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Demand Considerations in Fisheries Management--Hawaii's Market for Bottom Fish

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ABSTRACT

Fisheries management decisions are usually predicated on affecting the supply of fish at the point of harvest. However, changes in supply may have significant impacts on processors, wholesalers, and the final consumer.

Examination of Hawaii's market for bottom fish shows some price volatility in the short run, and quality premiums in both the short and long run. Long-term demand has been significantly positive, most closely associated with increasing population, tourist arrivals, and exports. Fisheries management decisions must take into account the impact of changing supply conditions on the availability and price of fresh bottom fish in the market.

INTRODUCTION

Fisheries management frequently affects not only the total volume of fish that reaches a market but also the timing and composition of supply. All three factors can affect the ex-vessel price of fish and thus commercial fishing incomes and, through the marketing chain, wholesale and processor incomes and consumer budgets. Once the nature of demand is determined, any management scheme (e.g., supply constraint) can be evaluated with respect to its effect on prices and income. This paper describes the market for fresh snappers and groupers in the U.S. as a whole (primarily the east coast) but emphasizes Hawaii in particular. Then the demand for fresh bottom fish in Hawaii is estimated through price flexibility functions. Finally, some management implications that derive from market demand estimation are explored.

DESCRIPTION OF THE MARKETS

International Markets

Fresh snappers are a high-value seafood product throughout their range: the east and gulf coasts of the mainland United States, Hawaii, the Caribbean, Australia, and New Zealand. Groupers are also an important seafood product in a number of these places, while jacks appear to be marginal commercial species but are valued for their sports fishing appeal. These species constitute the bottom fish management complex in Hawaii.

Annual landings of snappers on the mainland U. S. (primarily Florida) have declined recently to 4,200 metric tons (MT) valued at $15 million in 1984. Landings of grouper and sea bass have been growing, with 1984 landings of 7,800 MT with an ex-vessel value of $21 million ([U.S.] National Marine Fisheries Service (NMFS) 1985).

Hawaii's snapper-grouper market has always been considered marginal from a national perspective, but recent harvest records may change that assessment. There is, however, almost no competition between east coast and Hawaii snappers in either market area at this time, nor has there been substantial competition from imports. Imports of snappers and groupers to the U. S. have been relatively erratic in volume and appear to have a minimal impact on price determination for domestic species (Keithly and Prochaska 1984). Imports of snappers (and associated species) to the southeastern U. S. in 1984 were 3,800 MT, a record (Vondruska and Cunningham 1985).

In the U.S., snappers and groupers have a relatively low volume compared with apparently similar fish (e.g., west coast rockfish) and command considerably higher prices. The handline-harvested product is treated with considerably more respect than trawl-caught fish (although trawling for snappers has been instituted on the mainland U.S.) and receives appropriately higher prices. For example, April 1985 **wholesale** prices for red snapper at the Fulton Street Market in New York were in the range of $3-$5 a pound (roughly equivalent to Norwegian salmon), while sole and flounder were at $1.50. In Hawaii the ex-

vessel price for all bottom fish averaged $2.47 a pound (about $3.50 **wholesale**) in 1984, a year of record supply, and prices for individual species reached over $10 a pound during peak buying season for some species.

Economic studies of snappers and groupers emphasize the localized nature of their harvest and their primary markets. Cato and Prochaska (1976) reported a highly inelastic demand for fresh red snapper from Florida, indicating that there are relatively few substitutes for this species. Keithly and Prochaska (1984) found continued dominance of red snapper in the fresh market through 1982, with average prices for red snapper about double those for groupers. The primary source for growth in the price for snappers was growing total personal disposable income. More recent information shows that red snapper prices have been relatively constant over the past 4 years, while prices for other snappers and groupers have risen. This suggests that the market is broadening and that premiums for red snapper may diminish (Vondruska and Cunningham 1985). Rockfish from the west coast is already being marketed as snapper (at a substantially lower price) in some areas. Since harvests of red snapper may have already reached their biological limits in the United States, substitution of less heavily harvested species may be desirable, although this will have an unwanted income effect on commercial harvesters concentrating on red snappers.

It appears that the market for snappers in general is relatively independent of the demand for other seafood. It makes up a small percentage of average family household consumption (Keithly and Prochaska 1984), but the restaurant market for snappers may be relatively more important. Fluctuations in the price of snappers appear to be determined primarily by an exogenous domestic supply.

Snappers are also an important commercial sports fish on the east and gulf coasts (Huntsman et al. 1983), but this is not so in Hawaii (Samples et al. 1984). Huntsman points out that sports fishers prize large snappers, but that the commercial market has developed a niche for smaller fish, which may reduce the availability of larger, older snappers. One might conjecture that the development of the trawl fishery on the east coast, with its lower size selectivity, led to this development. In Hawaii, small snappers are also caught extensively by small-scale fishing vessel operators (part-time commercial and ostensibly recreational) for direct sale to households. Management problems appear to exist in both areas in terms of allocation between groups of fishers, i.e., between full-time and part-time commercial fishers and with recreational fishers.

Hawaii Market

Hawaii's overall seafood market is well-known for relatively high prices based on local preference for a limited number of species of fresh fish. Included in this consumption bundle are a number of snappers, groupers, and jacks of which opakapaka, *Pristipomoides filamentosus*, is the most important. A fisheries management problem has developed because bottom fish and reef fish stocks in the main Hawaiian Islands (MHI) appear to be at or near maximum sustainable yields while market demand for bottom fish (especially in "up-scale" restaurants) has grown substantially in the past 5 to 10 years. The household market for small bottom and reef fish also continues to grow.

Hawaii's overall seafood market has been surveyed a number of times and is depicted in Figure 14.1. This diagram shows the market channels for all types of seafood in Hawaii. The bottom fish market, including fresh bottom and reef fishes and imported frozen snapper, follows these channels. Hawaii's retail market for fresh and frozen bottom fish and reef fish has been estimated at 2,750 MT ($13.7 million), which constitutes approximately 11% of the final retail market. Frozen snapper imports to Hawaii (mainland U. S. and foreign) are estimated at 800 MT (1.8 million lb), $2.5 million wholesale value (Higuchi and Pooley 1985; Pooley Unpub.; data from an unpublished 1981-1982 NMFS survey).

Figure 14.2 depicts retail outlets for all varieties of seafood in Hawaii and is representative for bottom fish. The Hawaii wholesale seafood business has three major components: (1) 10 major wholesale dealers who predominate in the fresh fish market; (2) 50 smaller fresh fish dealers who sell wholesale and retail; and (3) 50 wholesalers and brokers who handle frozen seafood imported from the U.S. mainland and foreign sources. The fresh bottom fish market operates around an auction in Honolulu, although sizable market channels exist outside the auction. The latter channels are based on bilateral exchange with negotiated pricing, typical of other fresh fish markets in the U.S. (Wilson 1980). The overall market might be termed one of contestable competition

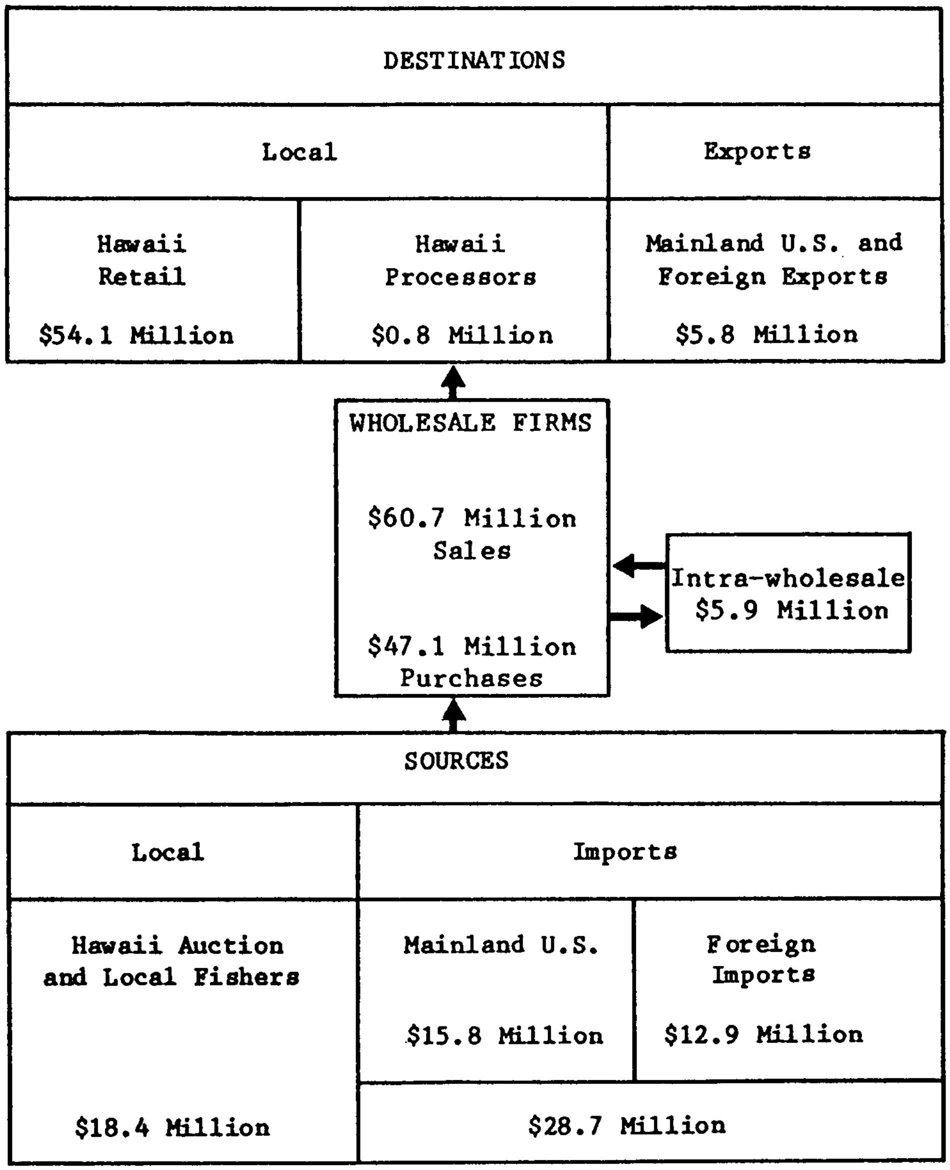


Figure 14.1 Market channels for Hawaii seafood sales, 1979 (millions of dollars)

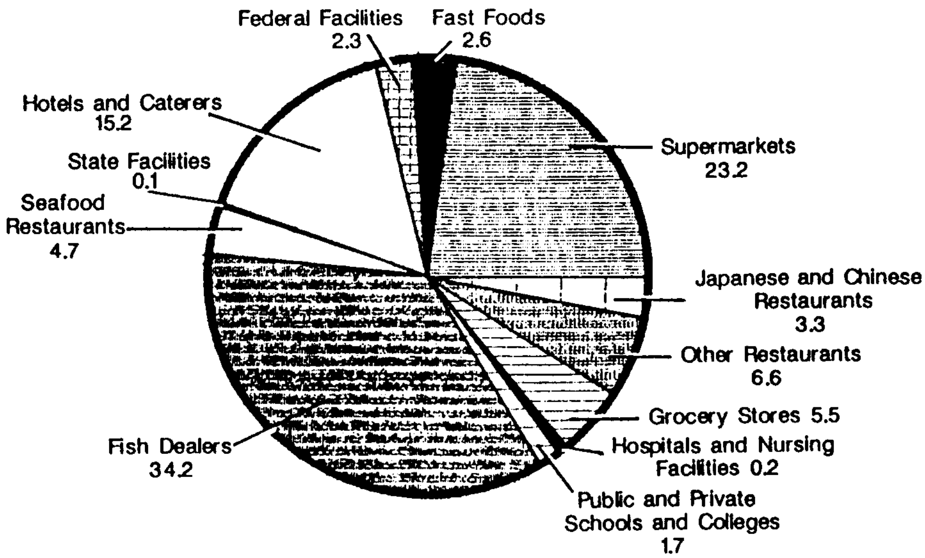


Figure 14.2 Retail outlets for all types of seafood in Hawaii (percentage of total revenue)

(Baumol 1982) in which a relatively small number of wholesale dealers of fresh and frozen seafood are able to generate economies of scale and scope in their product exchange functions. This reduces transactions and information costs while maintaining product heterogeneity, including an abundance of high quality, fresh seafood (Cooper and Pooley 1983). Retail prices are competitive.

Retail sales to Hawaii consumers include two components: regular purchases within a household's weekly food budget and a strong seasonal demand based on a cultural interest in large, red snappers for ceremonial occasions such as New Year's. This cultural demand also includes nonseasonal events such as weddings and birthdays. Favored fish in this category include the opakapaka, onaga, Etelis coruscans, and uku, Aprion virescens. The regular household component can be served by small bottom and reef fishes, by fillets of larger bottom fish, and by frozen snappers imported from the mainland United States and New Zealand. Although consumer substitution between product forms occurs, the frozen product is considered an inferior alternative for local bottom fish consumers. The price differential is substantial. In 1981 frozen snappers from New Zealand were entering Hawaii as fillets at $1.40 per pound. During that year the average price for whole bottom fish was $2.30 per pound and for opakapaka alone, it was $2.80 (NMFS unpublished wholesale market survey 1981-1982).

Restaurant demand for fresh bottom fish is centered on fresh opakapaka and is based on catering to "up-scale" tourist preferences (Takenaka et al. 1984; Monaghan 1985). Successful market promotion and a fairly regular supply of this species in large sizes has led to its introduction on restaurant menus as a high quality item. Substitution of other bottom fish and reef species has begun to occur, but this is not a preferred practice.

Exports of opakapaka and a few other large bottom fish have followed the growth of the tourist restaurant market, much as a market for red snapper moved north from Florida to New York years ago, but exports are still a fairly small component of the demand for local bottom fish. Fresh bottom fish is imported increasingly from American Samoa, Guam, Fiji, and Micronesia.

HAWAII PRODUCTION

From the production side, the bottom fish market is served by two types of Hawaii-based commercial fishing vessels as well as by import brokerage. Relatively large-scale (12-20 m, i.e., 45-65 ft), full-time commercial fishing boats ply the waters of the relatively distant (500-1,000 nmi) Northwestern Hawaiian Islands (NWHI). These modern vessels have the capacity to flood the fresh market at the conclusion of their 2- to 3-week trips, landing up to 7,000 kg of mixed bottom fish, but their boats have not developed an effective market for frozen product. This limits not only their catch total but their fishing range (Hau 1984). Opakapaka is the major catch of the NWHI fishery.

On the other hand, the MHI are the site of a mixed commercial and part-time fishery of relatively small vessels. Their catches fill a niche with smaller bottom and reef fishes. Their boats land <1,000 kg and usually much less. The MHI vessels are frequently operated on extra-economic rationales and are faced with substantial resource pressure. Both the NWHI and the MHI vessels compete in the same fresh fish market, although size composition tends to allocate the larger fish of the NWHI catch to restaurants and the smaller fish of the MHI catch to the household market (Table 14.1). This competition between large- and small-scale vessels, each representing

TABLE 14.1
Hawaii bottom fish sales, 1984 (numbers in pounds rounded). Scientific names are given in the text. MHI = Main Hawaiian Islands; NWHI = Northwestern Hawaiian Islands. (Source: Western Pacific Regional Fishery Management Council 1985:152)

Group/ Species	Landings		Prices		Total Revenue
	MHI	NWHI	MHI	NWHI	
Group 1					
Uku	146,100	10,600	$2.30	$2.50	$362,500
Ulua	59,700	80,300	1.90	1.05	197,700
Subtotal	205,800	90,900	2.18	1.22	560,200
Group 2					
Opakapaka	211,600	331,900	3.35	2.70	1,605,000
Gindai	4,600	2,800	2.20	2.95	18,400
Hapuupuu	55,300	98,100	1.80	1.65	261,400
Lehi	16,300	0	2.30	0.00	37,500
Subtotal	87,800	432,800	2.97	2.46	1,922,300
Group 3					
Onaga	190,700	6,500	4.00	2.95	782,000
Ehu	36,800	5,000	2.75	2.10	111,700
Kalekale	23,800	2,500	2.20	1.60	56,400
Subtotal	251,300	14,000	3.65	2.40	950,100
Other	165,000	8,600	1.25	1.10	215,700
Total	909,900	546,300	2.65	2.25	$3,595,900

small business enterprises, has increased pressure for government regulation, including limited entry (Western Pacific Regional Fishery Management Council (Council) 1985; Pooley Unpub.).

Such institutional factors should be considered in fisheries management planning but generally are not. Since the supply of fish is the major variable affected by fishery management plans, its effect on the market needs to be investigated. In the next section, the demand for fresh bottom fish in Hawaii is estimated with a view toward understanding the relationship between fisheries production and marketing. The final section examines the economic impact of regulated changes in supply.

ECONOMIC DEMAND

The demand for fresh bottom fish represents a specific behavioral relationship: Consumers are said to determine the quantity demanded of a particular type of fish based on a number of demand determinants (characteristics). The primary determinant is the price of the fish, but other determinants include the price of substitutes, the size and quality of the fish, and seasonal considerations. Long-term characteristics include per capita disposable income and the size of the market, i.e., the population. The data available for estimating the demand for Hawaii's bottom fish are based on wholesale purchases of fresh product in the round. Therefore, in this paper a short-run price formation function of the following general form is utilized.

$$P_f = f(Q_f, Q_a, SD, CD)$$

where P_f is the ex-vessel price per pound of a particular type of bottom fish, Q_f is the market quantity of that type of fish, Q_a is the market quantity of substitute (alternative) species, SD is a dummy variable representing product quality based on the source of the product, and CD is a dummy variable representing seasonal consumer demand. In the short run, population and income are assumed to be fixed. Wholesale buyers make their offer prices to harvesters based on expectations of conditions in the final consumer markets. This offer is not significantly affected by inventories in a fresh fish market. Therefore, the price formation curve is mathematically equivalent to the inverse of the demand curve.

The price-quantity relationship can be depicted as a linear or logarithmic relationship and through two summary measures: (1) elasticity, which is not directly applicable to wholesale market analysis, and (2) its inverse, a price flexibility coefficient, F_p, which measures the percentage rate of change of a product's price relative to the rate of change of the product's quantity sold, i.e.,

$$F_p = - \frac{\%dP_f}{\%dQ_f} * 100$$

A logarithmic transformation of the price and quantity variables translates regression coefficients directly into estimates of elasticity or price flexibility, depending on the form of the equation.

The problem of explanation for seafood market price-quantity relationships is not trivial and is not unlike problems in understanding population dynamics and other features of fish stocks where observable phenomena have an uncertain relationship to underlying forces. The seafood market is a complex institution embedded in a network of social structures. The quantitative measures of market behavior are limited and interpretation of market forces is frequently contested. Previous explanations of seafood markets in Hawaii have explored the social side of fresh fish auctioning (Peterson 1973), the nature of market channels (Garrod and Chong 1978), the econometrics of a fresh fish cooperative (Hudgins 1980), industrial structure (Adams 1981), and characteristics of market transactions (Cooper and Pooley 1983). This paper builds on those explanations but does not completely "explain" the demand for fresh bottom fish. Although microeconomic theory of price determination has been developed in great detail (it is probably the most elaborate theoretical structure within economics), it is a relational theory of static aggregations of interpersonal interactions in an implicitly formulated general equilibrium framework. Therefore, the best that econometric analysis of market price can hope to accomplish is to reveal the pattern of exchange characteristics that can be directly observed, i.e., the variations in price and quantity.

None of the characteristics that describe the seafood market has causal properties in and of itself; each is a manifestation of underlying human activity. On one side, commercial fishers require monetary equivalents for their harvest; on another side there is the institutional arrangement of wholesale dealers in transacting commodity exchange; and on a third side are the preferences of consumers concerning their consumption expenditures. Econometric analysis of the wholesale market for fresh bottom fish distills this behavior and social structure into a limited number of quantitative variables, but it is examination of, and experience with, the particular characteristics of this market, and the existence of a lengthy intellectual tradition pertaining to microeconomic analysis, that make this distillation practical and informative.

Assuming a competitive equilibrium market, price and quantity data represent the intersection of supply and demand where only the point of equality is revealed. Therefore, a time series is subject to an identification problem: What is being discovered, the demand or the supply relationship? This problem is solved in short-term analysis of a highly perishable product like fresh seafood by the prior restriction that supply be independent of price. Demand is considered stable over a year. The exogenous determination of quantity supplied to the market allows statistical determination of the demand curve from market data.

MARKET DATA

Basic data for this analysis come from two sources. The only publicly available long-term source of price and quantity information is the State of Hawaii's landing records. The Hawaii Division of Aquatic Resources (HDAR) requires all commercial fishers in Hawaii to report their sales of fish on a monthly basis. These data are summarized and provide a monthly time series of market volume and price by individual species. The HDAR data were

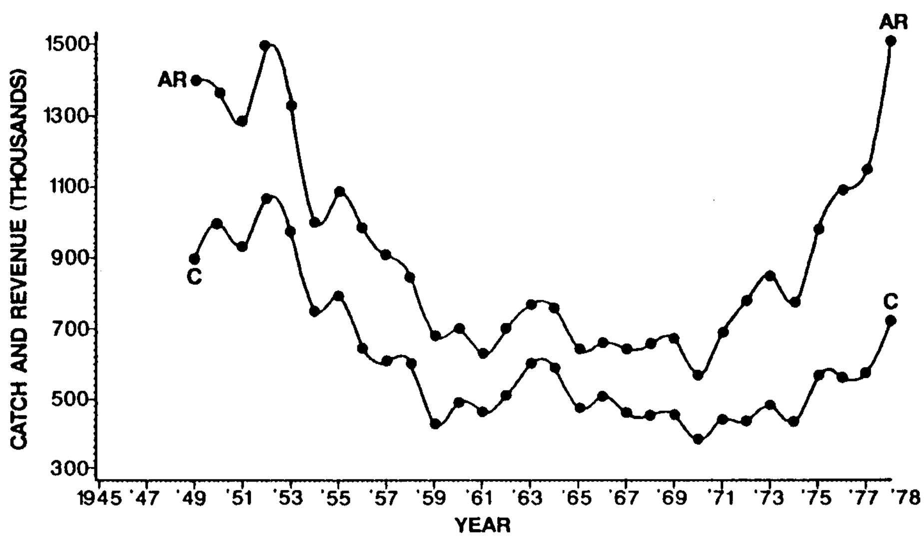


Figure 14.3 Bottom fish landings in Hawaii, 1949-1978 (AR = adjusted revenue in 1981 prices; L = catch in 1,000s of pounds)

TABLE 14.2
Hawaii fresh fish market: Monthly summary statistics, 1965-1982. N = 216

Variable Description	Variable Name	Average	Standard Deviation	Coefficient of Variation (%)	Logarithmic Mean
Pounds Sold					
Bottom fish	QBTTM	37,000	15,000	41	3.53
Group 1	QBTTM-G1	14,000	7,000	49	2.52
Group 2	QBTTM-G2	16,000	9,000	60	2.57
Group 3	QBTTM-G3	7,000	4,000	51	1.86
Tunas	QTUNA	825,000	621,000	75	6.46
Mahimahi and wahoo	QMAHI/ONO	21,000	15,000	71	2.75
Average Monthly Prices		**Inflation-Adjusted Prices Per Pound (December 1982 Price Level)**			
Bottom fish	PBTTM[R]	$2.09	0.42	20	0.72
Group 1	PBTTM-G1[R]	1.65	0.35	21	0.48
Group 2	PBTTM-G2[R]	2.01	0.59	29	0.66
Group 3	PBTTM-G3[R]	3.14	0.54	17	1.13
All fresh fish	PFISH[R]	1.11	0.44	40	0.02
Fresh fish, excluding skipjack tuna	PFISH-SJ[R]	1.55	0.35	23	1.55
Hawaii Demographics					
Defacto population	POP	900,000	95,000	11	6.79
Resident population	RES	841,000	31,000	53	6.73

(Continued)

TABLE 14.2 (Cont.)

Variable Description	Variable Name	Average	Standard Deviation	Coefficient of Variation (%)	Logarithmic Mean
Average daily visitor census	VISIT	59,000	--	--	3.91
Real disposable personal income per capita (monthly)	RDINC	$876	$112	13	6.77
Consumer dummy: 1=Jan., Dec., Mar., or Apr.; 0=normal demand	CD	0.25	--	--	--

available for bottom fish through December 1982. This analysis uses the data beginning in 1965, the year in which Hawaii's overall commercial fishery "bottomed out" following much higher sales following World War II. Figure 14.3 presents bottom fish landings in the postwar period and Table 14.2 presents average monthy values. The HDAR revenue figures are "adjusted" for inflation by basing all prices on the December 1982 consumer price index for Honolulu.

For the long-term analysis, monthly Hawaii population and tourist arrival information was obtained from regular State of Hawaii Department of Planning and Economic Development reports. Hawaii has experienced considerable growth in population and visitor arrivals (averaging roughly 2.5% annually since 1965), and the variables are highly correlated (r = 0.92). Data on real disposable personal income per capita (RDINC) were obtained from U.S. Bureau of the Census and Hawaii Department of Planning and Economic Development sources. The RDINC has declined since 1976 due to structural and cyclical economic factors in Hawaii's economy.

The source of short-term market information is the Council, which has a regular monitoring program of wholesale bottom fish purchases from Hawaii's commercial fishery. These data represent a large proportion of the entire fresh fish market in Hawaii and were collected throughout 1984. However, to protect the confidentiality of their source, the quantity data have been scaled to levels approximate to an estimate of the overall market volume. The data were aggregated into weekly quantities and prices, and summaries appear in Table 14.3.

TABLE 14.3
Hawaii fresh bottom fish market: Weekly, 1984. (MHI = main Hawaiian Islands; NWHI = Northwestern Hawaiian Islands)

Variable Description	Variable Name	Average	Standard Deviation	Coefficient of Variation (%)	Logarithmic Mean
Pounds Sold					
Bottom fish	QBTTM	24,700	11,200	45	9.9
Group 1	QBTTM-G1	5,700	3,900	68	8.42
Group 2	QBTTM-G2	13,900	7,500	54	9.34
Group 3	QBTTM-G3	5,100	3,500	69	8.25
MHI	QMHI	14,300	8,000	56	9.38
NWHI	QNWHI	10,300	7,000	68	8.98
Average Weekly Prices			**Price Per Pound**		
Bottom fish	PBTTM	$2.91	0.74	25	1.04
Group 1	PBTTM-G1	2.12	0.75	35	0.69
Group 2	PBTTM-G2	2.95	0.80	27	1.05
Group 3	PBTTM-G3	4.03	0.89	22	1.37
MHI	PMHI	3.31	0.88	27	1.16
NWHI	PNWHI	2.45	0.74	30	0.86
Consumer dummy: 1=peak season; 0=normal demand	CD	0.17	--	--	--

For both the long-term and short-term analysis, a consumer dummy variable takes on a value of 1 during peak demand periods (Christmas, New Year's, and Easter) and 0 otherwise.

METHODOLOGY

The basic question is: How do seafood consumers (or wholesale dealers acting on expectations of consumer behavior) react to changes in the supply of fresh bottom fish? If consumers have a number of substitutes for fresh bottom fish, then we can expect the price formation function to be relatively flat as consumers adjust their purchases to price. On the other hand, if consumers accept few substitutes, we would expect a steep demand curve and high price flexibility. It appears that the former is the case, but the purchase decision appears to be a "limited choice" decision, i.e., there is little likelihood of substitution to apparently comparable fresh fish when prices rise, and the range of purchases is limited.

With the assumption that the quantity supplied to the market by the commercial fishery is independent of price, at least in the short run, a simple linear model using ordinary least squares regression techniques can be applied to the price and quantity data to estimate the price formation curve. Although this is a rudimentary technique, it appears to be viable in this case.

Previous analysis of similar data indicated a problem with serial correlation of the residuals from regression analysis of the time series (Higuchi and Pooley Unpub.). Therefore, the data are transformed through an autoregressive lag technique called the Hildreth-Lu procedure, which corrects for such serial correlation. The autoregressive factor, g, is indicated for each equation. The equations are in the appendix.

Price flexibility coefficients are calculated from the regression coefficients of the price equations. Logarithmic conversion of the data provides continuous estimates of price flexibility from the regression coefficients. The logarithmic form also deals with some nonlinearities in the demand function. Although it is unlikely that consistency of the price flexibility parameter across the entire range of quantity applies, the results of the logarithmic and the linear models (equations not shown) showed no significant differences.

Substitution is examined for three groups of Hawaii's bottom fish taken from depth-groupings (Ralston 1979). All but two of the species are snappers.

Group 1: uku, Aprion virescens
ulua, Caranx spp. (jacks)

Group 2: gindai, Pristipomoides zonatus
hapuupuu, Epinephelus quernus (sea bass)
lehi, Aphareus rutilans
opakapaka, P. filamentosus

Group 3: ehu, Etelis marshi
kalekale, P. sieboldii
onaga, E. carbunculus

These groups, based on depth habitats, reflect neither commercial harvest nor market comparability characteristics. A simple factor analysis of prices and quantities for the nine species could find no stronger relationships, and an alternative specification of groups showed no stronger overall average bottom fish price-quantity relationship than the groups chosen, although individual group prices were better explained in some cases.

RESULTS

Short Run Demand, 1984

The weekly data for 1984 show a statistically significant negative price-quantity relationship for fresh bottom fish sales in Hawaii. The average weekly price of all bottom fish is negatively correlated with the weekly quantity supplied, and the relationship is statistically significant at the 99% confidence level (Equation 1). The same is true for monthly aggregations (Equation 2). The consumer dummy variable is also significant in both situations. Variation in quantity supplied and in the consumer dummy variable statistically explains half the price variation (R^2 = 53% for the weekly data and R^2 = 59% for the monthly data). The weekly price-quantity relationship, corrected for seasonal effects, is plotted in Figure 14.4. Interestingly, the price-quantity relationship for weekly bottom fish sales in 1984 is almost exactly the

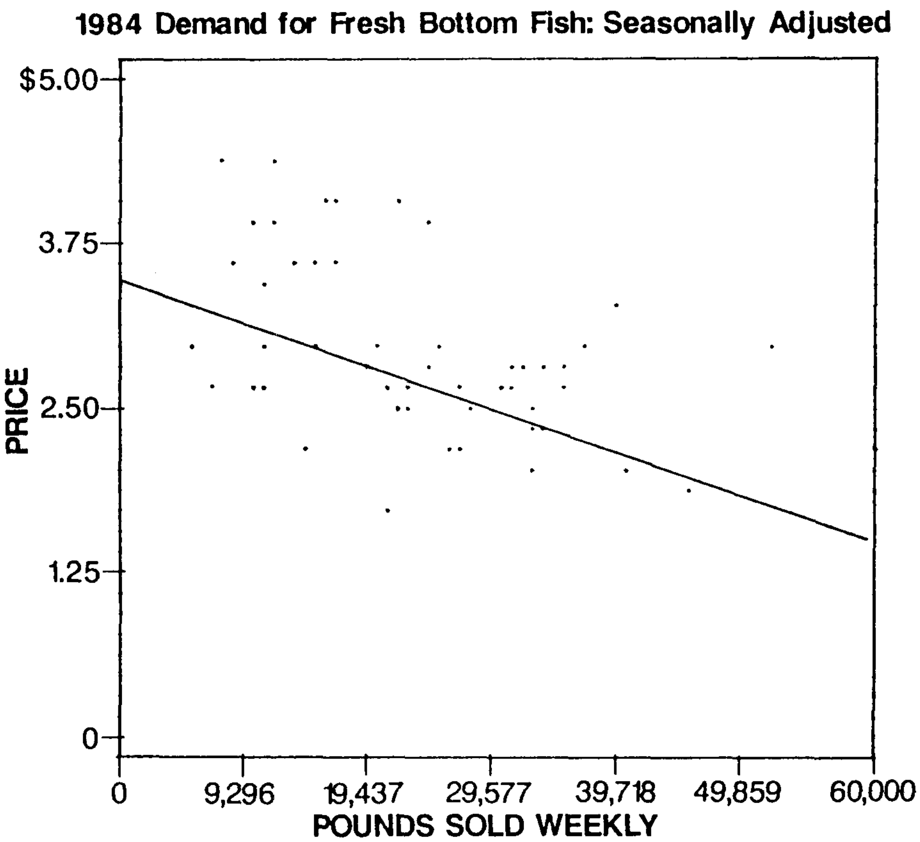


Figure 14.4 Demand for fresh bottom fish, 1984

same as a previous analysis based on 1976-1977 weekly sales (Higuchi and Pooley Unpub.).

The price flexibility coefficent calculated from the regression equation on weekly data is 23%, while the monthly coefficient is 42% (calculated from Equations 1 and 2) . This means that price does not vary as much as quantity. The average weekly market sales are 11 MT (25,000 lb) with a standard deviation of 5 MT (11,000 lb). A change in landings of one standard deviation raises or lowers price a predicted 30 cents, approximately 10%. Price volatility is occasionally much greater than predicted by this simple statistical technique. In most cases, wholesalers ride out reductions in the quantity supplied in the short run through short-term "inventories." However, if quantity is suppressed or increased for several weeks, then such discounting cannot be maintained and price will fluctuate more widely. This is shown by the higher price flexibility coefficient for monthly aggregations. The range in actual prices (one standard deviation) was ±$1.13, or a price flexibility of 100%.

Central to the fresh bottom fish market in Hawaii are quality premiums: Fish handled carefully and those caught closer to the Honolulu market have longer shelf life and commensurately higher prices. Although this price formation behavior can be observed at the Honolulu auction, specification of a quality factor is extremely difficult because it is only reflected in the judgment of bidders and final users. Fish caught in the MHI are caught nearer to the market (thus have longer shelf life) and are caught in smaller numbers (thus maximizing the potential for individual handling). This advantage is offset by the fact that NWHI fish are generally larger and thus have a larger yield and because the NWHI vessels have better refrigeration. Smaller fish are valued by many local consumers because they can be used as single meals, but larger fish are prized by restaurants for their fillets.

Using the 1984 market sample and discriminating between fish landed from the MHI and the NWHI, the conflicting effects of quantity and quality are revealed. A pooled cross-section time-series approach was used to test for price differences based on location of catch. Average weekly sales for each species group were divided into MHI and NWHI and pooled together into a data set where a dummy variable was used to specify the MHI fish. The source dummy is statistically significant (Equation 3) and indicates that fish landed from the MHI can expect approximately a 50% price "bonus" because of quality consideration. However, some fish from the NWHI are handled well and receive comparable prices and paradoxically, the more fish landed from the NWHI (variable QN:Q), the higher the average price. (This is explained by short-run supply effects whereby NWHI vessel operators attempt to land during peak demand periods or when rough weather restricts the smaller MHI vessels from fishing.)

Breaking quantity sold into species groups substantially improves the price formation function (Equation 4). The strongest simple correlation comes from the shallow water group (ulua and uku), which receives the lowest average price. Price flexibility for each of the species groups is also estimated (Equations 5-7).

One expects the determination of price to be improved by examining the market by species group. However, this leads to another interesting question: To what extent do landings of other species affect the price of a particular species? This relationship is termed cross-elasticity, and its effect is represented by the statistical significance of the regression coefficient for the quantity supplied of the alternative species group. These results (Equations 8-10) show a fair degree of separability for the high-priced groups (opakapaka and onaga), since the cross-elasticities are not large.

Examination of data for 1976-1977 shows almost no cross effects with other types of fresh seafood in Hawaii, e.g., tuna, mahimahi, and wahoo (Higuchi and Pooley Unpub.). Landings of one bottom fish group have some effect on the prices in the other bottom fish groups. However, landings in the rest of the fishery (i.e., tunas, mahimahi, wahoo, and marlins, etc.) seem to have no noticeable influence in the short-term price formation for bottom fish, which supports the idea that their short-term demand is relatively independent (see also Equation 14).

Another question important to Hawaii's commercial fishery is: To what extent is market price determined by relative landings from the two main harvesting areas? The strongest correlation with overall market price is with NWHI landings, which is not surprising since they provide larger fluctuations in volume (Equation 11). However, a price determination equation for the MHI alone shows that NWHI landings appear to have little causal effect on MHI prices, compared with the effect of MHI landings and the consumer dummy variable (Equation 12). Because landings from the MHI are considered of higher quality, their volume appears to determine their own price level independently of NWHI landings.

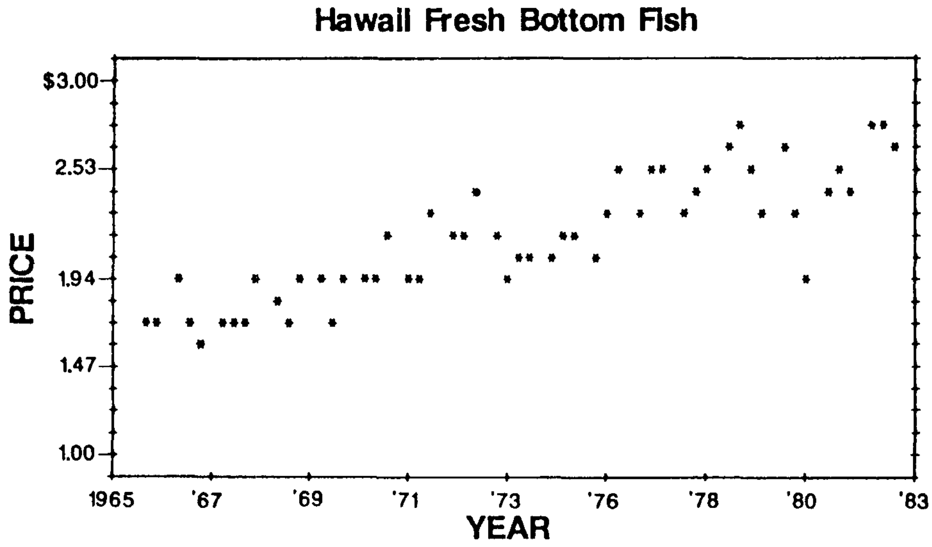
Long-Term Demand, 1965 to 1982

In the short run, one can assume that consumer demand for a product, such as fresh bottom fish, is rather stable, since consumer preferences are themselves relatively stable. However, in the long run, a number of factors will affect the market demand for a product. First, the size of the market may change through population growth or expansion into new markets such as restaurants, retail promotion, and exports. Second, the characteristics of consumers may change through a change in their disposable income (income after taxes), or their basic preference structures may change through advertising, perceived health effects, generational shifts, etc. Summary statistics for this period appear in Table 14.2.

Not surprisingly, the statistical information suggests that the strongest long-term impact on the price for bottom fish is the growth of Hawaii's de facto population (resident and tourist combined). The simple correlation between the resident population and the inflation-adjusted price for fresh bottom fish was statistically significant, $r = 0.441$. Relationships with actual landings, the seasonal dummy variable, and real disposable income per capita were much weaker. However, when placed in a linear regression format, seafood volume and the consumer seasonal dummy variable, as well as resident population, are highly significant, while real disposable income per capita is not (Equation 13). These variables "explain" 60% of the variation in the inflation-adjusted price of bottom fish over the period 1965-1982.

I also investigated the cross effect of other species groups on bottom fish prices and somewhat surprisingly found a strong negative relationship between local landings of tuna (ahi--yellowfin and bigeye tunas, and aku--skipjack tuna) and the price of bottom fish (Equation 14). A regression on the price of bottom fish with bottom fish, tuna, and mahimahi or wahoo landings (using the logarithmic transformations as before) as well as the consumer dummy variable "explains" 34% of the monthly variation in price over the 18-year period. The negative effect of tuna on bottom fish price suggests some substitution, while the positive effect of mahimahi and wahoo indicates the parallel marketing of these white-fleshed species (Takenaka et al. 1984). A 22,700 kg (50,000 lb) increase in the total supply of tuna reduces bottom fish prices by only 1.8 cents; however, this change in supply is <10% of the standard deviation for tuna landings.

Finally, although prices for fresh fish in Hawaii track together to a certain extent (Equation 15), the relationship is weaker than one might expect. Over the long term, the price of bottom fish rose more rapidly than the price of all fresh fish (Figure 14.5) except skipjack tuna, which increasingly shifted from the cannery to the fresh market in Hawaii. The nonskipjack tuna prices rose at an annual rate of 1.5%, of which bottom fish prices rose by 3.1% after adjustment for inflation. In terms of the three species groups, prices tracked quite closely for the two groups with the highest percentage of catch in the NWHI, i.e., the ulua-uku and opakapaka groups (Table 14.4). The opakapaka group had the strongest time-trend



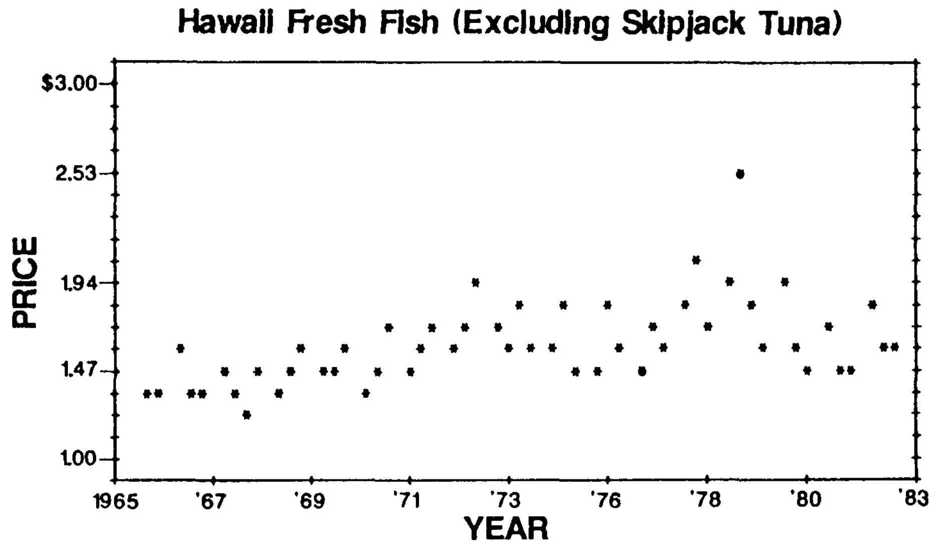


Figure 14.5 Inflation-adjusted prices for fresh bottom fish and all species, excluding skipjack tuna, Hawaii 1965-1982

(r = 0.809) and the onaga-ehu group had the lowest (r = 0.302). This also suggests the importance of the restaurant market, which has promoted opakapaka, compared with the traditional home market, which prizes onaga, for growth in the demand for fresh bottom fish in Hawaii.

TABLE 14.4
Hawaii bottom fish prices (inflation-adjusted) 1965-1982 simple correlations. All correlations are significant at the 99.9% confidence level. Monthly average prices for bottom fish and bottom fish groups

	Simple Correlation Coefficients			
	PBTTM	PBTTM-G1	PBTTM-G2	PBTTM-G3
PBTTM[R]	1			
PBTTM-G1[R]	0.888	1		
PBTTM-G2[R]	0.864	0.731	1	
PBTTM-G3[R]	0.643	0.454	0.523	1
Month (1-216)	0.664	0.596	0.809	0.302

CONCLUSION

The evidence obtained from examining the interaction of pounds sold and prices in Hawaii's fresh fish market suggests that factors affecting the supply of fresh bottom fish and exogenous changes in Hawaii's markets, especially in the growth of the domestic and export markets, may have important effects on prices. As a result, to the extent that wholesale prices are parallel to ex-vessel prices, the incomes available to the commercial fishery will be affected. The commercial fishers in Hawaii have long worried about large swings in the price for fresh fish, particularly on the "down" side, such that the total revenue to the vessel (and hence its captain, crew, and owner) is actually reduced despite increased landings. In particular, MHI vessel operators worry that landings from the larger vessels which ply the NWHI and make less frequent landings will flood the market and reduce income for the MHI fishery. The same problem also affects the NWHI vessel operators who depend on some type of price stability to rationalize their fishing schedules.

The average "swing" in the Hawaii bottom fish market in terms of pounds sold, prices, and gross revenues is substantial: pounds and revenue vary by 45% weekly, while prices vary by 25% (Table 14.3, coefficient of variation). In other words, although prices and quantities tend to be negatively related, there are sufficiently large exogenous effects on the market so that the income effects of "swings" may be considerable. Thus not only are Hawaii's commercial fisheries related in terms of the resource, they are linked in the market.

A particularly visible example is the effect of the newly developed NWHI bottom fishery. Using somewhat hypothetical cost and catch rate data, one NWHI vessel unloads a total of 4,500 kg (10,000 lb) of mixed bottom fish at the end of a normal trip, based on 1984 data. The captain can expect an average price of $2.45 per pound for the catch, $25,000 in gross revenue, a crew share of some $10,000, and a net income (after all expenses) of approximately $1,500 (Hau 1984; and unpublished vessel simulators by Pooley). At the same time, some 20-40 MHI vessels (fishing relatively full-time) can expect a price of $3.31 based on their total landings of 6,400 kg (14,000 lb). This would represent weekly crew incomes of $400 per person and net vessel incomes of $300 per vessel after expenses (data from NMFS cost-earnings surveys (Lyman and Hawaii Opinion 1984) and unpublished vessel simulators).

If an **additional** NWHI vessel off-loaded during a particular week, total landings would increase by 4,500 kg (10,000 lb), increasing total market volume by 42%. Average prices would fall approximately 10%: for the NWHI vessels to approximately $2.20 and for MHI vessels to $3.00 (using Equation 1 and Table 14.3). The effect on gross sales is still positive: Gross sales increase from $70,800 to $86,000, or 17.5%. However, the effect on the individual vessels is, of course, negative: Each NWHI vessel gets $2,500 less than otherwise and each MHI vessel gets $150 less. This translates into smaller crew shares and net returns per vessel. Similar effects could occur from other factors which would increase landings for one sector of the overall fishery and not another, such as increased sales by "recreational" fishers.

These competitive effects are well known and are a substantial reason why the fishing industry favors some form of management. Fishery managers, however, usually concentrate on the biological effects of overfishing on fish stocks without as much attention to the overall economic effect of such decisions. Yet simply by affecting the **timing** of total landings (optimized at whatever long-run level), fishery managers can have substantial effects on short-run liquidity and long-run profitability for harvesters and processors.

Seasonal closures and quotas (including the currently popular share system known as "individual fishermen's quotas"), which tend to "clump" landings early in the quota period, may depress incomes for vessels landing any species subject to price flexibility. (There are of course other effects.) Consumers, on the other hand, would be faced with higher prices during the off-season, during which MHI vessels would receive relatively higher prices. While such price effects are frequently not relevant for "industrial" fisheries such as tuna, shrimp, and rockfish, it is certainly the case for fresh snappers.

For example, in Hawaii's fishery, a 2-month closure of the NWHI with no effect on total annual landings (implying increased effort during the "on-season" and no shifting of effort into the MHI) would increase weekly landings during the on-season by 910 kg (2,000 lb). This would have only a marginal impact on prices, which might be expected to decline by 5 cents. However, for the NWHI vessels, which are incurring larger costs during the on-season, this will affect total net income, reducing their annual gross sales by $27,500. During the off-season, the amount of bottom fish available in the Hawaii market would decline by 4,800 kg (10,500 lb) per week. This would increase prices by 28 cents per pound, on average, and thus increase the value of the MHI catch during the off-season by a total of $40,000. The net gross sales effect of the price changes in the two seasons would be almost exactly offset for the MHI fleet.

The Council calculates that the maximum sustainable yield (MSY) for the NWHI fishery is approximately 320,000 kg (700,000 lb) of mixed bottom fish (Council 1985). This is approximately 30% more than was landed in 1984 as the fishery was still developing. This increase in landings might be expected to depress market prices until additional export markets are found: The price effect would be 19 cents, so that gross revenue would increase by only 20%.

If the fishery stabilizes at MSY over the long term, and Hawaii's domestic market grows because of population effects, then there would be a positive price effect. The State projection of population in 1990 is for a 10% increase. The price effect of a growing market would be 45 cents (15.6%), raising gross revenue on the MSY level of landings by $300,000.

The market for fresh bottom fish in Hawaii appears to be much as the markets for snappers are throughout the world--a market for a product highly valued with significant quality premiums. Short-run (weekly) fluctuations in landings are reflected in price but perhaps less than the commercial fishers might expect. Medium-run (monthly) fluctuations are greater and indicate the kind of problems that might arise with management measures affecting the scheduling of landings (such as annual catch quotas or seasonal closures). At the same time, the market seems capable of domestic expansion, which increases the potential biological pressure on fish stocks. Proposals for managing Hawaii's bottom fish may have to reflect the quality premiums that exist for fish coming from the MHI as well as the weak substitutability between species, especially in the case of opakapaka (Pooley 1985). Whether a high-quality frozen product would be acceptable in Hawaii and whether it would compete with the MHI catch or with frozen snapper imports is another important issue.

The total income effects shown in this section are not dramatic because of the relatively low short-term price flexibilities and small landings volume in Hawaii's fishery. However, for this small-scale industry, which is similar to other snapper fisheries throughout the world, the individual effects are important. Perhaps the state of fisheries science is not sufficiently precise to emphasize the effect of the market on the impact of fisheries regulations and development, but a general awareness of such effects would seem to be an important contribution to obtaining the highest level of social value from these unique resources.

NOTES

Appreciation but neither blame nor responsibility to three reviewers: L. Hudgins, D. Squires, and J. Waters.

1. The recorded supply of fresh bottom and reef fish in Hawaii is only some 1,250 MT (2.5-3 million lb). The discrepancy with the retail survey is not explained but may relate to double counting on the retail side (i.e., resale) and undercounting on the harvest side (through "back door" sales).

2. Disequilibrium models are not applicable to fresh fish markets.

3. Data manipulation was assisted by Jim Baxter, computer aid, and Wesley K. Higuchi, mathematics aid.

4. Kurt Kawamoto of the Western Pacific Regional Fishery Management Council was responsible for this data collection.

5. A value of -1.0 on the regression coefficient for quantity purchased (Qd) indicates price and quantity changes are strictly (negatively) proportional and the price flexibility coefficient is 100%. A value less than -1 indicates an inelastic demand where price changes relatively more than pounds sold. A coefficient of -2.0 translates into a price flexibility of 200%. A value between 0 and -1 indicates an elastic demand where pounds sold change relatively more than price. A coefficient of 0 shows a price flexibility of 0 and a coefficient of -0.50 translates into a price flexibility of 50%. However, translation of elasticities into price flexibilities, especially between ex-vesssel and retail levels, is somewhat suspect (Manderscheid 1964; Houck 1965).

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APPENDIX EQUATIONS

All equations involve logarithmic transformation of the continuous variables. The variables are also transformed to account for significant levels of serial correlation (determined by the Durbin-Watson test) through the Hildreth-Lu procedure (Pindyck and Rubinfeld 1981). The regression estimates are calculated using ordinary least squares techniques.

The results are given in the following form: The first line presents the equation number, a brief description, and the data source. The second line presents the dependent variable on the left and the independent variables on the right; the third line presents the beta coefficients of the regression; the fourth line presents the t-statistics; the fifth line presents summary information on the equation, including the coefficient of multiple determination (R^2), the resultant Durbin-Watson (DW) statistic for serial-correlation, the Hildreth-Lu serial-correlation correction factor (g), and the number of observations. Abbrevations for each variable are introduced below the equation. The quantity data are in pounds and prices by per pound. Statistical significance is represented by an asterisk (*), corresponding to a 95% confidence level.

All values are in natural logarithms except for the consumer dummy variable.

Equation 1: Hawaii bottom fish demand--1984 weekly wholesale data

PBTTM =	CNST	QBTTM	CD
Beta	3.24	-0.23	0.42
t-statistic	-4.73*	5.14*	

R^2 = 48.5%, DW = 1.93, g = 0.2, N = 51

BTTM: The average price per pound of bottom fish, natural logarithms

QBBTM: The average quantity of bottom fish sold in pounds per period, natural logarithms

CNST: The constant

CD: A consumer dummy variable taking the value of 1 for the high demand season and the value of 0 for the low demand season

***Significant at the 95% confidence level.**

Equation 2: Hawaii bottom fish demand--1984 monthly wholesale data

PBTTM =	CNST	QBTTM	CD
Beta	5.68	-0.42	1.04
t-statistic		-3.33*	2.21

R^2 = 55.9%, DW = 2.07, g = 0.8, N = 12

Equation 3: Hawaii bottom fish demand by source of supply--pooled 1984 MHI and NWHI weekly data

PB:N:M =	CNST	QBTTM	QN:Q	CD	M:N:S
Beta	2.62	-0.20	0.34	0.29	0.36
t-statistic		-4.00*	2.91*	4.29*	6.92*

R^2 = 45.3%, DW = 1.88*, g = 0, N = 104

PB:M:N: Average weekly price of bottom fish landed either from the MHI or NWHI, natural log

QN:Q: Ratio of NWHI landings to total landings for the week

M:N:S: A dummy variable valued 1 for MHI landings and 0 for NWHI landings

Equation 4: Hawaii bottom fish demand by group--1984 weekly wholesale data

PBTTM =	CNST	QBTTMG1	QBTTMG2	QBTTMG3	CD
Beta	2.99	-0.13	-0.13	0.04	0.35
t-statistic		-3.30*	-2.90*	0.97	4.11*

R^2 = 54.5%, DW = 1.91*, g = 0.2, N = 50

QBTTMG1: Quantity for bottom fish group 1 (uku and ulua), natural log (equivalently for other groups)

Equation 5: Hawaii bottom fish demand group 1 (ulua and uku)--1984 weekly wholesale data

PBTTMG1 =	CNST	QBTTMG1	CD
Beta	1.52	-0.11	0.47
t-statistic		-1.64	3.87*

R^2 = 30.9%, DW = 1.84*, g = 0, N = 52

Equation 6: Hawaii bottom fish demand group 2 (opakapaka, et al.)--1984 weekly wholesale data

PBTTMG2 =	CNST	QBTTMG2	CD
Beta	3.04	-0.22	0.41
t-statistic		-6.19*	6.06*

R^2 = 57.5%, DW = 1.77*, g = 0, N = 52

Equation 7: Hawaii bottom fish demand group 3 (onaga, et al.)--1984 weekly wholesale data

PBTTMG3 =	CNST	QBTTMG2	CD
Beta	3.31	-0.11	0.31
t-statistic		-3.48*	1.96

R^2 = 29.8%, DW = 1.96*, g = 0.6, N = 52

Equation 8: Hawaii bottom fish group 1 (ulua and uku) cross effects--1984 weekly wholesale data

PBTTMG1 =	CNST	QBTTMG1	QBTTM2&3	CD
Beta	2.98	-0.08	-0.18	0.54
t-statistic		-1.25	-2.85*	4.70*

R^2 = 40.9%, DW = 2.17*, g = 0, N = 52

QBTTM2&3: Quantity for groups 2 and 3 combined, natural log (equivalently for other groups)

Equation 9: Hawaii bottom fish group 2 (opakapaka, et al.) cross effects--1984 weekly wholesale data

PBTTMG2 =	CNST	QBTTMG2	QBTTM1&3	CD
Beta	3.43	-0.19	-0.08	0.39
t-statistic		-4.36*	-1.26	5.77*

R^2 = 57.5%, DW = 1.75*, g = 0, N = 52

Equation 10: Hawaii bottom fish group 3 (onaga, et al.) cross effects--1984 weekly wholesale data

PBTTMG3 =	CNST	QBTTMG3	QBTTM1&2	CD
Beta	3.58	-0.10	-0.03	0.32
t-statistic		-2.65*	-0.53	1.97

R^2 = 23.9%, DW = 2.03*, g = 0.6, N = 50

Equation 11: Hawaii bottom fish demand by source--1984 weekly wholesale data

PBTTM84 =	CNST	QMHI	QNWHI	CD
Beta	2.12	-0.10	-0.03	0.43
t-statistic		-2.04*	-0.88	4.08*

R^2 = 32.9%, DW = 2.02, g = 0.2, N = 47

QMHI: Quantity landed from main Hawaiian Islands, natural log

QNWHI: Quantity landed from Northwestern Hawaiian Islands, natural log

Equation 12: Main Hawaiian Islands bottom fish prices--1984 weekly wholesale data

PMHI =	CONST	QMHI	QNWHI	CD
Beta	2.29	-0.16	0.03	0.38
t-statistic		-3.43*	1.21	3.84*

R^2 = 15.53%, DW = 1.98*, g = 0.2, N = 44

PMHI: Average price for bottom fish landed from the main Hawaiian Islands, natural log

Equation 13: Hawaii commercial landings, bottom fish demand--HDAR monthly data, 1965-1982 (prices adjusted by the December 1982 consumer price index for Honolulu)

PBTTM[R] =	CNST	RES	RDINC	QBTTM	CD
Beta	-9.29	1.56	0.05	-0.23	0.145
t-statistic		11.30*	0.67	-8.45*	4.25*

R^2 = 44.9%, DW = 2.12, g = 0.4, N = 214

PBTTM[R]: Inflation-adjusted price of bottom fish, natural log

QBTTM: Quantity of bottom fish (1,000s lb), natural log

RES: Resident population in Hawaii (1,000s), natural log

RDINC: Real disposable income per capita in Hawaii, (inflation-adjusted), natural log

Equation 14: Hawaii commercial landings, cross effects--HDAR monthly data, 1965-1982 (prices adjusted by the December 1982 consumer price index for Honolulu)

PBTTM[R] =	CNST	QBTTM	QTUNA	QMAHI	CD
Beta	1.78	-0.18	-0.13	0.13	0.12
t-statistic		-5.98*	-7.02*	6.65*	3.03*

R^2 = 33.5%, DW = 1.88*, g = 0.4, N = 214

QTUNA: Quantity of fresh market tuna (1,000s lb), natural log

QMAHI: Quantity of mahimahi and wahoo (1,000s lb), natural log

Equation 15: Hawaii bottom fish price trends--HDAR monthly data, 1965-1982 (prices adjusted by the December 1982 consumer price index for Honolulu)

PBTTM[R] =	CNST	PFISH[R]
Beta	0.71	0.29
t-statistic		8.85*

R^2 = 25.7%, DW = 2.08*, g = 0.4, N = 214

PFISH[R]: Price of all species, inflation-adjusted, natural log