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Title: THE UNITED STATES' IMPORTATION OF FISHERY PRODUCTS: AN ECONOMETRIC CASE STUDY OF THE SOUTHERN ATLANTIC AND GULF SHRIMP INDUSTRY

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The objective of this study was to identify and investigate the underlying basis for the increasing volume of U.S. imports of fishery products from 1958-1969. It was recognized that many institutional constraints contributed to the high marginal cost of domestic harvesting which placed the United States at a comparative disadvantage in fish production. However, the fact that both shrimp and tuna were in great demand by American consumers at the same time that these fishery resources were near their maximum sustainable yield contributed to an increased volume of shrimp and tuna imports. It was hypothesized that increasing domestic demand, together with an inelastic domestic supply schedule, contributed to increased prices and encouraged U.S. importation of fishery products. It was also hypothesized that these phenomena resulted in U.S. direct investment abroad for the exploitation of foreign fishery resources.

The Heckscher-Ohlin theory of trade was utilized to examine the relationship of this hypothesis to other empirical studies of trade.

A monthly time series regression analysis of the domestic Gulf and South Atlantic shrimp industry from 1958 through 1969 established that both the domestic supply schedule and the domestic demand schedule for these shrimp were price inelastic. Domestic demand was income elastic. An attempt to specify and estimate an import demand function was unsuccessful due to the lack of data necessary to estimate the simultaneous effects of import supply. However, after hypothesizing several supply relationships in a simultaneous model, it became apparent that increasing world and U.S. per capita incomes would put strong upward pressure on U.S. wholesale prices, *ceteris paribus*. These findings are not totally applicable to the U.S. groundfish industry; however, they are appropriate with reference to the tuna industry.

Policy implications of these results were examined from a consumer, fisherman, national, and world perspective. Many policies which would benefit one group would not necessarily benefit all groups. Because free trade results in income redistribution between nations and individuals, the answer to the question of whether or not increasing imports are a cause for concern is contingent upon the identification of policy objectives.

The United States' Importation of Fishery Products: An Econometric Case Study of the Southern Atlantic and Gulf Shrimp Industry

by

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I. INTRODUCTION

The Problem

World fish production [1/] has tripled over the last two decades. During this same time period, the United States' fish production has remained nearly constant: fluctuating between approximately 4, 500 million pounds and 5, 000 million pounds (U. S. D. C., 1972c, p. 20). This constancy has occurred despite an increase in effective demand: although per capita consumption has hovered near 11 pounds of edible flesh per annum since 1950 [2/], absolute population has increased greatly from 150. 8 million persons in 1950 to 206. 5 million persons in 1972 (U. S. D. C., 1973, p. 70). Even more fish products are consumed if one takes account of indirect consumption such as consuming poultry which have previously been fed fish

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1/ Production is defined throughout this study as synonmous with harvest.

2/ This figure has recently begun to climb: per capita consumption of fish was 12. 2 pounds in 1972, up from 11. 4 pounds in 1971 and equal to the record per capita consumption in 1927. (U. S. D. C., 1973).

meal. [3/] This growth in effective demand, along with constant U.S. production, has resulted in the United States obtaining the position of the largest fish importer in the world. In 1968, these imports reached a record 13.2 billion pounds and accounted for 76% of the total quantity available for consumption in the United States. The import share has since declined to 58% in 1971, or 60% of edible fish supply (Figure 1). While the U.S. catch has remained constant since 1950 (1950 = 4,901 million pounds, 1971 = 4,969 million pounds), imports have more than doubled over this period. (1950 = 25% of the total U.S. fish supply, 1971 = 58%) (U.S.D.C. 1972c, p. 20.)

It is not immediately clear why this should be so. The United States is one of the largest seafood markets in the world, and U.S. fishermen have an obvious geographic advantage in meeting such demand. The fishery resources available to these fishermen appear to be highly productive and abundant. Why then, have U.S. fishermen failed to increase production and capitalize on the advantages they seem to enjoy? Or, phrased in other terms, why does the U.S. import such a large percentage of its fishery supplies? This is the problem that will be investigated by this study.

[3/] Per capita utilization in 1972 was 65.9 pounds, down from a high in 1968 of 86.6 pounds (U.S.D.C., 1973, p. 70).

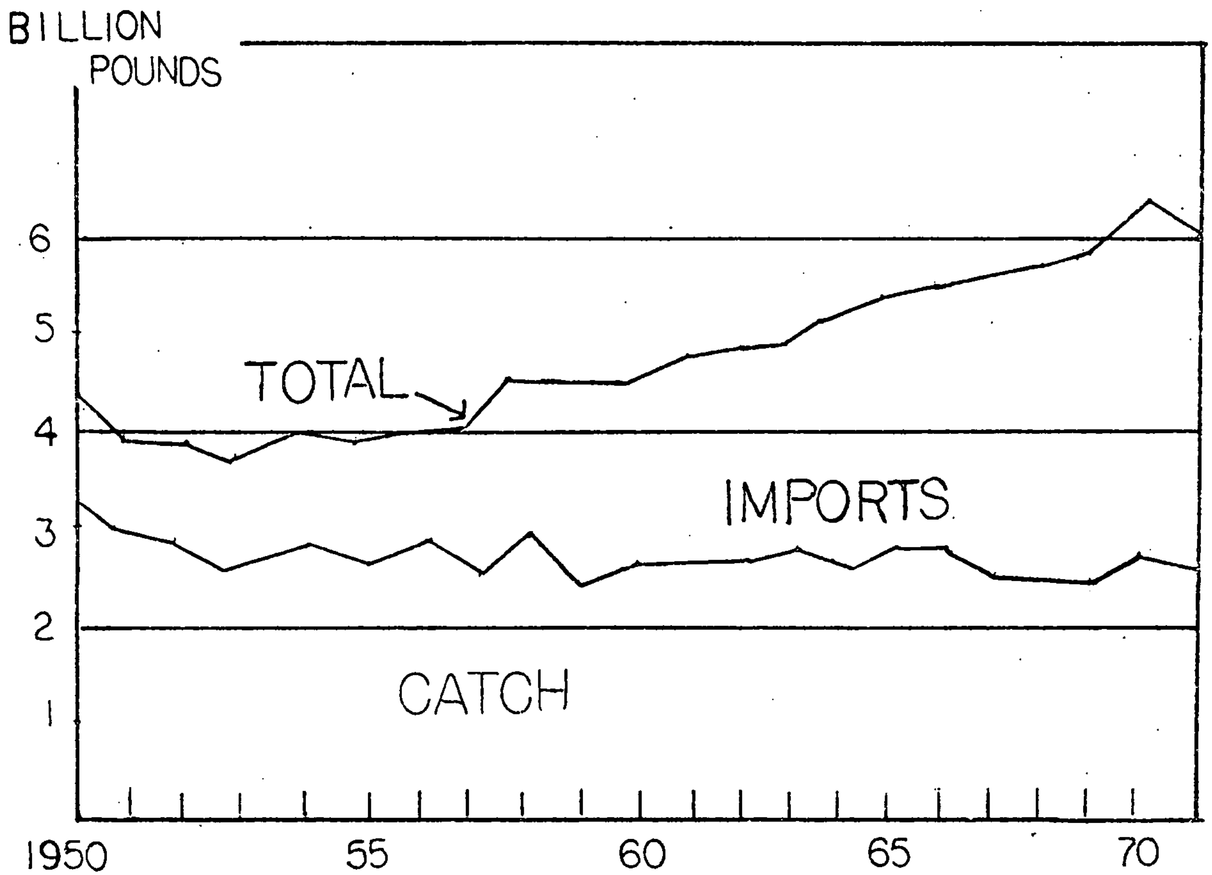

Figure 1. U.S. supply of edible fishery products.

Institutional Constraints and the U.S. Fishery

An obvious answer to the above question as to why the United States imports a large percentage of her total fish supply is that it is cheaper to import than to expand domestic production. Or more formally, given the assumption of perfect markets, the foreign marginal cost of production of these fishery products in conjunction with foreign internal forces of demand result in prices that, even with the inclusion of transaction costs, remain competitive with U.S. domestic prices. That is, the marginal cost of importation is less than the marginal cost of domestic production.

Equally obvious is that this is not a very satisfying or satisfactory answer. Rather, it leads one to ask why are imports cheaper. Much of the debate as to the problems of the U.S. fishery involve hypotheses and analyses as to why the U.S. does not expand domestic fisheries; or, in the terminology expressed before, why the marginal costs of domestic harvesting are relatively high. These high costs have been ascribed to various situations, all of which act to depress the marginal productivity of the U.S. fishing inputs.

One frequently discussed problem is that of institutional constraints. These are laws, customs, or conflicts with other users, that limit catch and raise costs. Whitaker (1972) in a discussion paper, identifies seven such constraints:

1. High initial cost of vessels
2. High cost of insurance
3. Competition for resources of the environment
4. Selective demand for a handful of species
5. Structure of the industry
6. Government owned and government supported foreign competitors
7. Non-regulation of common property resources.

The first item listed here, the high initial cost of vessels, refers to the effect of a 1793 law that prohibits fishermen from landing fish in U.S. ports using a foreign constructed vessel. Unfortunately for fishermen, U.S. constructed boats are approximately 100% more expensive than foreign built boats (Dykstra and Holmsen, 1968, p. 106; Redfield, 1971, p. 7 (ftnote 35)). In 1964, a subsidy plan was enacted in the Fishing Fleet Improvement Act to aid in eliminating some of the differences in construction costs. This act is reviewed periodically and subject to an uncertain future. In addition, the act is very specific as to whom may claim benefits, so that many fishermen are unable to take advantage of the act. For example, Oscar Longnecker, Jr., writes "There have been no shrimp vessels constructed under the Bureau of Fisheries' Fishing Vessel Construction Differential Subsidy Program. Operators generally complain that after all the requirements in construction are met, the costs usually will offset the advantages of the subsidy." (Longnecker, Jr., 1968, p. 114)

Financing can also be a problem. Most financing, particularly for purchase of boats, is done by local banks (Longnecker, Jr., 1968).

> "The New England fishermen are faced with considerably higher construction costs [than foreign competitors], and in addition, the cost of financing here is excessive. The terms by commercial banks in Rhode Island are 50% down payment, a true interest rate of about 11%, and a 5 year repayment period. In ports where there is closer cooperation between the banks and the fishing industry, for instance in New Bedford, Mass., the interest rate for vessels over 60 tons is 6% (Summer 1967), but the smaller vessels are facing much higher interest rates." (Dykstra and Holmsen, 1968, p. 106).

The high initial cost of vessels [4/] is significant when considering the marginal cost of domestic production. Fishermen will be interested in replacing their older boats with larger capacity vessels only if they are reasonably confident that the resulting average total costs will be sufficiently lower than their previous average total costs for the expected output level. (They must be sufficiently lower in order

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4/ There is also a high initial cost for major items of fishing gear. Many items such as nets and twine could be obtained from foreign sources at a greatly reduced price if it were not for high import duties. The same is true for some types of instrumentation such as sonar scanning gear and basic and auxiliary power sources. (Panel Reports, 1969, VII-54) to compensate for the opportunity costs of the funds used in the construction.) High capital costs will be reflected in the average total cost figure and could inhibit expansion.

The same effect may result from high insurance costs.

> "To the extent that coverage is difficult to obtain, capital investment is discouraged. Financial institutions may be unwilling to grant loans to fishing vessel owners if they fear they will be unable to obtain insurance on the collateral - the boat . . . . To the extent insurance costs absorb gross revenue and reduce profit, they will in this way also discourage investment." (Redfield, 1971, p. 13)

Michael L. Redfield discussed these high insurance rates and focused on large claims as the source of the problem. He cites a Coast Guard study (A Study of Cost Benefits and Effectiveness of the Merchant Marine, U.S. Coast Guard, May 1, 1968) as identifying fishing vessels as having the poorest safety record of any group of vessels. For example, Longnecker, Jr., (1968) states that not only is insurance a costly part of the shrimping operation, there are few companies writing insurance on shrimp trawlers. He estimates that premium costs vary from 5-1/2 to 9-1/2% of the hull value with $1,000.00 deductible, the variation in rates being based on loss experience.

The third constraint listed is competition for resources of the environment. Conflicts over resource use in the various fisheries have resulted in numerous pieces of legislation that, in effect, penalize the efficient. These laws prohibit efficient fishing devices such as fish wheels and traps, small mesh nets, electronic sonar fishing location devices, or they limit catch, fishing time, or fishing grounds. (Chapman, 1965, p. 8-15; Chapman, 1968, p. 262-269; Hamlisch, 1962; Fulton, 1968; Crutchfield, 1969, p. 40-47). The goal of such regulations may be conservation, but one result is the discouraging of capital investment in those inputs that result in increased productivity. For, it is just such devices that are legislated against. Lower productivity of an input implies a higher marginal cost of the output and a discouragement of the expansion of the industry, as well as a "sheltering" of the inefficient entrepreneur.

There is also competition for resources that is destructive to the fish populations. Every year dredging and filling of estuaries for housing developments, marinas, oil drillings, channel improvements, etc., destroys over 250,000 acres of U.S. wetlands, (Whitaker, personal communication) These wetlands are the nursery grounds for many fish populations or those species on which fish feed.

A further complication is the fact that the U.S. fish consumer is an extremely discriminating diner. Americans prefer only a few marine species such as shrimp, lobsters, perch, halibut, and salmon. They shun, for the most part, such species as squid, spiny dogfish, tanner crab, and numerous finfish (Nash, 1970b).

The result of this highly selective demand is that over the years extreme pressures have been put on the populations of these preferred species. When these resources show decline, the industry is unable to shift to alternative species due to the lack of a market. George Fulton (1968) worded the problem this way:

> "Who is the greatest enemy of the American trawlerman? The Russian who fishes our coasts? The foreigner who sells his product to the American buyer at a low price? The State Fisheries Departments that places restraints on his efforts? The government that taxes him brutally? True, these are also enemies, but compared to the American housewife, all combined do him less damage. 'The flesh is too soft, has bones, has skin, is dark-colored, red colored, dries when frozen, is soggy when thawed, is too small, too big, too long, too short, too oily, not oily enough, and it smells'. The housewife is not concerned as to how much effort and cost went into production and processing of a piece of fish . . . . The fact that American trawlers discard some 80% of their catch consisting mostly of edible fish of one sort or another, in coming up with the species she is accustomed to buying is of no moment." (Fulton, 1968, p. 157)

Another constraint frequently discussed is the structure of the industry. Of main concern is the institution of a lay system of wages. This is a system of wage payments, that is somewhat similar to rural share cropping payments. This system provides that the crew on a vessel are paid a set percentage of the revenues of a trip. The usual formula is that most trip expenses are removed from gross revenue of the catch. This net figure, called net stock is divided in some way, say 60-40, between owner and crew. [5/] The crew deducts certain remaining expenses and divides the residual between themselves (White, 1954, p. 59). The lay system produced a situation where fish catch determines wage, but wages do not directly determine the demand for labor. As would be expected, this also reduces the incentive to innovate in order to lower costs or substitute labor saving devices because only 60% of any improvement in productivity accrues to the owner (Bell, 1966, p. 127). Concern has also been expressed for the difficulties of recruiting a stable and efficient labor force under this system (Miller and Norton, 1967, p. 135-146; Navratil, 1968, p. 280).

Many fishing nations subsidize their fishing industries which compete for the U.S. fish dollar. Canada is the frequently cited example, since, "financial support has been much broader and larger to the Canadian Atlantic groundfish industry." (Cleary, 1970a, p. 7) Some countries, such as Norway, have very extensive subsidies that combine price support, with subsidies for gear,

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[5/] This is called the broken lay and is supposedly a common lay among New England fisheries. Here 40% of the gross stock goes to the boat and 60% to the crew after trip expenses have been deducted (Dykstra and Holmsen, 1968, p. 106).

bait, insurance, acquisition of new vessels, and guaranteed minimum wages (Stewart, 1969). An argument is sometimes made for offsetting U.S. tariffs to eliminate the effect of foreign subsidies and thereby "give our fishermen an opportunity to compete on an equal basis." (Dykstra and Holmsen, 1968, p. 107). Americans are, to the extent foreign subsidies are not offset in some way, consuming foreign subsidized fish and enjoying a lower retail price for that reason, while both fishermen's total receipts and the balance of payments may suffer.

The final institutional constraint that may produce high marginal costs of domestic harvesting is that of the common property nature of the resource. A common property resource is a resource characterized by the fact that no single user has exclusive rights of exploitation (Christy and Scott, 1965, p. 6). It is argued that the problem of common property resources is that there is no incentive for an individual to refrain from using a resource or to encourage future production from such a resource, because such improvements cannot be captured by the individual. The costs of appropriating and defending exclusive rights are felt to be higher than any added returns that such appropriation might bring. The results of this tend to be faster use rates than would otherwise be the case, and excessive amounts of capital and labor in any given fishery, as well as reduced marginal products per unit of effort. [6, 7]

It might be argued that technological obsolescence should be added to the list of factors that account for high marginal costs of domestic harvesting. However, technological obsolescence is a symptom of the problems occurring due to the institutional constraints discussed above. Also, although technological

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[6] Victor Arnold (1970) concludes in his "An Analysis to Determine Optimum Shrimp Fishing Effort by Area" that overcapitalization occurs in the Dry Tortugas fishery and is reflected in excess capacity. (p. 102) He states, "The presence of overcapitalization substantiates Knights' hypothesis which was elucidated in Chapter II. Common property ownership in natural resources will result in excessive allocation of labor and capital because average product is considered instead of marginal product." (p. 102)

[7] For an excellent summary of the traditional literature dealing with common property problems of the fishery see Bromley (1969). Bromley criticizes what he detects as weaknesses in the theoretical arguments of the traditional authors. Relevant to this argument, Bromley states, "Thus, the allegation by traditional theorists that common property leads to overexploitation is an inductive statement with little theoretical support; it is possible for a common property fishery to be overfished, underfished, or properly fished, and the aim of current fisheries programs is to reduce the probabilities of overfishing . . . . As long as the workings of the market place call for production levels different than that quantity which can safely be removed from the fishery, changes in ownership of the resources will not eliminate the resulting disequilibrium." (p. 148-149) This is not to deny, however, that if market conditions are such that fishing is taking place beyond maximum sustainable yield of the fishery, then the money marginal costs of production are higher than if fewer inputs were in the fishery. Whether or not marginal social costs are higher depends on the opportunity costs of these inputs. Bromley's point, I believe, is that it is not the institution of common property ownership *per se* that causes overexploitation, but rather the combination of demand conditions with technological abilities of production that provides the impetus to fish beyond the optimal level.

obsolescence is a genuine problem in some parts of the industry, it should not be assumed that the lack of enormous "factory type" vessels in a fishery is a signal of such obsolescence. Factory vessels are necessary only when there is an absence of accessible processing plants ashore or when there is need to protect foreign exchange balances by limiting the demand for services of non-domestic ports. Otherwise, it is cheaper to process ashore (Chapman, 1968, p. 266; Panel Reports, 1969, VII-52). It also is not true that a larger vessel is necessarily a more efficient vessel. A fisherman, if maximizing profit, will seek to build a vessel of the size that will yield the largest difference between acquisition costs and the expected present value of future earnings. Victor Arnold (1970) in his study of the Dry Tortugas shrimp fishery characterized nine classes of vessel size, from five gross tons to over 80 gross tons. The 10 to 19 gross ton class and the 40 to 49 gross ton class had the lower average total cost per pound ($.108 to .350, respectively). This difference in production costs was not compensated for by increased production capabilities, as the vessels of class size 80 gross lost an average of 6.1 cents per pound of shrimp while fishing in the Dry Tortugas; the vessels of the lowest production cost class received an average profit of 26.2 cents per pound and 20.7 cents per pound, respectively (p. 105).

There is one other factor that can account for the relatively high marginal cost of domestic production: the physical inability of the fishery resource to respond to increased production. Although this was alluded to in discussing the tastes and preferences of the American fish consumer, it deserves to be reemphasized. At any given time there is a certain standing crop, or biomass, of a fish species present in any defined area. This biomass, which is a weight measure, will over time be subject to change due to growth rates of individual fish in the population, mortality and natality within the population, and recruitment of new members or dispersal of old members out of the defined area.[8/] Numerous factors can act and interact to influence this biomass productivity or the rate of weight change produced by a population. If man begins to fish a population and eventually captures more pounds of fish than is accounted for by the biomass productivity, the standing stock of fish must decline. There is some size or standing stock of population that will yield a maximum biomass productivity. This maximum biomass productivity is frequently termed maximum sustainable yield: the maximum catch that can be repeatedly removed from a population.

[8/] See Watt (1968) p. 21-53, for a summary of the principles of ecology. See Crutchfield (1969) p. 207-218, for a discussion of how these principles directly relate to a marine fishery.

Fishing beyond this maximum sustainable yield will eventually fail to yield increased poundage catches, production must of necessity either decline or remain constant at a level below that of maximum sustainable yield. This is frequently referred to as, 'overfishing', thereby usually inferring a negative evaluation, because when overfishing occurs more fish could be had for less effort.

Identifying a fisheries' maximum sustainable yield given the state of the arts is difficult to do because of the extremely complex nature of the dynamics of fish populations. However, Donald Whitaker (1972) has tabulated those stocks in various geographical areas of the U.S. that the National Marine Fisheries Service has evidence to believe are being fully utilized or overfished (Table 1). If one compares this list with a list of percentages of U.S. imports by species (Table 2), it is apparent that many of the species are found on both lists. [9/] Ground fish and other fillet fish imports,

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[9/] One must proceed carefully here, because to some extent the identification of those species which are presently at or beyond m.s.y. (maximum sustainable yield) reflect consideration of the fact that U.S. catch has remained constant for some years. That is, since aggregate catch per aggregated number of tons or vessels has fallen or remained constant, this is viewed as symtomatic of an overfished resource. This is an attempt to measure empirically some counterpart of the theoretical construct of catch per unit of effort as defined for a physical production function, because a declining catch per unit of effort is synonmous with exceeding maximum sustainable yield. Yet, catch per unit of effort assumes a homogenous set of inputs ($\equiv$effort); this is not necessarily reflected in such empirical counterparts as catch per vessel ton. Catch per

Table 1. Stocks of Fish Currently at or Beyond Maximum Sustainable Yield.

Alaska	
King crab	Salmon
Pacific cod	Walleye pollock
Pacific halibut	Yellowfin sole
Pacific ocean perch	
Hawaii	
Bigeye tuna	Yellowfin tuna
California, Oregon, and Washington	
Abalone	Petrale sole
Herring	Salmon
Pacific cod	Spiny lobster
Pacific Mackeral	Yellowfin tuna
Pacific ocean perch	
Gulf of Mexico	
Brown shrimp	Oysters
Pink shrimp	Red snapper
White shrimp	Turtles
Menhaden	
South Atlantic	
Bay scallop	Oysters
Blue crab	Stone crab
Menhaden	Turtles
New England and MidAtlantic	
American plaice	Scallop
Cod	Scup
Haddock	Silver hake
Halibut	Surf clams
Lobster	Yellowfin flounder
Menhaden	

Continued

Table 1--Continued.

Great Lakes	
Chub	Salmon
Lake Herring	Walleye
Lake trout	Whitefish

Source: Whitaker, 1972

for example, represent 31.8% of the United States edible fishery products by weight. Groundfish are so named because they inhabit the water column near the bottom and are caught by trawls which sweep the area close to the continental shelf floor. They include such species as haddock, silver hake, red hake, yellowtail flounder, American plaice, cod, ocean perch and petrale sole, among others. These same species are also viewed as fully utilized in the New England area and to a lesser extent in the Western States. Tuna is

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vessel ton may decline, therefore, for reasons other than a decline of the fishery resource (e.g., a new set of restrictive regulations, migration of fish population, strikes, voluntary tieups, inclement weather, etc.); this would be equivalent to a shift in the production function rather than a movement along a production function. To the extent that this may be true, the attempt to identify overfished resources by catch statistics may be subject to error and, therefore, to conclude these same fisheries have not expanded production because of exceeding m.s.y. would also be erroneous. Other methods of determining abundance such as experimental surveys of adult and larval populations would not be subject to this criticism. For a more detailed analysis of m.s.y. of American fisheries see the section entitled Raw Material Supply in The Future of The Fishing Industry of the United States (Gilbert, 1968).

Table 2. United States' Imports of Edible Fishery Products, 1970.

Item	Thousand pounds	Percent of poundage	Thousand dollars	Percentage of dollars
Fresh and frozen				
Ground fish fillets	186, 107		64, 010	
Other fillets	136, 102		63, 592	
Blocks and slabs	272, 655		70, 622	
Total	594, 864	31. 75	198, 224	24. 4
Halibut	18, 213	. 97	8, 124	1. 0
Lobster	57, 337	3. 06	101, 758	12. 52
Sea scallops	16, 830	. 90	19, 666	2. 42
Shrimp	218, 715	11. 68	200, 035	24. 62
Fresh and frozen salmon	7, 448		6, 656	
Canned salmon	2, 441		1, 577	
Total	9, 889	. 53	8, 233	1. 01
Fresh and frozen tuna				
Albacore	205, 261		56, 897	
Other	234, 279		41, 528	
Lions and discs	3, 229		2, 099	
Canned tuna				
Other	72, 262		44, 309	
Bonito and yellowtail	1, 232		524	
Total	516, 263	27. 56	145, 357	17. 89
Canned sardines	46, 908	2. 50	19, 355	2. 38
Other	394, 281	21. 05	111, 778	13. 76
TOTAL	1, 873, 300	100. 00	815, 530	100. 00

Adapted from U. S. D. C., 1972c, p. 35.

also a large import; however, it is found in pelagic non-coastal areas. Those that enter near U.S. domestic waters such as albacore off California and Oregon, and yellowfin and bigeye off the shores of Hawaii are listed as fully utilized. Shrimp: brown, white, and pink, are also found on both lists; they comprise approximately 11.7% of the poundage of total edible fishery products imported.

Because a 'wild' fish is necessarily an input into the production of a 'captured' fish, a reduction in the standing stock available implies that the remaining inputs will have a reduced marginal productivity. This in turn implies higher marginal costs of production than otherwise, *ceteris paribus*.

Objectives and Procedures

It is apparent that the problems associated with America's domestic fisheries are complex. In order to more fully investigate these problems and how they are reflected in the import volume, the next chapter (Chapter II) will relate the fishery import situation to the theories of international trade. The insights gained from this examination of trade theory will then be utilized in Chapter III to identify and determine the relative importance of the principle import motivating forces. This will be accomplished through the specification of an econometric model of the Gulf and South Atlantic shrimp industry.

The case study of the shrimp industry was selected for several reasons. The American fisheries are diverse, and the number of products imported are numerous and varied; an aggregated investigation of imports would not be as revealing as an individual species approach. This was the assumption that led to the selection of a case study. The selection of shrimp as a species was partly based on the fact that shrimp is the major U.S. fishery import with respect to value and accounted for 25% of the total value of the imported edible fishery items in 1970 (U.S.D.C., 1972c, p. 35). Shrimp imports into the United States have experienced tremendous growth from around five million pounds in 1940 to 218,715,000 pounds in 1970. Also, the United States is the major shrimp consuming market in the world, [10/] and there are no tariffs or quotas on imported shrimp. The shrimp fishery inputs are easier to identify than in some fisheries, as boat owners and operators are for the most part specialists in shrimp fishing and do not utilize their boats and gear in fishing for non-shrimp species (Longnecker, Jr., 1968, p. 116). Although vessels vary greatly in tonnage, essentially all use the double rigged otter trawl net as the means of capture. (Longnecker, Jr., 1968, p. 112). Data series that are available for shrimp, while lacking many economic variable series, are quite good with regard to landings.

10/ Recently (1970-1973) Japan has entered world markets for shrimp as a very competitive demander of the world resources of shrimp.

There are compromises made with the selection of shrimp for a case study of imports. Some of the problems outlined above are not prevalent in the shrimp industry. For example, U.S. constructed shrimp boats are the notable exception to the statement that equal or superior vessels can be constructed abroad at substantially lower prices than are available in the U.S. (Panel Reports, 1969, VII-54)[11/]. There are however, labor shortage problems in the fishery (Longnecker, Jr., 1968, p. 116) as well as high insurance costs. Nevertheless, these lowered construction costs are apparently significant enough to allow some authorities to consider the shrimp and also the tuna industry as exceptions to the high cost generalizations made earlier. (Panel Reports, 1969, VII-51, VII-54). However, it is apparent from Table 2 that, in terms of value, shrimp and tuna comprise almost 43% of the U.S. edible fishery imports. Groundfish and other fillet fish account for only 24.3% of the total value of edible fishery imports. The groundfish industry of New England is frequently listed as an illustration of the high cost situation.

[11/] With regard to shrimp vessels, Longnecker (1968) writes, "A Texas boat builder complained that foreign competitors with the backing of their governments are able to outbid him for fishing boat construction mainly on terms and time of negotiating a contract." (p. 114)

Ideally, a complete analysis of the imports of fishery products would examine all three of these fishery products: shrimp, tuna and groundfish. Unfortunately, both time and fund restrictions do not allow such an approach for this study. Instead, a thorough analysis of the shrimp industry will be undertaken in Chapters III and IV; Chapter III will examine the domestic aspects of the industry, and Chapter IV will examine the import relationships with the aid of a regression analysis. Policy implications of the conclusions of this research will be presented in Chapter V. The limitations of those conclusions when applied to the groundfish and tuna industries will be discussed in Appendix A.

II. INTERNATIONAL TRADE THEORIES AND THE UNITED STATES' IMPORTATION OF FISHERY PRODUCTS

The Classical Approach

The classical theory of trade, stated in simplest terms, claims, "the fundamental reason for trade is the presence of different productive processes in different countries." (Caves, 1960, p. 44) A country, then, exports those products in which its productivity per unit input is relatively higher than in other countries; it imports those in which its productivity per unit input is relatively lower. This principle is known traditionally as the "law of comparative advantage", where, in this case, advantage is based on relative costs of production.

In addition, the classical theory as expounded by David Ricardo (1772-1823) held that the value of a good could be determined by the amount of labor time required in the good's production 12/; therefore, countries export (import) those goods in which their productivity per man-year is relatively higher (lower) than in other countries. Most western economists no longer examine trade with the aid of the labor theory of value, believing the concept

12/ This is the labor theory of value.

of opportunity cost to be far superior. [13/]

Although the opportunity cost approach is considered a superior alternative to an approach such as the classical system which relied on comparative labor costs, [14/] it is complementary to a comparative cost approach based on relative productivities (or relative production costs). This is because different opportunity costs imply different comparative costs, assuming perfect markets. Either approach can be used for exploring the underlying cost conditions represented by factor proportions and factor supplies.

An interesting paper by S. V. Mikhaĭlov (1962) presented to the 22nd Congress of the Communist Party of the Soviet Union utilizes a comparative cost approach in terms of average productivities in order to examine land products versus sea products, although Mikhaĭlov does not extend the analysis to trade considerations. Specifically, Mikhaĭlov states, "for a socialist society with its

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[13/] The opportunity cost of producing one unit of a good, X, is the value of the production of another good, Y, that must be sacrificed in order to utilize resources to produce X rather than Y, where Y is the best alternative use of the resources.

[14/] See Snider (1971), p. 26, for a tabulation of the weaknesses associated with the labor theory of value.

planned economic system and scientific analysis of production, it is far from being a matter of indifference at what cost in labor and materials expended one or another product is obtained." The conclusions of the study are summarized in Table 3 (Mikhaǐlov's Table 2).

Table 3. Basic Economic Indices for the Production of One Million Centners of Meat and One Million Centners of Fish. a/, b/

Index	Meat	Fish	Difference in favor of fish
Capital investment in billions of rubles	2-2.5	1.5-1.7	.5-.8
Production costs in millions of rubles	600	200	400
Labor expenditures in millions of man-days	5.4	1.35	4.05

a/ Figures rounded off.

b/ One centner = 100 kilograms (220.46 lbs)
Therefore, one million centners = 220.46 million pounds or 110,230 tons.

Source: Mikhaǐlov (1962).

Elsewhere in his paper, Mikhaǐlov estimates that the production of one head of beef requires 20 man-days, while the production of an equivalent amount of protein in the form of fish would only take 5 man-days. [15, 16] Mikhaǐlov concludes that, "The relatively high efficiency of capital investment in fisheries gives us an obligation to use all means to develop the resource base by seeking new fishing areas and new species to exploit, by improving commercial fish culture in interior waters, and by broad measures for the artificial propagation of commercial species." (p. 12)

This article is interesting for two reasons. First, this article may have accounted in part for the growing expansion of U.S.S.R. fisheries; the lack of price information indicates that this effort may not reflect the desires of the consumers as much as it does a cost analysis. [17] Secondly, the article is interesting in the type of questions it suggests with regard to the U.S. For instance, is the underlying basis of importation of U.S. fishery

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[15] This is the comparative cost of producing beef versus fish in terms of man-days given the current U.S.S.R. technology. If this were to be an opportunity cost analysis, some valuation of output must be included (e.g., market price schedules).

[16] Christy and Scott (1965, p. 122) state that this is equivalent to 13-14 man-days per metric ton of fish, whereas a report to the U.S. Senate Committee on Commerce, "The Postwar Expansion of Russia's Fishing Industry (Washington, D.C., U.S. Govt. Printing Office, Jan. 23, 1964) estimates that 70 man-days is the average required per ton of fish.

[17] As Christy and Scott recognize (1965, p. 40).

products simply that the U.S. has a comparative advantage (in terms of opportunity costs) in protein production from land based industries while other countries have a comparative advantage in protein production from the sea? And, if this is the case, would not the United States be better off, in terms of economic efficiency, to allocate scarce resources toward land based protein production? These items could then be traded to gain exchange for the importation of fishery products. For reasons that will become clear in the next section, these are difficult questions to answer empirically.

The Modern Theory of Trade

The modern theory of trade owes a debt to both Bertil Ohlin and Eli Heckscher whose works contain "a theory which is different in certain fundamental respects from the classical model, namely in its handling of the relation between international trade, factor allocation, and the distribution of income." (Caves, 1960, p. 24) 18/

The Heckscher-Ohlin theory of trade differs from the classical theory in that it assumes that although production functions between goods differ, production functions for a good between

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18/ The actual evolution of the modern theory of trade is quite involved. Caves'book (1960), particularly p. 6-44, gives an excellent detailed review of this evolution.

countries do not. [19] Countries, then, export (import) those commodities which are intensive in those factors of production that are plentiful (scarce) in comparison with the factor endowments of other countries. [20] Factors of production in this case are those factors of natural resources, human resources, and capital which are of like quality. [21] The comparative advantages depend, then,

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19/ Clement, Pfister and Rothwell (1967) provides a list of the major assumptions of the two commodity, two country, two factor version of the Heckscher-Ohlin theorem (p. 87):
1. Perfect competition exists in factor and goods markets in both countries.
2. Complete mobility of factors applies internally and complete immobility of factors externally.
3. Production possibility curves are concave to the origin, meaning that we are dealing with increasing cost industries and factors with partial substitutability.
4. Techniques of producing identical goods are the same in both countries, meaning that a given bundle of tangible factors yields the same quantity of a given output in both countries.
5. The different production functions for the two commodities are linear and homogenous, meaning constant returns to scale of inputs used.
6. Factor intensity in the production of a commodity distinguishes production functions, and goods can be uniformly classified by their factor intensity.
7. Factors are of identical quality in the two countries.
8. Factor supplies are given, are fixed, and are fully employed--though each country is differently endowed.

20/ Differential endowments as envisioned by Ohlin, embraced both qualitative and quantitative characteristics of the factors and the influence of social institutions.

21/ This sketch of the Heckscher-Ohlin theory abstracts from difficult theoretical issues that are well discussed in the literature. Definitional problems are of considerable concern, and the interested reader should consult Clement, et al. (1967) p. 10-17, for a review of on not only differing factor endowments available to each nation, but also on differing factor intensity requirements in the production of various commodities (e.g., capital-intensive, labor-intensive). If relative factor endowments did not differ between countries and factor intensities were identical for all commodities, there would be no comparative advantages and no trade opportunities. It is the nature of the production functions between goods and the supplies of factors of production between countries that determine the pattern of trade.

The classical theory and the Heckscher-Ohlin theory both tend to abstract from demand conditions. In the factor endowment theory, the underlying thesis is that relative scarcity of factors of production will be reflected in prices. Hence, those items which embody a relatively high proportion of these factors are likely to be less expensive than if otherwise, and therefore they are more likely to be in demand at that price elsewhere in the world community. However, although a country will tend to produce those goods using relatively more of its plentiful factors, whether or not these goods will be exported depends on the preferences of

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of this literature. For the purposes of this chapter, production functions are broadly defined to include such items as the necessary climatic conditions. These climatic conditions are therefore productive factors. Relative factor endowments are conceived of as ratios of physical measurements of quantities of two different factors of production within the country.

consumers for these goods relative to others.

> "If one makes the plausible assumption that in comparison to productive abilities consumer tastes do not vary much from country to country, then it becomes very unlikely that a country would not export products requiring abundant quantities of its plentiful factors." (Caves, 1960, p. 28)

However, different demand patterns in different countries could theoretically constitute a cause for the emergence of trade, even if the production possibilities of the countries are identical. Therefore, the modern theory of international trade incorporates consideration of demand forces as well as those of supply.

Summary of the Modern Pure Theory of Trade and the Relationship to the Problems of the Fisheries of the United States

The model of the pure theory of international trade, assuming the assumptions in the Heckscher-Ohlin theory, including zero transaction costs, can be outlined as follows (following Snider, 1971, 37ff):

1. Trade between nations responds to absolute price differences between nations' goods. Or $P_{a_1} > P_{a_2}$ and $P_{b_1} < P_{b_2}$ where there are two countries, 1 and 2, two goods, a and b, and two factors of production, K and L. Good a is L intensive and good b is K intensive.

2. Absolute price differences between different nations' goods are the result of differing relative prices between commodities within each country. Or

$$\left(\frac{P_a}{P_b}\right)_1 > \left(\frac{P_a}{P_b}\right)_2$$

3. With the assumption of perfect competition, different relative prices imply different relative marginal costs (opportunity costs) of production 22/

$$\left(\frac{MC_a}{MC_b}\right)_1 > \left(\frac{MC_a}{MC_b}\right)_2$$

4. Differing marginal (opportunity) cost ratios of commodities between nations imply either different transformation surfaces between nations or different points of production-consumption on identical transformation surfaces.

5. Differently shaped transformation surfaces are the result of different relative factor supplies 23/ (rather than differing production functions). These transformation surfaces will reflect a lower marginal cost for the good relatively intensive in the abundant factor. Or

$$\left(\frac{L}{K}\right)_1 < \left(\frac{L}{K}\right)_2$$

6. The transformation curves are assumed to be concave. They, therefore reflect increasing opportunity cost conditions because of different factor intensities for different goods.

7. The point of production consumption of the transformation curve is determined by demand considerations. So, countries with identical production possibilities could have differing relative marginal cost ratios due to demand considerations, i.e., different production consumption points on identical curves.

22/ If perfect competition exists for both factors and goods, then the prices of the output equal the marginal cost of output; the price of each factor is equal to the marginal value product ($MP_{input} \times P_{output}$)of the factor and money costs are equal to opportunity costs.

23/ Defining factors in the broad sense (following Ciriacy-Wantrup (1968, p. 29)) of natural, human, and cultural.

This model, while simplistic, 24/ does provide the framework for examining the relationship of the problems of the U.S. fisheries listed on page 5 to the phenomenon of increasing imports of fishery products.

The framework presented above implies the following. The U.S. imports such a large percentage of its edible fishery products because in the pre-trade position, the marginal cost of producing additional units of fish was greater than the marginal cost of producing goods for export to trade for fish; the situation was reversed for exporting countries (also in the pre-trade position). 25/ Remembering that, with the assumption of perfect competition, the marginal cost of the output equals the price of the input multiplied by the inverse of the marginal product of the input, the marginal cost of producing an additional unit of fish is high relative to

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24/ For a thorough discussion of the limitations of this model see Clements et.al.(1967), particularly pages 1-125.

25/ After commencement of trade, the marginal cost ratios of commodities between nations will tend to equalize (assuming increasing cost conditions). "Note, however, that trade itself does not cease when comparative cost differences are eliminated. Rather the mechanism is that the volume of trade increases, causing changes in comparative costs, and this increase in trade stops at a point where comparative cost differences no longer obtain. Barring changes in certain underlying conditions--technology, factor supplies, commodity demands--the resulting volume of trade continues to take place and comparative cost differences are kept non-existent. 'At the margin', international commodity flows cease, yet international trade continues." (Clement, et al., 1967, p. 5) exported goods production because either the price of the input (P_i) is relatively high or the marginal product of the input (MP_i) is relative low, or both. The price of the fishery inputs could be high relative to other domestic goods because of (a) high cost of insurance, vessels, and gear, (b) wages paid to labor that are higher than their marginal value product or (c) domestic subsidies that are given for the production of the exported goods (e.g., grain growers subsidies). The marginal product of the input(s) could be low because of resource exhaustion due to biologically adverse factors such as environmental destruction and overfishing. If this were the case, the marginal productivity of labor, capital, and the water resource could all be relatively low compared to other domestically produced goods. If, due to the commonality of the property rights to the water resource, there is an over abundance of capital and labor inputs relative to the water resource, then the marginal products of capital and labor could be relatively low. Technological obsolescence of capital would lower the productivity of labor as well. Finally, fishing laws which restrict capital employment imply a relatively low marginal product of labor and of the water resource.

There is no shortage of hypotheses that could be developed using a modern trade theory framework specifically applied to the U.S. fisheries. The empirical testing of such hypotheses, however, is an extremely difficult problem. The most fundamental difficulty is that expressed in footnote 25; that is, after commencement of trade, the marginal cost ratios of commodities between nations will tend to equalize (assuming increasing cost conditions.) 26/ The problem becomes one of examining the pre-trade situation to compare the ratio of marginal costs of fishery goods with exported goods. Even if this were accomplished (and there are many definitional and measurement problems involved with measuring marginal costs 27/), there would remain the task of identifying the underlying basis for the differing ratios. This has been attempted with regard to other goods as a test of the Heckscher-Ohlin theorem, and "this seemly easy task has not been accomplished" (Clement, et.al., 1967, p. 97). 28/

26/ This also assumes that factor intensity reversals are not such as to interfere with this equalization. This assumption is probably realistic in the case of fisheries. For further discussion of factor intensity reversals see Clement, et al. (1967), p. 56-60.

27/ One particularly difficult problem with regard to a common property resource is the definition of the marginal product, $\frac{\partial q}{\partial x_i}$, when inputs are combined with a fugitive and dynamic resource. Marginal product evaluations require that the productivity of an input be measured while other inputs are held constant (i.e., it is a partial derivative measure); the dynamism of the fishery resource is such that it is difficult to assume constant without assuming away the problem of interest.

28/ Snider (1971), p. 84-85, lists four difficulties encountered when empirically testing theories of trade: (1) the absence of pre-trade situations that can be compared with post-trade situations, (2) influences on trade patterns of tariffs, quotas, exchange controls, It is illuminating to review the literature with respect to empirical studies of the factor endowment theory, and to relate the conclusions and implications of these studies to the fishery import situation.

Empirical Studies of the Theories of Trade

An outstanding study of the classical comparative cost doctrine was undertaken by G. D. A. MacDougall (1951). The hypothesis MacDougall investigated was that a country would tend to export those products in which its productivity per unit is relatively higher than in other countries. He compared the productivity of labor in the United States with that in the United Kingdom in 1937, a year in which U. S. average manufacturing wages were approximately twice those of the U. K. MacDougall reasoned that, *a priori*, there should be a significant difference between export ratios for goods whose productivity ratios were greater than two and those whose ratios were less than two. That is, the U. S. should export those goods where output per worker was more than twice that of the U. K.'s and import those where this was not the case. His analysis supported his contention.

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subsidies, imperfectly competitive markets, etc., (3) paucity of complete and accurate data, and (4) difficulties of finding appropriate empirical counterparts of theoretical concepts such as "factors of production".

Critics of MacDougall's analysis point out that many relevant variables were excluded. Caves (1960, p. 269) claims that (1) different import content of the two countries exports and (2) differences in import preferences of consumers are particularly important. However, subsequent studies by Stern (1962), Kravis (1956b), and Balassa (1963) seem to support MacDougall's conclusion that relative labor productivities are important forces in determining comparative advantage (Clements, et al., 1967, p. 98; Caves, 1960, p. 272).

However, as Snider (1971) notes, "there is no necessary inconsistency between the classical theory and the Heckscher-Ohlin theory in their predictions of trade patterns. Hence, neither confirmation nor rejection of the classical theory implies either the validity or the invalidity of the Heckscher-Ohlin theory. In short, regardless of the outcome of empirical testing of the classical theory, the testing of the Heckscher-Ohlin theory is warranted on the basis of its own merits." (Snider, 1971, p. 86)

The Heckscher-Ohlin theory is more difficult to empirically test than is a study (such as MacDougall's) which can focus on relative labor productivity. Nevertheless, some studies have been undertaken, the most widely discussed being that of W. W. Leontief (1953). Leontief began with the hypothesis of the Heckscher-Ohlin theorem: that a country will tend to export (import) those commodities which are relatively intensive in the abundant (scarce) factors of production relative to the factor endowments of other countries. Leontief also assumed that the United States was a capital rich country, therefore, the United States' exports should be capital intensive and her imports labor intensive. Leontief studied U.S. import replacement industries and U.S. export industries with the aid of an input output model and came to the conclusion, now known as the Leontief paradox: U.S. import replacement industries required more capital relative to labor than did U.S. export industries. It appeared that the capital abundant U.S. exported labor intensive commodities and imported capital intensive commodities; the reverse of what the Heckscher-Ohlin theorem predicted.

Leontief, himself, did not view this as a refutation of the theorem; he explained the contradiction by arguing that labor in the U.S. was more productive than U.K. labor, therefore the U.S. had relatively more "efficiency units" of labor than units of capital.

Leontief's study generated numerous criticisms, comments and studies. Vanek (1959, 1963) argued that Leontief made a serious omission when he failed to explicitly consider natural resources.[29/]

[29/] Also see Buchanan (1955).

Vanek (1959) computed the factor requirements ratios of exports and competitive imports (Table 4) and concluded the United States' scarce factor is that of natural resources:

> "The results in Table 1, plus the fact that capital appears strongly complementary to, and labor substitutable for, the natural resource factor in the cross section of American industries lead to an important conclusion: it may well be that capital is actually a relatively abundant factor in the United States. Yet relatively less of its productive services is exported than would be needed for replacing our imports, because resources, which are our scarce factor, can enter productive processes only in conjunction with large amounts of capital." (Vanek, 1959, p. 153)

Diab (1956) reached the conclusion that in those sectors of the economy with high net imports and high capital intensities, "the role played by nature is so important as to relegate the special significance of the capital-labor ratio to secondary position."(p. 51) Diab also suggested that if those imports which were produced by American owned firms abroad were eliminated from the analysis, then production in the import replacement industries would be more labor intensive than the U. S. export production.

Another critic of Leontief's study, I. B. Kravis (1956a) states that this phenomena of direct investment abroad by U. S. firms in natural resource intensive industries tends to support the conclusion that natural resources are the scarce factor in U. S.

Table 4. Vanek's Table I and Computation of Export/Import Ratios.

Table I

Domestic Capital, Labor and Natural Resource Produce Requirements Per Million Dollars of U.S. Exports and Competitive Import Replacements, 1947.

	Exports	Imports
1. Capital (dollars in 1947 prices)	2,550,780	3,091,339
2. Labor (man years)	182,313	170,004
3. Natural resources products (dollars in 1947 prices)	340,000	630,000

Ratios of export and import competing requirements of:

Labor	1.07
Capital	.83
Natural resource	.54

Source: Vanek (1959)

production. [30] This phenomenon of direct investment becomes quite important with regard to fisheries, as will be shown later.

In addition to the criticisms dealing with the exclusion of natural resources as a factor of production, there were other comments on both statistical and methodological considerations of Leontief's study. [31] R. W. Jones (1956) faulted Leontief's methodological approach of examining trade patterns to infer factor endowments rather than making direct comparisons of actual domestic and foreign endowments. The Heckscher-Ohlin theory suggests this latter procedure should be followed; as Jones points out, it is possible that both U.S. exports and import competing products are more capital intensive relative to those methods of production abroad. A better methodological approach would be to examine factor endowments and then use actual exports and imports. Ford (1963) claimed that since this was not done, Leontief's study is not a definitive test of the Heckscher-Ohlin theory.

Other attempts to reconcile the Leontief paradox are summarized by Clemhout (1963, p. 105) and include Leontief's explanation in terms of efficiency units of U.S. labor, a relaxation of the assumption of identical production functions and zero transaction costs, and

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[30] Direct investments abroad by U.S. firms are preponderant in such resources as petroleum, iron, copper, pulp and sugar.

[31] Leontief incorporated many of these suggestions in a second study (1956). The findings of this second study corresponded with those of the first.

an inclusion of demand considerations. [32/] The inclusion of demand consideration was mentioned both by Robinson (1956) and Valavanis-Vail (1954). If demand for commodities domestically in the United States favors capital intensive goods, then the U.S. might not have sufficient supply to export such goods. Brown (1957) (as cited by Clement, et al., 1967, p. 103) suggests this is not the case, as the U.S. population consumes relatively more of labor intensive services. However, if natural resources are the limiting factor, as Vanek (1963), Diab (1956) and Buchanan (1955) believe, then demand considerations again assume importance. This is exactly what Kravis (1956a) claims in his article where he states that the explanation of Leontief's paradox lies in the availability of certain natural resources abroad and their growing scarcity at home:

> "Foreign production of these materials can be profitably expanded at existing market prices, while domestic production can not be increased or perhaps even maintained without large price increases. In short, it is the elasticity of supply abroad and its inelasticity at home that gives rise to this trade, not the relative capital or labor requirements." (Kravis, 1956a, p. 150)

[32/] See Clement, et al. (1967) p. 102-103 for a more detailed summary and references for these points.

Importation of Fishery Products and Resource Availability

Kravis' hypothesis appears to be very applicable to the U.S. importation of fishery products. In Chapter I it was suggested that the significant portion of imported fishery species are also those thought to be at their physical limits domestically. Shrimp is a case in point. Shrimp fishermen in 1970 took a record $129.7 million. This was also a record year for shrimp imports. Shrimp is a highly favored product for consumption in the U.S. and has a high income elasticity (estimated from 1.280 to 2.316). (Suttor, 1969, p. 15). Suttor (1969) estimates that with a one percent annual U.S. population growth and a two percent growth in deflated per capita income, the demand for shrimp (presumably holding price constant) would increase approximately five percent per year.

What appears to be happening then, is that the demand curve for shrimp is shifting outward through time. Yet the domestic yearly supply of shrimp, due to biological constraints is relatively inelastic and subject only to minor shifts as new domestic grounds are discovered or temporary major shifts due to especially advantageous biological conditions. Thus, without development of foreign resources, domestic prices would rise, but domestic production would not increase.

This hypothesis can be illustrated with the aid of static Marshallian graphics. In Figure 2, the U.S. supply curve, SS_{US} of import competing fishery products is relatively price inelastic. The world supply, SS_W, is considerably more elastic because of the limited exploitation of the world resources compared to U.S. exploitation of domestic resources. As a result, relative price difference between the U.S. and the rest of the world exists (P_{US} versus P_W). If one assumes perfect competition so that price equals marginal cost, then this implies that the marginal cost of producing for export is less in foreign countries than the marginal cost of expanding fish production in the United States. The foreign price is at P_W before trade, the U.S. price at P_{US}. After trade, exports equal imports and the equilibrium price in the U.S. is lower than the before trade price of P_{US}. The rest of the world produces more than before trade, while the U.S. produces a little less, depending on the elasticity of supply, _ceteris paribus_.

It is interesting to note that this phenomenon of increasing importation of fishery products seems to fit a more general scheme of the imporation of other goods in the United States. In his book, Vanek (1963) argues that there has been a bias of U.S. Technology toward capital and labor intensive goods that has caused a production path favoring the capital and labor intensive goods, whereas the

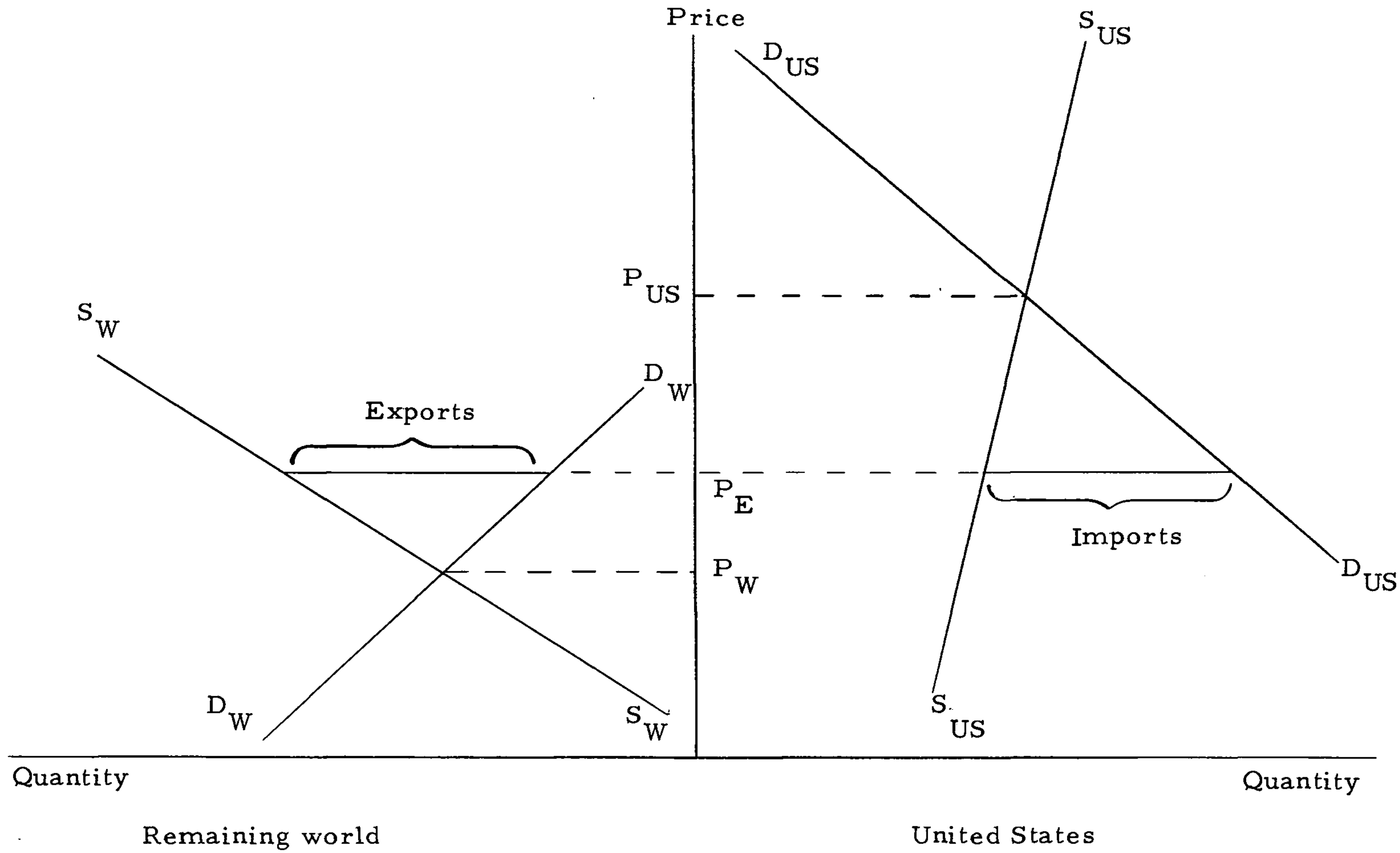

Figure 2. Marshallian graphics: importation of fishery products.

consumption path reflects the desires of American consumers for more of both goods. In Figure 3, the production path in conjunction with the U.S. production possibilities frontier is originally (before 1900) above the consumption path. The difference between these two paths is trade. Early in America's history, the U.S. was exporting natural resource intensive products and importing capital and labor intensive products; now, the U.S. has become a net importer of those goods intensive in natural resources. This is illustrated by the position of the consumption path as demanding more natural resource intensive commodities than are presently being domestically produced.

The fisheries resources fit into a more general scheme of importation in another way: that of direct U.S. investment abroad. M. Diab (1956) in his book U.S. Capital Position and Structures of Foreign Trade, has verified the preponderance of U.S. investments abroad in those type of industries where the domestic supply is not sufficient to meet demand, i.e., the domestic supply is inelastic. Examples given were fruit, sugar, rubber, petroleum, iron, copper and pulp. To this list can be added fishery products.

The late W. M. Chapman claims that much of the import increase has "not been a factor of foreign fish firms building markets in the U.S. as much as it has been U.S. fish trade firms building markets and then reaching out to foreign suppliers for raw material

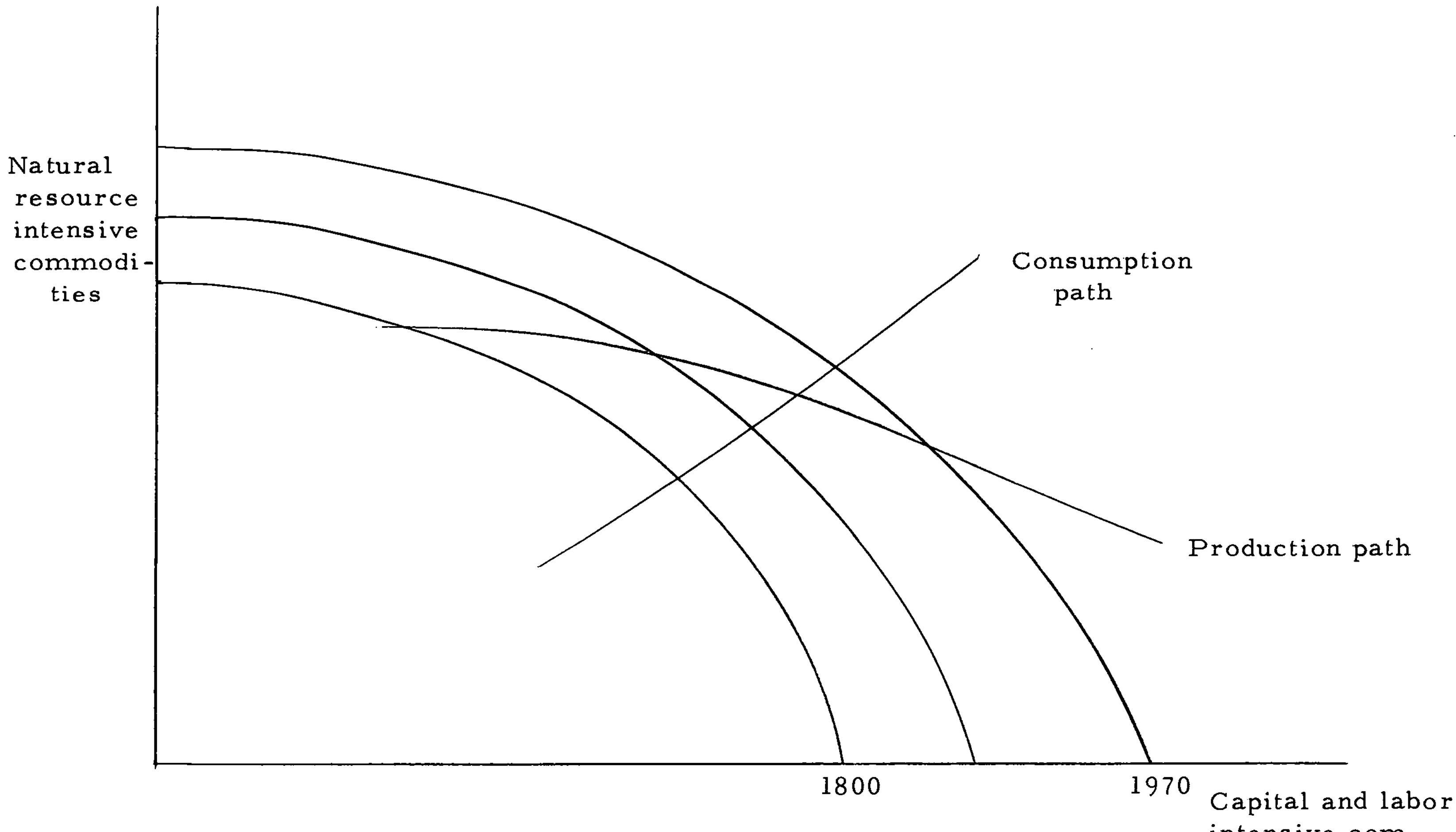

Figure 3. U.S. production and consumption paths.

with which to supply them." (Chapman, 1969, p. 37) This would suggest that domestic supply of these fishery items is price inelastic, at least at the prevailing import price level. Chapman states, with reference to fish meal,

> "The increase in supply of this commodity has come chiefly from imports . . . . To a considerable degree these imports derive from production by plants owned by U. S. fish firms . . . ."

Referring to tuna, Chapman goes on to state,

> "The U. S. tuna canners, as with the U. S. shrimp processors and marketers, have created a complex and very extensive global producing and collecting system for tuna raw material. The general details of the tuna system are more easily pointed out, not necessarily because there is more trade secrecy in shrimp than tuna, but because tuna trade is in much fewer hands. The Ralston Purina Company (Van Camp Division), for instance, uses more than 10% of all the tuna caught in the world, and the Heinz Company (Starkist Foods) is not far behind . . . . They have assisted in financing the construction of tuna fishing fleets . . . they have assisted suppliers in various ways in securing and financing supply bases, cold stores, transshipments of supplies . . . ."

With regard to shrimp, Chapman continues,

> "Quite substantial operations involve numerous U. S. owned vessels, partially manned by U. S. crews, delivering to U. S. owned freezing and storage plants in foreign ports for shipment to the U. S. market."

This amounts to as much as 50 million pounds caught by U. S. shrimp vessels off Central and South America (Whitaker, 1970, p. 6), but these are landed in other countries and exported to the United States. Thus, they do not show in the statistics as domestic landings, but rather as imports. In essence, these imports are really 'repatriation' of American capital.

Groundfish imports differ a little from this pattern in that Canadian, Icelandic, and Norwegian firms have direct sales outlets in the U.S.

> "Nevertheless, in this field also there has been substantial reaching out by U.S. firms for supplies. Notable in this activity have been Gorton's, W. R. Grace, F. E. Booth, Washington Fish and Oyster Company of California, and some others . . . . In the last few years this has expanded to subsidiary branches, probing actions, or joint ventures seeking new supplies or markets . . . ." 33/

Chapman's statements lend substantiation to the hypothesis of domestic inelasticity of supply. For, if overfishing is leading to a declining marginal product of the domestic resource at the same time that the price of the output is rising, then there is an increasing value placed on the discovery and exploitation of new resources. This would be in agreement with Diab's findings: that the inelasticity of supply was the motivating force for direct investment.

Aubrey (1955) is in agreement with the arguments of Kravis (1956a) and Vanek (1959, 1963) when he suggests that there are increasing gaps in raw material between the growth rates of demand and the domestic supply. He suggests import demand is a residual;

33/ This is part of the reason as to why the U.S. does not have a large fishing fleet in the image of Russia's or Japan's. U.S. companies have preferred the course of direct investment abroad.

that imports are drawn on in the long run only to the extent necessary to supplement domestic supply. Harberger (1953) also felt that import demand should be viewed as a residual. Ferguson and Polasek (1962) agree in that "for any commodity which is sufficiently homogenous, import demand may be viewed as an excess demand function, a schedule showing the quantities demanded at various levels of world price." (p. 673)

What Ferguson and Polasek are suggesting can best be illustrated with Figure 4. If DD is domestic U.S. demand for fishery products and SS is domestic supply of fishery products (excluding imports), then II is the difference between these two schedules, and it is an excess demand schedule, i.e., a demand for imports. This formulation of imports as an excess demand function suggests that the import demand function should include domestic supply variables (Leamer and Stern, 1970, p. 11). It also indicates the importance of understanding those factors that influence the domestic demand and supply. The next chapter, therefore, will examine domestic demand and supply, whereas Chapter IV will investigate the import demand function.

Before examining the domestic variables, however, it is interesting to ask if the Kravis' hypothesis is incompatible with the comparative advantage thesis. Clement et al. (1967) argued that when commodities are unavailable at home due to the lack of natural

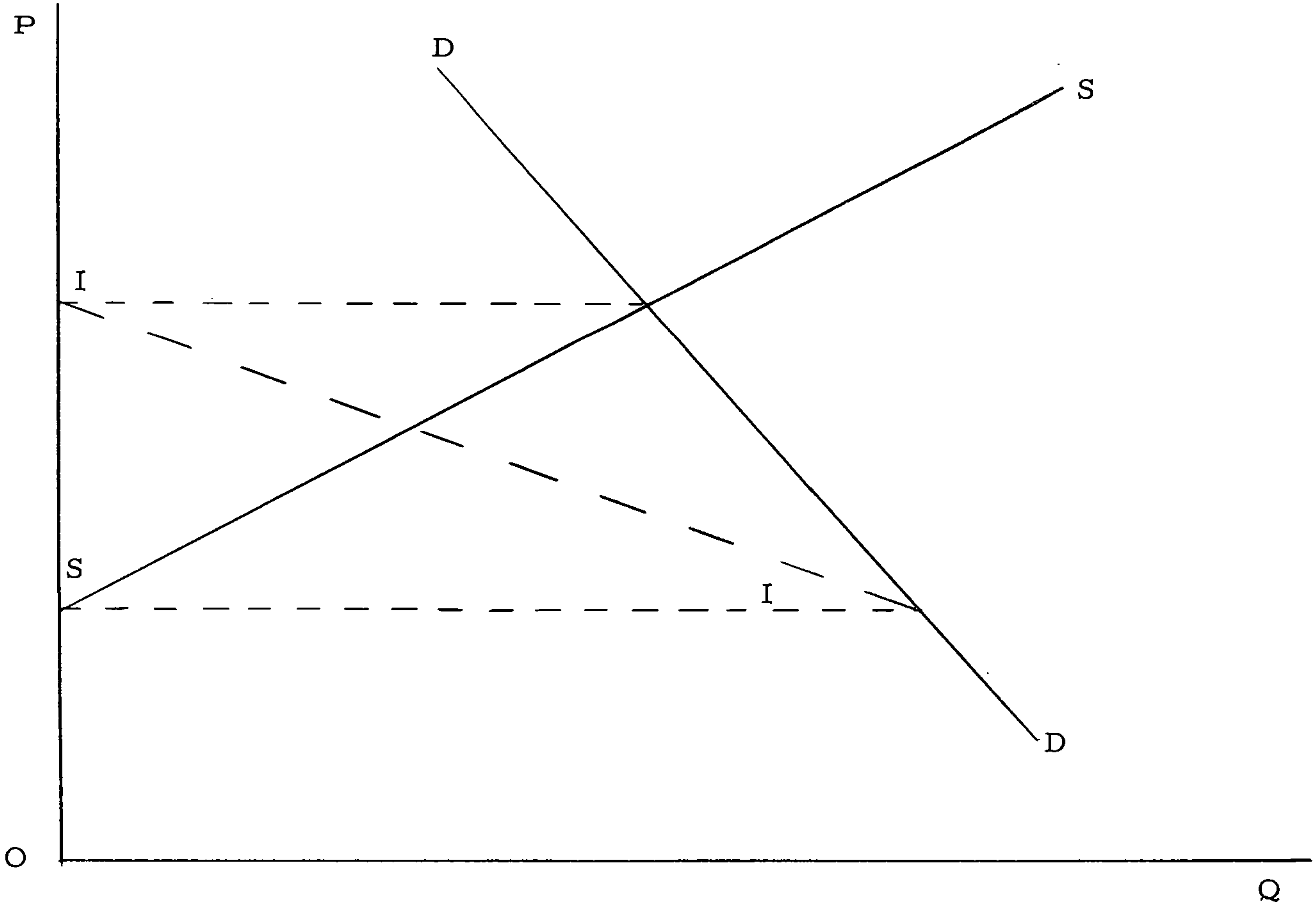

Figure 4. U.S. import demand as a residual.

Adapted from Leamer and Stein (1970), p. 11.

resources in relation to demand, the comparative advantage doctrine is irrelevant.[34/] This would seem to be too strongly worded, for what is the reason for trade at all if it is not that the composition of domestic demand is not the same as the composition of domestic production? The explanation for these differing compositions would seem to be that a country has a comparative advantage in production of some goods, and hence, a comparative disadvantage in others. All that is necessary to incorporate Kravis' point of view into the comparative advantage framework is to consider natural resources as a scarce commodity. Indeed, Vanek (1963) utilizes such an approach in his work.

[34/] Clement *et al.* (1967) implied that this was also Kravis' view. Kravis, however, stated that "when unavailability at home is due to lack of natural resources relative to the demand, the comparative advantage explanation is *adequate*." (Kravis, 1956a, p. 143)

III. THE ROLE OF DOMESTIC VARIABLES IN THE DETERMINATION OF IMPORTS: THE DOMESTIC MODEL FOR SHRIMP

The previous chapter emphasized that domestic demand and supply variables influence the volume of imports of fishery products. In addition to domestic demand and supply effects on trade, there is also the influence of foreign demand and supply factors, including any tariff or quota barriers that might exist between trading nations. An argument was also presented that the domestic supply responses of those fishery items that compete with imports are price inelastic. This chapter will examine the shrimp industry of the Southern Atlantic and Gulf of Mexico in an attempt to empirically verify this inelasticity and to examine the domestic demand and supply relationships.

The Gulf and South Atlantic Shrimp Industry

The selection of the shrimp industry for a case study was partly based on the consideration of the importance of shrimp imports in the total volume of trade. Also, annual consumption of shrimp per capita has been increasing over time, from .98 pounds in 1955 to 1.42 pounds in 1972 (U.S.D.C., 1973). There are no U.S. tariffs or quota on imported shrimp, and fishermen for the most part specialize in shrimp only. The gear is fairly standardized, and no large technological advances have taken place since the introduction of the double rigged otter trawl in the mid 1950's. [35/] All these facts simplify the specification of the model.

The major shrimp industry [36/] of the United States extends approximately from Beaufort, North Carolina, to Brownsville, Texas, and includes eight southern states; however, shrimp vessels fish off the coast of Mexico below Brownsville and also off the Yucatan Penninsula of Mexico (Idyll, 1963). All the species of commercial importance in this area are from the tropical and temperate water family Penaeidae; Penaeus setiferus (white shrimp) [37/] Penaeus duorarum (pink shrimp)[38/], and Panaeus aztecus (brown shrimp)[39/] are the three main species. There is also a minor

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35/ Ninety-seven percent of all shrimp in 1967 were caught by otter trawls. (Whitaker, n.d.-b, p. 3).

36/ Large shrimp are sometimes referred to as prawns.

37/ Also known as green shrimp (Southport, N.C.) green-tailed shrimp (Pamlico Sound), blue-tailed shrimp (Ocracoke, N.C.) common shrimp, and lake shrimp (Louisiana) (Survey, 1958, p. 13).

38/ Also known as grooved shrimp, Brazilian shrimp, golden shrimp (Texas), "brownies", red shrimp (Texas), (Survey, 1958, p. 13).

39/ Also known as brown spotted shrimp, grooved shrimp, blue-tailed shrimp (Cateret Cty., N.C.) and channel shrimp Cateret Cty.,N.C.) (Survey, 1958, p. 13).

amount of sea bobs (Xiphopeneus kroyeri) and royal red shrimp (Hymenopenaeus robustus) that are marketed (Kutkuhn, 1962). These three main species accounted for 94% of the catch in 1960 (Idyll, 1963) and 73% of the total U.S. catch of shrimp in 1969 (Whitaker, n.d.-b). Other shrimp fisheries off the Pacific States and New England accounted for the remainder of the catch. These northern shrimp are of the family Pandalidae and are becoming of increasing importance in the domestic catches. This study, which includes the time period 1958-1969, will consider only those species landed in the southern states, because by 1965 the northern catch accounted for only 8% of the total domestic catch, reaching 27% of the total catch by 1969.

The southern fishery operates through the year; however, as the histogram in Figure 6A illustrates, most of the annual catch (80%) is landed between June and December. The reason for this seasonality of catch is the unique life history associated with the penaeid shrimp. Eggs of these shrimp are hatched offshore in oceanic waters. After a short incubation period a nauplius (small larva) emerges and migrates into bays and estuaries. Here the shrimp, now a postlarva or juvenile, grows rapidly for two to three months and then departs the "nursery" grounds as an adult to return to open sea and spawn to complete the life cycle.

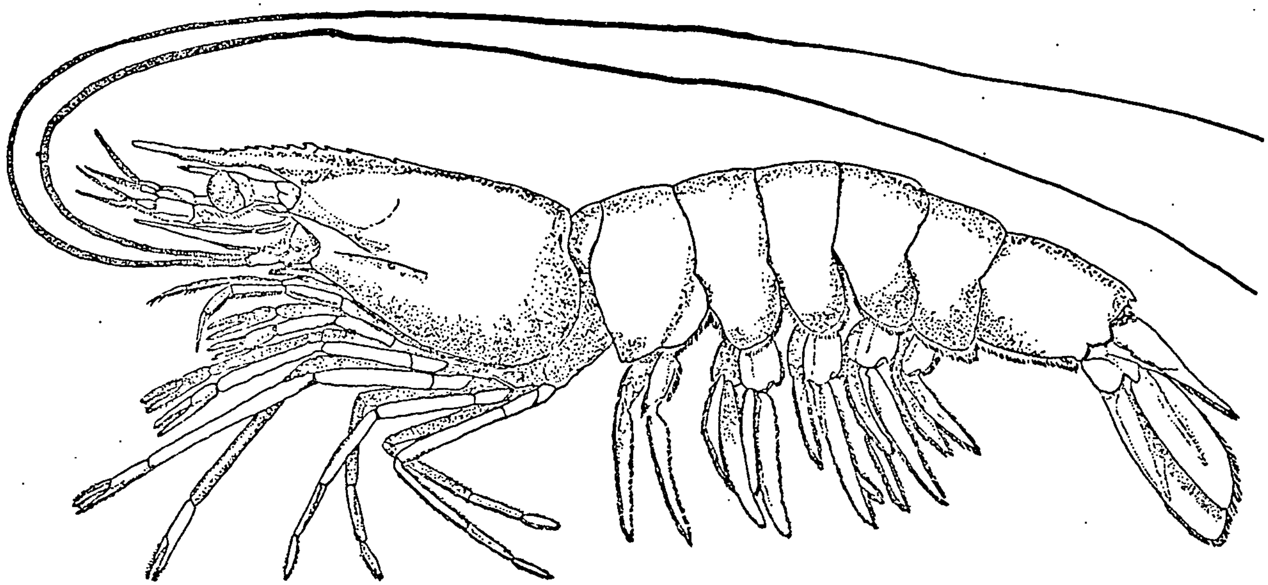


Figure 5. Brown shrimp: Panaeus aztecus.

Estimates of average life spans differ from around one year (Whitaker, n. d.-b, p. 2) to 18 months (Kutkuhn, 1962, p. 308). The following quote indicates how this cycle directly influences the commercial fishery:

> "There is no debating the fact that spring broods (of brown shrimp), first appearing en masse as 3 to 4 week old larvae at the entrances to inshore waters during late March and mid-April, sustain inshore fisheries for the ensuing two to three months. Juvenile brown shrimp, for instance, comprised 87 to 99 percent, respectively, of commercial bait shrimp landings from Galveston Bay in June and July, 1960. These shrimp grow rapidly during the inshore phase and, by the time they begin migrating to offshore waters, usually in June and July, they may attain a size equivalent to that at which 42 specimens (heads on) weigh 1 pound." (Kutkuhn, 1966, p. 332)

Thus, small shrimp are found in the inshore waters in the early summer months while larger shrimp are found later in the year and deeper. However, the largest shrimp are rarely found at depths exceeding 45 fathoms.

The female shrimp is extremely fecund and will carry between 500, 000 and 1, 000, 000 eggs and may spawn more than once (Whitaker, n. d.-b, p. 2). However, the larva and eggs are planktonic and as such are subject to high predation and mortality. The biological abundance of shrimp that will enter a fishery in any given year is therefore very difficult to predict, being apparently a function of such environmental factors as salinity, wind and current direction, and temperature rather than being primarily dependent on the size of the parent stock. "Unlike many other fisheries, the size of the

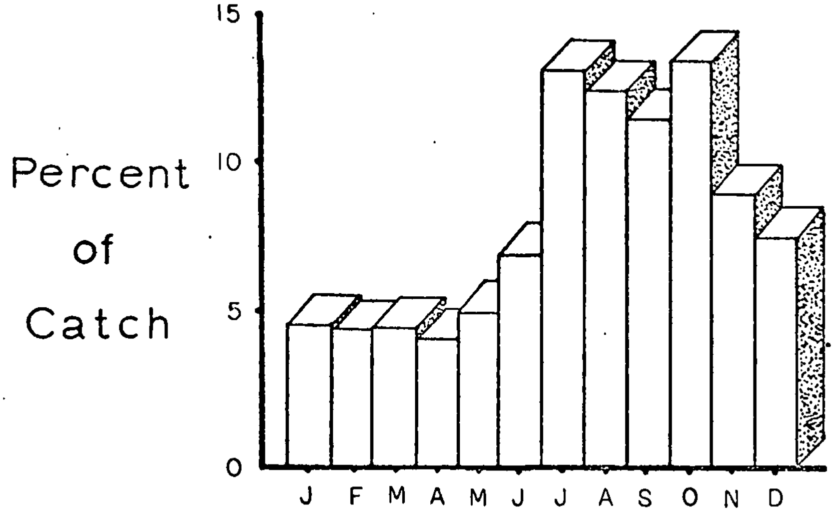


Figure 6A. Histogram of total offshore Gulf and South Atlantic shrimp catch.

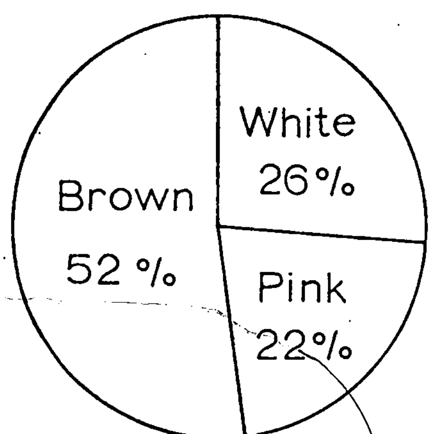


Figure 6B. Species percentage of total offshore catch.

shrimp catch does not appear to affect future shrimp populations." (Whitaker, n. d.-b, p. 2-3.)

All sizes of vessels are represented in the shrimp fleet ranging from boats suitable only for close shore work to those vessels with freezing plants aboard that fish throughout the entire Gulf. Vessels which are large enough to do so migrate between shrimping grounds in accordance with abundance and biological availability. The fishing season starts along the Atlantic Coast in spring and moves steadily southward ending in December or later in the Mexican grounds. Shrimping in the Carolinas and Georgia begins in May, reaches a peak in mid-summer, and drops off until the close of the season in November. The histograms and the maps of abundance in Figures 7 and 8 give a perspective as to how individual species differ in monthly percentages of catch as well as location. The white shrimp, for instance, support a fall fishery, with almost 80% of the landings made from September to December, the heaviest catches being off the Louisiana coast. Browns support a summer and early fall fishery with 80% of the landings made from June to October; the largest catch per units are off the Texas coast. Pinks, in contrast, support a year-round fishery; however, there is a decline in late summer. Catches are heaviest off Florida and the Yucatan Penninsula.

Most shrimp landed in the United States are taken by shrimpers close to shore after trips that last no more than five days.

However, trips from the Campeche grounds off Mexico can cover as long as seven weeks.

> "In this latter situation, vessels may transship their catches on others periodically departing for home port and then continue to fish until they too leave the fishing grounds at the end of the period indicated. Depending on the species sought, only a relatively small proportion of the time away from port may be spent in actual fishing." (Kutkuhn, 1962, p. 313)

The Supply Relationships: Single Equation Estimates

The biological fluctuations associated with shrimp populations are frustrating not only to the shrimper who is planning future production, but also to economists who would like to model a supply response function for research and policy purposes.

Various studies which have considered the supply relationship have assumed supply to be an exogenous random variable. This is the approach used by C. Peter Timmer in his article, "Projection Model of the U.S. Shrimp Market," and by John Doll (1972) in his econometric analysis. Doll writes,

> "The factors that cause shrimp abundance are biological in nature and exogenous to the marketplace. Further, the lack of a trend in successive generations of shrimp suggests that one year's catch does not affect abundance the next year. The biological factors causing shrimp abundance are not clearly identified and can not be forecast. Thus, domestic landings are both variable and unpredictable and are regarded as exogenous in the model." (Doll, 1972, p. 432).

Timmer states,

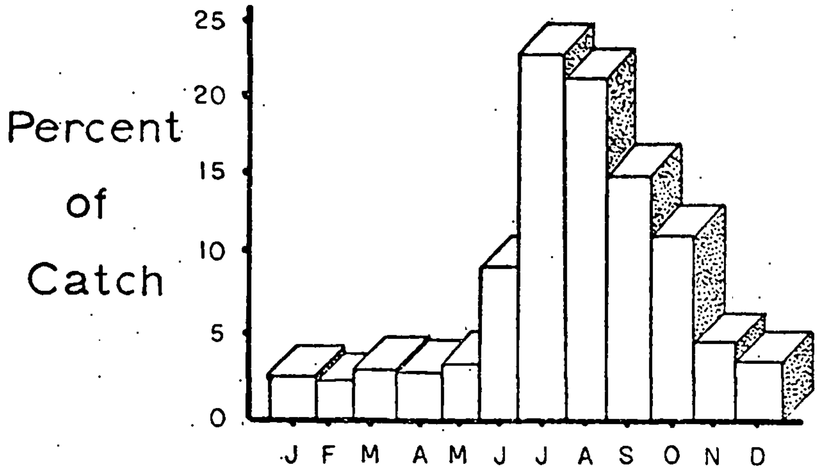


Figure 7A. Histogram of annual brown shrimp catch.

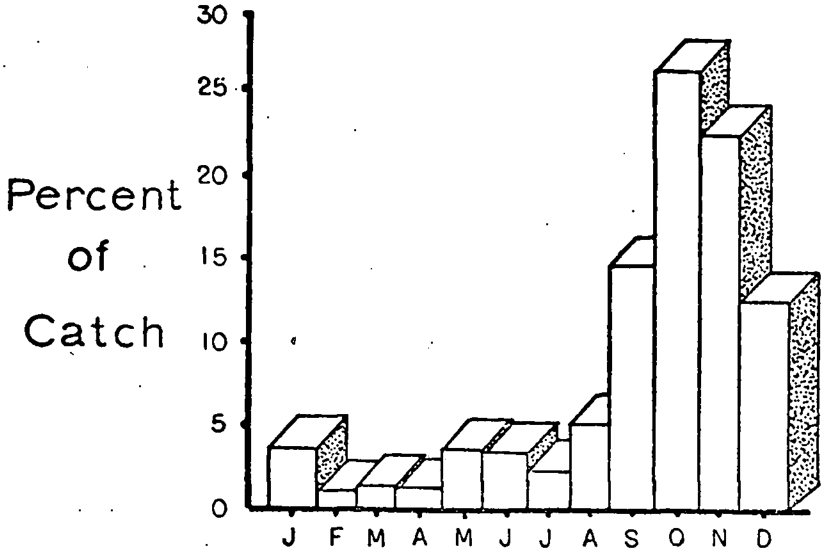


Figure 7B. Histogram of annual white shrimp catch.

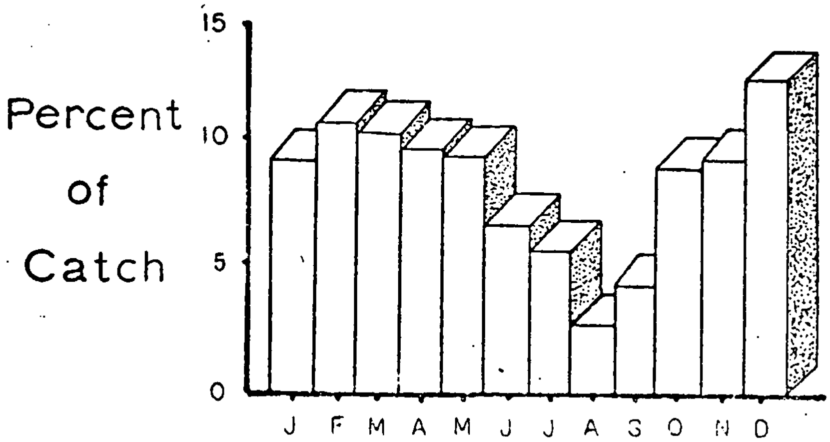
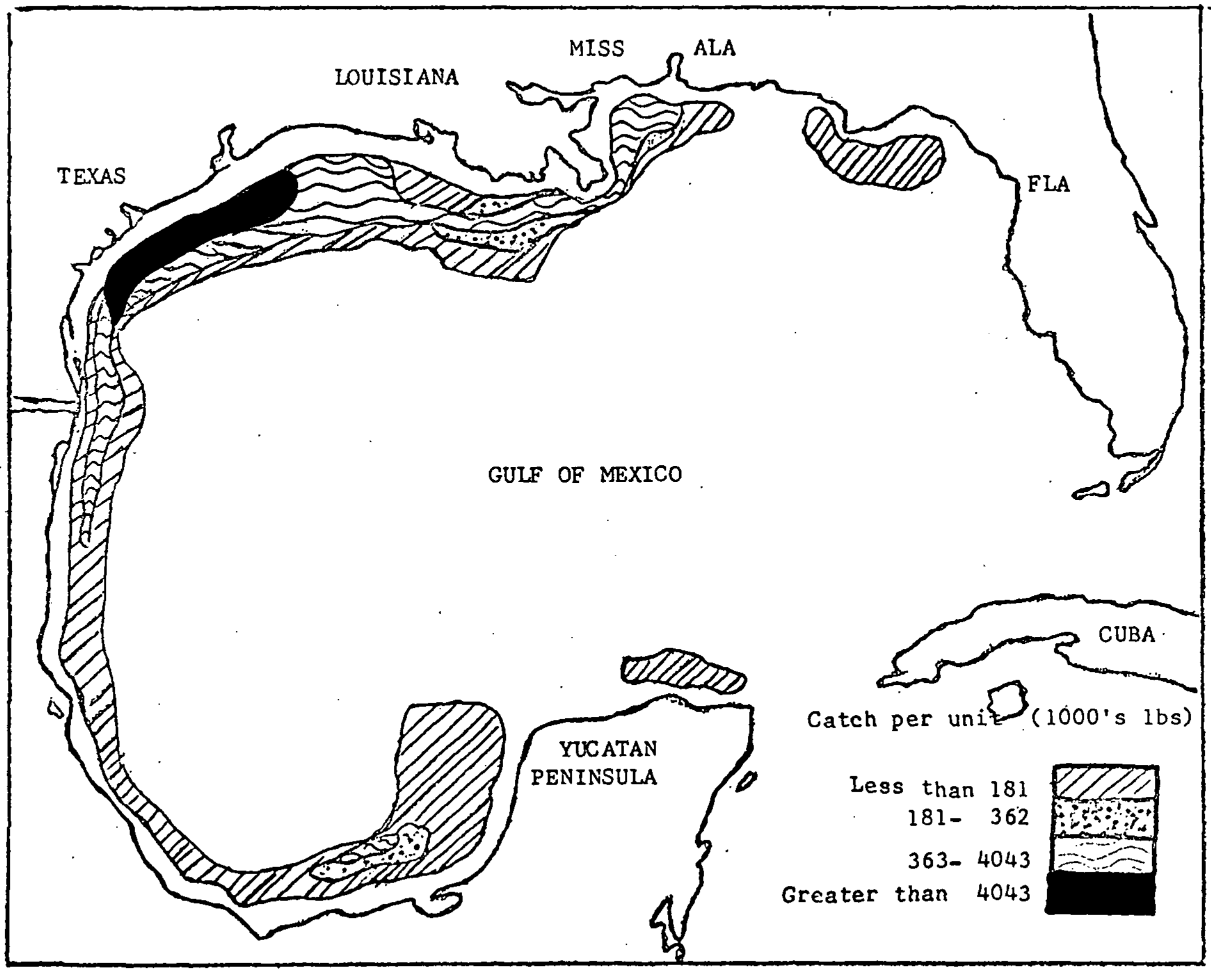
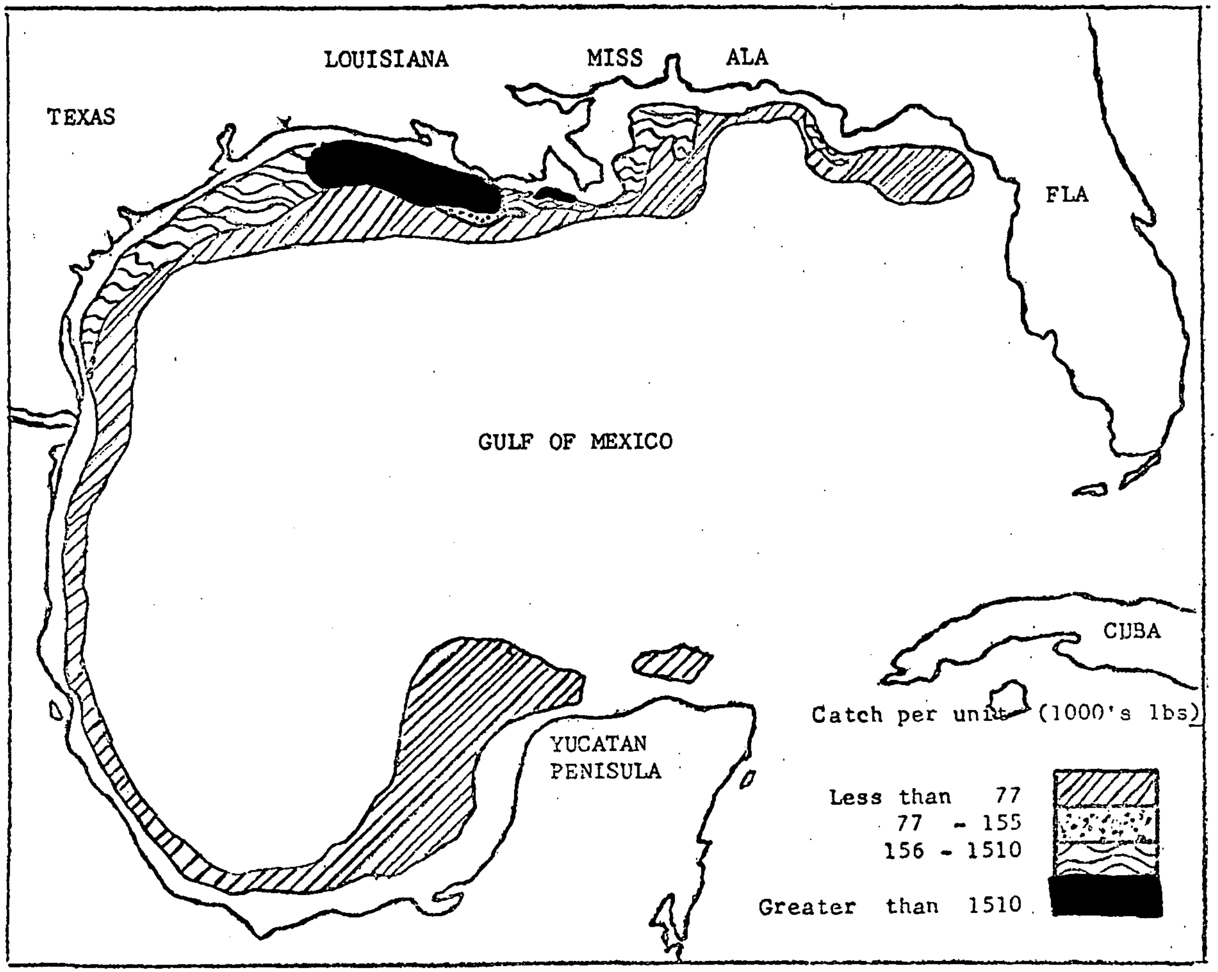


Figure 7C. Histogram of annual pink shrimp catch.



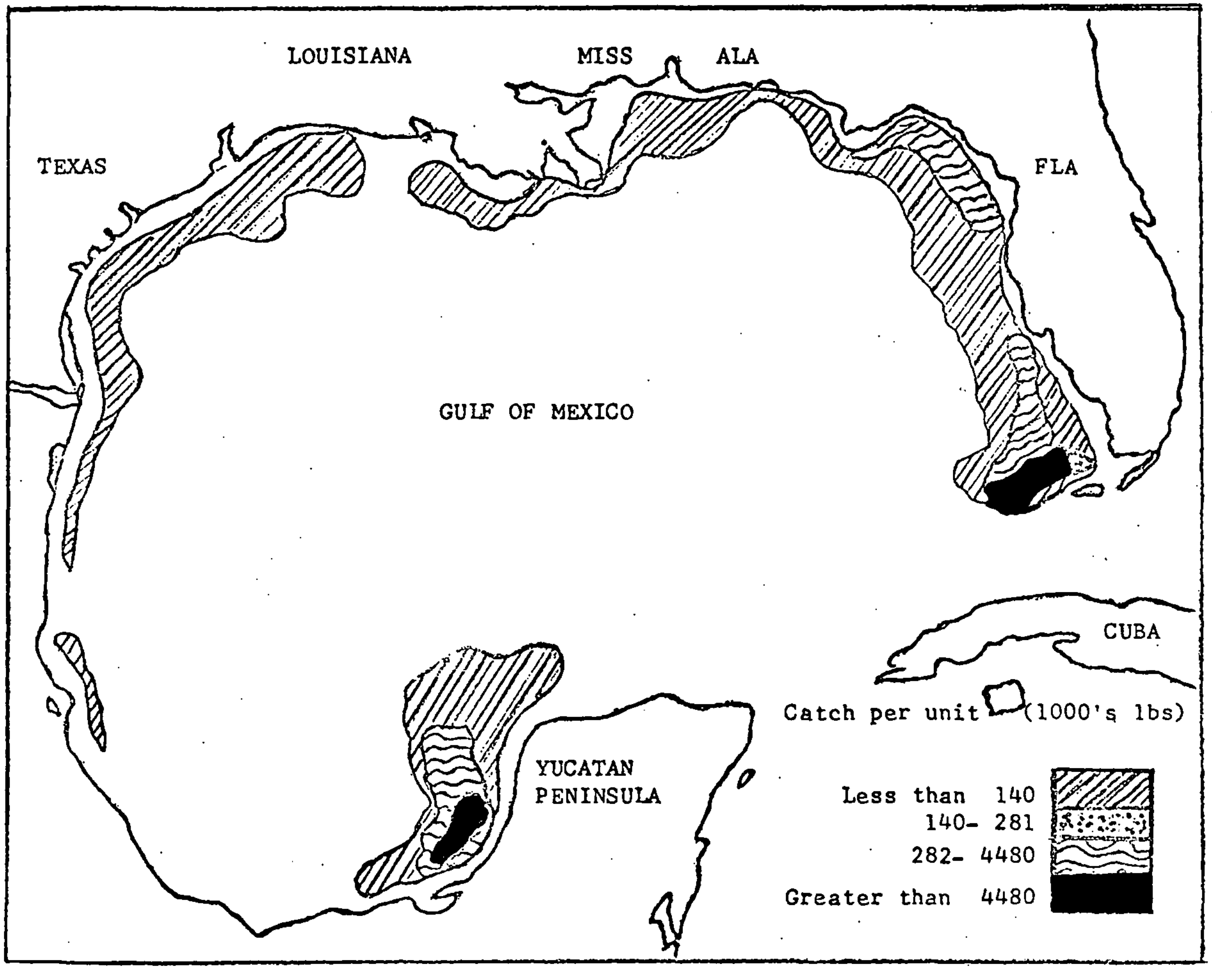
Source: NMFS

Figure 8A. Brown shrimp annual catch.



Source : NMFS

Figure 8B. White shrimp annual catch.



Source: NMFS

Figure 8C. Pink shrimp annual catch.

> "In theory, it should be possible to specify a shrimp-catching production function, with the relevant arguments likely to include number of boat-hours, quality of fishing gear, number of hands engaged in fishing, skill of the boat operators, the size of the shrimp population at any time, and some random factors mostly connected with weather and fishing luck. A preliminary investigation along these lines was unrewarding--the dominant factors turn out to be the random elements and the size of the population. The former cannot enter as an independent variable in the production function and the latter is non-observable until after the fact. Since it is impossible, given current knowledge and data to fit a satisfactory production function, to explain the U.S. shrimp catch, it is treated as a random variable . . . ." (Timmer, 1968, p. 243-244).

Gillespie, Hite, and Lytle (1969) sidestepped the issue with the questionable technique of using an identity as a supply function intended for estimation. Their theoretical model was

$$Y_1 = f\,(X_1,\ X_2,\ X_3,\ .\ .\ .,\ X_n;\ Z_1\ .\ .\ .\ Z_{n+1})$$

where

Y_1 = quantity available in the wholesale market

X_1 = ex-vessel landings

X_2 = wholesale price

X_3 = cold storage holdings

X_4 = quantity of imports

X_5-X_n = storage cost and transportation cost

and Z_1, . . . , Z_{n+1} = parameters (p. 15)

The problem associated with this approach is that Y_1 (quantity available in the market) equals X_1 (ex-vessel landings) + X_4 (quantity of imports) - X_3 (cold storage holdings). It is not surprising, then, that the estimated regression had the high R^2 of .95. (Gillespie, et al., 1969, p. 34).

Actually, the theoretical production function for the output of landings is $q_1 = f(X_1, X_2, X_3)$. Landings per day are a function of capital (X_1): vessels and gear, and labor (X_2) expended per day, and the density of catchable shrimp per volume of water (X_3). X_3, density of shrimp, is itself a function of the time of the year, the temperature and salinity of the water of the nursery grounds, numbers of predators, amount of pollutants in the nursery ground, food supply, availability of nursery grounds, and other factors such as depth of the water column and type of bottom strata. Any attempt to estimate a production function must consider these environmental factors in some manner.

A preliminary experiment was conducted to determine if there was some index that could be constructed to serve as a proxy for those variables represented by X_3 so as to capture some of the variation in landings due to environmental factors. Monthly data for 1963 was collected for average temperature and salinity readings at six different oceanographic stations around the Gulf. Fish catches at each of these six Gulf locations were also investigated as a proxy for food supply and predators. These were then related to landings at these geographical areas of the three main species of shrimp: pink, brown and white; shrimp trips completed during the month;

and ex-vessel prices. A principal component analysis [40/] examined the variation of several variables; trips, temperature, salinity and ex-vessel price. The first principal component weighted the "number of trips completed" variable most heavily. After removal of the effect of trips, the variation of temperature and salinity achieved dominance. On the basis of this preliminary evidence, estuary temperature, lagged six months, was chosen as a proxy variable for the biological factors that influence catch. Lags were utilized in selecting the temperature variable because the adult population of shrimp in the fishery was thought to be a function of those larva which six months earlier entered the estuarine nursery grounds and successfully metamorphosed.

There is additional evidence that estuarine temperature is an extremely critical variable. Gunter (1950) wrote concerning the shrimp migration:

[40/] Principal component analysis is a method devised first by Hotelling, in which a group of variables is analyzed in an attempt to discover a more fundamental set of independent (i.e., orthogonal), components or "factors". The analysis proceeds to find a linear function of the group of given variables such that the sum of the squares of the correlation coefficients of each variate with the requested linear function is a maximum. (Tintner, 1965, p. 102-103). Essentially, principal components summarizes the commonality of all the variables of the group into a few independent factors and therefore is an excellent technique for data reduction. It is also used for examining systematic interdependence among the set of variables, although economic interpretations of such analysis is not always apparent. For more information the interested reader should consult Tintner (1965), p. 102-114.

"This general exodus of shrimp and other invertebrates as well as fishes from the bays is correlated with annual temperature cycle and not with salinity changes or any other phenomena. Therefore, it may be stated that temperature is a much more important factor than salinity in the general movement of marine animals . . . ." (Gunter, 1950, p. 44)

Also, Kutkuhn writes,

"Alignment of periods of maximum spawning intensity with annual sea temperature curves suggests, however, that spawning is associated with seasonal temperature reversals rather than some optimum temperature . . . . Continuous sea temperature data for the northern Gulf shelf are scanty with most of those available representing surface measurements taken at selected shore stations . . . . Assuming reasonable correspondence in the shape and displacement of annual shore-surface and offshore-bottom temperature curves, it may be concluded . . . that peak spawning activity in the upper Gulf's brown shrimp stock is associated with initiation of: (1) a rapidly increasing rate of temperature change in the spring and (2) a rapidly decreasing rate of change in the fall." (Kutkuhn, 1962, p. 331-332)

It also has been ascertained that water temperatures significantly affect the growth rate of shrimp (Anderson, 1970, p. 60).

The supply response model chosen for estimation was:

$$Q_s = f(X_1, X_2, \ldots, X_9)$$

where

Q_s = aggregate monthly landings of brown pink, white and "other" shrimp [41/] in the Gulf and South Atlantic (in thousands of pounds)

41/ "Data of commercial landings may be considered complete and quite precise. However, they may not always represent the total amount of shrimp actually caught, because of the periodically widespread practice of discarding small or undesirable shrimp at sea." (Kutkuhn, 1962, p. 316) Therefore, Q_s is actual landings of commercially valuable shrimp in the Gulf and South Atlantic.

X_1 = number of trips completed by shrimpers for month t

X_2 = tons of vessels in the fishery (yearly data)

X_3 = seasonal dummy: 1 if in the second quarter of the year; 0 otherwise

X_4 = seasonal dummy: 1 if in the third quarter of the year; 0 otherwise

X_5 = seasonal dummy: 1 if in the fourth quarter of the year; 0 otherwise

X_6 = number of fishermen in fishery (yearly data)

X_7 = yards of otter trawl in fishery (yearly data)

X_8 = principal component index of three minimum monthly temperatures (Pensacola, Florida; Eugene Island, Louisiana; Galveston Bay, Texas), lagged six months (F^o)

X_9 = weighted ex-vessel prices: monthly averages for browns, pinks, and whites in dollars

The specific form of these variables was selected only after experimentation with principal component analysis on both landings and ex-vessel price of the three main species of commercially exploited shrimp. The results of this principal component and regression analysis and the potential of such an approach are discussed in Appendix B.

The use of monthly data rather than quarterly or yearly data was essential if the variation in landings was not to be lost through aggregation. This is particularly true because there are three separate populations of shrimp species involved, and one species abundance can be altered quite dramatically without greatly affecting a yearly aggregated figure. Dummy variables, X_3, X_4, X_5, are used to capture the effect of the changing seasons on the landings. Variables X_2, X_6, X_7 (tons of vessel in the fishery, number of fishermen in the fishery, and total yards of otter trawl used in the fishery) were used as proxies for production capacity and effort. Unfortunately, monthly data were not available and yearly figures had to be used. The observations on these variables have less variation than would actually be expected if monthly effort could have been estimated. To some extent, however, the "trips" variable alleviates this limitation. 42/ This variable is the total

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42/ There is data available on "fishing effort" which is obtained by interview of shrimpers by the N.M.F.S. "The quantity of effort expended is calculated by merely dividing their known catches by a projection factor derived from catch-effort ratios of the vessels." Unproductive effort goes unaccounted for "since effort is estimated for and assigned only to vessel-trips for which a shrimp sale is recorded." (Kutkuhn, 1962, p. 315). This fishing effort would not be suitable to use in the regression of interest since catch is used to estimate effort and, therefore, there is of necessity a high correspondence between yield and "fishing effort." Trips completed during the month do not have this problem, although there may be some grounds for suspecting that "trips" as a variable may be part of a larger simultaneous system and not totally independent of catch or yield. In this model, trips was assumed to be exogenous; however, the model was examined to determine its sensitivity to this assumption. The results are reported in Appendix B.

number of trips completed by shrimpers in the Gulf area (only). It is a reasonable proxy for the amount of effort expended (or percentage of capacity used) since the Gulf accounts for an average of 88% of the total landings per annum. (U. S. D. C., 1972b, p. 28)

The price index variable was calculated by weighting the deflated monthly ex-vessel price for brown shrimp (dollars per pound at Brownsville-Port Isabel, Texas), for white shrimp (dollars per pound at Morgan City, Louisiana) and for pink shrimp (dollars per pound at Tampa, Florida) [43/] by the species percentage of the total monthly catch. These three figures were then summed for each monthly observation. [44/]

The temperature variable is an index formed through principal components analysis. The first eigenvector (principal component) gave equal weighting to each of the three monthly minimum temperatures and accounted for 98.2% of the total variation:

$$Z_1 = .577\ T_1 + .577\ T_2 + .578\ T_3$$

43/ Prices were deflated by the Consumer Price Index (C. P. I., 1967=100). The ex-vessel prices are for the 31-35 count, the size of shrimp that averages 31-35 shrimp per pound.

44/ Other price variables were tested, including lagged prices. The results are reported in Appendix B.

Apparently, the monthly temperatures move quite closely together. This index variable was lagged six months.

All variables contain 144 observations and cover the months between January, 1958, and December, 1969, inclusive. All data series, with the exception of temperature, were obtained from the National Marine Fisheries Service (N. M. F. S.) of the National Oceanic and Atmospheric Administration (N. O. A. A.). The temperature data were obtained from the Oceanographic Survey Branch of the Descriptive Oceanography Section, also of N. O. A. A.

An ordinary least squares regression was then used to estimate a supply response equation. The results of the least square estimation were extremely encouraging given the previous lack of success by other authors. The regression is displayed in Table 5, Regression S-1. The R^2 of .89 was quite good. T-values are shown in parentheses below the coefficients, and significance at the 99% confidence level is indicated by double asterisks. The three dummy variables were also tested for significance as a unit and are significant at the 99% level. The significant variables are "number of monthly trips completed", the seasonal dummies, "number of fishermen", the temperature index, and ex-vessel price. The signs of the parameters are those that would be expected *a priori*, with the exception of the negative sign on ex-vessel price. This relationship states that as real ex-vessel prices rise, landings fall. This is of

Table 5. Preliminary Supply Regressions.

		Trips	Tons	Dummy 1	Seasonal Dummy 2	Dummy 3	No. of fishermen	Yards of otter trawl	Temp. index	Ex-vessel price index
Regression S-1: Preliminary least squares single equation regression										
$Q_s =$	3267.9	$+ .23706X_1$	$- .0017319X_2$	$- 2541.3X_3$	$+ 1979.4X_4$	$+ 3097.1X_5$	$+ 1.2485X_6$	$- .013647X_7$	$-81.659X_8$	$- 8735.5X_9$
	(.73)	(11.67)**	(-.26)	(-3.11)**	(1.87)	(5.45)**	(3.80)**	(-.71)	(-3.87)**	(-5.90)**
										$R^2 = .89$
										D-W = 1.10
Regression S-2: Preliminary least squares single equation regression corrected for serial correlation a/										
$Q_s =$	3214.3	$+ .22020X_1$	$+ .0021108X_2$	$- 2383.1X_3$	$+ 1558.3X_4$	$+ 3127.6X_5$	$+ 1.0181X_6$	$+ .0014749X_7$	$- 90.849X_8$	$- 9297.6X_9$
	(.97)	(11.75)**	(.20)	(-3.63)**	(1.83)	(5.88)**	(2.09)*	(.05)	(-4.87)**	(-4.29)**
										$R^2 = .82$
										D-W = 1.90

* Significant at the 95% level

** Significant at the 99% level

a/ Significant levels are not strictly applicable after serial correlation correction.

no great concern in a preliminary analysis of this type because price is probably an endogenous variable influenced by demand for shrimp as well as supply. Obtaining negative price weightings on single equation supply response equations is not an unusual phenomenon (Working, 1927).

There is, of course, the possibility that this is the proper specification and that fishermen react to declining prices by increasing their fishing effort and catch in order to maintain income levels. Doll (1972) hypothesizes this as one explanation for the fact that domestic landings increased during ex-vessel price recessions in 1959, 1963, and 1967. This, however, appears doubtful because the monthly measure of effort, number of trips completed during the month, is positively correlated with the deflated ex-vessel price index (.129) as well as with each individual undeflated ex-vessel price:

Trips X Brown ex-vessel price	.199
Trips X White ex-vessel price	.211
Trips X Pink ex-vessel price	.229

The negative weighting on the temperature variable is due to the cyclic nature of the temperature and catch data. The graph represented in Figure 9 represents this relationship between six-month lagged temperatures and monthly catches. It is open to speculation as to whether this temperature index is truly representing a causal biological phenomenon influencing abundance or is

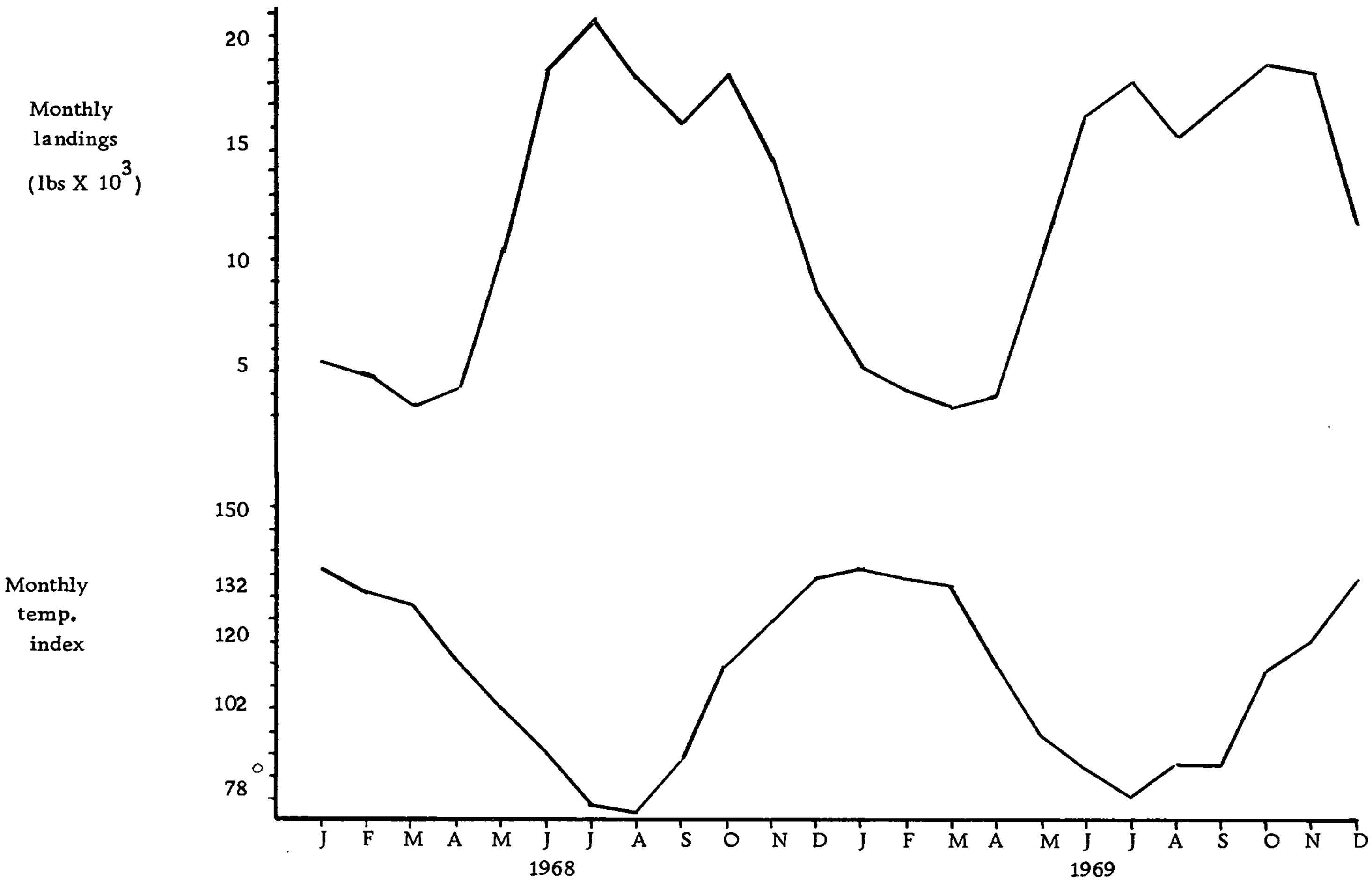

Figure 9. Temperature index and monthly aggregate landings, 1968-1969.

simply capturing the cyclic nature of monthly landings. It is well known that high correlations do not necessarily demonstrate a causality. [45/]

There is no evidence of multicollinearity among the dependent variables (Table 6), although the simple correlation of .815 between X_6 (number of fishermen) and X_7 (yards of otter trawl) is somewhat high. The Durbin-Watson value of 1.10 indicates the presence of serial correlation. When the serial correlation is corrected for the result after one iteration is regression S-2 in Table 5.[46/] In this equation, the Durbin-Watson statistic is now 1.90 and there is no evidence of serial correlation. The coefficients have proven to be reasonably stable with little change in either magnitude or in

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45/ Waugh and Miller (1969) have investigated fish cycles using a harmonic analysis. No doubt such an analysis would work well for shrimp landings. However, since they write that, "landings and prices of many species of fish follow fairly regular cycles. The most apparent are the 12 month or seasonal cycles, induced generally by a combination of natural factors, for example, weather and spawning cycles" (Waugh and Miller, 1969, p. 1), there are strong theoretical reasons for preferring temperature over a sine function of time as the cyclic variable. Temperature was selected *a priori* in this model in an attempt to proxy "abundance variables" rather than after visual inspection of the cyclic phenomenon.

46/ Serial correlation was corrected for by a technique presented in a paper by T. M. Hammonds (n. d.) entitled "The Elimination of Autocorrelated Disturbances in Regression Analysis: a Revised Estimator" in which the author demonstrates the errors which are intrinsic in some of the textbook recommended corrections for autocorrelation and provides a substitute procedure.

Table 6. Correlation Matrix for Supply Regression S-1.

	Q_s	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	Means
Landings Q_s	1.00	.825	.124	-.171	.549	.250	.190	.127	-.664	-.135	10774.0
Trips X_1		1.00	.193	.129	.305	.185	.207	.189	-.641	.129	18941.6
Tons X_2			1.00	.000	.000	.000	.720	.725	-.007	.442	142456.1
Dummy 1 X_3				1.00	-.333	-.333	.000	.000	-.291	.117	.25
Dummy 2 X_4					1.00	-.333	.000	.000	-.685	-.142	.25
Dummy 3 X_5						1.00	.000	.000	.305	-.018	.25
No. of fishermen X_6							1.00	.815	-.007	.426	16328.8
Yards of net X_7								1.00	-.016	.491	162037.1
Temp. index X_8									1.00	.066	111.49
Ex-vessel price X_9										1.00	.7375

significance levels; however, the conventional measures of statistical fit (R^2, t-values) are no longer strictly applicable after the correlation procedure.

Additional discussion of the supply relationships will be presented in the section entitled "The Complete Domestic Model" on pages 92-101.

The Demand Relationships: Single Equation Estimates

Many studies have examined the demand for shrimp (Cleary, 1969; Doll, 1972; Gillespie, 1969, Suttor, 1969; Timmer, 1968), but none of these have used monthly data. There is actually not one demand for shrimp, but several. Not only is there the market demands such as ex-vessel, wholesale, and retail, but in each of these market sectors, there are demands for various species, count sizes, and preparations, as well as the demand for imports.

For the purposes of this research, two equations were used to investigate demand: an apparent monthly consumption model [47/] and a cold storage holdings model. These choices were due partly

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[47/] Apparent consumption is defined as being equal to monthly landings + monthly imports + beginning of the month cold storage - transshipments - exports - end of the month cold storage holdings - canned shrimp. Transshipments are those shrimp which are imported for purposes of re-exportation. (All of these variables were measured to the nearest thousand pounds.)

to data availability limitations. There areno data available on quantities moving between marketing channels; the only data that are available are that of ex-vessel, wholesale, and retail prices; landings, imports, exports, product forms, and cold storage holdings. These two equations, while not ideal for examining the market relationships, are sufficient for obtaining an understanding of the general magnitude and direction of the effect of the various variables that influence demand.

Total consumption of shrimp in the U.S. has increased over two and a half times between 1950 and 1960: from 140 million pounds heads-off weight to 362 million pounds (Whitaker, n.d.-b, p. 10). This has been illustrated in Figure 10 which graphs consumption of shrimp, both total and per capita. Figure 11 demonstrates how this total consumption is divided into fresh and frozen forms or canned forms.

In the demand model, apparent consumption of the fresh and frozen forms was considered to be a function of population, real disposable income, substitute product prices, the time of the year and the real wholesale price. (Other specifications of demand are discussed in Appendix B.) Although these are the variables that demand theory would suggest, two, substitute product price and deflated wholesale price, should be discussed.

Real wholesale price was selected as the price variable for

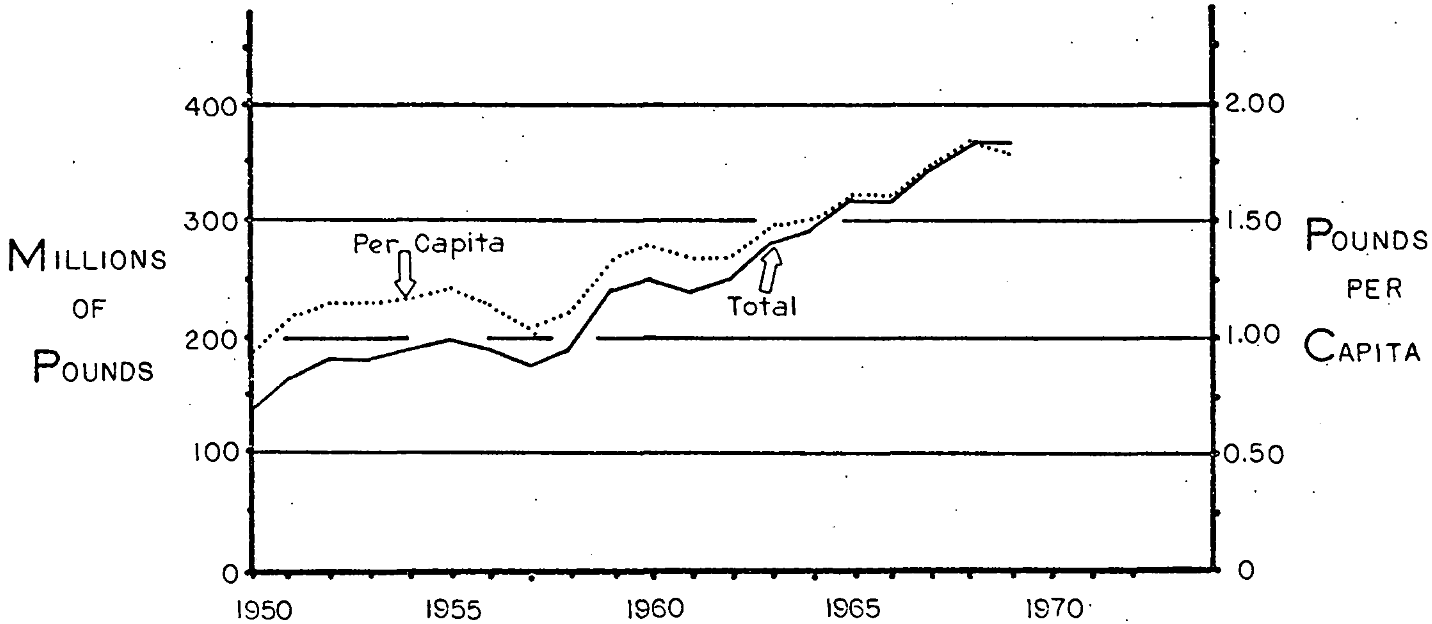
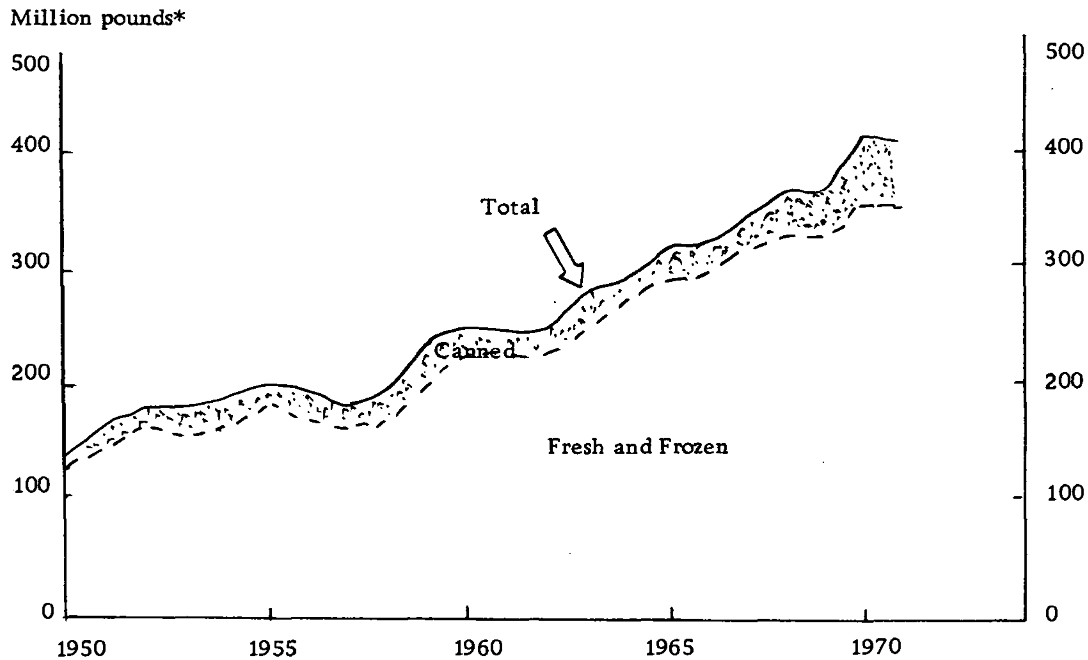


Figure 10. Total and per capita consumption of all shrimp.



*Heads-off weight

Figure 11. Shrimp consumption.

two reasons. First, approximately 60% of the shrimp market is institutional (Whitaker,n. d.-b, p. 10), most of which is restaurant trade. Since no data series is available for average restaurant meal prices, wholesale price is better suited for "explaining" this demand than is a retail price series. Secondly, the retail price series available from the N. M. F. S. is not complete for the months covered by this research: 1958-1969. The retail price series that is frequently used involves changes in product specification over the period of interest.[48/]

Theoretically, substitute and complement product prices should be included in a demand equation. Yet, experiments by the authors who have modeled demand for shrimp have been unsuccessful in establishing substitutes and complements to shrimp. Darrel A. Nash's survey of fish purchases by socio-economic characteristics (Nash, 1970) provides estimates of regional

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48/ It is interesting to note that annual wholesale price is highly correlated with average annual retail price (.93) and a principal component analysis shows that "the three annual shrimp prices (ex-vessel, wholesale, and retail) move together closely and that the wholesale price index would serve as an almost perfect index for the three series." (Doll and Chin, 1970, p. 592). Monthly retail price (1964-69) (raw headless, Baltimore, Maryland) is correlated at the 60% level with the wholesale and ex-vessel indexes. Average U.S. monthly retail price would probably be more highly correlated.

per capita consumption of various shellfish and finfish. From visual inspection of this data, several of these species might be considered as possible candidates for substitute goods. However, the relationships are far from conclusive. Fish price indexes are available; but most of these are heavily weighted by shrimp prices, and are therefore unsuitable. Meat indexes have proven to be unsatisfactory. From the basis of Nash's survey, and from data availability, real haddock prices were chosen as a substitute price for this research; no complements were selected. The actual identification of complements and substitutes for shrimp has not been accomplished.

The monthly change in cold storage holdings was also formulated as a model: $(S_{t+1} - S_t)$ = f(domestic monthly landings (Q_s), imports (I), time of year (X_3, X_4, X_5), and real wholesale price (W)). This regression was estimated by ordinary least squares and is shown in Table 7.

Demand (apparent consumption) was also estimated on a per capita basis and is included in Table 7, where

Q_d' = apparent monthly per capita consumption in pounds $(X\ 10^{+3})$

X_3 = seasonal dummy: 1 if in third quarter of the year
0 otherwise

X_4 = seasonal dummy: 1 if in third quarter of the year
0 otherwise

Table 7. Single Equation Estimates for Apparent Consumption and Cold Storage Holdings.

Apparent monthly consumption regression:

$$\begin{array}{lcccccccccccccc} Q_d' = & 27.880 & - & 1.4176X_1 & + & 14.097X_4 & + & 15.318X_5 & + & 62663.Y' & - & 59.878H & - & 31.727W \\ & (1.07) & & (-.42) & & (4.20)^{**} & & (4.53)^{**} & & (8.59)^{**} & & (-1.31) & & (-3.19)^{**} \end{array}$$

$R^2 = .56$
D-W = 1.94

Cold storage holdings regression

$$\begin{array}{lcccccccccccccc} (S_{t+1} - S_t) = & -7323.7 & + & .28045Q_s & + & 2607.4W & + & .010421I & - & 88.272X_3 & + & 1580.6X_4 & + & 5604.3X_5 \\ & (-.62) & & (6.06)^{**} & & (1.99)^{*} & & (.20) & & (.16) & & (2.11)^{*} & & (8.54)^{**} \end{array}$$

$R^2 = .75$
D-W = 1.69

** Significant at 99% test level
* Significant at the 95% test level

Table 8A. Correlation Matrix: Apparent Consumption Regression.

	Q_d'	X_3	X_4	X_5	Y'	H	W	Means
Q_d'	1.00	-.260	.211	.276	.593	-.327	.102	105.578
X_3		1.00	-.333	-.333	-.018	-.030	.093	.25
X_4			1.00	-.333	-.002	-.042	-.055	.25
X_5				1.00	.067	.067	-.022	.25
Y'					1.00	-.358	.554	.0020448
H						1.00	.049	.427
W							1.00	1.006

Table 8B. Correlation Matrix: Cold Storage Holdings Regression.

	$(S_{t+1}-S_t)$	Q_s	W	I	X_3	X_4	X_5	Means
$(S_{t+1}-S_t)$	1.00	.672	.085	.427	-.337	.192	.671	236.264
Q_s		1.00	.004	.174	-.171	.549	.250	10774.0
W			1.00	.407	.093	-.055	0.022	1.006
I				1.00	-.200	-.269	.560	13452.8
X_3					1.00	-.333	-.333	.25
X_4						1.00	-.333	.25
X_5							1.00	.25

X_5 = seasonal dummy: 1 if in fourth quarter of the year
0 otherwise

Y' = real per capita monthly disposable income in dollars ($X\ 10^{-6}$)

H = real haddock price in dollars

W = real wholesale price in dollars

The signs of the apparent consumption regression are those that would be expected from demand theory. Haddock price is significant at the 80% confidence level, whereas per capita real income and real wholesale price are significant at the 99% confidence level. The seasonal dummies, X_3 - X_5, when tested as a unit, were also significant at the 99% level.

If supply were considered exogenous and perfectly elastic, the coefficients of monthly wholesale price and monthly per capita income could be used to estimate the price and income elasticity for demand.[49/] At the mean values for real wholesale price and real per capita income, the real wholesale price elasticity of

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[49/] If supply were exogenous, but perfectly inelastic, a price-dependent demand regression would yield unbiased price flexibility estimates; the inverse of the flexibility measure would provide a lower limit estimate of price elasticity (Houck, 1965). A price-dependent demand equation was estimated and price elasticity computed at -.23.

demand is -.302 and the income elasticity of demand is 1.214. This compares well with those estimates by researchers using other price series and annual data (Table 9). The results accumulated to this point would indicate that the demand for shrimp is price inelastic and income elastic; although, a cross sectional analysis would be desirable to obtain more supportive evidence as to actual elasticities.

These elasticity measures, as well as those from other studies, suggest that for the price ranges considered over the last decade and a half, shrimp is a price inelastic good. If moderate price increases occur, quantity demanded will not decline to such an extent as to lower total revenues (wholesale price X apparent consumption), _ceteris paribus._ Conversely, moderate increases in quantities supplied of shrimp will decrease real wholesale price to such an extent as to cause declines in former total revenues, _ceteris paribus_. Also, an increase in real per capita income will be accompanied by an increase in per capita apparent consumption, _ceteris paribus_. Shrimp is apparently a luxury good, and as per capita incomes increase, so will the consumption of shrimp. This is verified by the preponderance (60%) of shrimp that are consumed in institutional trade, such as restaurant meals. Meals eaten away from home also increase as per capita income increases. Shrimp purchases, however, command a very small

Table 9. Elasticity Measures of Shrimp Demand.

Authors	Technique	Data series	Price elasticity	Income elasticity
Cleary (1970)	Retail price	Annual	-.46	+1.77
Cleary (1969)	O. L. S., single equation deflated retail price	Annual	-.60 to -.65	1.70
Doll (1972)	3-stage L-S, price dependent, deflated retail price	Annual	-.63	+1.12
	Undeflated retail price	Annual	-1.15	1.52
Suttor and Aryan-Nejad (1969)	O. L. S. ex-vessel price deflated with time trend	Annual	-.273	1.280
	W/O time trend		-.287	2.284
	2-stage L-S with time trend		-.280	1.289
	W/O time trend		-.325	2.316
Cleary a/	Retail price O. L. S.	Annual	+.376	
Doll a/	O. L. S. wholesale	Quarterly	-.41	1.14
Elkin a/	O. L. S. wholesale	Quarterly	-.38	
Elkin a/	O. L. S. wholesale	Annual	-.46	1.24

a/ As reported in Nash and Bell (1969).

portion of total income for most individuals, particularly because shrimp is only a part of the typical shrimp dinner menu. This would account for the price inelasticity of demand.

The coefficient of determination of .56 of the estimated demand equation is low when compared to the other studies which had coefficients of determination in the 90 percentiles. This difference in estimation results is due to the use of monthly data series. Monthly data have more fluctuations than will data taken from yearly averages. To demonstrate this, a regression was formed by summing the monthly data and using the average of 12 monthly prices for the yearly wholesale price estimate. The resulting regression(s), with and without a time trend, on these 12 observations are shown in Table 10. The R^2 of .95 reflects the linear nature of the aggregated data. The estimates of wholesale price elasticity are now: -.51 with a time trend and -.47 without a time trend. The estimates of income elasticity are .47 with a time trend (not significant) and 1.36 without a time trend.

The cold storage holding single equation regression is displayed in Table 7. As estimated by this regression, most cold storage holdings are significantly and positively related to both monthly aggregated catches and monthly wholesale price, as well as increasing significantly during the last two quarters of the year. Figure 12 illustrates the cyclic nature of cold storage holdings.

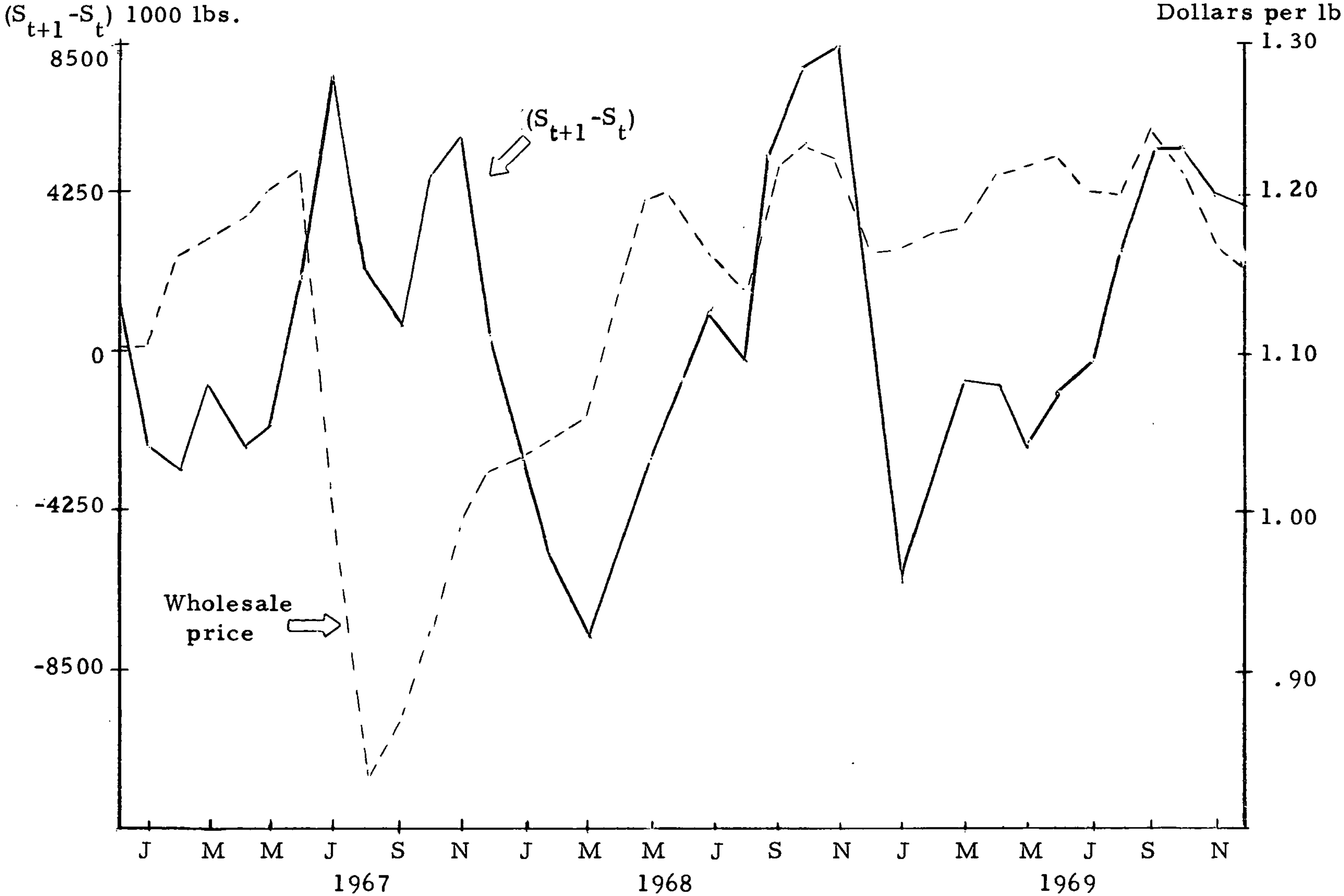

Figure 12. Cyclic nature of cols storage holdings $(S_{t+1} - S_t)$ and wholesale price, 1967-1969.

Table 10. Twelve-year Data Regression: Apparent Consumption.

Regression 1: With time trend

$$Q_d' = \underset{(2.33)}{15.840} + \underset{(.068)}{2411.7Y'} - \underset{(-1.40)}{76.940H} - \underset{(-3.95)^{**}}{53.146W} + \underset{(1.97)^{*}}{4.3862t}$$

$R^2 = .95$
D-W = 2.39

Regression 2: Without time trend

$$Q_d' = \underset{(1.11)}{38.540} + \underset{(7.02)^{**}}{70221.Y'} - \underset{(-.99)}{62.773H} - \underset{(-3.19)^{**}}{49.508W}$$

$R^2 = .93$
D-W = 1.22

** Significant at the 99% test level
* Significant at the 95% test level

Doll (1972) argues that "frozen shrimp cannot be held long periods without deterioration and even though domestic landings are unpredictable, speculation does not appear to be the major purpose, for holdings. Stocks are small relative to annual supplies and a large portion of holdings would seem to be for supply purposes." (Doll, 1972, p. 434). To some extent, the regression supports this statement as the increases in cold storage holdings are occurring at the same time that wholesale prices are beginning to rise, and are falling during the winter and early summer when wholesale prices are generally experiencing a decline. (Figure 12) Notice, however, that absolute prices can still be higher at the time of the reduction in inventories because of the general deflated price rise that has been associated with shrimp through time. Therefore, although maintenance of a stable supply is a prime motivator for cold storage holdings, anticipation of a higher wholesale price could also play a role.

Interestingly, changes in monthly cold storage holdings are not significantly related to imports, ceteris paribus. Because cold storage holdings can be utilized to maintain a stable supply throughout the year, it was assumed a priori that imports would have a significant and positive coefficient. The problem is not one of multicollinearity as the Table 8B demonstrates. Monthly data, however, enables the regression to illustrate that the Gulf and

South Atlantic monthly landings have the greatest influence on changes in cold storage holdings. This is an interesting finding. What appears to be happening is that there is a lagged effect: the chain of influence is not that imports of time period t influence changes in cold storage holdings of time period t, rather cold storage holdings of time period t influence imports of a future time period. This hypothesis will be examined in the next chapter.

The Durbin-Watson statistic does not indicate any significant serial correlation. The R^2 of .75 is relatively good considering the problems associated with estimations from monthly data series.

The Complete Domestic Model

Single equation models are designed with the assumption that all variables on the right hand side of the equality are exogenous, determined outside the model. This assumption is obviously violated in cases where price is a function of, say, quantity demanded, and quantity demanded is a function of price. If such simultaneity is present, single equation procedures are invalid and a system of equations is necessary (Johnston, 1960). The difficulty present in the modeling of the shrimp industry using monthly data is to determine whether or not such simultaneous mutual effects exist. It is possible that although both supply and demand influence ex-vessel price, the influence is over time and is lagged rather than simultaneous within the same month.

It was initially assumed that such simultaneity was present and a system of equations was used to model the industry. This system consists of the same three equations as presented before, with the addition of an identity and a fourth equation relating the two prices, deflated wholesale and deflated ex-vessel price index. The system of equations is presented in Table 11. The system of equations was over-identified, and therefore was estimated with the use of two-stage least squares. (Johnson, 1960, p. 258).

This analysis produced an improvement with regard to the supply function. This is shown in Table 12 (S-3); the single equation estimates are repeated here for comparison. [50/] Serial correlation was indicated by the Durbin-Watson statistic, and this was corrected for and included in Table 12 (S-4).[51/] The regression coefficients of the significant variables remained stable

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[50/] The statistical meaning of the R^2 presented here is unclear as there are not statistically valid measures of fit for simultaneous equations.

[51/] The statistical methodology associated with correcting serial correlation in two-stage least square regressions is not perfected. This equation was estimated using the technique documented in footnote 44. The coefficients remained reasonably stable, but the accuracy of the estimation procedure is not known.

Table 11. Model for Two-stage Least Squares Analysis.

Equation	Dependent variable		Constant	Trips	Tons	Dummy 1	Dummy 2	Dummy 3	No. of fishermen	Yards of trawl	Temp. index
Supply	Q_s	=	a_{11}	$+ b_{11} X_1$	$+ b_{12} X_2$	$+ b_{13} X_3$	$+ b_{14} X_4$	$+ b_{15} X_5$	$+ b_{16} X_6$	$+ b_{17} X_7$	$+ b_{18} X_8$
Apparent consumption	Q_d'	=	a_{21}			$+ b_{23} X_3$	$+ b_{24} X_4$	$+ b_{25} X_5$			
Cold storage holdings	$(S_{t+1} - S_t)$	=	a_{31}			$+ b_{33} X_3$	$+ b_{34} X_4$	$+ b_{35} X_5$			
Price	W	=	a_{41}								
Identity	Q_d	=									

Equation	Ex-vessel price	Change in cold stor.	Income per capita	Haddock price	Wholesale price	Landings	Imports	Error term
Supply	$+ b_{19} X_9$							$+ u_{1\,16}$
Apparent consumption			$+ b_{2\,11} Y'$	$+ b_{2\,12} H$	$+ b_{2\,13} W$			$+ u_{2\,16}$
Cold stor. holdings						$+ b_{3\,14} Q_s$	$+ b_{3\,15} I$	$+ u_{3\,16}$
Price	$+ b_{49} X_9$	$+ b_{4\,10}(S_{t+1} - S_t)$						$+ u_{4\,16}$
Identity		$- (S_{t+1} - S_t)$				$+ Q_s$	$+ I$	

Table 12. Preliminary and Two-stage Supply Regressions.

		Trips	Tons	Dummy 1	Seasonal dummy 2	Dummy 3	No. of fishermen	Yards of otter trawl	Temp. index	Ex-vessel price index
Regression S-1: Preliminary least squares single equation regression										
Q_s =	3267.9	+ .23706X_1	- .0017319X_2	- 2541.3X_3	+ 1979.4X_4	+ 3097.1X_5	+ 1.2485X_6	- .013647X_7	- 81.659X_8	- 8735.5X_9
	(.73)	(11.67)**	(-.26)	(-3.11)**	(1.87)	(5.45)**	(3.80)**	(-.71)	(-3.87)**	(-5.90)**
										R^2 = .89
										D-W = 1.10
Regression S-2: Preliminary least squares single equation regression corrected for serial correlation a/										
Q_s =	3214.3	+ .22020X_1	+ .0021108X_2	- 2383.1X_3	+ 1558.3X_4	+ 3127.6X_5	+ 1.0181X_6	+ .0014749X_7	- 90.849X_8	- 9297.6X_9
	(.97)	(11.75)**	(.20)	(-3.63)**	(1.83)	(5.88)**	(2.09)*	(.05)	(-4.87)**	(4.29)**
										R^2 = .82
										D-W = 1.90
Regression S-3: Two-stage least squares regression										
Q_s =	3109.2	+ .22416X_1	- .005145X_2	- 2790.0X_3	+ 2001.0X_4	+ 3288.6X_5	+ 1.2674X_6	- .031422X_7	-91.210X_8	-2586.4X_9
	(.62)	(9.07)**	(-.65)	(-2.98)**	(1.68)	(5.05)**	(3.44)**	(-1.24)	(-3.68)**	(.52)
										R^2 = .87
										D-W = .93
Regression S-4: Two-stage least square regression corrected for serial correlation a/										
Q_s =	2773.0	+ .21191X_1	- .002286X_2	- 2617.3X_3	+ 1465.0X_4	+ 3058.7X_5	+ .86882X_6	- .0083434X_7	- 97.368X_8	- 1848.0X_9
	(.83)	(9.46)**	(-.17)	(-3.80)**	(1.66)	(5.15)**	(1.49)	(-.25)	(-4.62)**	(.30)
										R^2 = .78
										D-W = 1.92

** Significant at the 99% test level

* Significant at the 95% test level

a/ Significance levels are not strictly applicable after serial correlation correction.

Table 13. Correlation Matrix for Supply Regression S-4.

	Q_s	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	Means
Q_s	1.00	.718	.044	-.148	.236	.267	.108	.065	-.569	-.028	5025.61
X_1		1.00	.076	..220	-.136	.191	.098	.080	-.433	.291	8831.44
X_2			1.00	-.013	-.013	-.072	.691	.685	.039	.597	66609.6
X_3				1.00	-.449	-.109	-.006	-.009	-.197	.291	.11646
X_4					100	-.458	-.006	-.009	-.515	-.355	.11646
X_5						1.00	-.033	-.050	.253	-.077	.12022
X_6							1.00	.766	.019	.563	7561.91
X_7								1.00	.016	.628	75183.3
X_8									1.00	.191	51.4535
X_9										1.00	.3955

throughout these operations, with the exception of the price variable. Although the ex-vessel price index coefficient did not become positive, it is not significantly different from zero. The ex-vessel price index coefficient is, however, significantly different from the value that would indicate unitary positive supply elasticity (at the mean values of quantity and price) at a 99% confidence limit for both equation S-3 (two-stage uncorrected for serial correlation) and equation S-4 (two-stage corrected for serial correlation).[52/] This supply inelasticity corresponds well with Kravis' contention that those natural resource goods which are imported in large volumes are characterized by a domestic supply schedule which is price inelastic. Indeed, the very fact that supply price is not significantly different from zero suggests that, for this specification of the model, ex-vessel price has little influence on landings. The implications of this inelasticity are examined in Chapter V, Conclusions and Policy Implications.

The other significant coefficients in the supply regression did not change appreciably; however, after correction for serial correlation, the coefficient of number of fishermen (X_6) is no longer significant at the 99% confidence limit. It is significant, however,

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[52/] Supply ex-vessel price elasticities equal -.68 and -.14, respectively (S-3 and S-4).

at the 85% confidence limit. The significance of the number of fishermen variable probably reflects the mobility of this input (annually) in the fishery relative to the mobility of vessel tonnage and yards of otter trawl. The graph, Figure 13, compares the yearly fluctuations of the number of U.S. fishermen vessels and boats, and yards of otter trawl, and indicates this tendency. This would be an interesting area for further research if reliable monthly data could be obtained.

The apparent consumption and cold storage equations were not improved by the two-stage regression (see Table 14). Indeed, the price coefficient became positive. The reason for this can be traced to poor regression estimates of the hypothesized jointly determined wholesale price variable ($R^2 = .42$) in stage one of the two-stage analysis. Experiments to improve this regression were unsuccessful.[53/] This suggests that the wholesale price variable is not jointly determined with the ex-vessel price index. Apparently, although demand pressures of month t do influence the real ex-vessel price index of the same month;[54/] the relationship is not reversible and the total quantity landed influences wholesale

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53/ This problem is probably due, in some part, to the lack of an adequate import supply function. Ex-vessel prices and wholesale prices are influenced by import supply as well as domestic supply, although there is undoubtedly a lag operating in this part of the market as well. Unfortunately, the data necessary for a satisfactory estimate of an import supply schedule do not exist. The next chapter analyzes this problem in some depth.

54/ A personal communication with Peter De Marco, Chicago office of the N.M.F.S. Market News Service, indicated that dock brokers do watch the Chicago wholesale market on a daily basis.

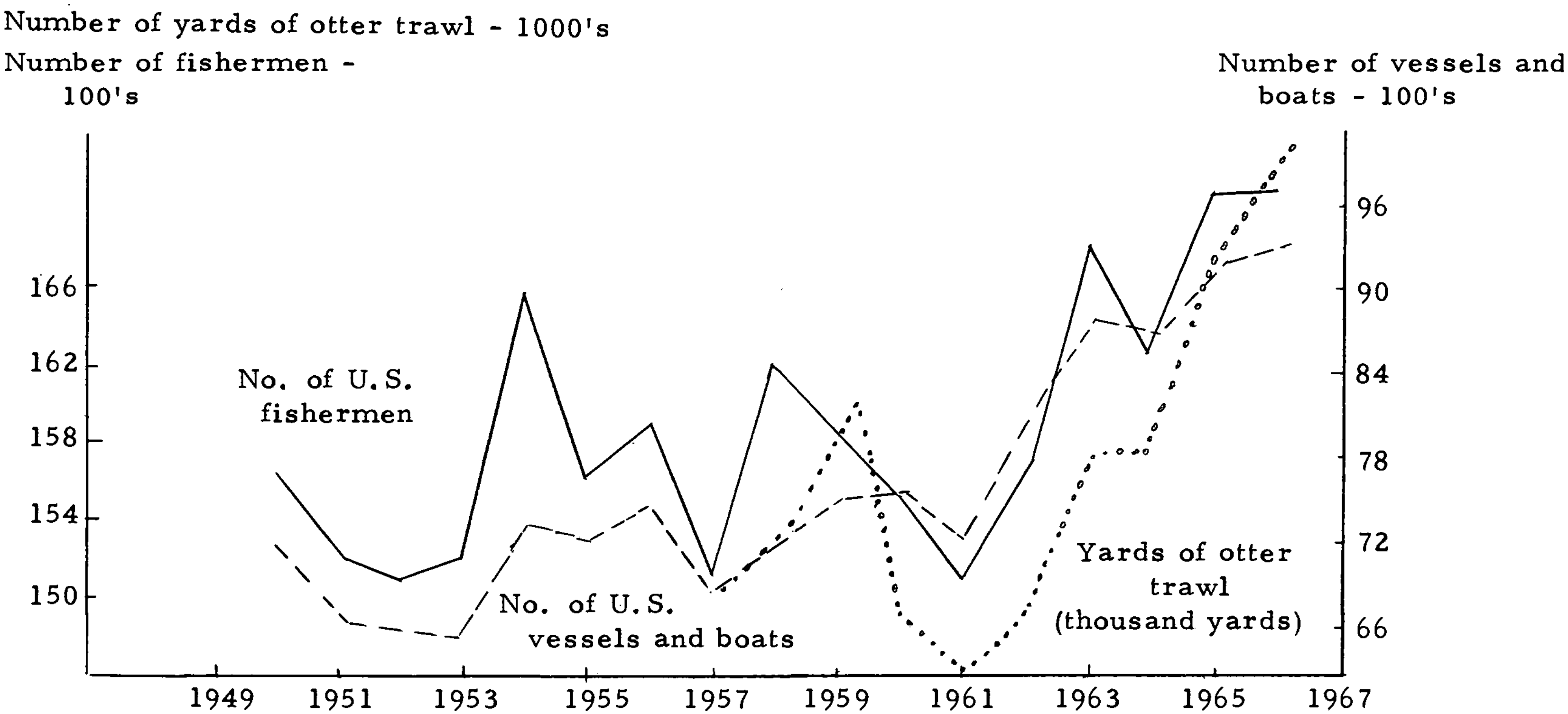

Figure 13. Yearly fluctuations of fishermen, number of vessels and boats and yards of otter trawl.

Table 14. Two-stage Least Squares Regressions. Apparent Consumption, Cold Storage Holdings, Price.

Apparent Consumption

$$Q_d' = \underset{(3.68)^{**}}{122.19} \; \underset{(-1.65)}{-\,5.7106\,X_3} \; \underset{(4.97)^{**}}{+\,16.818\,X_4} \; \underset{(5.71)^{**}}{+\,20.079\,X_5} \; \underset{(-.83)}{-\,15711.Y''} \; \underset{(4.38)^{**}}{-\,320.09\,H} \; \underset{(3.60)^{**}}{+\,143.48W''}$$

$R^2 = .56$
D-W = 1.58

Cold Storage Holdings

$$(S_{t+1} - S_t) = \underset{(1.5128)}{-3801.1} \; \underset{(4.49)^{**}}{+\,.28540\,Q_s''} \; \underset{(-.637)}{-\,2081.1\,W''} \; \underset{(1.34)}{+\,.10141\,I} \; \underset{(.18)}{+\,106.72\,X_3} \; \underset{(1.75)}{+\,1606.2\,X_4} \; \underset{(5.59)^{**}}{+\,5058.8\,X_5}$$

$R^2 = .72$
D-W = 1.57

Price Equation

Original single equation: $W = \underset{(9.40)^{**}}{.20691} \; \underset{(36.89)^{**}}{+\,1.0834\,X_9} \; \underset{(2.99)^{**}}{+\,.00000297\,(S_{t+1} - S_t)}$

$R^2 = .91$
D-W = .84

Two-stage equation: $W'' = \underset{(1.76)}{.16019} \; \underset{(9.35)^{**}}{+\,1.1464\,X_9} \; \underset{(1.24)}{+\,.00000356\,(S_{t+1} - S_t)}$

$R^2 = .38$
D-W = .23

** Significant at 99% level
* Significant at the 95% level
' Per capita
'' Per capita and jointly determined.

price only after a lag.

Doll and Chin (1970), using annual prices, concluded that apparently a lag between annual retail and ex-vessel price does exist, but only occurs when prices suffer severe downward price breaks (e.g., 1955, 1958, 1960, 1964, 1967, 1968). The situation is not as clear when monthly retail price series are compared with monthly wholesale price series. A study similar to that of Doll and Chin (1970) was conducted using monthly deflated data; the complete analysis is presented in Appendix B. Generally, however, these monthly price series did move together (Figure 14A, 14B), although occasionally ex-vessel prices do lead wholesale prices. Comparisons made between Figures 14A and 14B and those that graph quantity landed and apparent consumption (Figures 15A and 15B) indicate that except for those months where landings are extremely high relative to demand, wholesale and ex-vessel prices are responding mainly to demand forces.

The Import Function

The preceding investigation provides insight into the components of the demand for imports. The next chapter will summarize these insights and then utilize them to construct an import demand function.

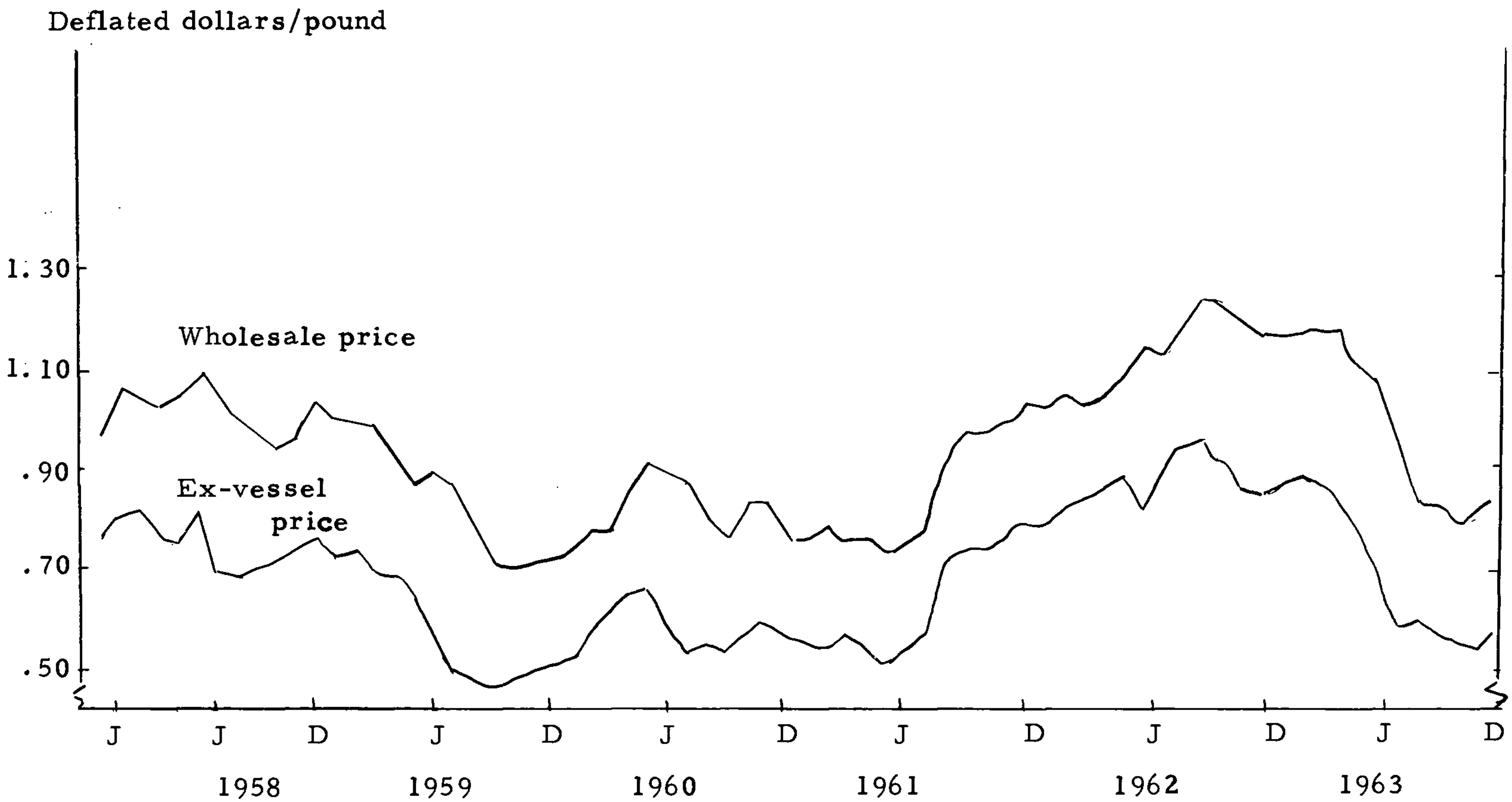

Figure 14A. Real wholesale price and ex-vessel price index, 1958-1963.

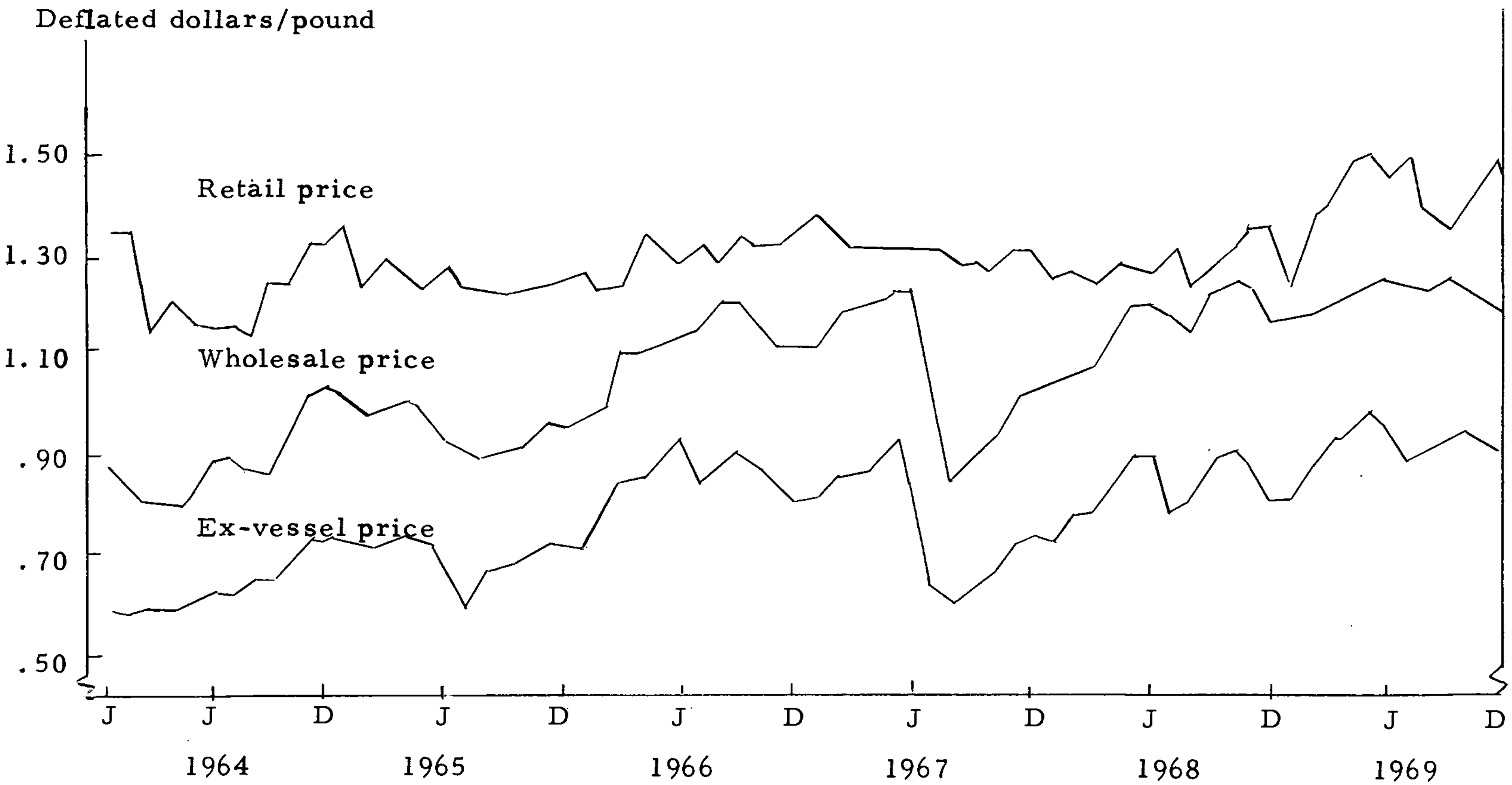

Figure 14B. Real wholeprice and ex-vessel price index, 1964-69.

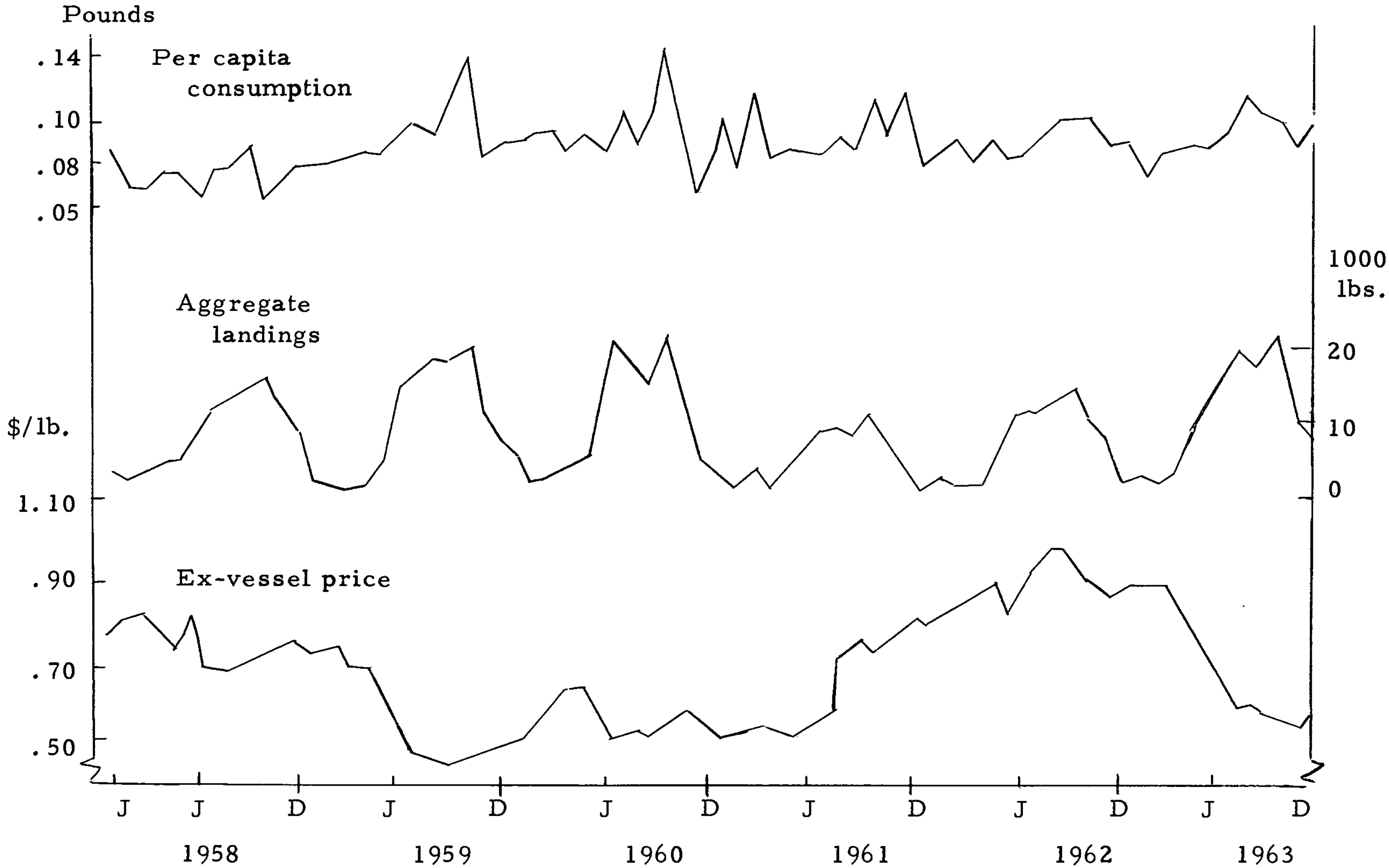

Figure 15A. Per capita consumption, aggregate landings and ex-vessel price index, 1958-1963.

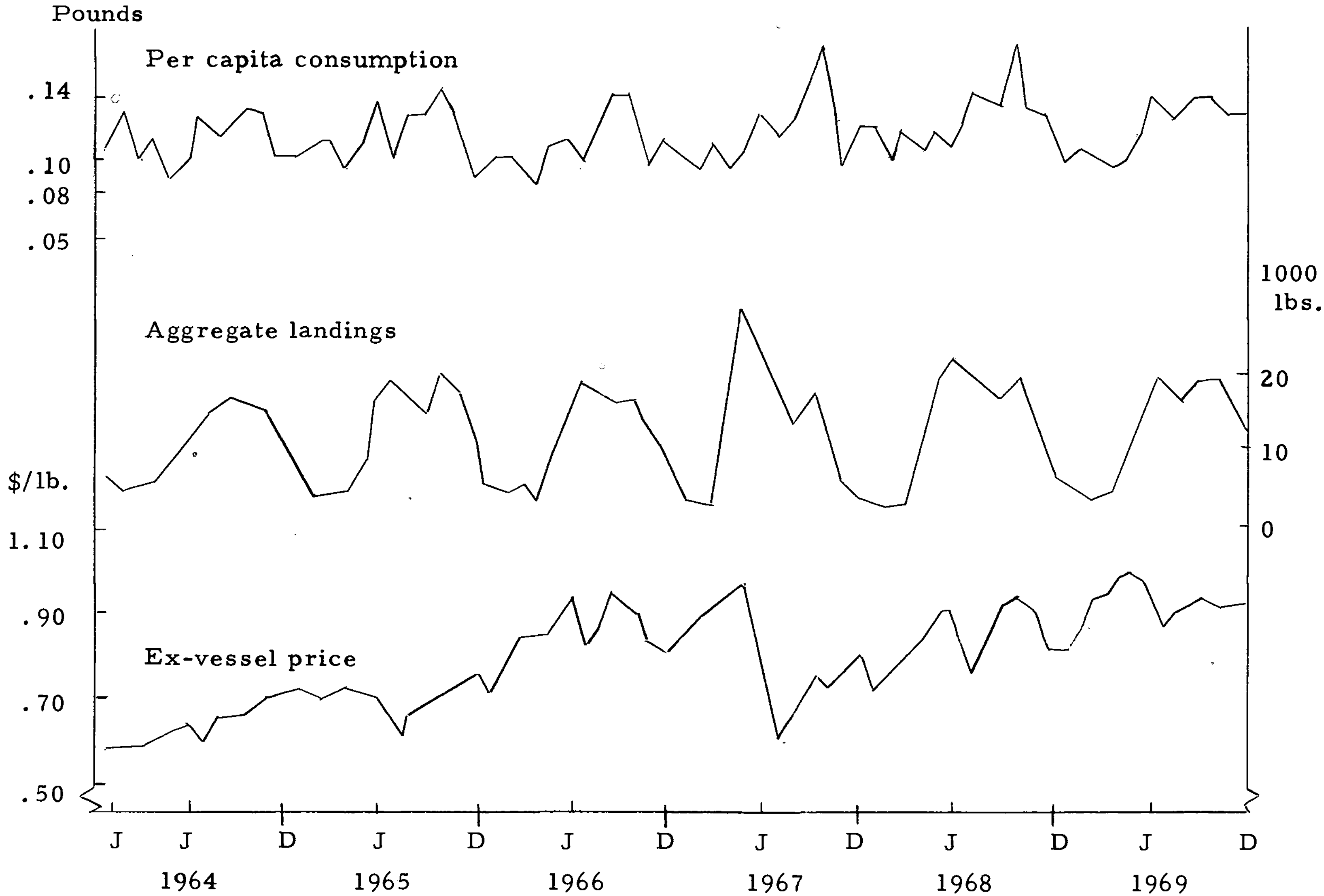

Figure 15B. Per capita consumption, aggregate landings and ex-vessel price index, 1964-1969.

IV. THE IMPORT DEMAND FUNCTION FOR SHRIMP

The previous chapter which examined the domestic market for shrimp has verified that supply is relatively price inelastic. This corresponds directly with the hypothesis presented in Chapter II that the basis of increased imports of natural resources is the physical scarcity of domestic resources at a price that is competitive with foreign production. This, of course, is not a verification of this hypothesis, but the shrimp market does demonstrate the characteristics predicted by such authors as Kravis (1956a), Vanek (1963), Diab (1956), and Aubrey (1955).

In addition, it became apparent that lags operate within the market. Specifically, it was hypothesized that lagged cold storage holdings influenced imports. Finally, those variables which influence apparent consumption will also influence the demand for imports over time, although a lag will be operative for these variables as well.

Import Demand as a Residual

In Chapter II, it was suggested that for those products which are reasonably homogenous, import demand could be treated as a residual. Import demand was expressed as an excess demand function, and Figure 4 was used to demonstrate this concept graphically. Imports demanded, in this case, are not a function of relative foreign and domestic prices, rather imports demanded are a function of domestic demand and supply variables.

Leamer and Stern (1970) illustrate the difference between these two formulations by hypothesizing a situation where the international supply of an imported good is infinitely elastic. They then assume that a domestic investment has increased the capacity of the import competing industries. The imported good is a perfect substitute for the domestically produced good.

> "In our first situation [relative prices specification] domestic prices will fall and imports will be reduced. In our second situation, domestic and import prices must be the same as long as some of both goods is being sold. Accordingly, no price change is observed, yet at the same time imports will be reduced. The only way to account for this is to include the capacity of the import competing industries as an explanatory variable in the import demand function." (Leamer and Stern, 1970, p. 11)

The assumption of infinite supply elasticity internationally is an important one. If international supply is infinitely elastic, then estimation of import demand as a single equation estimate will yield unbiased estimates of price elasticity. Orcutt (1950) described this problem when investigating other studies on the demand for imports, and illustrated the problem using a figure similar to Figure 16. In this figure, assume DD to be an import demand function for a good and SS to be the supply function. DD now shifts outward to D'D', and the price increases. This implies

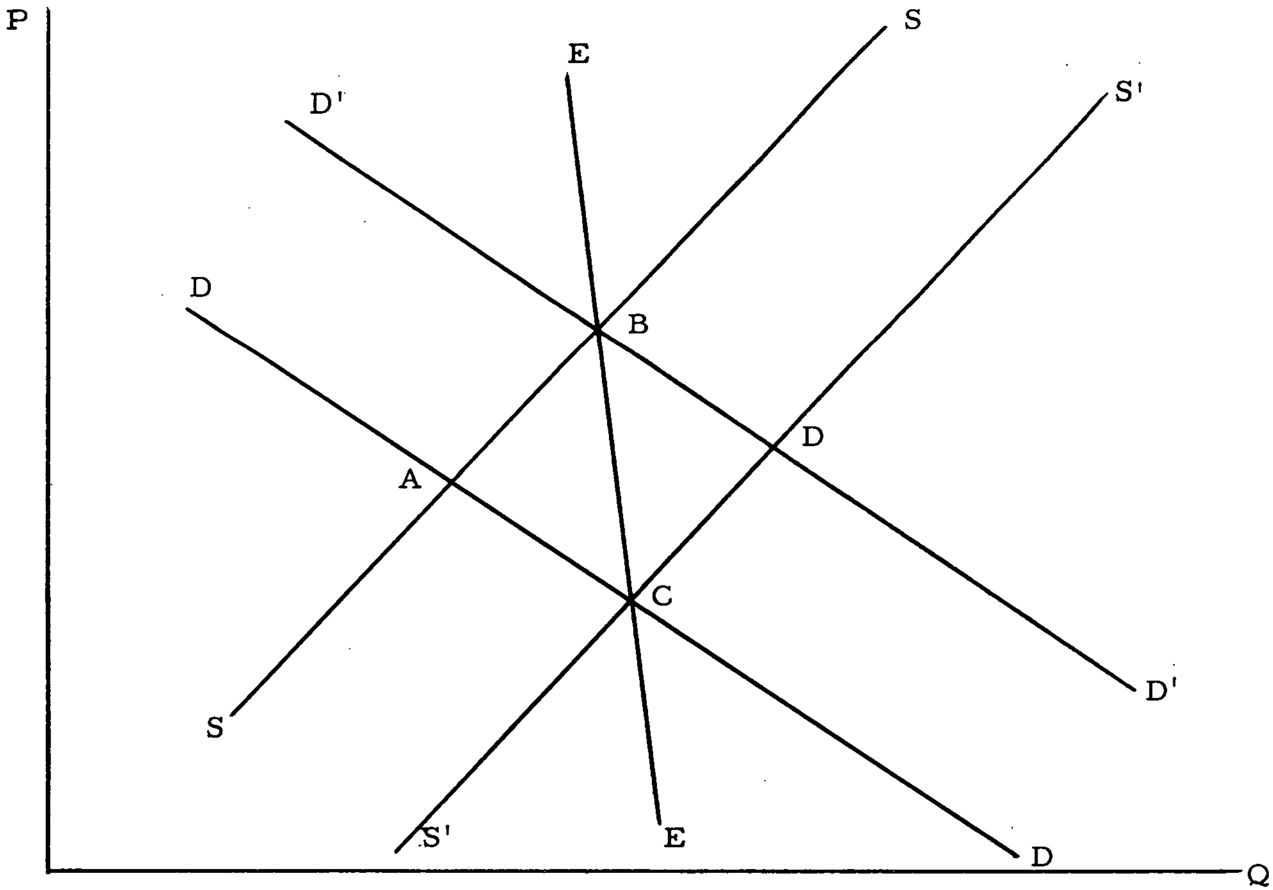

Figure 16. Downward bias in the estimated price coefficient.*

*Adapted from Leamer and Stein (1970), p. 30.

that high values of the error term, u, will be associated with high values of price; this correlation is a violation of the assumptions necessary for least squares to yield unbiased estimators. The estimate of price elasticity will be biased downward, somewhere between the true negative elasticity and the positive elasticity of supply.

This bias can be illustrated by assuming the supply schedule to shift randomly between SS and S'S' and the demand schedule to shift randomly between DD and D'D'. The data points that will be observed are those in the parallelogram of ABCD. A regression fitted through these points will appear as EE. The price elasticity estimate of EE will be biased downward (absolutely) from that of the true elasticity associated with DD and D'D'.

If, however, the international supply is infinitely elastic, the error term will not be correlated with price. This is illustrated in Figure 17, where quantity is measured on the ordinate for clarity. In this case, the perfectly elastic and shifting supply curve, in conjunction with a shifting and downward sloping demand curve, will result in observations scattered randomly throughout the parallelogram ABCD. The regression line, EE, that minimizes the vertically summed squares of the deviations will therefore yield an unbiased estimate of the parameter of the price variable.

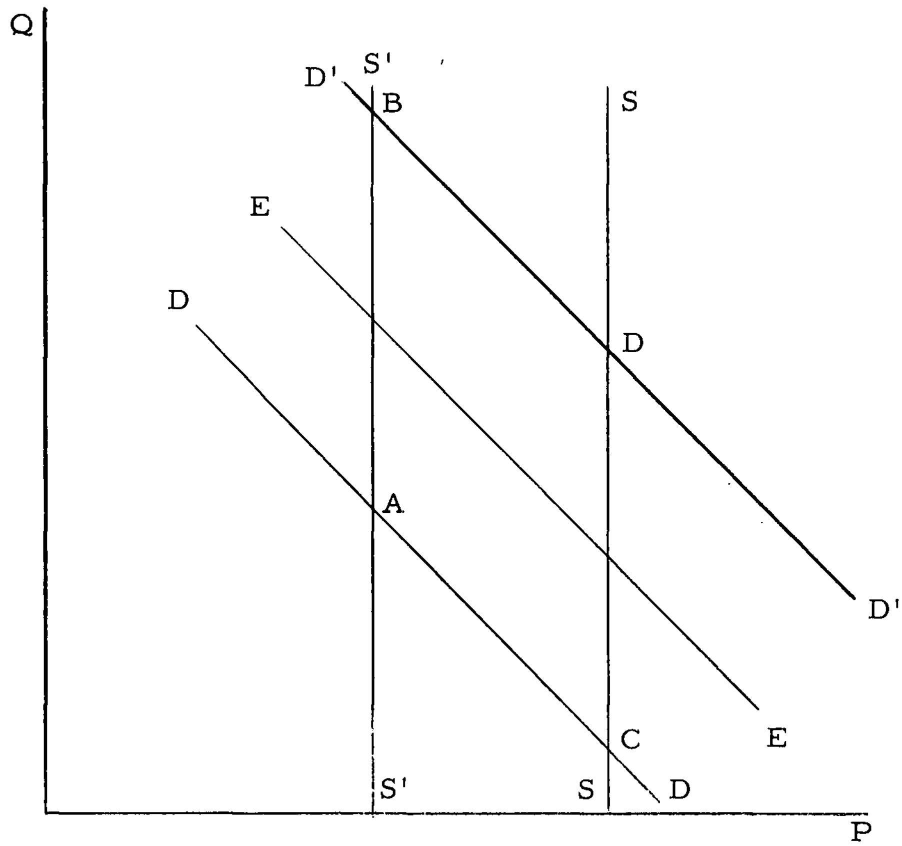

Figure 17. Unbiased estimate of price coefficient.*

*Adapted from Leamer and Stern (1970), p. 3.

The use of single equation ordinary least squares estimate may be indicated when the shifts in the supply schedule are large relative to those of the demand schedule, and/or when the supply schedule is highly elastic.

> "In employing ordinary least squares, care should be taken therefore [to notice] the particular economic conditions affecting the relationship. Thus, in the case of a small

country that imports only a relatively small fraction of total world exports, it may be quite realistic to assume an infinitely elastic supply schedule. In contrast, a country like the United States may face a rising supply schedule because of its relatively large size." (Leamer and Stern, 1970, p. 31)

Initially, it was assumed that for 1958-1969, the international supply of shrimp was highly price elastic; undoubtedly it was more elastic than the domestic supply schedule because of the far greater quantity available on the world market from numerous and diverse fishing grounds. Also, import demand was considered to be a residual. Thus, imports of shrimp are supplementary to domestic production in the sense that they "materialize only where American capacity (measured at the level of minimum average costs) is not sufficient to satisfy demand at the corresponding normal price." (Neisser, 1953, p. 146)

In this case, the import demand schedule should be more elastic than the total pre-trade domestic demand schedule, depending on the elasticity of domestic supply. Figure 18 is Figure 4 re-drawn to reflect inelasticity of domestic supply. Notice that if the domestic supply schedule were completely inelastic, the slope of the import demand schedule would be identical to that of the total pre-trade domestic demand schedule. An estimate of (point) elasticity at a mean value of quantity and price would therefore be identical. Import demand in this specification is a

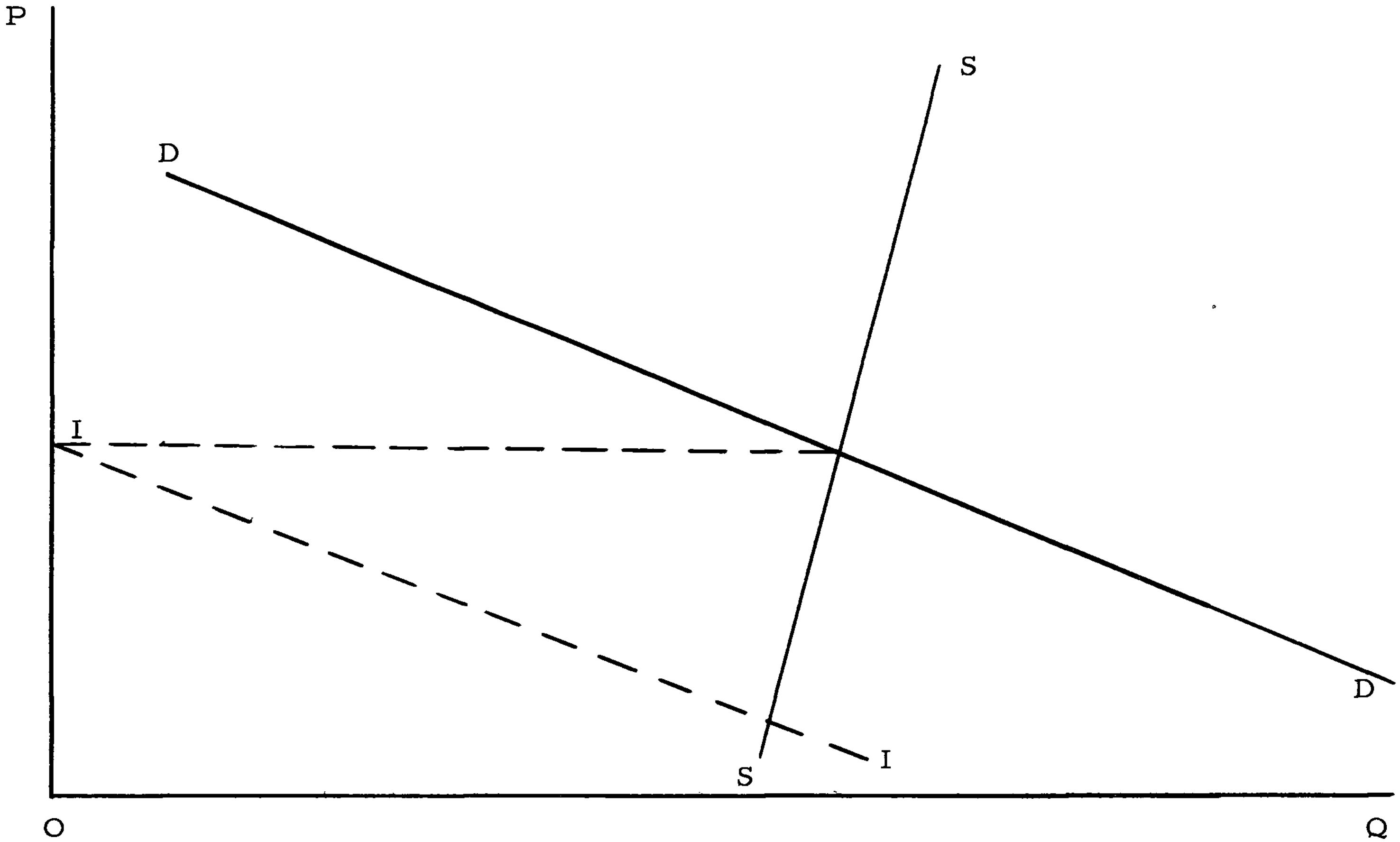

Figure 18. Import demand as a residual: Inelastic supply.*

* Adapted from Leamer and Stein (1970), p. 11.

function of domestic demand and supply variables, and a change in the domestic supply schedule will directly influence the import schedule.

The implicit assumption in formulating import demand as a residual is that of perfect substitutability between the imported shrimp and the domestic shrimp. It is assumed, therefore, that the cross-elasticities between these two classifications of shrimp are quite high. This also implies that the import price of the shrimp was identical to domestic prices over the period of the study, and therefore, wholesale domestic price could be used as the price variable of interest. Figure 19 demonstrates that these prices do follow each other closely.[55/]

Import demand was assumed, therefore, to be formulated so that I' (imports per capita in 1, 000 pounds) were a function of:

X_3 = seasonal dummy: 1 if in second quarter of the year
0 otherwise

X_4 = seasonal dummy: 1 if in third quarter of the year
0 otherwise

X_5 = seasonal dummy: 1 if in the fourth quarter of the year
0 otherwise

[55/] Figure 19 graphs the data for part of the period for which published import prices are available: 1970 to the present.

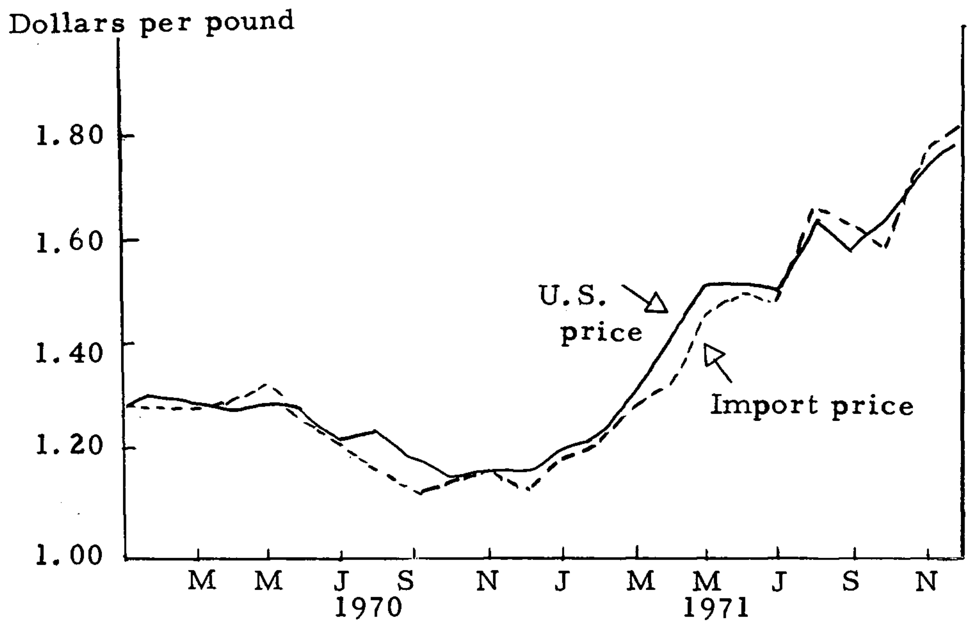

Figure 19. Wholesale prices for domestic and imported shrimp, 1970-1971.

Y'_{t-x} = real per capita disposable income per month in dollars (x 10^{-6})

H_{t-x} = monthly real haddock price in dollars

W_{t-x} = monthly real wholesale prices in dollars

${Q_s}_{t-x}$ = monthly aggregate landings in 1000 pounds

$(S_{t+1} - S_t)_{t-x}$ = changes in monthly cold storage holdings.

where t-x are different time periods with x assuming values from 0 to 6. The various lags were employed in an effort to determine the sensitivity of the function to various lags between orders placed and actual arrival of shrimp. 56/

Q_s, aggregate landings, was specified as a substitute for the supply schedule. The rationale for this substitution is the price inelasticity of domestic supply; any significant changes in the magnitude of aggregate landings imply a shift in the supply schedule and not a movement along the supply schedule. However, for comparison, one regression was estimated utilizing these supply variables:

$$
\begin{aligned}
I_t' = & \underset{(-3.27)}{-10.795} \; \underset{(-1.35)}{- 6.0851X_3} \; \underset{(1.44)}{- 8.5012X_4} \; \underset{(6.67)^{**}}{+ 21.214X_5} \; \underset{(5.40)^{**}}{+ 76289.Y_t'} \\
& \underset{(-.06)}{-2.7314H} \; \underset{(1.35)}{+ 10.471W} \; \underset{(2.11)^{*}}{+ .0024007X_1} \; \underset{(.74)}{+ .000040979X_2} \\
& \underset{(-2.91)^{**}}{- .0063903X_6} \; \underset{(-.26)}{- .000032279X_7} \; \underset{(1.00)}{+ .11755X_8}
\end{aligned}
$$

R^2 = .80
D-W = 1.80

56/ A representative of the N. M. F. S. estimated that this lag was "at least two months" between the time of order and arrival.

When the supply variables were removed and aggregate landings, Q_s, substituted, the coefficient of Q_s (.000191) was significant at approximately the 55% level. The coefficient of determination was .77. When Q_s was replaced by per capita aggregate landings, Q_s', the coefficient was significant at less than the 50% level. (R^2 = .79)

The final specifications utilized are displayed in Table 15.[57/] There is not an appreciable difference between those equations in Table 15 characterized by differing lags. All have a positive, but insignificant coefficient on wholesale price. All have a Durbin-Watson statistic near the lower limit, indicating some serial correlation. This is not surprising given the monthly nature of the data. A correction procedure performed on equation I-6 (the four-month lag regression) yielded no significant changes, however (Equation I-7, Table 15). The income variable accounted for a large amount of the mutual linear variations, as did the three seasonal dummy variables.

Equation I-3, which is included for reference, is not a proper theoretical specification because $(S_{t+1}-S_t)$, changes in cold storage holdings, are a function of imports of the same time period. Coefficients on lagged cold storage holdings are not significantly different from zero. No serious multicollinearity is present (Table 16).

[57/] A principal component specification is discussed in Appendix B.

Table 15. Import Demand Functions.

	Imports	Constant a_1	Seasonal Dummy 1 X_3	Seasonal Dummy 2 X_4	Seasonal Dummy 3 X_5	Monthly income per capita (defl.) $Y'_{(t-x)}$	Haddock price (defl.) $H_{(t-x)}$	Wholesale price (defl.) $W_{(t-x)}$	Monthly aggregate landings $Q_{s(t-x)}$	Change in cold storage holding $(S_{t+1}-S_t)_{t-x}$
Imports No lag (x=0) I-1	I=	-8893.1 (-2.53)*	$-1310.1X_3$ (-2.33)*	$-2203.8X_4$ (-2.84)**	$+4450.3X_5$ (6.65)**	$+52625.Y'_t$ (12.47)**	$-1082.7H_t$ (-.16)	$+1636.6W_t$ (1.07)	$+.036959Q_{s_t}$ (.75)	$R^2 = .81$ D-W = 1.67
Imports per capita No lag (x=0) except for Q_s where x=1 I-2	I'_t=	-61.851 (-2.98)**	$-6.0977X_3$ (-2.26)*	$-8.0802X_4$ (-1.88)	$+26.020X_5$ (6.25)**	$+62586.Y'_t$ (10.06)**	$-11.537H_t$ (-.31)	$+7.3400W_t$ (.89)	$-.000130Q_{s_t}$ (-.39)	$R^2 = .77$ D-W = 1.62
Imports per capita No lag (x=0) I-3	I'_t =	-50.196 (-2.61)**	$-6.2815X_3$ (-2.32)*	$-14.494X_4$ (-3.82)**	$+10.275X_5$ (2.50)*	$+68205.Y'_t$ (12.00)**	$-17.393H_t$ (-.52)	$-3.6181W_t$ (-.47)	$-.000550Q_{s_t}$ (-1.99)**	$+.002347\ (S_{t+1}-S_t)_t$ (5.11)* $R^2 = .81$ D-W = .69
Imports per capita 2 month lag (x=2) I-4	I'_t =	-66.977 (-7.06)**	$-5.5184X_3$ (-1.78)	$-9.2781X_4$ (-3.04)**	$+25.997X_5$ (6.77)**	$+60078.Y'_{t-2}$ (10.07)**		$+10.425W_{t-2}$ (1.19)	$+.00011768Q_{s_{t-2}}$ (.32)	$-.00022227\ (S_{t+1}-S_t)_{t-2}$ (-.47) $R^2 = .76$ D-W = 1.58

Continued

Table 15. Continued.

	Imports	Constant a_1	Seasonal Dummy 1 X_3	Seasonal Dummy 2 X_4	Seasonal Dummy 3 X_5	Monthly income per capita (defl.) $Y'_{(t-x)}$	Haddock price (defl.) $H_{(t-x)}$	Wholesale price (defl.) $W_{(t-x)}$	Monthly aggregate landings $Q_{s(t-x)}$	Change in cold storage holding $(S_{t+1}-S_t)_{t-x}$
Imports per capita 3 month lag (x=3) I-5	I'_t =	-68.034 (-7.14)**	$-2.9355X_3$ (-.67)	$-8.8331X_4$ (-2.16)*	$+24.923X_5$ (6.90)**	$+59285.Y'_{t-3}$ (10.67)**		$+11.043W_{t-3}$ (1.35)	$+.000315Q_{s_{t-3}}$ (.99)	$+.000002(S_{t+1}-S_t)_{t-3}$ (.0035) R^2 = .76 D-W = 1.59
Imports per capita 4 month lag (x=4) I-6)	I'_t =	-67.128 (-7.55)**	$-6.610X_3$ (-1.67)	$-12.436X_4$ (-3.25)**	$+23.784X_5$ (7.36)**	$+59449.Y'_{t-4}$ (12.00)**		$+13.516W_{t-4}$ (1.86)	$-.000343Q_{s_{t-4}}$ (-.96)	$+.000220(S_{t+1}-S_t)_{t-4}$ (.87) R^2 = .79 D-W = 1.53
Imports per capita 5 month lag (x=5) I-7	I'_t =	-67.009 (-7.40)**	$-5.7673Y_3$ (-1.73)	$-10.967X_4$ (-3.19)**	$+24.491X_5$ (8.19)**	$+61222.Y'_{t-5}$ (12.46)**		$+10.228W_{t-5}$ (1.39)	$-.000097Q_{s_{t-5}}$ (-.32)	$+.000133(S_{t+1}-S_t)_{t-5}$ (.56) R^2 = .78 D-W = 1.58
Imports per capita 6 month lag (x=6) I-8	I'_t =	-64.581 (-7.02)**	$-9.0160X_3$ (-2.06)*	$-12.178X_4$ (-2.88)**	$+25.499X_5$ (8.23)**	$+64065.Y'_{t-6}$ (12.71)**		$+6.6899W_{t-6}$ (.91)	$-.000127Q_{s_{t-6}}$ (.31)	$-.000200(S_{t+1}-S_t)_{t-6}$ (-.62) R^2 = .78 D-W = 1.54

Continued

Table 15. Continued.

	Imports	Constant a_1	Seasonal Dummy 1 X_3	Seasonal Dummy 2 X_4	Seasonal Dummy 3 X_5	Monthly income per capita (defl.) $Y'_{(t-x)}$	Haddock price (defl.) $H_{(t-x)}$	Wholesale price (defl.) $W_{(t-x)}$	Monthly aggregate landings $Q_{s(t-x)}$	Change in cold storage holding $(S_{t+1}-S_t)_{t-x}$
Equation I-6 corrected for serial correlation I-7	I''_t =	-50.506 (-5.96)**	$-8.0956X_3''$ (-2.05)*	$-13.389X_4''$ (-3.45)*	$+21.485X_5''$ (6.74)**	$+58467.Y''_{t-4}$ (9.39)**		$+14.411W''_{t-4}$ (1.63)	$+.000340Q''_{s\,t-4}$ (1.16)	$-.000505(S_{t+1}-S_t)_{t-4}$ (-1.44) $R^2 = .73$ D-W = 2.00

Table 16. Correlation Matrix for Import Demand Equations.

	I	X_3	X_4	X_5	Y'_t	H_t	W_t	Q_{s_t}	$(S_{t+1}-S_t)_t$	Means
I	1.00	-.20	-.27	.56	.73	-.21	.41	.17	.41	13452.8
X_3		1.00	-.33	-.33	-.02	-.03	.09	-.17	-.34	.25
X_4			1.00	-.33	-.00	-.04	-.06	.55	.19	.25
X_5				1.00	.07	.06	-.02	.25	.67	.25
Y'_t					1.00	-.36	.55	.17	.06	.00205
H_t						1.00	.05	-.05	.09	.43
W_t							1.00	.00	.09	1.006
Q_{s_t}								1.00	.67	10774.
$(S_{t+1}-S_t)_t$									1.00	236.264

	X_3	X_4	X_5	Y'_{t-3}	H_{t-3}	W_{t-3}	$Q_{s_{t-3}}$	$(S_{t+1}-S_t)_{t-3}$	Means
X_3	1.00	-.33	-.33	-.01	.03	.00	-.62	-.42	.25
X_4		1.00	-.33	.02	-.01	.11	-.16	.01	.25
X_5			1.00	+.03	-.03	-.04	.57	.70	.25
Y'_{t-3}				1.00	-.51	.53	.18	.03	.00203
H_{t-3}					1.00	-.02	-.11	.02	.43
W_{t-3}						1.00	-.03	.15	1.002
$Q_{s_{t-3}}$							1.00	.60	10676.
$(S_{t+1}-S_t)_{t-3}$								1.00	201.298

Continued

Table 16. Continued.

	Y'_{t-3}	H_{t-3}	W_{t-3}	$Q_{s_{t-3}}$	$(S_{t+1}-S_t)_{t-3}$
Y_t	.99	-.51	.51	.17	.01
H_t	-.36	.79	.08	-.07	.09
W_t	.56	-.09	.79	-.14	.01
Q_{s_t}	.18	-.06	.21	.06	.36

There are at least three possible explanations for the positive (and insignificant at the 95% test level) coefficient on wholesale price. Firstly, import supply is not infinitely elastic; there is a simultaneous relationship between import demand and supply, and therefore import demand can not be estimated with a single ordinary least squares equation. Secondly, there is the possibility that the propensity to import (percentage change in imports/percentage change in income) is so high relative to the import price elasticity (percentage change in imports/percentage change in wholesale price), that the income effect overshadows the price effect and the insignificant price coefficient is unbiased and efficient. In equation I-6, the propensity to import is +1.73; the price elasticity is +.14 (not significant) at the mean values of income, imports, and wholesale price.[58/] Thirdly, the original specification of the domestic supply function (S-1, Table 5) could be the proper specification and the domestic supply schedule is negatively sloped with an absolute slope that is less than that of the demand schedule, so that the import demand as an excess demand function is positively sloped.

Of these three explanations, the first has the most intuitive

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[58/] The income elasticity of the import demand function at the mean quantity of apparent consumption and mean income is +1.16 as compared to 1.21 estimated from the total apparent consumption regression.

appeal. The U.S. is the largest world importer of shrimp and therefore probably does face a rising international supply curve. Evidence of this was provided by events in 1971 when the Japanese outbid the United States in the world shrimp market. As a result, Japan's shrimp imports rose 38% while America's declined for the first time in 17 years (Whitaker, 1972, p. 3). Traditionally, the Japanese have relied mainly on Asian sources of supply, whereas U.S. importers have been supplied by Central and South America. "Thus, both the United States and Japan have been able to increase their imports at the same time." (U.S.D.C., 1972a, p. 10). However, as Table 17 indicates, of the 15 largest shrimp suppliers, Mexico and India supply both Japan and the U.S.

Also, a graph of imports versus wholesale price (Figures 20A and B) indicates that both imports and real wholesale price have increased over the last decade and a half. This suggests that there is a simultaneous influence on wholesale price in addition to imports demanded.

It is probable, therefore, that the international supply curve is price elastic (but not infinitely so) and is upward sloping. Because this curve is shifting outward through time as more fishing grounds are discovered and exploited, it is reasonable to assume that the single equation approach has yielded biased estimates.

Table 17. Comparison of the 15 Largest Suppliers of Shrimp to Japan and the United States, January-June, 1972.

Japan			United States		
Country	Quantity	Rank	Country	Quantity	Rank
	Million pounds			Million pounds	
Indonesia	13.4	1	Mexico	34.5	1
India	12.5	2	India	18.4	2
Thailand	8.6	3	Venezuela	5.4	3
Malaysia	8.0	4	Panama	5.3	4
Mexico	5.9	5	Brazil	4.9	5
Taiwan	4.2	6	Guyana	3.9	6
Mainland China	4.0	7	Nicaragua	3.5	7
Australia	3.9	8	Ecuador	2.9	8
Pakistan	3.3	9	Columbia	2.8	9
Kuwait	3.3	10	Pakistan	2.0	10
Hong Kong	3.0	11	Salvador	1.9	11
U.S.S.R.	2.5	12	Thailand	1.6	12
Cuba	2.4	13	Fr. Guiana	1.6	13
Brazil	2.0	14	Taiwan	1.6	14
Madagascar	2.0	15	Honduras	1.5	15

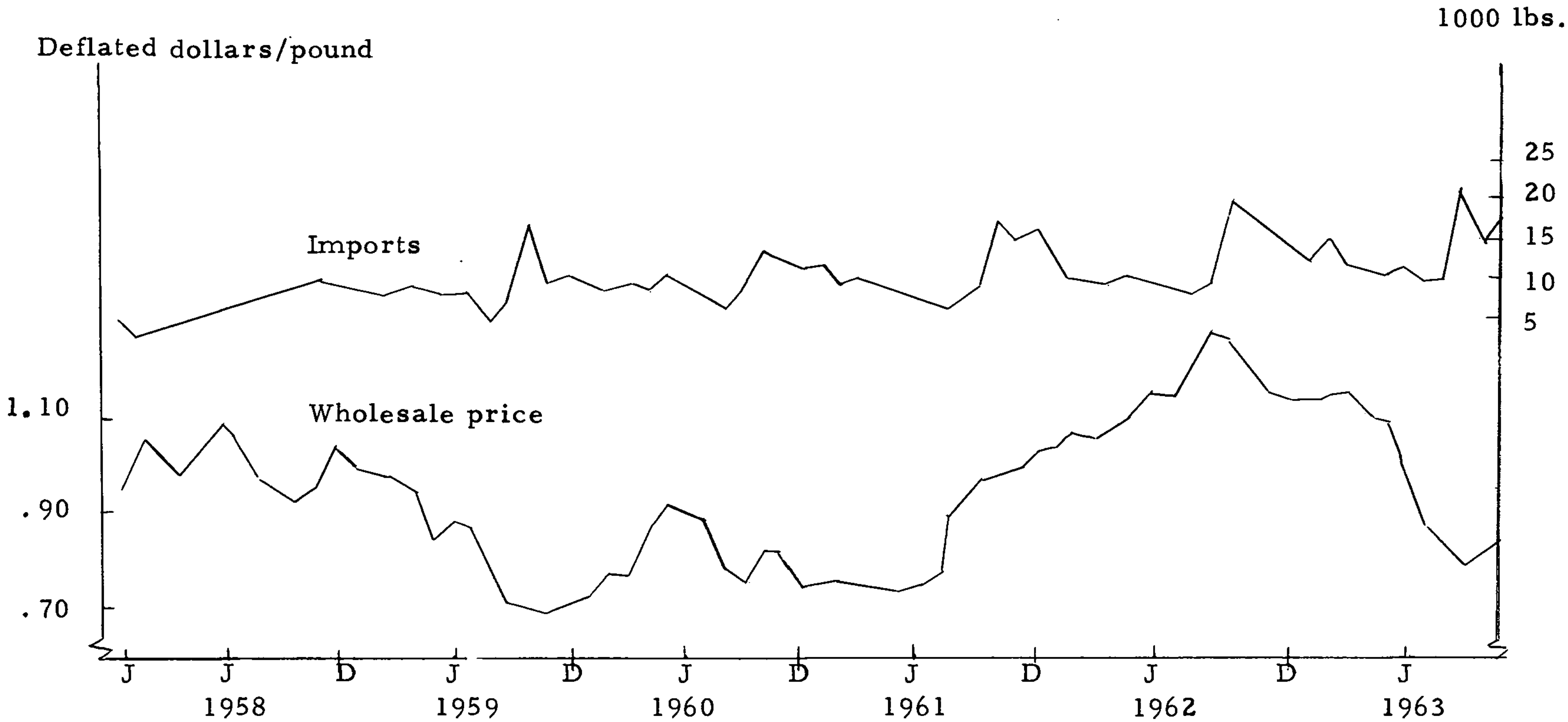

Figure 20A. Monthly imports and real wholesale prices, 1958-1968.

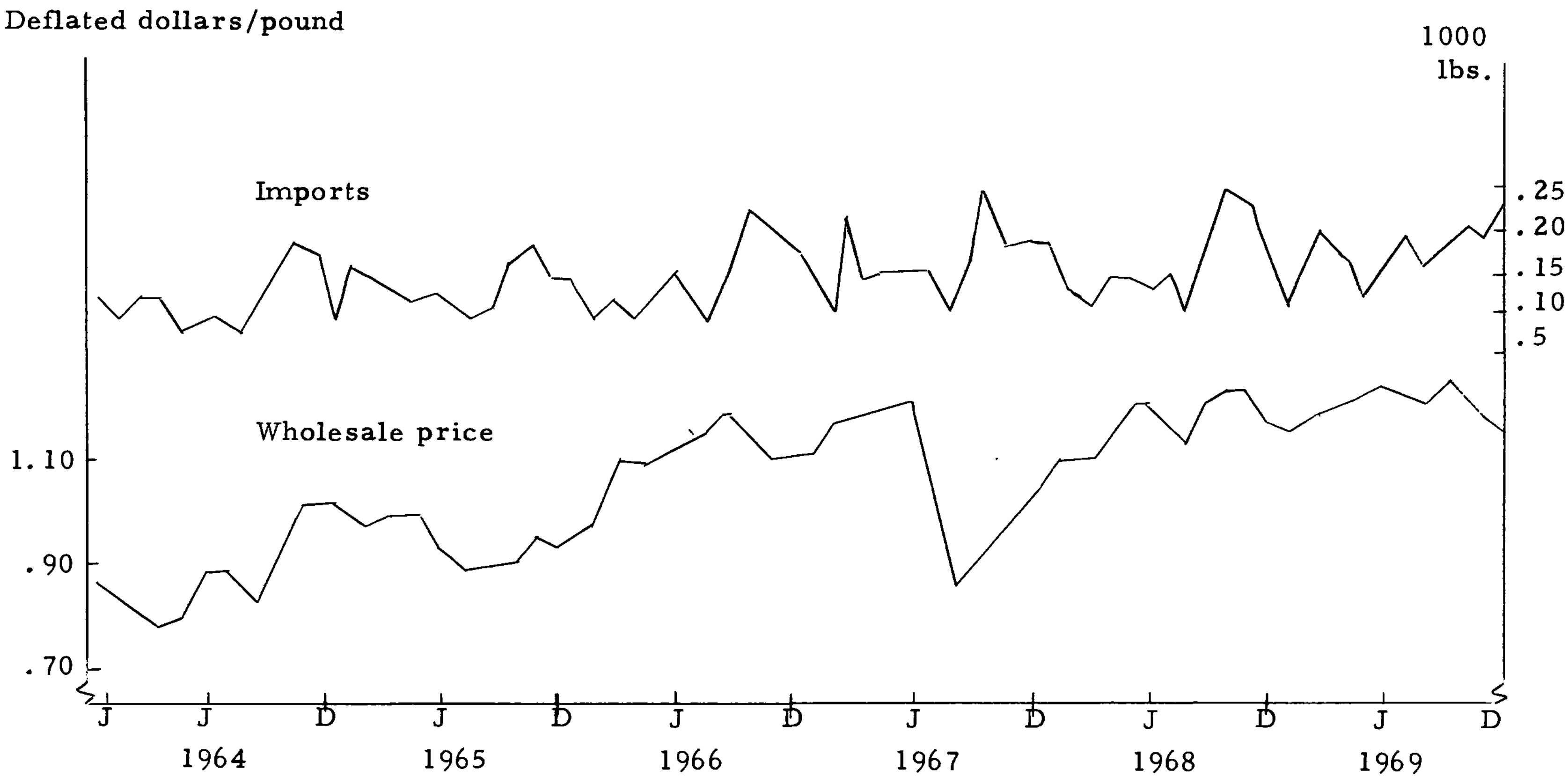

Figure 20B. Monthly imports and real wholesale price, 1964-1969.

International Supply and U.S. Direct Investment Abroad

An obvious approach to account for an upward sloping international supply schedule is to employ a set of simultaneous equations and estimating techniques. This requires the identification of an international supply schedule of shrimp.

World shrimp landings did increase dramatically over the period of this study reaching approximately 1.7 billion pounds of live weight in 1968. This is a percentage increase of approximately 4.1 percent per year. In 1968, Japan consumed 14.9 percent of all world shrimp landings; the U.S. consumed 32.2 percent. Together, these two countries accounted for approximately two-thirds of the world trade (Whitaker, n.d.-a). Japan's importation of shrimp accelerated in 1962 (Figure 21), and Japan therefore was competitive in bidding for world shrimp during the latter part of this study (1962-1969).

Direct investment by both Americans and the Japanese have had a large influence on the quantity of total world shrimp produced and exported. Japan, for example, has 70 trawlers, owned by seven different firms, fishing off the Guianas in South America; the United States has 244 boats in this same area (Table 18). "As of October, 1971, the Japanese had formed new joint ventures in ten foreign countries with a total investment of $2 million. This brings

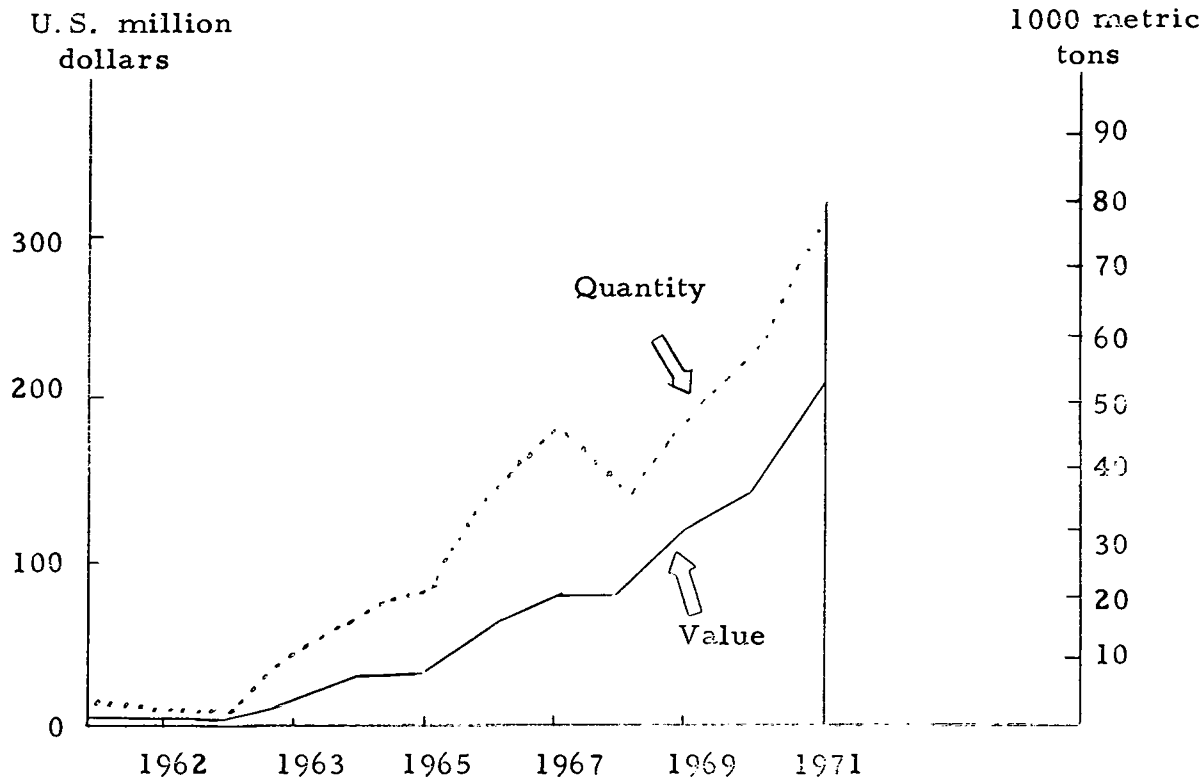

Figure 21. Value and quantity of frozen Japanese imports, 1960-1971.

Table 18. U. S. Shrimp Industry in the Guianas as of June, 1971.

Country	No. U.S. boats	1970 Shrimp production	Value of annual production	Value of U.S. investment (shore plants)	Value of U.S. investment (boats)
		(thousands of pounds, heads off)	(millions of dols.) U.S.	(millions of dols.) U.S.	(millions of dols.) U.S. (estimated)
Guyana	112	7,825	9.75	.75	9.0
Surinam	14	4,000	5.00	5.00	1.1
Fr. Guiana	42	3,671	4.75	2.00	3.4
Trinidad	76	4,800	5.50	5.00	6.0
Total	244	20,296	25.00	12.75	19.5

Source: (Gross, 1971)

the total number of Japan's fishing ventures in all countries to 72 projects totalling $19 million." (Whitaker, 1971, p. 18)

Interestingly, data on Japanese foreign investments are easier to obtain than are data on American investments. Folsom (n. d.), for example, tabulates information on joint ventures and Japanese financed fishing fleets.59/ However, the information that is available on U.S. direct investments abroad indicates that such investments are substantial.60/ Table 18 indicates that U.S. shrimp investments in the Guianas alone total $12.75 million as of June, 1971. U.S. companies funding these investments include subsidiaries of Borden's, Bumble Bee Seafoods (Astoria, Oregon), Thompson Enterprises (Tampa, Florida), International Foods, and Georgetown Seafoods. Other South American countries also have large U.S. investments. Gross (1973), in an updating of a 1967 report by Richard Croker, identified El Salvador (freezing plant partially owned by Consolidated Foods of New York), Nicaragua (freezing plant in San Juan del Sur operated by Booth Fisheries, includes a fleet of 14 steel trawlers), Costa Rica (vessels and freezing plants owned by the Henderson Portion Pak, an affiliate of

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59/ See also "International Shrimp Market by Folsom (1972).

60/ The U.S. Dept. of Commerce, which collects information on U.S. direct investments abroad, is unable to release that information dealing solely with investments related to shrimp due to the confidentiality of individual records.

Borden Foods), Panama (freezing plant in David owned by Henderson Portion Pak), Peru (small U. S. owned freezing plant), Honduras (extensive fishery began in 1958 when U. S. operators brought in trawlers and freezing plant), Venezuela (two freezing plants in Punto Fijò), and Brazil (freezing plant in Belem, controlling interest held by Rowan Industries of New Jersey). There are also U. S. investments in India (Union Carbide, two trawlers and a plant), Thailand (one U. S. freezing and packing plant called Star East Company), as well as Australia (20% of shrimp industry controlled by foreign investments: U. S. investment is second to Japan's).

Although a total figure on the actual dollar value of direct U. S. investments in shrimp production is not available, investments are obviously sizeable and growing. These investments were also appreciable in the decade of the 60's, and should therefore be included in an import supply schedule as an independent variable.

Unfortunately, data availability limitations are immense. Although data are now available on Japanese imports and total valuations by month, complete data series on direct investments abroad and other production capacity variables are unavailable. World catch figures are obtainable from the F. A. O. of the United Nations; however, these have a large error term associated with them. The identification of the import demand and supply functions await the availability of better data series.

However, some information can be gained through the examination of the import demand equations of Table 16. These do indicate that income has been quite significant in influencing the volume of imports per capita. This, in part, reflects simply a trend--imports have been increasing through time, and income has increased as well. (The simple correlation between I' and Y' is .66.) However, as the domestic demand model demonstrated, real income increases are an important factor in the increasing demand for shrimp. This variable overshadows the effect of both aggregate landings and changes in cold storage holdings. The insignificance of the aggregate landings variable, Q_s, would appear to indicate that demand considerations influence imports to a far greater extent than domestic supply. This is the expected long run relationship between Q_s and I', given the extreme inelasticity of domestic supply, Q_s. Japan's demand schedule for shrimp is apparently very similar to the United States'. Shrimp demand in Japan has been increasing rapidly: during 1966 to 1970, annual consumption growth increased about nine percent.(Japan, 1971, p. 57). The Frozen Shrimp Subcommittee on the Japanese Industrial Structure Deliberation Council predicts that Japan will have to import approximately 265 million pounds of frozen shrimp in 1980 to satisfy domestic demand, even after a doubling of price from the 1968 levels. These facts indicate that the Japanese demand schedule is income elastic.

Table 19 hypothesizes three world demand and supply schedules. The demand schedules were derived by estimating coefficients of real disposable income and real wholesale price that would be equivalent to an income elasticity of +1.20 and a price elasticity of -.30 at a wholesale price value of $1.20, the relevant hypothesized income values displayed in Problem A of Table 19, and the actual total consumption values of the United States, Japan, and the remaining world. Supply curves are assumed to be either (1) fixed, (2) elastic (1.50) at the 1968 total world consumption levels of 1,700 million pounds (W=$1.20), or (3) inelastic (.50) at 1,700 million pounds of world consumption (W=$1.20).

This simplistic model can be utilized to investigate future price pressures as real per capita income increases, assuming the demand equations remain unchanged. The approximate initial conditions of 1968 are displayed in Problem A, Table 19. A doubling of real income occasions a doubling of total consumption with a modest price rise of 80 cents a pound. This total quantity demanded of 3,400 million pounds is also the equilibrium consumption for shrimp if the world supply schedule were "elastic" as hypothesized. In contrast, an "inelastic" world supply schedule would put further pressure on price: wholesale price would increase

Table 19. Hypothesized Trade Model.

Supply	Hypothesized per capita income			World equilibrium price	U. S. demand $Q=55.0-137.5W + .264Y'$	Japanese demand $Q=26.3-63.33W + 202Y'$	World demand $Q=89.60-224.25W + 2.153Y'$	Total*
	Y'_{US}	Y'_{Jap}	Y'_{World}					
		Dollars		Dollars	Million pounds	Million pounds	Million pounds	Million pounds
Problem A: 1968 initial conditions								
1. Fixed = 1, 700	2, 500	1, 500	500	W=1.20	$Q_D = 550$	$Q_D = 253.3$	$Q_D = 897.0$	$Q_D=Q_s = 1,700$
2. Elastic world supply $Q_s = -850.14 + 2125.37W$	2, 500	1, 500	500	W=1.20	$Q_D = 550$	$Q_D = 253.3$	$Q_D = 897.0$	$Q_D=Q_s = 1,700$
3. Inelastic world supply $Q_s = 849.85 + 708.46W$	2, 500	1, 500	500	W=1.20	$Q_D = 550$	$Q_D = 253.3$	$Q_D = 897.0$	$Q_D=Q_s = 1,700$
Problem B: Doubling of world per capita income								
1. Fixed = 3, 400	5, 000	3, 000	1, 000	W=2.00	$Q_D = 1,100$	$Q_D = 505.7$	$Q_D = 1794.1$	$Q_D=Q_s = 3,400$
2. Elastic world supply $Q_s = 850.14 + 2125.37W$	5, 000	3, 000	1, 000	W=2.00	$Q_D = 1,100$	$Q_D = 505.7$	$Q_D = 1794.1$	$Q_D=Q_s = 3,400$
3. Inelastic world supply $Q_s = 849.85 + 708.46W$	5, 000	3, 000	1, 000	W=3.00	$Q_D = 9,625$	$Q_D = 442.4$	$Q_D = 1569.85$	$Q_D=Q_s = 2,975$

Continued

Table 19. Continued.

Supply	Hypothesized per capita income			World equilibrium price	U.S. demand $Q=55.0-137.5W + .264Y'$	Japanese demand $Q=26.3-63.33W + 202Y'$	World demand $Q=89.60-224.25W + 2.153Y'$	Total *
	Y'_{US}	Y'_{Jap}	Y'_{World}					
	Dollars			Dollars	Million pounds	Million pounds	Million pounds	Million pounds
Problem C: Japan and the world's per capita income increases proportionally more than the U.S.'s								
1. Fixed = 3,400	5,000	5,000	1,500	W=5.48	$Q_D = 621.5$	$Q_D = 689.42$	$Q_D = 2090.2$	$Q_D = Q_s = 3,400$
2. Elastic world supply $Q_s = -850.14 + 2125.37W$	5,000	5,000	1,500	W=2.58	$Q_D = 1020.25$	$Q_D = 872.99$	$Q_D = 2740.53$	$Q_D = Q_s = 4,633$
3. Inelastic world supply $Q_s = 849.85 + 708.46W$	5,000	5,000	1,500	W=4.306	$Q_D = 782.92$	$Q_D = 763.73$	$Q_D = 2352.58$	$Q_D = Q_s = 3,900$

* Rounded.

to $3.00 a pound and total world consumption would be at 2,975 million pounds.

If world real per capita incomes increased still further as in Problem C, a fixed supply of 3,400 million pounds would result in a wholesale price of $5.48; an "elastic" world supply would result in a price of $2.58, and an "inelastic" world supply would result in an equilibrium price of $4.306.

However, a 3,400 million pound harvest is approaching, if not surpassing the maximum sustainable yield for shrimp. Bell, et al. (1971) estimated maximum sustainable yield to be approximately 3,260 million pounds. Cleary (1970b) estimated maximum potential harvest to be 1,900 million pounds. If supply were fixed at 1,900 million pounds and the hypothesized demand schedules were applicable, wholesale price would be $5.53 rather than the $2.00 calculated in Problem B-1, Table 19, and $9.01 rather than the $5.48 calculated in Problem C-1.

If the variables included in this model are the significant variables in the world shrimp market, and if total world demand is price inelastic and income elastic despite large increases in price, the rate of equilibrium price increase in the future will be a function of the rate of per capita income increases and the nature of the world supply schedule. An "inelastic" world supply schedule will result in higher prices than an "elastic" world supply schedule, *ceteris paribus*.

Shrimp catch has not increased at the same pace as has many other fisheries. Shrimp catch has doubled over the last two decades, but catches of freshwater fish have nearly tripled since 1950. The total world 1970 catch of flounders, halibut, and sole were two and a half times than in 1950, the total catch of cod, hake, and haddock also increased two and a half times over the same period. This suggests that world shrimp supply may be more inelastic than other fish supplies, but more conclusive evidence awaits the specification and estimation of a world shrimp supply schedule.

V. CONCLUSIONS AND POLICY IMPLICATIONS

Chapter I of this study examined many of the institutional constraints that have been hypothesized as the basis for constant U.S. fish production and increasing imports over the last two decades:

1. High initial cost of vessels
2. High cost of insurance
3. Competition for resources of the environment
4. Selective demand for a number of species and the physical non-responsiveness of the resource to expansion
5. Structure of the industry
6. Government owned and government subsidized foreign competitors
7. Non-regulation of common property resources

The Gulf and South Atlantic shrimp industry was selected for a case study because shrimp is the major U.S. fishery import with respect to value and because of data availability. The shrimp industry deviates from the general pattern mentioned above in that domestic landings did increase over the period of study although imports increased at an even greater rate. In 1969, imports accounted for 52.9% of the total shrimp supply. The number of vessels and boats and the number of fishermen were increasing at the same time. Shrimp vessels have been constructed in the U.S. at prices competitive to those of foreign suppliers. Large foreign fleets do not fish off the Gulf and South Atlantic, rather U.S. financed shrimp vessels fish South American waters.

Why did imports increase rather than U.S. shrimp production expand? The answer appeared to be mainly that of number four: There was a large demand for shrimp, domestic shrimp resources were reaching their maximum sustainable yield, increased prices encouraged foreign imports and U.S. direct investments abroad. Chapter II established that this hypothesis was precisely the same as those advanced by other authors with reference to the changing composition of U.S. imports. Kravis (1956a) worded this hypothesis quite succinctly when he stated that it was the elasticity of supply abroad and inelasticity at home that give rise to the importation of certain natural resources, and not the relative capital and labor requirements of foreign versus domestic goods.

Chapter III estimated a domestic supply equation that corresponded well with Kravis' hypothesis: domestic supply was price inelastic. Also, demand was (wholesale) price inelastic, but income elastic. Thus a 10% increase in wholesale price would reduce the quantity demanded by less than 10% (at the price elasticity of -.30, quantity demanded would decline by 3%), cet. par. In contrast, a real per capita income increase of 10% would elicit a 12.2% increase in quantity at an income elasticity value of +1.22, cet. par.

The model developed indicated that demand pressures on the shrimp market are large because of the income effect. Apparently, the demand schedule has been shifting outward through time due to increases in per capita real income, and these shifts have been greater than those of supply. Figure 22 illustrates this. The demand curves are those derived from Regression 2, Table 10, with average values of income and haddock price for the years 1958 and 1969. $Q_{s_{58}}$ and $Q_{s_{69}}$ are hypothesized supply schedules for the same years, drawn to reflect price inelasticity. A hypothesized import schedule is then added to these curves to obtain $(Q_s + I)_{58}$ and $(Q_s + I)_{69}$. The import schedule $(Q_s + I)_{69}$ has shifted to the right to reflect increased production capabilities. Unless the true $(Q_s + I)$ is extremely elastic or inelastic, the demand schedule has been shifting outward more rapidly than has the total supply curve. All evidence indicates that this is a continuing phenomena. Notice in Table 20 that in 1972 a record total supply was available, but price increased--as did per capita consumption. The demand schedule was shifting outward, either on a stationary total supply curve, or was shifting to a greater extent than a shifting total supply curve.

Although the model developed in Chapter IV failed to adequately estimate import demand, the hypothesized schedules presented in Table 19 indicated that increasing world demand will definitely influence U. S. wholesale price and available U. S. supplies.

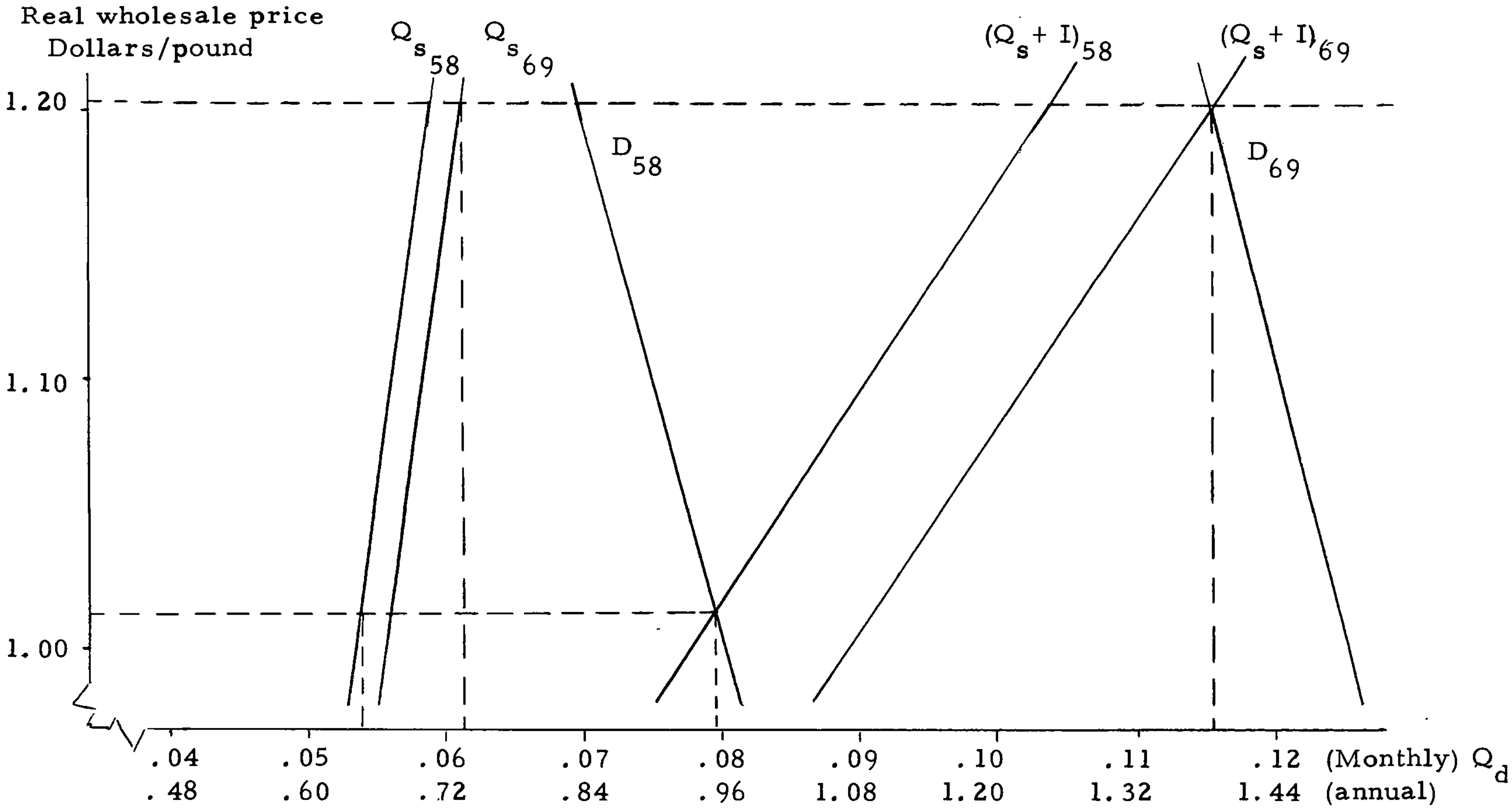

Figure 22. Hypothesized U.S. supply and demand schedules for shrimp.

Table 20. Supply of All Shrimp [a/], 1969-1972.

Year	Landings	Imports	Total supply	Per capita consumption	Ex-vessel price
	Heads off, thousand pounds				1967=100
1969	195,002	218,697	413,699	1.31	121.2
1970	224,272	245,658	469,930	1.44 b/	116.4
1971	236,328 b/	213,857	450,185	1.39	138.8
1972	234,432	253,065 b/	487,497 b/	1.42	153.2

a/ Including Pacific shrimp.
b/ Record
Source: U.S.D.C. 1973.

U.S. demand, as specified, is very inelastic even at the higher prices and quantities (at real wholesale price of 1.22 and monthly per capita consumption of .07, the elasticity estimate is only -.55). Hence, if real per capita income continues to increase, the future expectation is for rising prices.

Appendix A outlines the similarities between shrimp, tuna, and groundfish. Although tuna is much like shrimp in that near shore resources are limited relative to consumer demand, groundfish imports do not have a direct relationship to resource unavailability. Rather, groundfish imports have been motivated by lower Canadian costs of production that have their basis in lower labor costs and subsidized capital.

The policy implications that follow are directed at those fisheries where domestic supply is price inelastic given present harvesting techniques, and therefore may not be applicable to the groundfish industry of New England.

Policy Implications

The preceding chapters have provided an analysis of the economics of the shrimp industry; this analysis can now be used to illuminate some possible implications of various policies with regard to the nation's fisheries.

Policies, of course, can be examined from the perspective of various interest groups. The consequences of actions taken may differ with respect to world, national, producer or consumer welfare, and any analysis of policies should identify which viewpoint is being assumed.

For example, if the catch in the Gulf and South Atlantic were increased through discovery of a new fishing ground or exploitation of a new substitute species, the price inelasticity of demand suggests that for moderate increases in quantity (and moderate price declines), total revenue would fall relative to the former total revenue at the original lower quantity and higher price. [61/] As

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61/ This is true if neither world supply nor world demand schedules are perfectly elastic or inelastic. If world supply were perfectly elastic, foreign and domestic shrimp were perfect substitutes and the world demand schedule did not shift, then domestic

Table 21 demonstrates, in the short run shrimp consumers would benefit because of reduced expenditures for shrimp. Shrimp fishermen would share reduced total revenues and only a lowering of the average costs associated with catching this increased quantity would improve the profits of fishermen over the former situation. In the long run, some fishing firms might exit from the fishery and thus, total profit per boat might improve. National income would increase in the short run because some of the revenue decline would be experienced in the import market, whereas all of the benefits would accrue to consumers within the nation. The 'remaining world' income would decline by the amount of total imports (which are now reduced by the quantity of increased domestic harvest) multiplied by the reduction in price. If real income increased (i.e., if the <u>ceteris paribus</u> assumption were relaxed) then wholesale price, quantity imported, and total revenue decline would be less than otherwise.

The same analysis would apply if aquaculture of shrimp resulted in a competitive product substitute to landed domestic

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increases in harvest would replace imports, but world and domestic wholesale price would remain unchanged. (See Chapter IV)

Table 21. Short Run Policy Implications.

Ceteris Paribus changes	Increased harvest of shrimp from domestic waters	Aquaculture production of domestic shrimp	Environmental degradation reduces domestic catch	Quotas and tariffs reduce imports	Marginal costs of domestic harvesting reduced
U. S. wholesale price	Decline	Decline	Increase	Increase	No change
U. S. total shrimp consumption	Increase	Increase	Decline	Decline	No change
U. S. shrimp fishermen's total revenues	Decline	Decline	Increase	Increase	(Net income would) Increase
U. S. shrimp consumers	Benefit	Benefit	Not benefit	Not benefit	Not benefit
U. S. shrimp fishermen	Not benefit	Not benefit	Uncertain	Benefit	Benefit
National income	Increase	Increase	Decrease	Decrease	Uncertain
Quantity imported	Decline	Decline	Increase	Decline	No change
Changes in remaining world income	Decline	Decline	Increase	Decline	No change

shrimp[62/] Fishermen, given the inelasticity of demand, would not benefit from this new supply. Consumers would benefit from a lowered wholesale price. Imports would decline as aquacultured-shrimp replaced some of the import market, cet. par. 'Remaining world' income would decline because of reduced imports and reduced price, and national income would increase for the same reasons as before. If shrimp were cultured using warm water outfall from energy plants, there might be additional national benefits. Warm water disposal is a problem of considerable concern and cost to the producers and users of nuclear power, and productive utilization of these waters would be of benefit to these groups.

To the extent that environmental degradation reduces the quantity of shrimp available in southeastern coastal waters and no offsetting changes in other variables occur, price will increase. If the demand curve as estimated remains applicable and wholesale price does not increase so high as to be in an elastic area of the curve, reduced supplies will increase the total revenue available

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62/ Shrimp aquaculture may become a new industry in the near future. Sea grant researchers at Texas A&M University foresee future yields of up to a ton of shrimp per acre in 120 day cycles, expecting three to five crops annually. (Texas, 1973, p. 9-11).

to fishermen as a group. However, search costs would be likely to increase, and therefore the total short run profit for fishermen is uncertain. In this case, national income will decrease because expenditures will have increased although fewer pounds of shrimp will have been purchased, _cet. par._ In addition, some of this increased expenditure would be for additional imports would result in increased wholesale price and a short run increased profitability per fisherman, if such barriers reduced imports at a given price, _cet. par._ With freedom of entry into the fishery, overcapitalization relative to the resource in the long run would reduce individual profits. Subsidies to the fishermen would have the same long run effect on profits, unless entry into the fishery would in some way be limited. Although the U.S. balance of payments have improved, national income would be decreased, because real goods and services available for consumption in the United States have declined. Remaining world income would decline as well because of the resulting reduction in world harvest, _cet. par._

Also, in the shrimp industry, those investments which would result in increased efficiency through lowering costs may, in the short run, increase the profitability of shrimping. However, the lower cost structure will not have an appreciable effect on the quantity of shrimp landed from the Gulf and South Atlantic domestic waters, because of the inelasticity of the supply function, cet. par. In the long run, the additional profit should attract new boats into the fishery, and, unless catch increased proportionally, the extra profit would be dissipated among the new boats.

There will be an increase in national income only if the costs of the research are less than the discounted present value increase in total revenues. 'Remaining world' income should be unchanged.

It is obvious from the above discussion that the policy implications relative to individual fisheries depend on both the price elasticity of supply and the price elasticity of demand assuming per capita disposable income remains constant. In contrast to shrimp, price elasticity of demand for tuna is close to unity. Thus, changes in quantity supplied will be accompanied by offsetting changes in consumer prices and total revenues will remain constant. Rising costs of production will place producers in a cost-price squeeze, unless rising standards of living keep the demand schedule shifting outward enough to compensate for unitary elasticity.

Taking a broader perspective, there seems to be great potential in attempting to alter American tastes and preferences so that presently under-utilized species can be harvested. This might benefit consumers if substitutions were made between high-priced heavily-exploited fish products and the new species. New employment would be provided, and if new species replaced some imports, the balance of payments would improve. Fishermen harvesting the presently exploited species might experience a revenue decline from what it otherwise might have been, and remaining world income would probably decline. It is, however, difficult to generalize about the welfare implications of such a policy because little is known about individual utility tradeoffs when changing consumers' tastes and preferences. Whether or not consumers are truly better off substituting presently under-utilized species for the now favored shrimp is an unanswered question.

Finally, the policies considered in the above discussion and Table 20 have abstracted from real income considerations. Shrimp demand has been shown to be income elastic, and as real per capita incomes increase, domestic demand schedules will shift outward and wholesale prices will increase. For example, if real per capita income increased at 3% per year, total domestic per capita demand would rise 4.08% per year, assuming constant prices and an income elasticity of +1.36. If quantity demanded were to remain at the 1969 average monthly per capita level of .114, while real income increased at 3% per annum, then real wholesale prices would have to increase at 8.69% per annum, cet. par., at a price elasticity of -.46. If real income increased, the effect on the policies enumerated in Table 21 would be to increase price and domestic consumption from the price and quantity that would have otherwise prevailed had income remained constant. The other implications would be adjusted accordingly.

Imports

In the final analysis, are increasing imports a cause for concern? The answer to this question is contingent on the identification of objectives.

Much of the original trade literature was essentially a welfare analysis intended to demonstrate that the gains from free trade are positive in the sense that the world's production and consumption possibilities are maximized. Free trade, under the assumptions discussed in Chapter II, provides the world with the opportunity of consuming more of some goods while consuming no less of others. It is conceivable, however, that a single country's welfare could be reduced by trading, depending on the terms of trade. On an individual basis, those "owners" of the relative scarce factors of production and those consumers whose tastes and preferences favor exported products suffer negative income redistributions from trade.

Generally, increasing fishery imports have resulted in lower costs to processors and lower prices to consumers of these fishery products than would have existed otherwise. If foreign production is subsidized, domestic consumers are gaining the additional benefits from this subsidization. Fishermen, on the other hand, do not reap the benefits from increased competition, particularly if their fisheries are characterized by price inelastic supply relationships and their markets by price inelasticity of demand. If the domestic fisheries can respond by lowering the costs of production, they may be able to alleviate some of the problems associated with declining revenues. This is what has happened to rejuvenate the tuna industry in the last two decades.

If processors rely increasingly on foreign frozen supplies, the end result may be a decay of coastal communities as domestic processors and distributors relocate nearer the source of demand: the U.S. population centers. There are, of course, costs and benefits associated with such a relocation. New employment would be available, but at the same time unemployment may develop in the coastal communities.

The initial flow of dollars from the United States may result in healthier foreign economies, reduced foreign aid, and increased mutual trading.

It is apparent that the welfare implications of increased trade in fishery products are neither totally positive nor negative. A thorough analysis would require tracing at least the initial effects of fishery trade through the economies of the countries involved, determining which perspective (e.g., individual, regional, national, or world) is appropriate, and what the time span of consideration would be. Finally, these costs and benefits must be compared in some meaningful manner.

Unambiguous answers to the question, "Are increasing fishery imports a cause for concern?", must specify both the frame of reference and the tradeoff function utilized to compare these costs and benefits accruing to different individuals. Although such an analysis was not attempted in this study, it is hoped that the findings presented in this and previous chapters clarify the implications of various policies that may be enacted in response to increasing imports of fishery products.

BIBLIOGRAPHY

Anderson, W. W. 1966. The shrimp and the shrimp fishery of the southern U. S. U. S. Fish and Wildlife Service Fishery Leaflet #589. 8 p.

Arnold, Victor. 1970 (Jan.). An analysis to determine optimum fishing effort by area. Bureau of Commercial Fisheries: Div. of Econ. Res. Working Paper #40. 197 p.

Aubrey, H. G. 1955. The long term future of the U. S. imports and its implications for primary producing countries. American Economic Review. 45(1):270-287.

Balassa, Bela. 1963. An empirical demonstration of classical comparative cost theory. Review of Economics and Statistics. 45(3):231-238.

Bell, Frederick. 1966. The economics of New England fishing industry: the role of technological change and government aid. Federal Reserve Bank of Boston Research Report #31. 215 p.

________________ 1969 (June). Economic projections of the world demand and supply of tuna, 1970-90. Bureau of Comercial Fisheries: Div. of Econ. Res. Working Paper #18. 55 p.

Bell, Frederick W., D. A. Nash, E. W. Carlson, F. V. Waugh, R. K. Kinoshita and R. F. Fullenbaum. 1971. The future of the world's fishery resources to the year 2000. In: Preprints: 7th annual conference Marine Technology Society (Washington, D. C., August 16-18, 1971). Washington, D. C., Marine Technology Society. p. 541-544.

Bromley, Daniel Wood. 1969. Economic efficiency in common property natural resource use: a case study of the ocean fishery. Ph. D. thesis. Oregon State University. 162 n. p.

Brown, A. J. 1957. Professor Leontief and the pattern of world trade. Yorkshire Bulletin of Economic and Social Research 9:71.

Buchanan, N. S. 1955. Lines of the Leontief paradox. Economia Internazionale. 8:791-797.

Caves, Richard. 1960. Trade and economic structure. Harvard U Press, Cambridge, Mass. 317 p.

Chapman, W. M. 1965. Politics and the marine fisheries. In: The fisheries of North America. The first North American Fisheries Conference of Canada, U.S., Mexico at Washington, D.C. April 30-May 5th. U.S. Government Printing Office. 72 p.

_______________ 1968. Analysis of the social and political factors in the development of fish production by U.S. flag vessels. DeWitt Gilbert [ed.] The future of the fishing industry of the United States. U. of Wash. publications in Fisheries. Seattle, Wash. New Series 4:262-269.

_______________ 1969. How America "exports" a fishing industry. World Fishing 18(2):37-38.

Christy, Francis, Jr. and Anthony Scott. 1965. The commonwealth of ocean fisheries: some problems of growth and economic allocation. John Hopkins Press. Baltimore, Maryland. 281 p.

Ciriacy-Wantrup, S. V. 1968. Resource conservation: Economics and policies. U of Calif. Div. of Agr. Sciences. Berkeley, Calif. 395 p.

Cleary, Donald P. 1969 (June). Demand and price structure for shrimp. Bureau of Commercial Fisheries: Div. of Econ. Res. Working Paper # 15. 48 p.

_______________ 1970a (Aug). The determinants of actual and subsidized competitive strengths and weaknesses of U.S. and Canadian groundfish fisheries. Bureau of Commercial Fisheries: Div. of Econ. Res. Working Paper #73. 36 p.

_______________ 1970. World demand may outstrip supply during next decade. Commercial Fisheries Review 32(3):19-22.

Clement, M. O., Richard L. Pfister and Kenneth J. Rothwell. 1967. Theoretical issues in international economics. Boston: Houghton Mifflin Co. 449 p.

Clemhout, S. 1963. Production function analysis applied to the Leontief scarce factor paradox of international trade. Manchester School of Economic and Social Studies 31(2):103-114.

Croker, Richard S. 1967 (Feb.) The shrimp industry of Central America, the Caribbean Seas and Northern South America. N. M. F. S. Foreign Fisheries Leaflet #74. 127 p.

Crutchfield, James A. and Giulio Pontecorvo. 1969. The Pacific salmon fisheries: a study of irrational conservation. Resources for the Future. John Hopkins Press, Baltimore, Maryland. 220 p.

Diab, M. A. 1956. The U.S. capital position and structure of its foreign trade. Amsterdam. 67 p.

DeFever, Arthur. 1968. Modern U.S. tuna vessel construction. In: DeWitt Gilbert [ed.] The future of the fishing industry of the United States. U. of Wash. Publications in Fisheries. Seattle, Wash. New Series 4:134-140.

Doll, John P. 1972. An econometric analysis of shrimp ex-vessel prices, 1950-68. American Jour. of Agr. Econ. 54(3):431-440.

________________ n. d. An econometric analysis of the U.S. shrimp market. Unpublished. 87 p.

Doll, John P. and Sean B. Chin. 1970. A use for principal components in price analysis. American Jour. of Agr. Econ. 52(4): 591-593.

Dykstra, Jake J. and Andreas A. Holmsen. 1968. Cost of fishing and foreign competition, New England. In: DeWitt Gilbert [ed.] The future of the fishing industry of the United States. U. of Wash. Publications. Seattle, Wash. New Series 4:105-107.

Ferguson, C. E. and M. Polasek. 1962. The elasticity of import demand for raw apparel wool in the U.S. Econometrica 30:670-685.

Finch, Roland. 1963. The tuna industry. In: Maurice E. Stansby [ed.] Industrial fishery technology. Reinhold Pub. Corp., London. p. 87-106.

Folsom, William B. 1972. International shrimp market. In: U.S. Dept of Commerce. N. M. F. S. Market Research and Services Division (Sept.) Shellfish situation and outlook. p. 29-44.

_______________ n. d. Japanese imports of frozen shrimp, 1960-1970. N. M. F. S. (unpublished).

Ford, J. L. 1963. General observations on a dynamic 'theory' of the basis of commodity trade. Economia Internazionale 16:21-31.

Fulton, George. 1968. Pacific trawl fisheries problems. In: DeWitt Gilbert [ed.] The future of the fishing industry of the United States. U. of Wash. Publications. Seattle, Wash. New Series 4:155-159.

Gilbert, DeWitt, [ed.]. 1968. The future of the fishing industry of the United States. U. of Wash. Publication in Fisheries. Seattle, Wash. New Series, Vol. 4 346 p.

Gillespie, William C., James C. Hite and John S. Lytle. 1969. An econometric analysis of the U.S. shrimp industry. South Carolina Agric. Expr. Station: Economics of marine resources #2. 78 p.

Gross, G. B. 1971. The U.S. shrimp industry in the Guianas. June 4, 1971. Dept. of State airgram from the American Embassy in Mexico. 17 p.

_______________ 1973 (Jan.). Shrimp industry of Central America, Caribbean Sea and Northern South America. N. M. F. S. Foreign Fisheries Leaflet #72-1. 48 p.

Gunter, G. 1950. Seasonal population changes and distributions as related to salinity of certain invertebrates of the Texas coast, including the commercial shrimp. Public Institute of Marine Science. U. of Texas 1(2):7-51.

Hamlisch, R. [ed.] 1962. The economic effects of fishery regulations. F.A.O. Fisheries Report #5 (Papers presented at expert meeting Ottawa, 1961) Rome, F.A.O. 561 p.

Hammonds, T. M. n. d. Unpublished research on the elimination of autocorrelated disturbances in regression analysis: a revised estimator. Oregon State University, Dept. of Agr. Econ., Corvallis, Ore. (submitted for publication)

Harberger, A. C. 1953. A structural approach to the problem of import demand. American Econ. Review (proc.) 43:148-160.

Heller, H. Robert. 1968. International trade theory and empirical evidence. Prentice Hall, New Jersey. 189 p.

Herdt, Robert W. 1970. A disaggregate approach to aggregate supply. American Journ. of Agr. Econ. 52(4):512-520.

Houck, James P. 1965. The relationship of direct price flexibilities to direct price elasticities. Jour. of Farm Econ. 47(3):789-792.

Idyll, C. P. 1963. The shrimp fishery. In: Maurice Stansby [Ed.] Industrial fishery technology. Reinhold Pub. Corp., New York. p. 160-182.

Isard, Walter. 1956. Location and space economy. M.I.T. Press, Cambridge, Mass. 350 p.

Japan: Frozen shrimp market forecast for decade. 1971. Commercial Fisheries Review 33(5) p. 57-58.

Johnston, J. 1960. Econometric methods. McGraw Hill, New York. 300 p.

Jones, R. W. Factor proportions and the Heckscher-Ohlin model. Review of Econ. Studies 24:1-5.

Kesteven, G. L. 1970. Strategies for fisheries development. Australian Fisheries 29(7):25-30.

Kravis, I. B. 1956a. 'Availability' and other influences on the commodity composition of trade. Jour. of Political Economy 64:143-155.

________________ 1956b. Wages and foreign trade. Review of Econ. and Statistics 38:14-30.

Kutkuhn, Joseph H. 1962. Gulf of Mexico commercial shrimp populations and trends and characteristics, 1956-59. U.S. Fish and Wildlife Service Fishery Bull. 212(62):303-354.

Leamer, Edward E. and Robert Stern. 1970. Quantitative international economics. Allyn and Bacon, Inc., Boston. 209 p.

Leontief, W. W. 1953. Domestic production and foreign trade: the American capital position re-examined. Philosophical Society 97:331-349.

Leontief, W. W. 1956. Factor proportions and the structure of American trade: further theoretical and empirical analysis. Review of Econ. and Statistics 38:386-407.

Longnecker, Oscar M., Jr. 1968. Place of shrimping industry in the U.S. fishery. In: DeWitt Gilbert (Ed.) The future of the fishing industry of the United States. U. of Washington Publication in Fisheries. Seattle, Wash. New Series 4: 111-117.

MacDougall, G.D.A. 1951. British and American exports: a study suggested by the theory of comparative costs. Econ. Jour., Part I. 61:697-724.

________________ 1952. British and American exports: a study suggested by the theory of comparative costs. Econ. Jour. Part II. 62:487-521.

Marine resources and legal political arrangements for their development. 1969. Vol. 3. Panel reports of the Commission on Marine Science, Engineering, and Resources. Washington, D.C. U.S. Government Printing Office.

Mikhailov, S. V. 1962. On the comparative efficiency of production of some products of the land and sea. Okeanologiia 2(3): 385-392. Translated by W. G. Van Campen, Bureau of Commercial Fisheries. Biological Laboratory. Honolulu, Hawaii. Oct. 1962.

Miller, Norton M. and Virgil J. Norton. 1967. The fishing labor force scarcity or surplus? In: Frederick W. Bell and Jared E. Hazelton [eds.] Recent developments and research in fisheries economics. Oceana Publications Inc., Dobbs Ferry, N.Y. p. 135-146.

Nash, Darrel A. 1970a (Apr.) A survey of fish purchases by socioeconomic characteristics: Annual report - February 1969-January 1970. Bureau of Commercial Fisheries: Div. of Econ. Res. Working Paper #50. 163 p.

________________ 1970b. Who buys fresh and frozen seafoods in the United States--a quantitative survey of fish buying patterns. Paper presented at the twenty-fifth annual National Fisheries Institute Convention, New Orleans, Louisiana. April 15, 1970. 27 p.

Nash, Darrel A. and Frederick W. Bell. 1969. An inventory of demand equations for fishery products. Bureau of Commercial Fisheries: Div. of Econ. Res. Working Paper #10. 31 p.

Navratil, Z. A., A. J. Provan, and J. J. Strong. 1968. Education of technical personnel and fishermen. In: DeWitt Gilbert [ed.] The future of the fishing industry of the United States. U. of Washington Publication in Fisheries. Seattle, Wash. New Series. 4:279-284.

Neisser, Hans. 1953. U.S. demand for imports. American Economics Association papers and proceedings 43(2):134.

Orcutt, G. H. 1950. Measurement of price elasticities in international trade. Review of Econ. and Statistics 32(2):117-132.

Panel Reports of the Commission on Marine Science, Engineering, and Resources. 1969. Marine resources and legal political arrangements for their development. U.S. Government Printing Office, Washington, D.C. Vol. 3.

Redfield, Michael L. 1971. Costs and profitability in the commercial fishing industry: the insurance dilemma. Division of Marine Resources, U. of Washington, Seattle, Wash. (WSG-MP-71-4). 59 p.

Report of the Secretary of the Interior to the President and the Congress on the effects of imports on the United States groundfish industry. 1969 (May). Washington, D. C. 84 p.

Robinson, R. 1956a. Factor proportions and comparative advantage. Quart. Jour. of Econ. Part I (May) 70:169-192.

________________ 1956b. Factor proportions and comparative advantage. Quar. Jour. of Econ. Part II (Aug.) 70:346-363.

Snider, Delbert A. 1971. Introduction to international economics. Richard D. Irwin, Inc., Homewood, Ill. 469 p.

Stern, R. N. 1962. British and American productivity and comparative costs in international trade. Oxford Economic Papers 14(3):275-296.

Stewart, A. J. B. 1969. Norwegians aim for a self sufficient industry. World Fishing 18(2):27-29.

Survey of the U.S. shrimp industry. 1958 (Nov). Vol. I. Bureau of Commercial Fisheries. U.S. Fish and Wildlife Report. 311 p.

Survey of the U.S. shrimp industry. 1959 (June) Vol. II. Bureau of Commercial Fisheries. U.S. Fish and Wildlife Report #308. 167 p.

Suttor, Richard E. and Parviz Aryan-Nejad. 1969. Demand for shellfish in the United States. U. of Maryland Agr. Expr. Station, Misc. Pub. #695. 28 p.

Texas A&M University. Sea grant college report 1971-72. 1973 (Mar-Apr). The university and the sea. Sea grant college report 1971-72. 6(2). 24 p.

Timmer, C. Peter. 1968. A projection model of the U.S. shrimp market. Stanford U: Food Research Institute studies in agricultural economics, trade and development. 8(3):243-256.

Tintner, Gerhard. 1965. Econometrics. John Wiley and Sons, Inc., New York. 369 p.

U.S. Dept. of Commerce. National Marine Fisheries Service: Market Research and Services Division. 1972a (Mar). Shellfish situation and outlook: annual review 1971. 59 p.

________________ National Marine Fisheries Service. Market Research and Services Division. 1972b (Sept.). Shellfish situation and outlook. 75 p.

________________ National Marine Fisheries Service. Current Fisheries Statistics #5900, 1972a (Mar.). Fisheries of the United States 1971. U.S. Government Printing Office. 101 p.

________________ National Marine Fisheries Service. Current Fisheries Statistics #6100, 1973 (Mar). Fisheries of the United States 1972. U.S. Government Printing Office. 101 p.

Valavanis-Vail, S. 1954. Leontief's scarce factor paradox. Jour. of Political Economy 47:525-526.

Vanek, J. 1959. The natural resource content of foreign trade, 1870-1955 and the relative abundance of natural resources in the U. S. Review of Econ. and Statistics 41(2):146-153.

Vanek, J. 1963. The natural resource content of the United States foreign trade, 1870-1955. M. I. T. Press, Cambridge, Mass. 142 p.

Viner, J. n. d. Studies in the theory of international trade. New York: Harper and Brothers. 650 p.

Watt, Kenneth E. F. 1968. Ecology and resource management: a quantitative approach. McGraw Hill, New York. 450 p.

Waugh, Frederick N. and Morton M. Miller. 1969. Fish cycles: a harmonic analysis. Bureau of Commercial Fisheries: Div. of Econ. Res. Working Paper #30. 26 p.

Whitaker, Donald. 1970. Trends in world shrimp demand and production. Remarks presented at the Conference on Canadian Shrimp Industry. St. John, New Brunswick. Oct. 28, 1970. 24 p.

________________ 1972. National supply of fishery products. Discussion paper given at the meeting of the Committee on Aquatic Food Resource, National Academy of Sciences, Boston. June 8, 1972. n. p.

________________ n. d. -a. The world shrimp situation. National Marine Fisheries Service, Div. of Current Economic Analysis (unpublished). 7 p.

________________ n. d. -b. Trends in the United States shrimp industry (unpublished). 64 p.

White, Donald. 1954. The New England fishing industry: a study in price and wage setting. Harvard U. Press, Cambridge, Mass. 33 p.

Wilimovsky, Norman J. 1968. World sea fisheries: the present and the future. Canadian Fisheries 55(7):18-23.

Working, E. J. 1927. What do statistical demand curves show? Quar. Jour. of Econ. 41:212-225.

APPENDICES

APPENDIX A

The Shrimp Model Relative to the Tuna and Groundfish Fisheries

The argument presented in Chapters II through VI is that physical resource unavailability at home is the basis for the large importation of shrimp products. If "wild" shrimp are considered an input in the shrimp production function, operating near maximum sustainable yield implies increasing marginal cost as more boats and fishermen expend effort on a constant or declining population of shrimp. The high marginal cost of shrimp production hinders domestic expansion of the industry, and encourages importation of shrimp and direct investment abroad in those countries which have a comparative advantage in shrimp production.[63/]

Is, however, this argument applicable to the other large volumed imports such as groundfish and tuna?

[63/] The phenomenon of direct investment can be examined in the theoretical construct of locational economics. The fishing industry given its present cost structure is a resource-oriented industry; it is less expensive to establish production bases near the source of raw material rather than locate them at the point of consumption. This is not a theory in competition with that of comparative advantage. Ohlin stated that one of his objectives was to "demonstrate that the theory of international trade is only part of a general localization theory . . . ." (Isard, 1956, p. 283). Isard demonstrated the "long run opportunity cost doctrine and transportation orientation dogma are in essence one and the same." (Isard, 1956, p. 282)

Tuna

Tuna is a pelagic fish, migrating across thousands of miles of ocean during its lifespan. There is very little tuna captured within U.S. territorial waters: in 1972, only 61, 204, 000 pounds of the total 524, 375, 000 "domestic" catch was within the 12 mile limit (U. S. D. C., 1972). The remaining tuna (albacore, bluefin, little skipjack, and yellowfin species) were caught in international waters.

The U.S. fishery on tuna began about 1903 as California packers turned to tuna as a substitute for the failing sardine. By 1927, the demand for tuna had increased to a point where the U.S. fleet was catching more tuna in waters off South America than off the U.S. Average trips by the U.S. fleet today are as much as two to three months in duration as the fleet utilizes very distant waters. (Finch, 1963, p. 87).

Generally, the tuna fleet is modern and competitive, although the majority of vessels were not originally built as purse seiners but were converted from hook and line boats (De Fever, 1968). There are limitations on improving the efficiency of tuna vessels, not the least of which is the cost of various innovations which increase catch. The failure of canners to pay a premium for high quality fish also discourages investment in new equipment, as does the hesitancy on the part of the boat-owner to experiment with new ideas. (De Fever, 1968).

There is no doubt that foreign imports of tuna compete with the domestic catch, as in the shrimp case. Furthermore, "biologists estimate that most of the exploited tuna species are at or beyond maximum sustainable yield, with the principal (sic) exception of the Central Pacific skipjack." (Bell, 1969, p. 2) If the U.S. fleet is to increase domestic catch of present species, it will be at the expense of such countries as Japan and the South American fleets. The prevalent trend, however, is for large territorial limits (e.g., 200 miles) rather than the conventionally recognized 12 mile limit. Also, there is a tuna quota that limits the "fishing seasons" for yellowfin tuna. Any additional supply of tuna, therefore, will probably be derived from the skipjack catch. However, the problem with the skipjack tuna is primarily one of low yields from a widely dispersed resource. Increases in catch will undoubtedly be accompanied by increases in search costs, if the present technology prevails.

Tuna differs from shrimp, in that estimates of tuna demand price elasticity indicate a value close to unity (Bell, 1969, p. 19). This implies that as price increases, quantity demanded will decline to such an extent that total revenues will remain constant, <u>cet. par</u>. This will lessen the profit incentive for further expansion of the total tuna catch. The income elasticity of 1.41 (Bell, 1969, p. 19) indicates that the demand schedule should be shifting outward through time as the standard of living increases; this should counteract much of the price effect. This income effect, however, should be similar in other countries, and therefore the U.S. will experience more competition for the world's tuna resources.

Tuna, as a resource, appears to follow the same pattern as shrimp. Near-shore resources are limited and selective consumer demand for tuna has made it profitable to fish distant waters. The incentive for direct investment is high and "the U.S. tuna canners as with the U.S. shrimp processors and marketers, have created a very extensive global producing and collecting system for tuna raw material." (Chapman, 1969, p. 37) Thus, much of the tuna imports, as well as shrimp imports, are in part a repatriation of American capital.

Future increasing world demand[64/] for tuna will place increasing pressure on the resource, the cost of harvesting, and the retail and ex-vessel price.

[64/] With unitary price elasticity and projected increases in income and population, Bell (1969) estimates the increase to be 2,100,000 metric tons in 1990 from 1,320,000 metric tons in 1966.

Groundfish [65/]

The situation relative to groundfish is not as clearly related to a resource constraint. In the New England groundfish industry, the fleet continues to decline at the same time the Canadian fleet is being expanded and modernized in order to meet the growing consumer demand (Cleary, 1970, p. 2).[66/] The industry has been the subject of many studies and the underlying reason for the U.S. groundfish industry decline revolves around labor and capital costs:

> "Importation of groundfish in the form of blocks and slabs has boosted total imports and is making inroads into the basic markets for groundfish caught by U.S. fishermen. There has been a reduction in per capita consumption of fillets and steaks through the substitution of sticks and portions for fillets and steaks. Moreover, the fishing segment of the industry has not grown with the stick and portion processing business. A principal (sic) reason appears to be the inability of the industry to compete in block and slab production with foreign competition. Costs of catching fish in competing countries are lower than in the United States. Two factors contributing to this situation are lower vessel construction costs and Government subsidies to fishermen in various forms in competing countries. The future of the domestic groundfish industry has caused considerable concern among industry personnel." (Report, 1969, p. 45)

[65/] Groundfish is a name applied to those species of fish which inhabit the demersal areas of the continental shelf. They include cod, cusk, haddock, hake, pollock, ocean perch, as well as others. Sometimes flounders are considered in this group as well.

[66/] Per capita consumption in 1972 was 2.28 pounds for fillets and steaks and 1.78 pounds for sticks and portions (U.S.D.C., 1973).

In a recent study, Cleary (1970) investigated the "Determinants of Actual and Subsidized Competitive Strengths and Weaknesses of U. S. and Canadian Groundfish Fisheries". He concludes that labor costs in the provinces are nearly half those in New England, due to the fact that there is little alternative employment in the provinces and little geographic mobility of labor. Because there is not access to the fresh market, the cost of raw material (fish) to the processor is less. Financial support in the form of subsidies, grants and low interest loans" has been broader and larger to the Canadian Atlantic groundfish industry than to the U.S. Atlantic groundfish industry." (p. 7) Cleary also found that Canadian landings per trip were anywhere from 40 to 144% greater than U.S. landings. Landings per man were 35 to 200% greater. Landings per day at sea were 156 to 385% greater.

Bell (1966) concludes, "New England's foreign competitors obtained their advantage from a system of subsidies which enticed capital into their fishing industries. The capital found a 'trapped' supply of labor available at low wage rates." (Bell, 1966, p. 12) The end result is that the total costs of production in Canada are about 60% below those in the United States. (Report, 1969, p. 52), and these are not offset by the low tariff rates. Tariff rates were .8¢ per pound on frozen blocks and slabs; they became duty free in 1972. Fillets have tariff rates of 1.875¢ per pound and a quota of

15 million pounds (or 15% of average apparent annual U.S. consumption during the three immediately preceding calendar years, whichever is greater), after which tariff rates rise to 2.5¢ per pound (U.S.D.C., 1973).

Increasing imports depress the ex-vessel price to U.S. fishermen at the same time that domestic production costs are increasing.

> "Resource abundance has not been a factor in the decline of Atlantic coast landings of groundfish during the 1956-67 period. The major decline has been in production of ocean perch. This reduction is due to a decrease in fishing effort as a result of the cost-price squeeze on the fishing vessels rather than a lack of resource." (Report, 1969, p. 37)

Groundfish imports have as their basis high domestic harvesting costs relative to foreign imports. These costs are related to labor and capital domestic supply rather than resource availability. Groundfish as a group do not fit the supply inelasticity model. There has been, however, a tendency for U.S. producers to establish production facilities in the provinces in response to the lower cost environment. White (1954), as early as 1954, wrote concerning the New England groundfish industry,

> "The largest dealers in New England have already acquired extensive processing facilities in Canada. Not only are New England interests investing increasingly in foreign operations, but also domestic producers are importing quantities of groundfish fillets for sale under their own label in domestic markets . . . . The largest independent dealer in Newfoundland, already packages nearly four-fifths

> of this output for New England dealers." (White, 1954, p. 133)

A more recent study (Cleary, 1970) states of the same fishery, ". . . it should be recognized that in some locations in the Atlantic provinces . . . U.S. owned or financed processing plants are the major buyers of groundfish." (p. 4)

Again there is the phenomenon of large scale U.S. direct investment in response to lowered costs: in this case labor and capital reduced costs rather than resource reduced costs.

APPENDIX B

Supply Single Equation Estimates

The original specification of the single equation supply response function included a principal component index variable for both landings and ex-vessel prices as well as water temperature. This approach was used to investigate the interdependence among the three main species of shrimp: brown, pink, and white plus the residual catch of "other" commercially valued shrimp. Two principal components were extracted from the correlation matrix:

$$Z_1 = .6370B_L' - .6243P_L' - .1290W_L' - .4330O_L' \quad 44.4\%$$

$$Z_2 = .2060B_L' - .3235P_L' + .7437W_L' + .5475O_L' \quad 35.1\%$$

The primes indicate standardized variables, so that the variances sum to four. The largest eigenvalue was 1.776; therefore, the first principal component "explains" approximately 44% (1.776/4 X 100%) of the total summed variation of the four variables. The second principal component accounted for approximately 35.1% of the summed variance.

Interpreting principal components' economic meaning is more of an art than a science; yet, it is apparent that, in this case, Z_1

is capturing the time element of landings. The correlation matrix (Table B-1) of the individual landings indicates that brown landings are negatively correlated with all three remaining variables. Z_2 is more difficult to interpret, although it appears to measure the effect on variation when pink landings and brown landings move in opposite directions. It may also suggest that brown landings variation results from some source not necessarily shared by others, but this is doubtful.

Principal components can also be used as indices to reduce data and thereby save degrees of freedom. A principal component analysis of the three ex-vessel prices verified that the three prices move closely together. One ex-vessel price would serve well as an index of the other:

$$Z_3 = .57658P_B' - .57534P_W' + .58012P_p' \quad \text{67/} \qquad 97.14\%$$

Lagged ex-vessel prices were also examined. The eigenvector below is for "expected prices." This was formed by computing a new (deflated) ex-vessel price that was equal to $1/6\ (3P_t + 2\ P_{t-1} + P_{t-12})$. The assumption was, following Herdt (1970), that

67/ This eigenvector is for prices of January, 1964, to May, 1967, a total of 41 observations. The other eigenvectors are for 144 observations: from January, 1958 to December, 1969, inclusive.

Table B-1. Correlations Matrices: Principal Components and Landings

Principal Component Matrix

	Z_1	Z_2
B_L	.989	.405
P_L	-.692	-.456
W_L	-.118	.909
O_L	-.300	.339

Landings Matrix

	B_L	P_L	W_L	O_L
B_L	1.00	-.641	-.009	-.215
P_L		1.00	-.164	.255
W_L			1.00	.455
O_L				1.00

fishermen respond to an expected price formed from past experience. The eigenvector was:

$$Z_4 = .5770P_{Be}' + .5783P_{Pe}' + .5768P_{We}' \qquad 96.05\%$$

These eigenvectors on landings and expected price were then used to construct a regression; the results are reported in Table B-2.

The regression (S-5) which utilized Z_1, the first principal component, is different from that (S-6) which utilized the second principal component Z_2. Because Z_1 is most highly correlated with brown landings and Z_2 with white landings, it is not surprising that the seasonal dummies are not identical. Brown shrimp support a fishery in the summer and early fall; white shrimp support a fall fishery, and the coefficients of $X_3 - X_5$ reflect this. Both regressions have significant coefficients on trips; although the regression S-6 has a higher t value. The reverse is true for the coefficient of number of fishermen; regression S-5 has the higher t value. Interestingly, yards of otter trawl have a significant negative coefficient in regression S-5. This implies that increases in yardage of otter trawl used have resulted in declining catches (mainly of browns). This is quite possible if the thesis of resource unavailability is correct. Temperature is not significant in the regression S-6 involving Z_2 whereas it is quite significant with regression S-5. Price elasticity measures (η) from the two regressions are also different.

Table B-2. Supply Functions with Principal Components.

		Trips	Tons	Seasonal dummies 1	2	3	No. of fishermen	Yds. of otter trawl	Temp. index	Expected price eigenvector
Regression S-5										
Z_1 =	-1197.1	$+ .05657X_1$	$+ .0014069X_2$	$- 1786.8X_3$	$+ 348.86X_4$	$- 2083.6X_5$	$+ 1.4694X_6$	$- .052767X_7$	$- 100.38X_8$	$- 1218.4Z_4$
	(-.280)	(2.92)**	(.222)	(-2.31)**	(.347)	(-3.87)**	(4.66)**	(-2.96)**	(-5.01)**	(-1.22)
							R^2 = .76			
							D-W = 1.09			
							η = -.82			
Regression S-6										
Z_2 =	- 6534.5	$+ .13229X_1$	$- .0034322X_2$	$= 605.90X_3$	$+ 2356.5X_4$	$- 3275.9X_5$	$+ .34158X_6$	$+ .016654X_7$	$+ 11.428X_8$	$- 2568.4Z_4$
	(-2.50)**	(11.21)**	(-.89)	(-1.28)	(3.84)**	(9.96)**	(1.77)	(1.53)	(.93)	(-4.22)**
							R^2 = .86			
							D-W = 1.21			
							η = -1.08			
Regression S-7										
Q_s =	1481.2	$+ .23748X_1$	$- .0046223X_2$	$- 2548.1X_3$	$+ 2031.3X_4$	$+ 3132.5X_5$	$+ 1.5445X_6$	$- .024873X_7$	$+ 83.045X_8$	$- 5594.1Z_4$
	(.32)	(11.38)**	(-.68)	(-3.05)**	(1.87)	(5.39)**	(4.54)**	(-1.29)	(-3.84)**	(-5.19)**
							R^2 = .89			
							D-W = 1.09			
							η = -.66			

For purposes of comparison, regression S-7 utilized Q_s, aggregate landings as the dependent variable. Aggregate landings are correlated most highly with brown shrimp (.80) and then with white shrimp (.58) and finally with pink shrimp (-.53). The coefficients and significance levels reflect the aggregation procedure. The price elasticity measure is greater than that of regressions S-5 and S-6.

Regression S-7 was not selected for the two-stage regression, because a measure of price elasticity was desired. The theoretical interpretation of a coefficient on a principal component variable as a price elasticity is possible, but because weighted prices served equally as well in this case (see Table 5, Regression S-1) that specification was selected as the more easily interpreted. This same explanation applies for the specification of the model as a function of weighted deflated monthly price, rather than weighted deflated expected monthly price. The statistical measures of fit indicated that either specification resulted in similar R^2s. The use of monthly prices for elasticity estimates was easier to interpret theoretically. The elasticity measure for regression S-1, Table 5, is -.60.

The principal component approach is very useful for analyzing the various sources of the total variation in a data set (as with aggregate landings); or, to calculate a reliable index (as with ex-vessel prices). Further research utilizing this approach would be quite informative.

Import Demand: Principal Component Analysis

An interesting utilization of the principal components derived from landings is to use each as an independent variable in another regression. This approach for imports resulted in the following regression:

$$I = \underset{(-6.09)^{**}}{-8976.9} - \underset{(-1.95)}{1104.1}X_3 - \underset{(-2.31)^{**}}{1947.1}X_4 + \underset{(4.92)^{**}}{3826.1}X_5 + \underset{(13.53)^{**}}{51939.}Y_t$$

$$+ \underset{(.55)}{35.7637}H_t + \underset{(1.12)}{1637.8}W_t - \underset{(-1.15)}{.089881}Z_{1_t} + \underset{(1.53)}{.16500}Z_{2_t}$$

$$R^2 = .81$$
$$D\text{-}W = 1.71$$

This equation is parallel to that of I-1 in Table 16. Interestingly, the two eigenvectors considered separately are each more significant than the aggregated landings variable, Q_s, in I-1. What this regression appears to be capturing is the time element of the landings. As the histogram in Figure 7B demonstrates, the largest catches of white shrimp are in October. This is also the month that imports typically are the largest. Principal component Z_2 is more highly correlated with white landings, hence the positive and significant (at the 85% level) coefficient on Z_2. In contrast, brown landings are peaking in the summer months (Figure 7A), hence the negative and significant (at the 75% level) coefficient on Z_1, the principal component most highly correlated with brown landings.

For the purposes of this study, this is not illuminating information except for indicating the type of knowledge that is lost through the aggregation procedure.

Supply: The Trips Variable

Number of trips completed per month was assumed to be exogenous for the model presented in Chapter III. In order to determine the sensitivity of the model to this assumption, a new variable was formed by regressing trips against all other exogenous variables in the model and then utilizing this new variable, X_1', in place of X_1 in regression S-1. The resulting regression is displayed at the top of the following page.

The difference between this regression and S-1 in Table 5 is not dramatic; those parameters which were significant in S-1 remain significant and relative magnitude has changed little. The coefficient on X_9, ex-vessel price, has increased to -6728.6, changing an estimate of price elasticity from -.60 to -.46. This magnitude of change is not great enough to cast suspicion upon any of the conclusions reached in Chapter III. The assumption of the independence of the trips variable was maintained.

$$Q_s = \underset{(1.02)}{8134.2} + \underset{(1.39)}{.11970X_1'} + \underset{(.0096)}{.00009522X_2} - \underset{(-2.64)^{**}}{3035.6X_3}$$

$$+ \underset{(.38)}{675.30X_4} + \underset{(3.76)^{**}}{4293.1X_5} + \underset{(3.36)^{**}}{1.5837X_6} - \underset{(-.85)}{.023105X_7}$$

$$- \underset{(-.85)}{154.36X_8} - \underset{(-3.18)^{**}}{6728.6X_9}$$

$R^2 = 79\%$
D-W = 1.18

Demand: Single Equation Estimates

Other specifications of the apparent consumption model in addition to that in Table 7 of Chapter III were examined. Table B-3 displays a specification of demand that is not on a per capita basis and includes an index variable for expenditures on restaurant meals, E. This new variable exhibits a high multicollinearity (.97) with deflated disposable income, Y, and was therefore dropped from the final model. When population was included as an independent variable in this model, it too evidenced a high multicollinearity (.97) with income. The per capita model was therefore selected.

A per capita apparent consumption model was formulated that did not include haddock. This changed the coefficients slightly; the R^2 became 55% and the deflated wholesale price elasticity estimate increased (absolute) to -.35 and per capita income elasticity increased to 1.32.

Two other specifications were also examined and discarded.

Table B-3. Apparent Consumption: Alternate Specification.

$$Q_d = \underset{(.80)}{2586.6} - \underset{(-.44)}{283.14X_3} + \underset{(4.12)^{**}}{2702.9X_4} + \underset{(4.37)^{**}}{2848.6X_5} - \underset{(-.34)}{36.365E} - \underset{(.315)}{28.370H} + \underset{(3.99)^{**}}{66971.Y} - \underset{(-3.39)^{**}}{6548.4W}$$

$R^2 = .66$
D-W = 1.94

price elasticity = -.32
income elasticity = 1.30

Correlation matrix

	Q_d	X_3	X_4	X_5	E	H	Y	W
Q_d	1.00	-.23	-.19	.25	.68	-.35	.71	.21
X_3		1.00	-.33	-.33	-.03	-.03	-.01	.09
X_4			1.00	-.33	.03	-.04	-.00	-.06
X_5				1.00	.08	.06	.07	-.02
E					1.00	.33	.97	.60
H						1.00	-.36	.05
Y							1.00	.57
W								1.00

One included wholesale price with a one month lag. Another included lagged (by one month) apparent consumption. No improvement resulted for either specification relative to the regression estimated in Chapter III.

Ex-vessel, Wholesale, and Retail Price Analysis

Doll and Chin (1970) conducted a principal component analysis of the variation of three annual shrimp prices: ex-vessel, wholesale and retail. They discovered that annual variations in these series are almost identical, and any one of the price series would serve as a good index of the other. Doll and Chin also concluded that a lag existed between annual retail and ex-vessel prices, but only in those years that prices suffered a severe downward break.

A study similar to that of Doll and Chin was conducted using monthly deflated data. The data series was not parallel with that used by Doll and Chin, with the exception of the wholesale price series. Retail price used is that of raw headless shrimp at Baltimore, Maryland, from 1964 through 1969, inclusive. This series was chosen because the other retail price series involve product changes from raw forms to breaded forms in the time period of interest. Ex-vessel price is an index number in the analysis. All values are deflated; Doll and Chin's data do not appear to be deflated.

Whereas Doll and Chin's correlation matrix appeared as:

	R	W	E
R	1.00	.96	.90
W	.96	1.00	.95
E	.90	.90	1.00

the monthly series with all values deflated was:

	R	W	E
R	1.00	.60	.60
W	.60	1.00	.95
E	.60	.95	1.00

The three principal components were extracted from the correlation matrix. These are presented in Table B-4 with those of Doll and Chin reprinted for comparison.[68/] The first principal component reflects the fact that all three prices move together, but that deflated wholesale price is more closely associated with the deflated ex-vessel price index than the deflated retail price index. This is also obvious from Figures 14A and 14B which graph

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68/ Principal components were also extracted from the covariance matrix. Signs on the first two eigenvectors (principal components) were identical to those of the first two eigenvectors extracted from the correlation matrix. The third eigenvector had the signs reversed.

Table B-4. Principal Component Analysis of Prices.

First Principal Component

1964-1969 Deflated monthly data: $Z_1 = .5060R'_m + .6105W'_m + .6093E'_m$ 81.54%

1950-1969 Undeflated annual data: $C_1^* = .5750R'_a + .5842W'_a + .5729E'_a$ 96.0%

Second Principal Component

1964-1969 Deflated monthly data: $Z_2 = .8625R'_m - .3525W'_m - .3631E'_m$ 16.75%

1950-1969 Undeflated annual data: $C_2^* = .6691R'_a + .0672W'_a - .7401E'_a$ 3.0%

Third Principal Component

1964-1969 Deflated monthly data: $Z_3 = -.6868R'_m + .7093W'_m - .7049E'_m$ 1.71%

1950-1969 Undeflated annual data: $C_3^* = .4709R' - -.8088W' + .3523E'_a$ 1.0%

Annual Data Matrix

	R'_a	W'_a	E'_a
C_1	.97	.99	.97
C_2	.21	.02	-.23
C_3	.07	-.13	.06

Monthly Data Matrix

	R'_m	W'_m	E'_m
Z_1	.74	.97	.97
Z_2	.16	-.68	-.68
Z_3	.28	.59	.30

* Doll and Chin (1970)

wholesale, ex-vessel and retail deflated prices. The second principal component captures the variation when ex-vessel and wholesale prices are moving together, but in an opposite direction from the retail price. This happened occasionally in the years of 1964 to 1969, as retail price responded more to wholesale and ex-vessel price increases than it did to declines in these prices. The third principal component accounted for less than 2% of the total variation and corresponded with those occasions when ex-vessel and wholesale prices moved in opposite directions. This happened rarely. Generally these price series moved together; although occasionally ex-vessel prices do lead wholesale prices.