - value
Dependent			
Wholesale price of fish portions[a]	¢/lb.		
Independent			
Intercept		-7.234	
Stocks of fish portions & sticks	Million lbs.	- .483†	-1.327
Production of fish portions	Million lbs.	- .152†	-1.470
National disposable income	Billion dol.	.129*	2.350
Index of red meat prices	1967=100	.119	0.528
R^2 = 0.859		S.E.= 2.908	
N = 13		d'= 1.155 inconclusive	

[a]Weighted average of cod portion and haddock portion prices, 2-4 oz. portions.

†10 percent level of significance.

*5 percent level of significance.

Appendix Table 13. Estimated Annual U.S. Demand for Fish Sticks, 1960-72

Variable	Unit	Coefficient	t - value
Dependent			
Wholesale price of fish sticks[a]	¢/lb.		
Independent			
Intercept		18.233	
Stocks of fish sticks & portions	Million lbs.	- .499†	-1.728
Production of fish sticks	Million lbs.	- .272*	-2.511
National disposable income	Billion dol.	.056*	2.952
Index of red meat prices	1967=100	.414*	2.282

R^2 = 0.904 S.E.= 2.174

N = 13 d'= 1.249 inconclusive

[a]Weighted average of cod stick and haddock stick prices, in 8-oz. pkgs.

†10 percent level of significance, one-tailed test.

*5 percent level of significance.

Appendix Table 14. Estimated Annual U.S. Demand for Fish Sticks and Portions, 1960-72.

Variable	Unit	Coefficient	t - value
Dependent			
Wholesale price of fish sticks and portions[a]	¢/lb.		
Independent			
Intercept		-1.555	
Stocks of fish sticks & portions	Million lbs.	- .456†	-1.400
Production of fish sticks & portions	Million lbs.	- .131*	-2.216
National disposable income	Billion dol.	.103*	2.831
Index of red meat prices	1967=100	.334†	1.700

R^2 = 0.852 S.E.= 2.539
N = 13 d'= 1.095 inconclusive

[a]Weighted average price of fish sticks and of fish portions.

†10 percent level of significance, one-tailed test.

* 5 percent level of significance.

Appendix Table 15. Seasonal and Cyclical Coefficients for Selected Texas Finfish Landings and Prices and Length of Cycles, 1966-71.

A. Coefficients[a]

Species	Landings				Prices		
	Time	Seasonal	Cyclical	R^2	Seasonal	Cyclical	R^2
Redfish	n.s.	.052	-.224	.75	-.038	.046	.76
Seatrout	.005	.112	-.188	.54	-.025	.027	.68
Red Snapper	n.s.	n.s.	.124	.44	.009	-.088	.94
Flounder	n.s.	.289	n.s.	.58	-.017	.036	.65
Croaker	n.s.	-.531	n.s.	.30	n.s.	n.s.	---
Aggregate[b]	----	-.046	.060	.41	.031	-.032	.51

B. Length of Cycles

Species	Landings		Prices	
	Seasonal	Cyclical	Seasonal	Cyclical
Redfish	12 mo.	10 yr.	12 mo.	6 yr.
Seatrout	12 mo.	7 yr.	12 mo.	5 yr.
Red Sanpper	12 mo.	6 yr.	12 mo.	8 yr.
Flounder	12 mo.	8 yr.	12 mo.	6 yr.
Croaker	12 mo.	6 yr.	---	---
Aggregate[b]	12 mo.	5 yr.	12 mo.	8 yr.

n.s. = Not (statistically) significant, 10 percent level.

[a]At the 10 percent level or lower; coefficient is in the form of $\sqrt{a^2 + b^2}$ cos (X - arctan b/a).

[b]Includes all of the above species plus black drum and sheepshead.

Appendix Table 16. Price Flexibilities for Selected Texas Finfish, 1966-71.

Species	Seasonal[a]	Cyclical[b]	Direct[c]
Redfish	-.731	-.205	
Seatrout	-.223	-.144	
Red snapper	n.s.	-.710	
Flounder	-.059	n.s.	-.031
Croaker	n.s.	n.s.	-.069
Aggregate	-.674	-.533	

n.s. = Not statistically significant, 10 percent level.

[a]Yearly or 12-month; calculated by dividing price seasonal coefficient by landings seasonal coefficient for the same species in Part A of Appendix Table 15.

[b]Cycle of several years duration (see Part B of Appendix Table 15); calculated by dividing price cyclical coefficient by landings seasonal coefficient for the same species in Part A of Appendix Table 15.

[c]Calculated by regressing species price as a function of its landings only.

Appendix Table 17. Indices on Data of Important Market Variables

Variable	Unit	Mean	Range
Menhaden oil price	¢/lb.	7.9	4.4 - 10.6
Monthly fish oil prod.	Million lbs.	15.9	.3 - 57.3
Annual fish oil prod.	Million lbs.	184.1	119.1 - 265.0
Soybean oil price	¢/lb.	10.6	7.4 - 14.0
Inedible tallow price	¢/lb.	6.5	4.4 - 8.6
Annual fish oil exports	Million lbs.	137.6	65.1 - 229.9
Tallow price	$/MT	171.1	129.0 - 202.0
Peruvian fish oil price	$/MT	180.0	99.0 - 248.0
Margarine production	1000 MT	1656.6	1645.7 - 1677.6
Menhaden meal price	$/T	164.8	131.0 - 237.5
Monthly fish meal prod.	1000 T	20.7	2.3 - 57.0
Monthly meal imports	1000 T	38.7	2.3 - 99.3
Soybean meal price	$/T	88.0	78.1 - 196.0
Broiler placements	Million	238.3	192.0 - 295.9
Menhaden solubles price	$/T	52.3	35.9 - 80.9
Monthly solubles supply	Million lbs.	8.1	.6 - 18.8
Peruvian fish meal price	$/T	161.5	115.2 - 241.0
Gulf pet food fish landings	Million lbs.	88.1	76.4 - 99.5
U.S. pet food fish landings	Million lbs.	169.3	135.3 - 201.5
Gulf pet food fish price	$/T	37.1	33.9 - 40.0
U.S. pet food fish price	$/T	42.0	37.3 - 49.0
Wholesale price index of farm products	1967=100	108.1	98.7 - 125.0
Annual imports of fish blocks	Million lbs.	211.5	89.7 - 355.5
Wholesale price of cod blocks	¢/lb.	28.3	23.2 - 46.9
Price of fish stick & portions	¢/lb.	49.0	44.0 - 66.6
Ex-vessel price of Atlantic groundfish	¢/lb.	12.2	8.3 - 21.3
Wholesale price of Atlantic groundfish	¢/lb.	40.3	32.0 - 62.0
Stocks of groundfish	Million lbs.	43.1	33.2 - 57.7
Landings of groundfish	Million lbs.	134.3	86.2 - 165.1
Imports of fillets	Million lbs.	146.9	84.6 - 244.8
Nat'l. disp. income	Billion dol.	532.9	350.0 - 795.1
Consumer price index of red meats	1967=100	101.4	84.4 - 128.5
Wholesale price of fish portions	¢/lb.	42.8	35.0 - 62.1

Appendix Table 17. (Continued).

Variable	Unit	Mean	Range
Stocks of fish portions and sticks	Million lbs.	15.5	6.9 - 25.4
Production of fish portions	Million lbs.	152.3	49.4 - 268.7
Wholesale price of fish sticks	¢/lb.	58.6	51.7 - 77 1
Production of fish sticks	Million lbs.	87.0	65.1 - 115.9
Texas redfish landings (monthly)	1000 lbs.	99.4	43.8 - 257.8
Texas redfish price	¢/lb.	23.4	17.6 - 29.4
Texas seatrout landings (monthly)	1000 lbs.	121.1	40.8 - 211.7
Texas seatrout price	¢/lb.	23.1	18.8 - 29.3
Texas red snapper landings (monthly)	1000 lbs.	98.8	24.7 - 211.7
Texas red snapper price	¢/lb.	37.9	29.1 - 51.6
Texas flounder landings (monthly)	1000 lbs.	26.0	4.8 - 72.1
Texas flounder price	¢/lb.	23.2	19.4 - 26.6
Texas croaker landings (monthly)	1000 lbs.	9.9	.1 - 61.3
Texas croaker price	¢/lb.	6.3	3.0 - 11.2
Texas aggregated landings (monthly)	1000 lbs.	442.1	261.4 - 680.5
Texas aggregated price	¢/lb.	23.4	19.1 - 27.5

Source: Appendix Table 19.

Appendix Table 18. Hypothetical Quantities of Trawl Fish to be Landed in Texas (1,000 lb. Units).

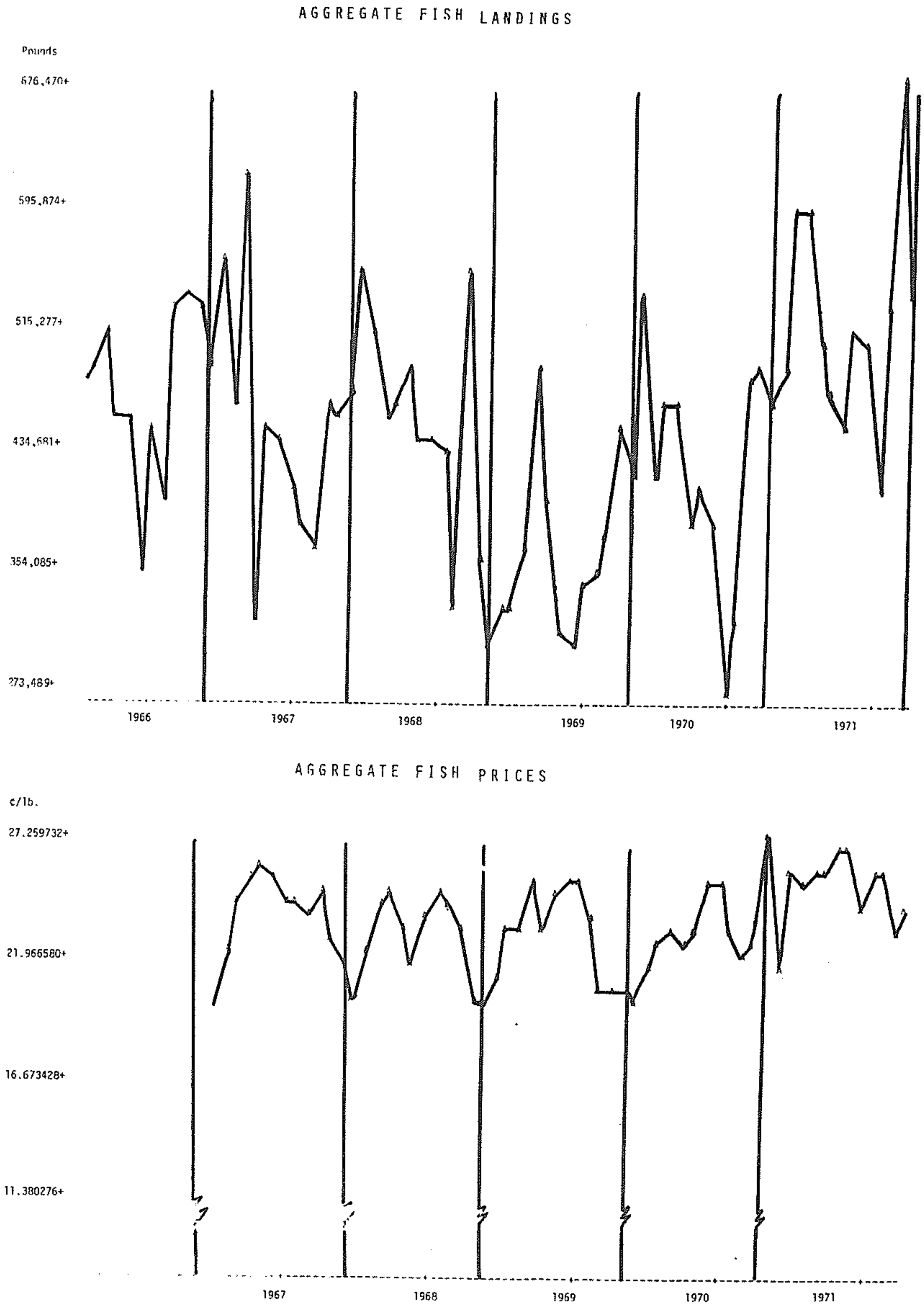
Ratio of shrimp to trawl fish	Quarter I	II	III	IV	Annual
1:1[a]	4,920	7,671	24,907	15,062	52,560
1:4	19,680	30,684	99,628	60,248	210,240
1:7	34,440	53,697	174,349	105,434	367,920

[a]Actual average quarterly and annual Texas shrimp landing, 1966-71, heads-off.

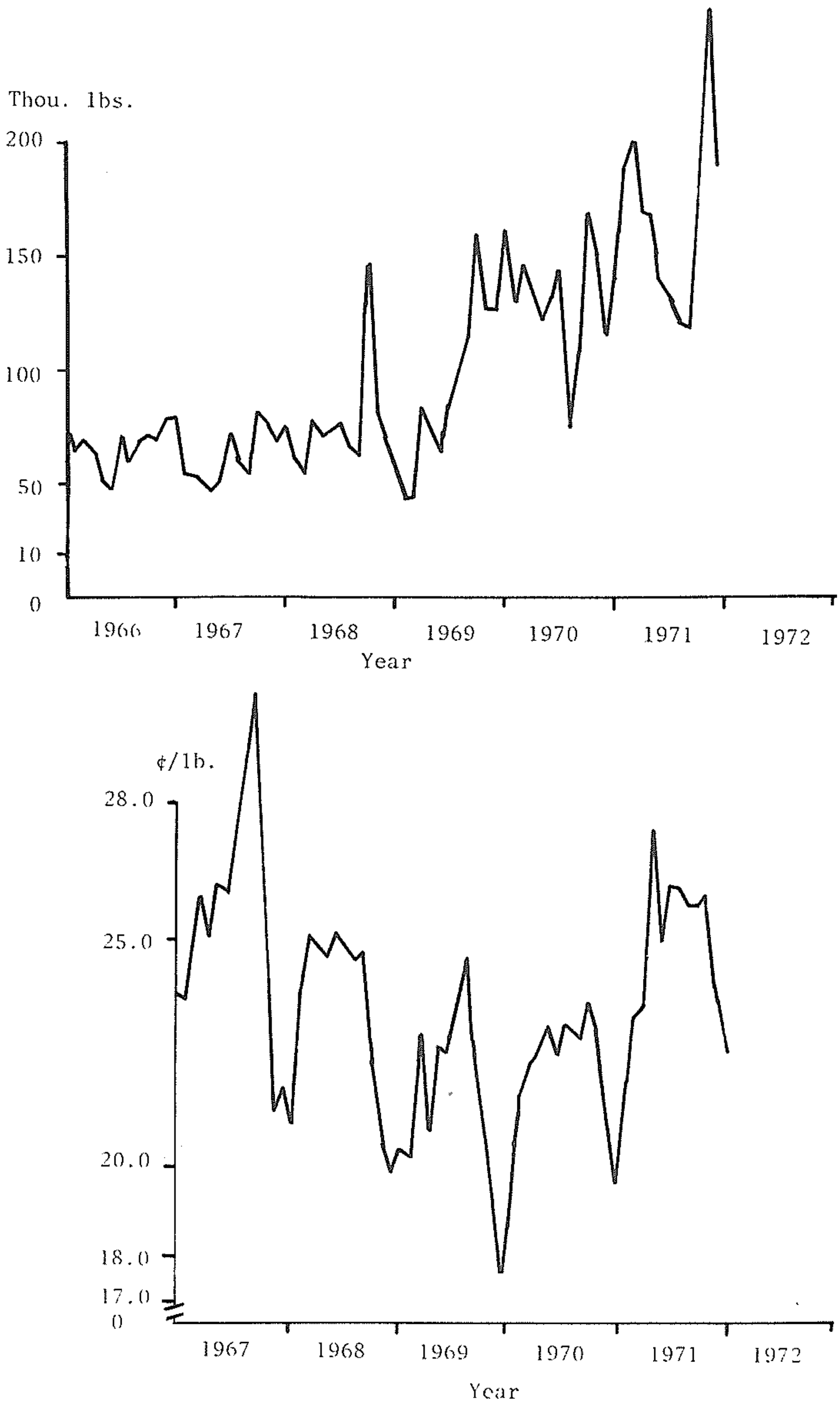
Source: "Texas Landings," Annual Summaries 1966-71, U.S. Dept. of Interior - U.S. Dept. of Commerce and Texas Parks and Wildlife Department.

Appendix Table 19. Sources of Data.

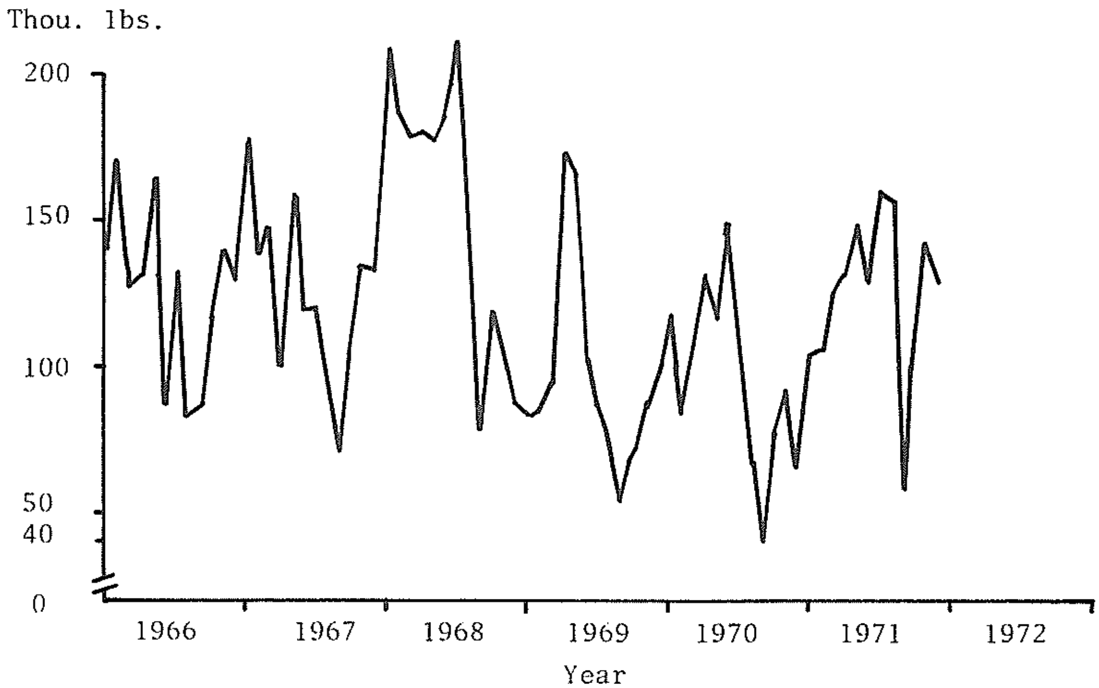
Market	Source
Reduction market	"Industrial Fishery Products Situation and Outlook" 1968-73, published quarterly by the Nat'l. Marine Fisheries Service, NOAA, Dept. of Commerce, Wash.,D.C. "U.S. Fats and Oils Statistics 1950-71," Stat. Bul. No. 489, and "Fats and Oils Situation," ERS, Dept. of Agriculture, Wash.,D.C. "Oil World" 1969-73, published monthly by Oil World Publications, ISTA Mielke & Company, Hamburg, W. Germany. "United Nations Statistical Yearbook, 1971," published annually by the Food and Agriculture Organization, Rome.
Pet food market	"Fishery Statistics of the U.S.," 1965-69, and "Fisheries of the United States," 1970-72, published annually by the Nat'l. Marine Fisheries Service, NOAA, Dept. of Commerce, Wash.,D.C. "Federal Reserve Bulletin," Board of Governors of the Federal Reserve System, Wash.,D.C.
Fish fillet/portion market	"Food Fish Situation and Outlook," Annual Review 1971: NOAA FFSOA 13, published quarterly by the Nat'l. Marine Fisheries Service, NOAA, Dept. of Commerce, Wash., D.C. "Federal Reserve Bulletin"
Fresh whole fish market	"Texas Landings," 1966-71, published annually by the Nat'l. Marine Fisheries Service in cooperation with the Texas Parks and Wildlife Dept., Austin.

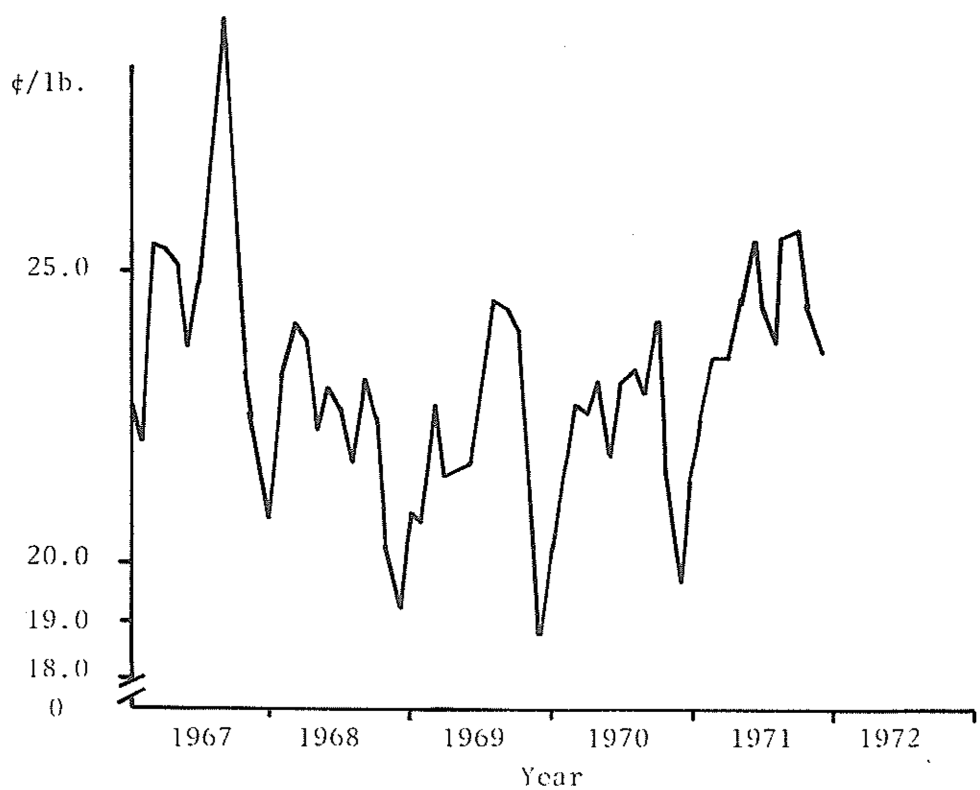


Appendix Figure 1. Aggregate Fish Prices (Dockside) and Landings in Texas, 1966-71.

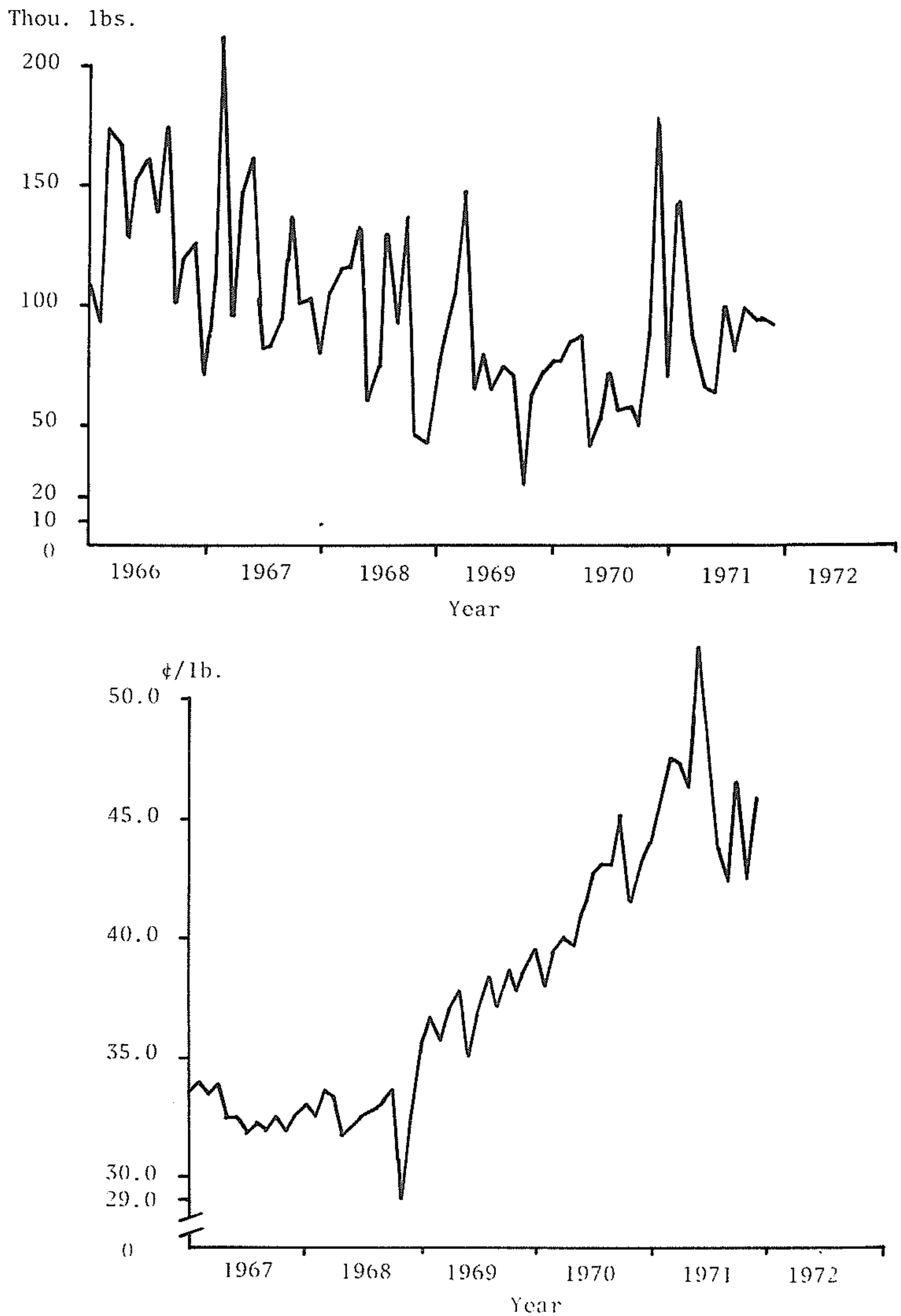


Appendix Figure 2. Monthly Landings and Prices of Redfish in Texas, 1966-71.

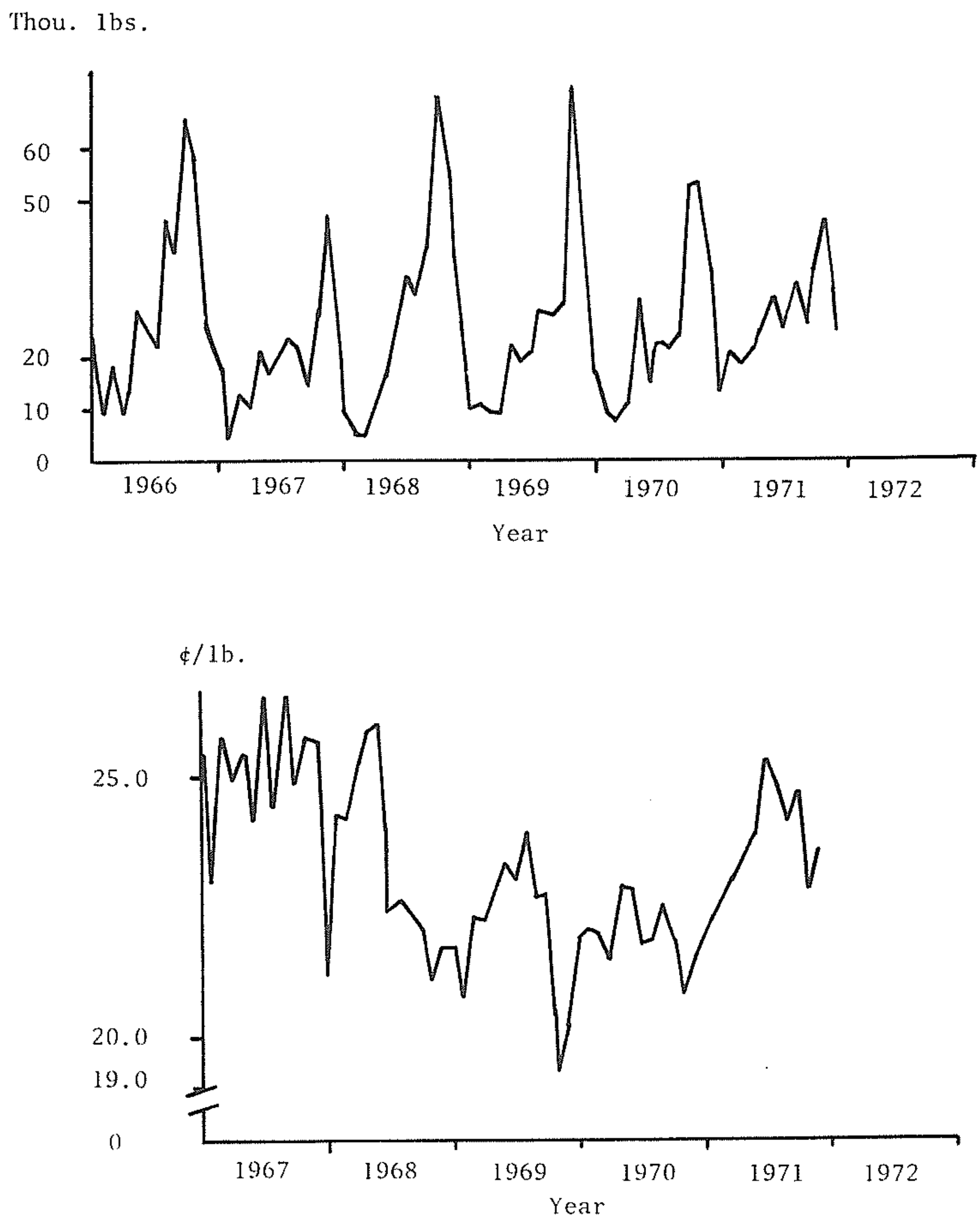




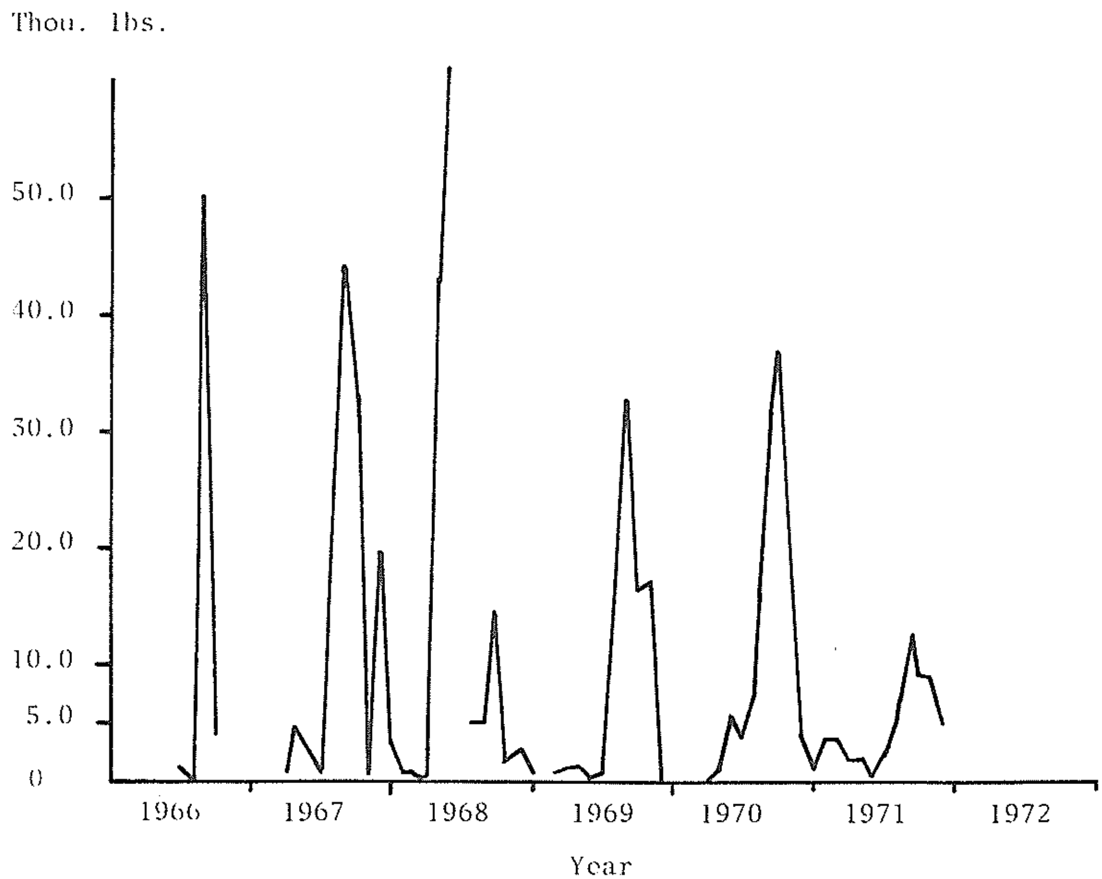
Appendix Figure 3. Monthly Landings and Prices of Seatrout in Texas, 1966-71.

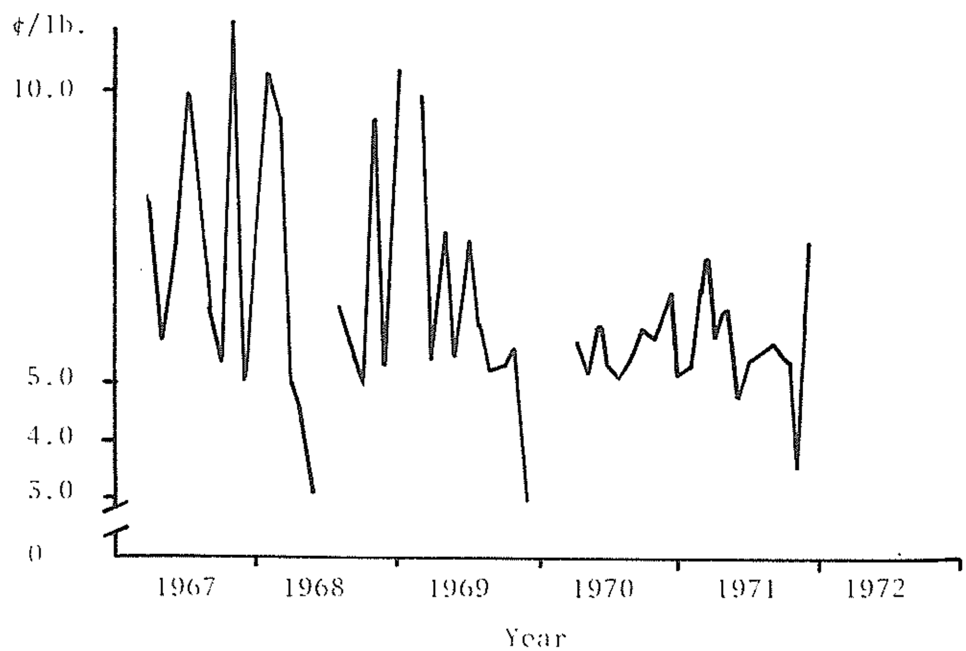


Appendix Figure 4. Monthly Landings and Prices of Red Snapper in Texas, 1966-71.



Appendix Figure 5. Monthly Landings and Prices of Flounder in Texas, 1966-71.





Appendix Figure 6. Monthly Landings and Prices of Croaker in Texas, 1966-71.