Market analysis of domestically produced rainbow trout and the impact of the introduction of pan-size salmon.

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ABSTRACT

The principal objectives of this study were to isolate and identify the factors governing the demand for domestically produced rainbow trout in a representative West Coast market--the greater Los Angeles Area--and assess the impact (if any) of the introduction of pan-size salmon on that demand. The report begins with some observations on the development of salmonid aquaculture and then turns to a discussion of the Los Angeles market for rainbow trout. The approach taken in the demand portion of the study was to identify those variables hypothesized to determine supply and demand for rainbow trout. Several testable hypotheses concerning the anticipated relations were specified. It was hypothesized that a negative relationship exists between the price of trout at the brokerage level and the quantity demanded at that level. That is, as the price of aquaculturally produced rainbow trout confronting the wholesale buyer at the brokerage level increases, one would expect him to substitute away from the domestic trout, thus reducing the quantity of that product demanded from the broker, *ceteris paribus*. Conversely, the price of trout at the wholesale level was hypothesized to be positively correlated with the quantity of trout demanded at the brokerage level. This implies that, as the price of domestic trout which retailers are willing to pay their wholesaler increases, the wholesaler would be expected to demand greater quantities of trout from his broker(s), *ceteris paribus*. Based on this hypothesis, the signs on the coefficients of variables accounting for wholesale prices at the brokerage level would be positive. For example, if the price the wholesaler could command from his retail customers for substitute items such as salmon, halibut, sole, etc. were to increase, the wholesale buyer would find it to his advantage to shift his purchases to those products while cutting back his demand for domestically produced trout at the brokerage level, *ceteris paribus*. If on the other hand, the wholesale buyer faced increased prices for those substitute items from his broker, one would expect him to reduce his demand for

those items and increase his purchases of domestic rainbow trout. It was hypothesized that Japanese and domestic trout are substitutes in consumption and, thus, that the presence of Japanese trout in the market place would have a negative impact on the quantity of domestically produced trout demanded. Personal disposable income was hypothesized to be positively correlated with the quantity of trout demanded. That is, as personal income increased, so would the consumption of domestically produced rainbow trout, *ceteris paribus*. Expectations were that seasonal factors (holidays, for example) tend to cause trout demand to fluctuate cyclically.

An econometric simultaneous equations model was specified from which estimates of the parameters of the demand equation were obtained using two-stage least squares techniques.* A recognition of the limitations associated with the available data set necessitates the emphasizing of the preliminary nature of these results.

Date on quantities and prices of rainbow trout and equivalent price series for hypothesized substitutes were obtained through personal interviews with market participants and close observers thereof.

The results of the study, while preliminary, tend to support the original set of hypotheses concerning the interrelationships between the quantity of domestic trout demanded and its associated market prices, the prices of close substitutes and seasonal fluctuations in demand. Somewhat unexpectedly, the research seems to have uncovered a negative income/demand relationship for rainbow trout. It raises some interesting questions which might best be addressed in terms of hypotheses for future analysis.

INTRODUCTION

The oceans have long provided a rich and varied source of food protein for human consumption. Under the dual burden of exploding population growth and an increasing global demand for animal protein sources in the diet, the struggle over distribution and exploitation of this common property resource--the sea and its organisms--has taken on new dimensions in recent years. The complexities of international management of several economically important species have been associated with serious depletion of natural stocks. As a result, numerous alternative techniques for either supplementing naturally occurring populations or propagating and rearing to maturity aquatic organisms in artificial environments have received priority attention. Of these two basic supplemental strategies just identified, this analysis focuses principally upon the latter, which is commonly referred to as aquaculture.

For the purposes of this study, the term aquaculture is intended to describe the fish culture technique wherein an organism is hatched, reared, and ultimately harvested under the constant control and management of a production facility's staff. In the case of salmon, the fish remain as private property on the farm site throughout their lives, thus avoiding loss through predation from natural sources and commercial fishing. In addition, this high-density impoundment technique theoretically can provide a continuously harvestable stock of marketable product, and a uniformity of produce size and quality lacking in commercially harvested ocean runs. This latter point is of particular importance to the institutional-restaurant trade, which accounts for a very significant portion of the total demand.

Salmonid aquaculture is not a new phenomenon in this country. Trout have been reared in closely managed environments for more than 100 years and the first trout farm in the Northwest was established in 1909 (Klontz and King 1975). However, for anadromous species, the concept of intensively managed food fish production is a relatively new development because technical and political barriers have only recently been overcome. The first commercial salmon production operation began in Puget Sound. By the spring of 1972 the initial crop of mini, or pan-size, salmon was harvested. This raising of mini salmon under controlled conditions was both a biological and marketing experiment. Chinook and coho species were reared under close supervision to a stage of development which, it was hypothesized, would incorporate the advantages of a single serving fish like the trout and yet retain the highly desirable taste and color traits of the much larger mature salmon. The experiment created enough interest so that by the early 1970s pan-size salmon production

*The econometric portion of this paper was presented at the 1976 meetings of the Northwest Fish Culture Conference.

facilities had appeared in Oregon, Idaho, and Canada as well as several additional sites in Washington (Brannon 1973). Investors included large national and multinational corporations such as Union Carbide, Ralston-Purina and Weyerhaeuser; fishermen's cooperatives; and several consolidated Indian tribes (Deloria 1973).

By the summer of 1975, considerable interest in the market potential of pan-size salmon had surfaced. Several early efforts had been made to appraise consumer response to pan-size salmon's arrival in the market. However, owing to the lack of available data on actual market performance, these tended to take the form of non-quantitative, opinion, or taste-panel evaluation surveys. The results of these market surveys generated an atmosphere of guarded optimism with regard to the new industry's future. By July of 1975, when the present study was being considered, it was supposed that sufficient data to do a preliminary quantitative analysis of the pan-size salmon market could be compiled. After considerable effort it became apparent that this supposition was incorrect. However, during this unsuccessful data collection effort, it became clear that, at least in the minds of industry members, rainbow trout was the closest potential substitute in consumption for the new product in the market place. Thus, it was hypothesized, the forces governing the market behavior of rainbow trout were similar to those confronting pan-size ✓ salmon. That is, by examining: (a) the sensitivity of consumer purchases of rainbow trout to changes in the price of rainbow trout, (b) changes in the prices of alternative food items hypothesized to be close substitutes in consumption for rainbow trout, and (c) changes in personal disposable income levels, one might predict the probable market response to the presence of pan-size salmon, and/or variation in any of the demand parameters. It was within this framework that this preliminary analysis of the demand for pan-size salmon shifted its focus to the demand for domestic rainbow trout, and the impact, if any, of the arrival of pan-size salmon in the market place on that demand. During the investigative stage of the study another development took place. Firms which had been marketing pan-size salmon began to have second thoughts. Pan-size salmon sales declined. When interviewed about the underlying causes of this decline, marketing managers and others close to the industry indicated that they believed consumers were treating pan-size salmon and trout as close substitutes. Salmon could not compete successfully with trout because of the lower unit price associated with the latter. This provided additional impetus for exploring the degree of substitution in demand between the two goods.

Because trout have been aquaculturally produced and marketed in the United States for more than 100 years (Klontz and King 1975), it was assumed that data on the product's market performance would be available and that some quantitative demand analysis on trout probably had been done. After an exhaustive search it became clear that neither assumption was correct.

An in-depth historical survey of the trout aquaculture industry is beyond the scope of this investigation. However, Klontz and King (1975) have produced an excellent compendium of aquaculture in the United States. For clarity's sake, however, a few highlights of the character of that industry must be identified.

Idaho is responsible for 90 percent of the nation's total food fish production of rainbow trout. There are 14 independent companies and 28 production facilities in the state. The industry is dominated by three major integrated operations accounting for more that 80 percent of the total output. The industry might best be characterized, historically, in terms of intense, personal rivalries. Even in the best of circumstances highly priced-competitive behavior, described by one industry member as "absolute cutthroat marketing," has been the keynote of Idaho trout aquaculture. Every effort at cooperative interaction among industry members has resulted in disharmony and mistrust. Not surprisingly, demand analysis and market research have received little or no attention and support as a result of apprehension on the part of producers at revealing accurate, detailed production and shipment information.

In spite of this general air of mistrust within the aquaculture industry in Idaho, there has been a growing recognition of the need for market research and demand analysis on the part of industry members. This realization contributed sufficient inroads to provide at least an interested and, to some extent, cooperative group of aquaculturalists to whom the project proposal was presented. Some limited production data were provided in confidence and thus are not reported here. In addition, general information on the character and capacity of the major Idaho trout production facilities and the associated sales and distribution networks of each were obtained through personal interview.

These preliminary explorations led to the decision to focus the analysis on the Los Angeles metropolitan market. This selection was made in light of information which indicated Los Angeles represented the distribution network within which rainbow trout, ocean-caught salmon, and pan-size salmon had been most consistently available over the longest continuous time span. Further, the Los Angeles market is relatively free of distorting influences believed to be associated with other west coast markets, such as ready availability of trout and/or salmon sport fisheries or a historical reputation for absorbing excess supplies of fish products. Time and resource limitations precluded consideration of other significant markets in the Rocky Mountain states, Midwest, or East Coast. Preliminary contacts were made with brokerage firms in the Los Angeles market that represent the major Idaho trout producers. While the project's reception was mixed, several brokers expressed interest in the analysis and were willing to provide access to sales records. Some data were immediately made available while other brokers indicated they would require permission from their Idaho clients before releasing the information on shipments. Some brokers were instrumental in providing lists of distributors of rainbow trout who, it was felt, could provide further data on the movement of the product in the Los Angeles area. Subsequently, several wholesale companies did provide sales and shipments information for use in this analysis. They were also very helpful in suggesting apparent substitutional relationships among fisheries products. Sales information on both prices and quantities of several popular fish products competing with rainbow trout in the Los Angeles market, including pan-size salmon, was made available to the researchers.

THE LOS ANGELES MARKET

The Los Angeles distribution network for rainbow trout can be viewed in terms of seven distinct divisions of activity. The first or primary supplier is the producer/processor. At least in Los Angeles this group is dominated by Idaho suppliers. The second link in the marketing chain is the broker, followed immediately by the wholesaler. Wholesalers distribute most of the product to the fourth stage, the institution-restaurant sector. Some small percentage of the total domestically produced rainbow trout moving through the system finds its way into retail market outlets. However, indications are that this retail market is dominated by trout imported from Japan. Beyond this primary network there exists a secondary avenue through which domestic rainbow trout are distributed to Los Angeles retail market outlets. This function is performed by food chain buyers who purchase in bulk directly from producers and then supply their affiliated retailers in Los Angeles.

The seventh and final link in the distributional chain is the buying public. The complete network and its interrelationships is represented as in Fig. 1.

Producer/Processor

The producer/processor, as discussed earlier, serves the dual function of propagating and rearing the fish to marketable size, then harvesting and processing the animal into a finished product ready for distribution. The Idaho Rainbow Trout Industry is expected to produce 39 million pounds of food fish and contribute $50 million to the state's economy by 1980 according to Dr. George Klontz of the University of Idaho. The state's production facilities serve, for all practical purposes, as the exclusive continuous supplier of domestically produced rainbow trout to Los Angeles.*

*For the sake of accuracy it should be noted that rainbow trout are produced in relatively significant numbers in Montana, Colorado, and Wyoming. Several other western states have production facilities but do not produce sufficient quantities of product to merit attention. However the volume of output of all of the above-mentioned producers is so minor when compared to the Idaho industry's production that for purposes of this analysis the term "Idaho rainbow trout" will be used interchangeably with the term "domestically produced rainbow trout." Conservative estimates of Idaho's dominance of the industry put the portion of total national production of rainbow trout reared and harvested in Idaho at 90-95 percent (Klontz and King 1975). The proportion of domestically produced rainbow trout distributed in the L.A. market originating in Idaho is even higher. Therefore, no attempt will be made to differentiate between Idaho, Montana, Colorado, and Wyoming trout entering L.A. The volume of non-Idahoan, but domestically produced, trout has historically been very insignificant when they appeared at all, at least over the period observed in this analysis.

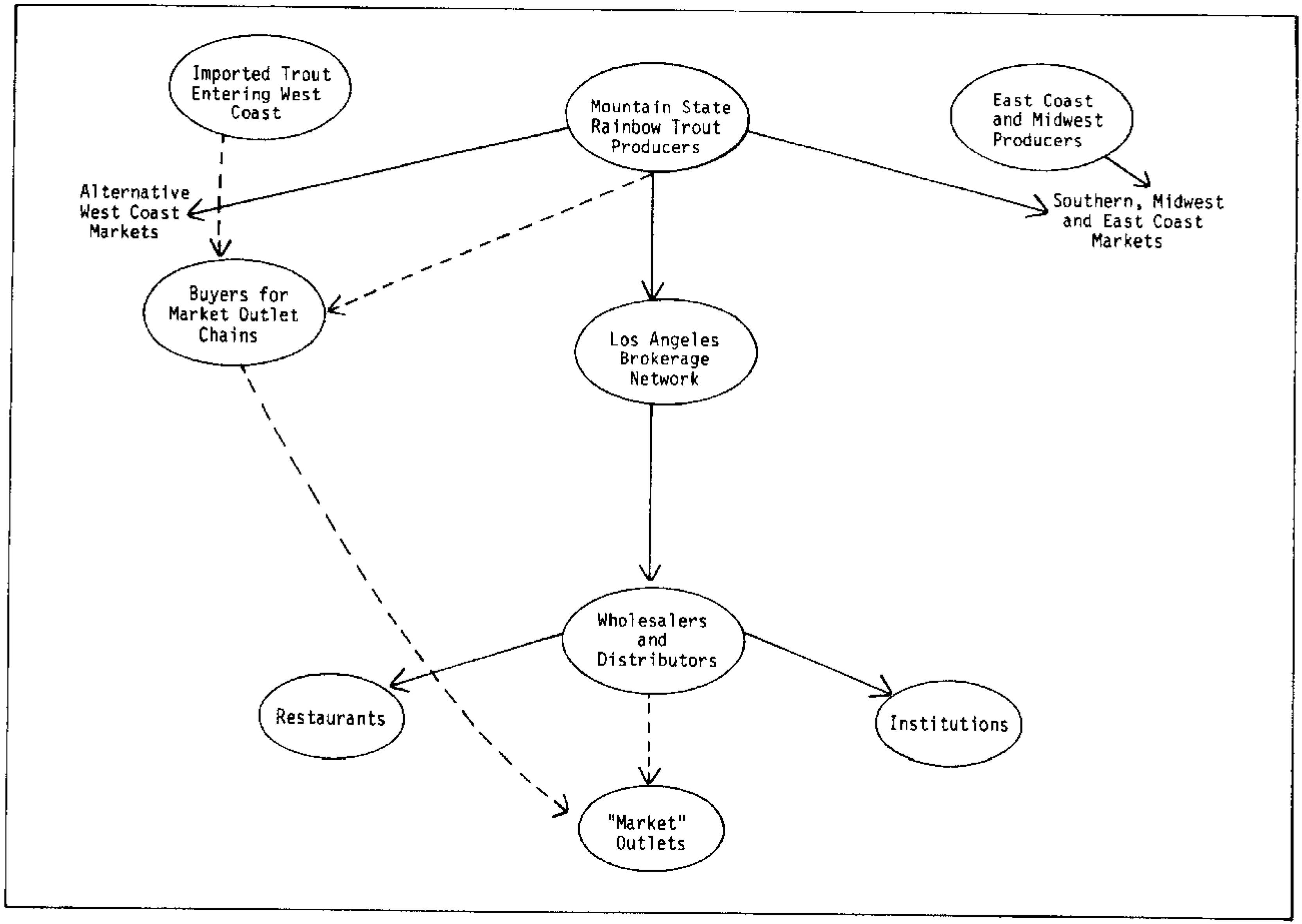


Fig. 1. Los Angeles Rainbow Trout Distribution Network. ——— Primary flow (domestic). -------- Secondary flow (domestic and foreign)

Broker

The broker, as defined by the National Food Brokers Association, serves as "an independent sales agent who performs the services of negotiating the sale of food and/or grocery products for, and on account of, the seller as principal, and who is not employed or established by, nor an affiliate or subsidiary of, any trade buyer, and whose compensation is a commission or brokerage paid by the seller." (O'Rourke and DeLoach 1971). Characteristic of the Los Angeles brokerage network, the broker does not usually take title to, or possession of, the product. Brokers serve to facilitate communication between buyers and sellers. Recent indications are that some producers are in the process of securing their own sales staff, thus bypassing the broker altogether. However, during the period under investigation the broker served as the link between producer and wholesale distributor in Los Angeles.

Wholesaler

The wholesale segment of the Los Angeles distribution network for rainbow trout tends to contain more participants than does the brokerage sector. Brokers typically maintain a one-to-one long-term relationship with a particular producer. The wholesaler, on the other hand, has characteristically shifted suppliers (producers/processors) over time. However, generally speaking, the wholesaler tends to market only a single supplier's product at any one time.

Retailer

The wholesaler is responsible for the distribution of the product to the retail level. In the case of Los Angeles, rainbow trout from domestic farms are almost exclusively destined for the restaurant-institution market. Approximately 95 percent of the domestically produced rainbow trout entering the Los Angeles distribution network are consumed by the institutional-restaurant trade (Queirolo 1977).

The retail level in the Los Angeles market has two distinctly different segments. As just mentioned, the majority of the domestically produced product finds its way into institutions and restaurants. This tends to be the case apparently due to the higher quality and uniformity of the domestic product when compared to the imported trout available in the market. However, accompanying this relative advantage in product quality, the domestic rainbow trout are consistently higher priced per unit than the Japanese fish. This price advantage enjoyed by the imported product has resulted in the dominance of the over-the-counter trade by the Japanese product. While some domestic product ultimately finds its way through the primary distribution network to the retail outlet meat counter, the percentage is not great. Perhaps, as indicated earlier, no more than five percent of the total shipment of rainbow trout entering Los Angeles reaches the consumer in this manner.

Some relatively significant numbers of domestic rainbow trout bypass the primary distribution network just described and arrive at the over-the-counter retail outlet via buyers. These buyers are employed by individual chain outlets such as Safeway, Inc. and A. & P. They serve as both brokers and wholesalers for their particular chain outlets in a region, buying in volume and distributing the product to each affiliate as demand for the product dictates. The volume of domestic rainbow trout moving through this secondary network has historically been relatively minor when compared to that of the primary distributional web or the volume of imported trout marketed at this "over-the-counter" level. Very recently, however, U.S. importation of foreign-produced trout has been declining as a result of increated demand for trout in Japan and Europe. Therefore it would appear reasonable to assume that some market adjustment in the distribution of the domestic product in response to the void created by reduced imported supplies may be inevitable. At the very least, it bears close observation in any future analytical research on this subject.

Consumer

The dimensions of the final consumption market in the Los Angeles Standard Consolidated Statistical Area (LASCSA), as defined by the U.S. Bureau of Census, are substantial. For the purposes of this analysis the total population of the LASCSA can be viewed as representing the latent market faced by suppliers of rainbow trout. The Department of Commerce, Bureau of the Census, placed the population of this region in excess of 10 million in 1975 with an adjusted gross income of over 40 billion dollars.*

THE MODEL

As indicated earlier, the emphasis of this study was to examine the nature of the demand for rainbow trout. Of particular interest was the influence of changes in prices, incomes and the appearance of pan-size salmon on the quantity of trout demanded. For reasons already discussed, the Los Angeles market was chosen as the area in which to conduct the analysis.

The market network was statistically approximated by the use of an econometric simultaneous equations model. The demand equation at the wholesale level was quantitatively estimated using two-stage least squares techniques. The wholesale level was selected because there were fewer gaps in the data at this level than at the retail level. The results of the regression are reported below and the interested reader is encouraged to explore this somewhat more technically detailed section. However, for the reader who is not familiar with, or particularly interested in, the statistical technique for the derivation of an econometric model and its coefficients, there would be no loss of continuity if he(she) chose to proceed, at this point, to page 11.

The economic model developed in an attempt to approximate the wholesale level of the Los Angeles distributional network for rainbow trout is specified as follows:

$$(1)\ \left(Q_d^{wt}/N\right)_t : P_{b_t}^{wt},\ P_{w_{t-1}}^{rt},\ P_{w_{t-1}}^{rms},\ P_{b_t}^{wlrgt},\ P_{w_{t-1}}^{rpss}\ \ P_{w_{t-1}}^{rpss}\ \ D_2,\ D_3,\ D_4,\left(Y/N\right)_t,\ D_t^{imt}$$

$$(2)\ \left(Q_s^{wt}/N\right)_t : P_{b_t}^{wt},\ P_{b_{t-1}}^{wnyt},\ T$$

and assumes the identity,

$$(3)\left(Q_d^{wt}/N\right)_t = \left(Q_s^{wt}/N\right)_t = \left(Q^{total\ trout}/N\right)_t$$

where the colon is read "depends on", a comma is read "and", (Foote 1958) and the variables are defined as follows:

$\left(Q_d^{wt}/N\right)_t$ - quantity of rainbow trout demanded at the wholesale level, per capita, in time t.

$P_{b_t}^{wt}$ = price of rainbow trout from broker to wholesaler in time t. This price is assumed to be endogenous. It is hypothesized to be negatively related to the quantity demanded by wholesalers in this model and positively related to quantity supplied to wholesalers.

$P_{w_{t-1}}^{rt}$ = price of rainbow trout from wholesale to retail in time t-1. This price is hypothesized to be an important explanatory variable in the simultaneous determination of $\left(Q_d^{wt}/N\right)_t$ and $P_{b_t}^{wt}$. The argument follows from the proposition that the price received in the latest preceding period, i.e., t-1, will contribute to the determination of demand for rainbow trout in time t. Thus $P_{w_{t-1}}^{rt}$ becomes a predetermined variable owing to the lag. It is hypothesized to be positively related to the "quantity demanded" variable.

$P_{w_{t-1}}^{rms}$ = price of medium-sized salmon, wholesaler, to retailer, in time t-1. Medium salmon is hypothesized to be a close substitute in consumption for rainbow trout and, thus, to be negatively related to the quantity of trout demanded. That is, as the price wholesalers receive for medium salmon increases, they are expected to demand a smaller quantity of rainbow trout. Again this variable is lagged to account for the most recent

*The adjusted gross income figure is for 1973, the most recent available. The source for this and the population figure cited above is The California Statistical Abstract, California Department of Finance, 1975, p. 7.

historical price information available to the wholesaler when he makes his current buying decisions.

$P^{wlrgt}_{b_t}$ = price of "large" trout from broker to wholesaler in time t. Because this appears to be determined in the "retail outlets" market, it is treated exogenously in this model. It is hypothesized to be positively related to the quantity of rainbow trout demanded.

$P^{rpss}_{w_{t-1}}$ = price of pan-size salmon from wholesaler to retailers. The argument for the inclusion of this variable is identical to that made above for P^{rms}_{w}. It, too, is hypothesized to be negatively related to the quantity of trout demanded.

$\left(Y/N\right)_t$ = per capita real personal disposable income for the Los Angeles SCSA in time t. This variable is assumed to be exogenously determined. It is hypothesized to account for demand-determining forces resulting from general economic conditions and to be positively related to the quantity of rainbow trout demanded.

D^{imt}_t = a binary variable included in the demand equation to reflect the potential influence of Japanese trout, as a demand shifter, upon total quantities of domestic rainbow trout moving through the Los Angeles market in time t. Its coefficient is hypothesized to be negative.

D_2, D_3, D_4 = a series of binary variables intended to detect any significant seasonal shift in demand on a quarterly basis. Several preceding studies on seafood demand have tentatively identified seasonal fluctuations in demand owing to, it has been hypothesized, such factors as religious holidays, traditional non-seafood main course dishes, i.e., Thanksgiving turkey, Christmas ham, etc. Industry sources, interviewed during this analysis, are divided as to the significance and timing of such seasonal shifts in demand for rainbow trout. It would seem, therefore, to be a natural hypothesis to investigate.

Equation (1), then, is the per capita demand equation for rainbow trout in the Los Angeles wholesale market.

Equation (2), the supply equation, contains, in addition to $P^{wt}_{b_t}$:

$\left(Q^{wt}_s/N\right)_t$ = quantity of rainbow trout supplied to brokers for sale to Los Angeles wholesalers in time t. The variable is expressed in per capita terms.

$P^{wnyt}_{b_{t-1}}$ = price of rainbow trout from broker to wholesaler in time t-1 for the Fulton Fish Market, New York. The variable is hypothesized to account for shifts in supply resulting from variation in the price of rainbow trout in alternative markets. Thus, the sign of its estimated coefficient is expected to be negative.

T = variable "time" accounting for supply shifters not otherwise observable given the available data.

All prices are deflated by the Wholesale Price Index for farm products, processed foods, and feeds, U.S. Bureau of Labor Statistics. Income, Y, is deflated by the Consumer Price Index, U.S. Bureau of Economic Analysis. The variable N_t is the population of the Los Angeles SCSA, in time t, as reported by the U.S. Bureau of the Census.

The identity $\left(Q^{wt}_d/N\right)_t = \left(Q^{wt}_s/N\right)_t = \left(Q^{total\ trout}/N\right)_t$ specified an equilibrium condition in which quantities supplies are exactly equal to quantities demanded, i.e., it is assumed that there are no inventories held at the brokerage, wholesale, or retail levels in this market, at least for longer than one month.

Several specifications (i.e., functional forms) of this basic economic model were hypothesized and quantitatively estimated using two-stage least squares techniques.*

*For a complete review of the alternative model specifications and resulting statistical evaluations the reader is referred to Queirolo (1977).

The most satisfactory in terms of R^2, F, and t statistics is reproduced below.

The data employed were monthly for the period May, 1972, to December, 1975. The results of the first stage of the 2SLS regression, wherein $\hat{P}^{wt}_{b_t}$, predicted price, is estimated in terms of all the exogenous variables in the model, are:

$$\hat{P}^{wt}_{b_t} = \underset{(2.68)}{.0125} + \underset{(2.79)}{.00334} P^{rt}_{w_{t-1}} + \underset{(.974)}{.00087} P^{rms}_{w_{t-1}}$$

$$- \underset{(-0.9505)}{.000136} D_2 + \underset{(.7088)}{.000112} D_3 + \underset{(.578)}{.00076} D_4$$

$$- \underset{(-1.16)}{.0000166} T - \underset{(-.656)}{.0000169} D^{imt}_t +$$

$$\underset{(3.45)}{.320} P^{wlrgt}_{b_t}$$

$$- \underset{(-2.67)}{.0486} P^{rpss}_{w_{t-1}} + \underset{(.960)}{.1273} P^{wnyt}_{b_{t-1}} -$$

$$\underset{(-2.71)}{.00000326} \left(Y/N\right)_t$$

$$R^2 = .910032 \quad F\text{ - statistic } 22.9889,\ 11,\ 25 \text{ d.f.}$$

In the second stage quantity-dependent equation, $\hat{P}^{wt}_{b_t}$ is included as an explanatory variable and yields:

$$\left(Q^{wt}_d/N\right)_t = \underset{(4.37)}{.0175} + \underset{(2.04)}{.00726} P^{rt}_{w_{t-1}} +$$

$$\underset{(.632)}{.000051} P^{rms}_{w_{t-1}}$$

$$- \underset{(-1.76)}{.000282} D_2 + \underset{(1.53)}{.000328} D_3 +$$

$$\underset{(.278)}{.0000459} D_4$$

$$- \underset{(-1.18)}{.0000388} D^{imt}_t + \underset{(2.05)}{.5607} P^{wlrgt}_{b_t} -$$

$$\underset{(-1.97)}{.0632} P^{rpss}_{w_{t-1}}$$

$$- \underset{(-3.91)}{.00000439} \left(Y/N\right)_t - \underset{(-2.35)}{1.549} \hat{P}^{wt}_{b_t}$$

$$R^2 = .5912 \quad F\text{ - statistic } 3.6155\ 10,\ 25 \text{ d.f.}$$

Durbin-Watson Statistic 1.667
where the t-values are in parentheses below the coefficients.
The critical t-value, $\alpha = .10$ is 1.316.

This second regression equation contains the estimated relationships of interest which is discussed below.

A Summary of the Results

In terms of the relationships postulated at the outset of this analysis concerning the market demand for rainbow trout, the results of statistically fitting the model are most interesting. Pan-size salmon has consistently been hypothesized to be a close substitute in this market for domestically produced rainbow trout. The results of this analysis tend to support this hypothesis. The variable accounting for the price of pan-size salmon enters the regression at a statistically significant level and with the expected negative sign. Data limitations with regard to pan-size salmon preclude the estimation of a cross-price elasticity figure. It is, however, possible to conclude with some certainty that pan-size salmon does serve as a substitute in consumption, i.e., a demand shifting factor, for rainbow trout. By recomputing the demand equation with data from those periods during which pan-size salmon was not present in the market it was discovered that the appearance of pan-size salmon does shift the demand curve for rainbow trout and that the magnitude of the shift may vary with the season of the year. That is, based upon these results, it appears that the presence of pan-size salmon in the market during certain seasonal periods may have a more pronounced impact on demand for rainbow trout than it would during other seasonal periods. While the results are only preliminary this hypothesis would seem to merit additional attention. Perhaps there is a trout season and a pan-size salmon season in terms of consumers' purchasing decisions.

The second quarter of the calendar year appears to reflect a period during which consumption of rainbow trout is on the decline. This seems to be in agreement with industry perceptions. The first quarter characteristically is the big seafood season as the Lenten period is observed. Following the end of the religious observance there tends to be some adjustment away from fish in favor of alternative food protein items. The decline in demand for rainbow trout in this period probably reflects a more general downward trend in seafood consumption.*

*On the other hand, seasonality may be more supply than demand related. However, an alternative specification of the model, in which quantities of rainbow trout supplied to the Los Angeles market were assumed to be exogenously and seasonally determined, failed to support this view.

The relevant market price of rainbow trout is represented at the wholesaler-to-retailer level and the broker-to-wholesaler level by $P^{rt}_{w_{t-1}}$ and $\hat{P}^{wt}_{b_t}$, respectively in the econometric model. Both price variables enter the regression at statistically significant levels and with the expected signs on their coefficients. In the case of the price of rainbow trout from wholesaler to retailer the relationship was expected to be positive. That is, as the price the wholesaler is able to command for rainbow trout from his retail customers increases, he will demand greater quantities of rainbow trout from his broker(s). The magnitude of this price sensitivity is reflected by the price elasticity, calculated in this case to be 5.9. The relationship is price-elastic inasmuch as a one percent increase in the price received by the wholesaler in the previous period for rainbow trout would be expected to result in nearly a six percent increase in the quantity demanded at the brokerage level, *ceteris paribus*. This elasticity figure is calculated at the mean value of the variables. In Fig. 2 this relationship is outlined. In Fig. 2a, $D^r_{w_{t-1}}$ depicts the quantities retailers are willing to purchase at various wholesale-to-retail prices, while $S^r_{w_{t-1}}$ depicts the quantities wholesalers would be willing to sell at these prices. Factors affecting the shapes of these curves are assumed to be invariant as one moves along these curves. Under these conditions the market-clearing price and quantity are P_α and q_α respectively.

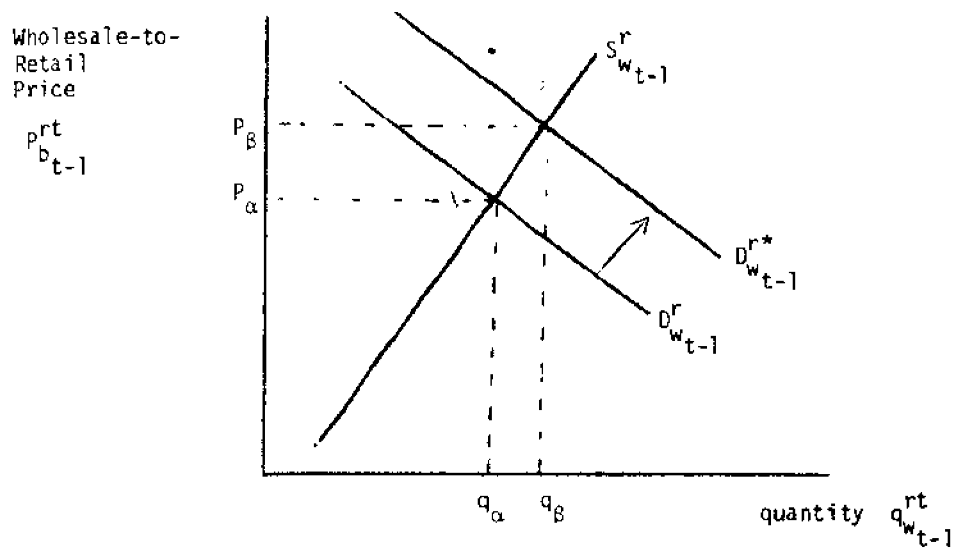
In the present study, it is hypothesized that, in the Los Angeles trout market the relationship between quantities of trout that brokers would supply and the broker-to-wholesale prices ($D^w_{b_t}$ in Fig. 2b) in the current time period (time t) is importantly influenced by the price the wholesaler received for trout during the preceding time period. Thus $D^w_{b_t}$ in Fig. 2b is drawn on the assumption that the wholesale-to-retail price in time t-1 is P_α.

Under these conditions, with $S^w_{b_t}$ representing the quantities brokers will supply wholesalers at various prices, the market is cleared at quantity q_a and broker-to-wholesaler price P_a. It should also be noted that, like the curves in Fig. 2a, both $S^w_{b_t}$ and $D^w_{b_t}$ have been drawn under the assumption that other factors affecting the shapes of these curves [and identified as explanatory variables in equations (1) and (2)] are invariant as one moves along these curves.

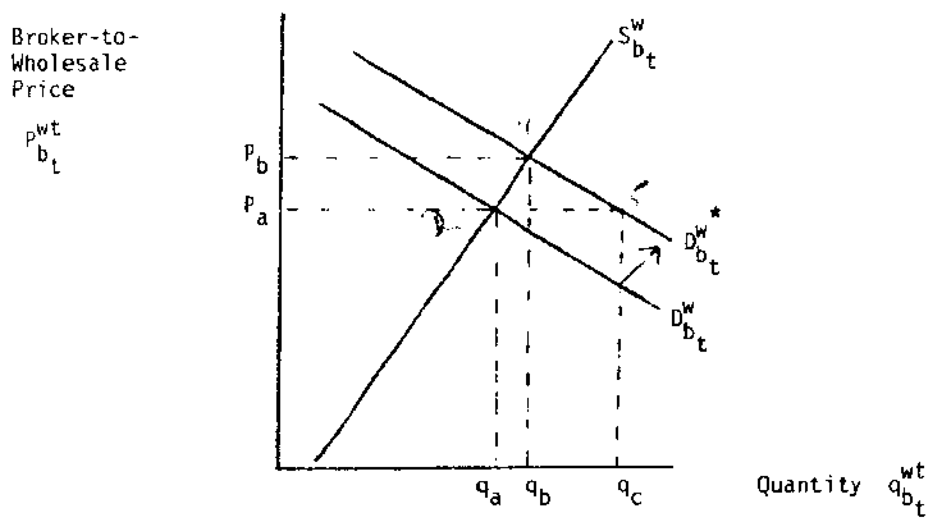
Suppose, now, that instead of $D^r_{w_{t-1}}$, the wholesale-to-retail demand were $D^{r*}_{w_{t-1}}$, perhaps as a result of promotional activities at the retail level. This would increase the wholesale-to-retail market-clearing price in time t-1 to P_β (and increase sales to q_β) which, in turn would shift the current broker-to-wholesale demand to $D^{w*}_{b_t}$. The resulting market-clearing price and quantity at that level would become P_b and q_b, respectively. Of interest in this study however, is the shift in the $D^w_{b_t}$ curve to $D^{w*}_{b_t}$. This says that, given the higher wholesale-to-retail price, wholesalers would now like to purchase greater quantities of rainbow trout at each of the prices they would have to pay. For example, they would now be willing to purchase q_c, rather than q_a, at price P_a because of the higher price they expect to receive. Of course brokers are unwilling to sell them q_c at price P_a. In fact, competition forces both price and quantity up (to P_b and q_b).

Here, then, is an interpretation of the positive relationship uncovered between the price of rainbow trout received by the wholesaler in the previous period and the quantity of rainbow trout demanded by the wholesaler during the current period. Other factors which are hypothesized to shift this demand relationship are the price of pan-size salmon, per capita personal disposable income, which is discussed below, the price of medium salmon, the availability of Japanese trout, and various seasonal factors.

The price elasticity of demand for rainbow trout at the broker-to-wholesaler level was calculated to be 9.1, once again highly price-elastic. This implies that, if the



2.a. Wholesaler-to-Retailer, t-1.



2.b. Broker-to-Wholesaler, t.

Fig. 2. Supply and Demand Relationships for Rainbow Trout, Wholesale-to-Retailer and Broker-to-Wholesaler: A Graphical Representation.

price of rainbow trout which the wholesaler must pay were to decline by one percent, the quantity demanded by wholesalers would increase by more than nine percent, *ceteris paribus*.* Therefore a reduction in the price of rainbow trout at the brokerage level, i.e. by producers, would be expected to increase total revenues accruing to fish culturists as a result of their increased sales of rainbow trout to the Los Angeles market. This assumes that the retail price of rainbow trout does not change in response to the quantity change. This is probably unrealistic and, therefore, any assessment of the effect on total revenue increases at the brokerage level of a retail price response would have to be incorporated into any decision strategy based upon the results of this analysis. Unfortunately the available data do not permit a quantitative evaluation of the magnitude of a retail price response to a decrease in brokerage prices.

Per capita personal disposable income, deflated by the consumer price index, entered the regression with a negative sign. This is contrary to the hypothesized influence of income on quantity of rainbow trout demanded. There are several possible explanations for this result. The negative coefficient may be the product of statistical problems within the data set. It is, of course, not theoretically inconceivable that, over some range, rainbow trout is in fact an inferior good, as the negative income coefficient would imply. The word inferior is used here only to describe the (negative) income elasticity of a good. . . (Ferguson and Gould 1975). When, over some range a good is observed to be inferior the implications are that as income increases the consumption of that good will decrease. This is not so difficult to imagine when one recalls that income can be perceived as a proxy for all other goods. In this sense for example, as a consumer increases consumption, including that of alternative food proteins such as beef, pork, poultry, and other seafoods, the utility he obtains from consuming rainbow trout may be diminished over some observed range.

During the period of this analysis the real per capita income in the Los Angeles Standard Consolidated Statistical Area has in fact been declining. It has simultaneously been observed that per capita consumption of trout has been on the increase. This may be the result of the rapid rise in the real prices of other goods for which rainbow trout serves as a potential substitute, while the real price of rainbow trout has remained relatively constant or at least has increased more slowly. If this were the case then consumers would maximize their utility subject to the increasing constraint implied by declining real income, by substituting away from the more price-inflated food items in favor of rainbow trout, thus producing the erroneous conclusion that rainbow trout is an inferior good. This is only conjecture at this point owing to a lack of suitable data on these several food protein commodities. Coincidently, the economic conditions existing during the duration of this analysis have been atypical in terms of the historically established pattern. The years 1972 through 1975 have seen price freezes, record inflation and unemployment, and a decreasing real personal disposable income. All of these factors may have served to generate an anomalous income/quantity relationship during the period observed in this analysis.

The need for additional analysis in this area seems indisputable based upon the interesting but very tentative results of this study. Any further quantitative examination of the proposed model and hypotheses resulting from it must await the release of more complete, detailed data.

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*All elasticities have been calculated at the means and should only be interpreted as being indicative of the results of very small changes about the mean values of the relevant variables. For the elasticities reported above those values are as follows: $P^{rt}_{w_{t-1}} = \$1.09$; $P^{wt}_{b_t} = \$.79$, $\left(Q^{wt}_d/N\right)_t =$ .0013 lbs.

For computational purposes the numbers used were 1.0967425; 0.007900299; and 0.00133139, respectively.

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List of Figures:

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