MARKET POTENTIAL OF THE SAN PEDRO WETFISH FISHERY: A DEMAND ANALYSIS APPROACH

DARREL A. NASH
National Marine Fisheries Service
College Park, Maryland

How can profits be improved in the San Pedro wetfish fishery? I think that is the central theme in the proceedings today. There are several facets of this problem. The resource base, vessel and gear efficiency, access to the resource, all are factors. Another most important consideration is the market potential for these products in terms of expected growth of the market, how variations in total landings affect prices and profits, and how the prices of one product affect another. This paper shows how profits are expected to be affected by changes in landings, prices, and changes in the general economy.

We all recognize that there have been several drastic changes in this fishery which are only loosely, if at all, related to economic forces. Therefore, some of the associations found between the fishery and these economic factors may be only apparent. Prices received by the fishermen and the amount sold to canners, at least in the short run, are not entirely a free market. Prices are generally set before the start of the fishing season and the canneries set quotas on purchases from the fishermen. Ideally, for an economic analysis, data are available which have been generated by prices and quantities which adjust freely to market forces.

Having expressed these cautions, we were pleasantly surprised at the results of a price and demand analysis of this fishery. The economic and statistical tests applied to the results show that several demand relations have been successfully estimated. The interpretation of the results, however, must be somewhat guarded.

I would like to cover briefly why demand analysis is undertaken and what we hope to accomplish by such efforts. Demand analysis is done to determine what factors — what economic forces—cause prices and quantities purchased to be at certain levels. Fishermen are well aware of price variations for fish and probably have a fairly good understanding of why prices behave as they do. Demand analysis attempts to isolate and quantify the net effects of the major factors affecting price and quantity. There are implications to be drawn as to profit potential based on the particular characteristics of the results. Armed with this knowledge, fishermen and processors can do several things. One is that by knowing what factors affect price and quantity purchased they can see the future courses of the market potential for their product. Secondly, revenue changes resulting from changes in amount sold can be determined. Finally, the results may indicate opportunities for changing demand through advertising, product development, and similar market expansion activities.

If you will permit, I will take a few minutes to review the general approach to demand analysis and discuss the expected outcome. According to economic principles, we expect that the amount of a product which is purchased is determined by price, consumer income, population, and prices of other products which are substitutes for the one under consideration.

The direction of the effect is also specified by these principles. As prices increase, we expect the amount purchased to decrease. Looking at it from another direction, as more is offered for sale, price must decrease in order to clear the market. Population and income increases are expected to increase the amount purchased. These are the two "growth variables" in most of the world today, and those products which are greatly affected by population and income are in an extremely fortunate position since both population and income are increasing steadily. On the other hand, there are some products which diminish in consumption as income increases. These are the losers, you might say, in the competition for the consumers' dollar. Consumption patterns differ by various socioeconomic characteristics of the population. Thus as these characteristics change over time, consumption of certain products will also change. Prices of substitute products tend to cause the amount of the product under consideration to move in the same direction. If the price of a good substitute goes down, you are likely to buy it, and therefore the quantity sold of another product goes down.

The next step is to put these theoretical economic relationships to work in obtaining statistical estimates.

The means used to derive the statistical estimates in this case is multiple regression analysis. This method, as you probably know, fits a functional relationship among the several variables in the analysis. Tests are applied to the estimates, both economic and statistical, to determine if our estimates can be accepted as valid.

I want to go directly to the estimates of demand and market potential which were estimated for the San Pedro wetfish fishery. This was done at two market levels—the landing and the wholesale level (that is sales f.o.b. the canners).

At the landing level, prices and quantities were analyzed using California data from 1950 to 1966 based on *Fishery Statistics of the U.S.* The species were Pacific mackerel, jack mackerel, anchovies, sardines, bonito, and bluefin tuna. Since the future resource availability of sardines is in question, the sardine analysis may be merely a study of history, however, the results are interesting.

A series of equations were run treating quantity landed as affected by all other variables, and a second set considers price as affected by the others. Other variables included were the prices of the other wetfish species and annual consumer income in the U.S. At the landings level total annual income was used, rather than per capita income. In this way the variable measures the effect of both population and income increases.

Mackerel

I think the best way of showing the results is to present one product at a time and discuss various analyses of each. So let's look at table 1 which shows the results of the mackerel analysis.

TABLE 1A

Price and Demand Analysis of California Mackerel (Landings Level)

Prob. No.	Dependent Variable	Statistic	Independent Variable: Price of Jack Mackerel	Price of Pacific Mackerel	Landings of Jack Mackerel	Landings of Pacific Mackerel	Consumer Income	a	R^2	D.W.
1	Jack Mackerel Landings	b	−3.86	2.95			−.33	8.18	.40	1.75[1,3]
		t	(2.66)[4]	(1.88)			(.21)	(.90)		
2	Price of Jack Mackerel	b		.79	−.10			.74	.89	2.36[1,3]
		t		(9.70)[4]	(2.88)[4]			(3.38)[4]		
3	Pacific Mackerel Landings	b	.26	−1.94				77.31	.68	1.87[3]
		t	(.311)	(2.72)[4]				(7.94)[4]		
		e	.21	−1.69						
4	Price of Pacific Mackerel	b	.75			−.0002		14.00	.87	1.74[3]
		t	(4.53)[4]			(2.72)[4]		(2.52)[4]		
		e	.69			−.22				

[1] logarithmic equations
[2] no autocorrelation 5 percent confidence level
[3] may or may not be autocorrelation at 5 percent confidence level
[4] significant at the 5 percent confidence level
e = percentage change in the dependent variable for a one percent change in the independent variable

TABLE 1B

Price and Demand Analysis of California Mackerel (Canners Level)

Prob. No.	Dependent Variable	Statistic	Independent Variable: Price of Canned Mackerel	Price of Tuna-Like Fishes—Canned	Price of Canned Alewives	Pack of Mackerel	Consumer Income	a	R^2	D.W.
5	Pack of Mackerel	b	−3.56	.79	.134			.43	.46	1.72[3]
		t	(3.27)[4]	(1.34)	(.05)			(1.46)		
		e	−2.22	1.34	.06					
6	Price of Canned Mackerel	b		.131	.39	−.00008	.00001	.05	.56	1.45[3]
		t		(1.22)	(.88)	(2.18)[4]	(1.41)	(.81)		
		e		.36	.26	−.13	.13			

[3] may or may not be autocorrelation at 5 percent confidence level
[4] significant at the 5 percent confidence level
e = percentage change in the dependent variable for a one percent change in the independent variable

At the landings level, the first step was to determine which of the other products of the wetfish fleet affected the price or sales of mackerel. This showed that only the two types of mackerel are related. Problems 1 through 4 show the relationships.

Table 1A will be discussed in some detail to explain the meaning of the various figures. The first row in each problem shows the coefficients of each variable, or the units of change in the dependent variable associated with a one unit change in the independent variable. For the logarithmic equations (problems 1 and 2), the changes may be considered to be in percentage terms, while the linear equations (problems 3 and 4), are in the units (pounds and dollars) used to make the estimates. For example, problem 1 shows that for a one percent change in the price of jack mackerel, landings change a net amount of 3.86 percent in the opposite direction, and that for a one percent change in the price of Pacific mackerel, jack mackerel landings change 2.95 percent in the same direction. The figures in parentheses—the second row—indicate how much confidence can be placed in the estimate directly above it. As a rule of thumb, if the t-value is greater than 2.0, we can be confident our results are accurate within a statistical tolerance. Even if some do not pass this test, our feeling is that in many cases these should be used rather than saying we have no information at all. The D.W. (Durbin-Watson) statistic tests whether the equation has been properly formulated. Generally, D.W. statistics between 1.5 and 2.5 indicate an acceptable equation.

The "e" values of problems 3 and 4 have the same economic meaning as the "b" values in problems 1 and 2. A logarithmic equation gives results directly in percentages, while for the linear equations, this must be computed. The percentage change is very important as it measures how profits are affected by changes in quantity and price. The relative percentage change between dependent and independent variables is known as the elasticity.

The four problems on mackerel taken in total, I think, give us quite a bit of understanding of the price-making forces in these markets. The strongest relationship is between the two prices (note the t-values in equations 2 and 4). As we expect according to our reasoning above, there is an inverse relation between price and landings (a negative sign), and a direct relation between the price or quantity of a product and the price of the substitute. All four of the equations show that for each of the two species the price and landings are definitely related. Although the relationships are quite strong, prices do not show great *percentage* changes in response to changes in landings. For example, in equation 2 a one percent increase in landings of jack mackerel would result in a .1 percent decrease in the price of the product.

A similar analysis was done at the canners (or wholesale) level shown in table 1B. First, prices of other canned fish products which may affect the products canned from the wetfish fishery were included. There is some indication of a relationship between "tuna-like fishes" and mackerel in both problems 5 and 6. As in the problems at the landings level, the strongest relationship in both equations is between price and quantity of the same fish. Again prices do not respond very much to a change in pack. There is a weak positive relation of mackerel price to consumer income. However, this cannot be considered as a major price determinant.

Mackerel Imports

A continuing factor of concern to U.S. fishermen is the effect of imports on the domestic fishery. Equations 5 and 6 were rerun including imports as a variable. We can report that this analysis came out about the same as most other attempts so far to measure the effects of fish imports—that is, the results were inconclusive. There is some evidence from the analysis that imports change in the opposite direction to domestic production, and change in the same direction as domestic price, indicating that a price increase attracts imports. This should not be considered as a conclusive analysis but does show what a preliminary look revealed.

Anchovies

After mackerel, which currently is the mainstay of the fleet, the most interest lies in anchovies, which may become an important resource for the wetfish fleet. The anchovy equations are shown in table 2. These also show a strong relationship between price and quantity and that prices change considerably less percentagewise than do landings. In this case, a one percent increase in landings results in a .14 percent decline in price (problem 8). The t-values again confirm that these two factors are strongly related. Jack mackerel prices seem to affect anchovy landings and prices, probably reflecting a tendency for buyers to use the major product of the fishery as a basis for establishing price offers. The price effect of Pacific sardines can be safely discounted. The negative relationship between consumer income and prices is attributed to the decline of the resource more than to a lowering of demand for the product.

Bonito

Again in table 3 we find a strong relationship between price and landings of bonito. There is also a very strong association between sardine price and bonito price and landings. There is also a weak relationship shown from price of Pacific mackerel, however, this can probably be safely discounted. There is a strong *negative* association between consumer income and bonito price. We feel this mainly represents a concurrent downward trend in price and upward in income, without any causal relationship between the two.

We did not learn very much about the demand for bonito at the canners' level. As an attempt to analyze this market, data on "tuna-like fishes" were used. Probably due to the conglomerate, statistical measurement is difficult. Problem 11 is shown as an example of several tried. Price and quantity packed seem to move in the same direction, which runs counter to the principle set out earlier.

TABLE 2

Price and Demand Analysis of California Anchovies (Landings Level)

Prob. No.	Dependent Variable	Statistic	Price of Anchovies	Landings of Anchovies	Price of Jack Mackerel	Price of Pacific Sardine	Consumer Income	a	R^2	D.W.
7	Landings of Anchovies	b	−2.91		4.44	−.67		2.49	.48	.77[1]
		t	(2.15)		(3.09)[4]	(1.15)		(1.40)		
8	Price of Anchovies	b		−.14	.61	.02	−.58	4.07	.67	1.11[1]
		t		(3.60)[4]	(2.84)[4]	(.21)	(2.72)[4]	(3.33)[4]		

[1] logarithmic equation
[4] significant at the 5 percent confidence level

TABLE 3

Price and Demand Analysis for Bonito (Landings Level)

Prob. No.	Dependent Variable	Statistic	Independent Variable: Price of Bonito	Price of Sardines	Price of Pacific Mackerel	Bonito Landings	Consumer Income	a	R^2	D.W.
9---	Bonito Landings	b	−.17	.14	.16		−.05	18.00	.85	2.07[2]
		t	(2.32)[4]	(4.07)[4]	(1.25)		(1.78)	(1.75)		
		e	−2.34	1.57	.14		−4.25			
10---	Price of Bonito	b		.53		−.04	−2.32	13.77	.97	2.13[1,2]
		t		(9.63)[4]		(1.77)	(19.81)[4]	(23.30)[4]		

(Canners Level)

			Price of Tuna-like fishes		Price of Canned Mackerel		Price of Canned Tuna			
11---	Pack of Tuna-like fishes	b	.33		.091		−.01	−.07	.66	1.94[2]
		t	(3.79)[4]		(1.94)		(.18)	(2.44)[4]		
		e	2.19		.71		−.09			

[1] logarithmic equations
[2] no autocorrelation 5 percent confidence level
[3] may or may not be autocorrelation at 5 percent confidence level
[4] significant at the 5 percent confidence level
e = the percentage change in the dependent variable for a one percent change in the independent variable

Sardines

Table 4 shows that Pacific sardines at the landings level are affected by the same market forces as bonito. Prices, as in the case of all other products analyzed, are very strongly related to landings. The percentage change in price (.13) is quite low for a one percent change in landings. In problem 13 an upward trend in sardine prices accompanies an increase in consumers' income. Sardines were not analyzed at the canners' level.

TABLE 4

Price and Demand Analysis of Pacific Sardines (Landings Level)

Prob. No.	Dependent Variable	Statistic	Independent Variable: Price of Sardines	Price of Bonito	Landings of Sardines	Pack of Sardines	Consumer Income	a	R^2	D.W.
12---	Sardine Landings	b	−2.63	.99				6.89	.87	1.88[1,2]
		t	(8.47)[4]	(2.92)[4]				(8.54)[4]		
13---	Price of Sardines	b		1.25	−.13		2.80	−15.39	.94	2.56[1,3]
		t		(5.77)[4]	(2.96)[4]		(4.82)[4]	(4.14)[4]		

[1] logarithmic equations
[2] no autocorrelation 5 percent confidence level
[3] may or may not be autocorrelation at 5 percent confidence level
[4] significant at the 5 percent confidence level

TABLE 5A

Price and Demand Analysis for Bluefin (Landings Level)

Prob. No.	Dependent Variable	Statistic	Independent Variable: Price of Bluefin	Price of Jack Mackerel	Bluefin Landings	a	R^2	D.W.
14---	Bluefin Landings	b	−5.25	1.87		12.80	.46	1.42[1,3]
		t	(3.45)[4]	(2.32)[4]		(4.67)[4]		
15---	Price of Bluefin	b		.33	−.08	2.04	.65	1.69[1,3]
		t		(4.02)[4]	(3.44)[4]	(13.44)[4]		

[1] logarithmic equations
[2] no autocorrelation 5 percent confidence level
[3] may or may not be autocorrelation at 5 percent confidence level
[4] significant at the 5 percent confidence level

TABLE 5B

Price and Demand Analysis for Bluefin (Canners Level) [5]

Prob. No.	Dependent Variable	Statistic	Price of Tuna	Price of Salmon	Price index of meat, poultry and fish	Consumer Income	a	R^2	D.W.
16	Per capita consumption of tuna	b t	−.99 (7.19)	.15 (.94)	−.22 (.73)	1.41 (6.78)	−2.40	.97	1.28[1]

[1] logarithmic equations
[5] from Bell, Frederick W., "Forecasting World Demand for Tuna to the Year 1990, "*Commercial Fisheries Review*, Bureau of Commercial Fisheries, U.S. Department of the Interior, December 1969, p. 24.

Bluefin

Bluefin prices and landings are strongly related to jack mackerel price (table 5A), although the reverse was not shown to be true. As in the case of anchovies, this probably reflects the tendency to base prices on the major product. The price and landings as before, are highly related.

At the canners' level (table 5B) bluefin is undoubtedly affected by the same factors affecting all tuna. Equations for all types of tuna combined have been previously derived. One such equation is problem 16. This can be considered to show the factors affecting bluefin sales. In this case we find that in the present market the relation between per capita consumption and price is such that the cost to the consumer is constant. Note also that rising incomes will cause tuna consumption to increase about 1.4 percent for each 1 percent increase in income.

Implications

We have some idea now of how the various products of the fishery are related to each other in a statistical sense. Most of these results also find support in economic expectations. As for any analysis, the question is "So what?"

One very important finding, which we might say is "bad news," is the lack of any strong relationship between landings or pack and consumer income except in the case of tuna and sardines. Therefore, we cannot count on rising income to cause growth in the size of the market for the major species of the fishery. At the landings level the income was total income—not per person or per capita—so even population increase cannot be counted on to increase market size.

The other major finding we may classify as "good news." This is the matter of how sensitive prices are to landings, or vice versa. In every case analyzed, it was shown that prices change percentagewise very little in response to changes in landings. From the standpoint of the seller (the fisherman and canner) this means that they probably should produce more because gross receipts will increase. That is, the receipts from added landings will more than compensate for a price fall due to more products available on the market.

Note that I said, "Should probably produce more." The reason for the uncertainty is that it is not the gross receipts that make the difference on the profit and loss statement—it is the net earnings after expenses are covered. Fortunately in this case, we have information we can use to determine the effect of quantity increases on the net returns of the wetfish fleet (Perrin and Noetzel 1970).

If it is possible from the standpoint of available resources, fishing capability, and catch quota regulations, any one boat could increase catch at any time without affecting the price noticeably, and therefore increase profits. The question here is, what happens if the whole fleet increases catch? According to the price equations discussed previously, this would cause a price decrease. As noted, however, this would result in a total revenue *increase*.

TABLE 6

Effect of 10 Percent Catch Increase on Gross Revenue, Crew Earnings and Return to Vessel Owner

Vessel size, capacity in tons	100 percent mackerel				50 percent each of mackerel and anchovies			
	Gross revenue (dollars)	1 crew share (dollars)	Profit (dollars)	Return on investment (percent)	Gross revenue (dollars)	1 crew share (dollars)	Profit (dollars)	Return on investment (percent)
70	100,000 108,841	6,080 6,791	7,328 9,935	26.0 35.3	100,000 108,876	6,157 6,754	4,576 6,670	16.2[a] 23.7[b]
100	100,000 108,841	5,340 5,966	8,341 11,089	29.6 39.4	100,000 108,876	5,408 5,933	5,604 7,840	19.9[a] 27.8[b]
120	100,000 108,841	5,297 5,917	8,745 11,540	31.1 41.0	100,000 108,876	5,365 5,884	5,917 8,289	21.0[a] 29.4[b]
150	100,000 108,841	4,656 5,201	10,071 13,146	35.8 46.6	100,000 108,876	4,715 5,172	7,361 9,885	26.1[a] 35.1[b]

[a] as shown in Perrin and Noetzel (1970)
[b] above source with 10 percent increase in landings adjusted for price change

To see how this may affect an individual boat, selected cases in the Perrin and Noetzel study were rerun. It is assumed that the average increase in catch by all boats in the fleet is 10 percent. According to our demand equations, price will drop. But total revenue goes up for all boats whose increase in catch is greater than the average increase for the fleet. Table 6 shows this and the effect on vessel and crew earnings. Computations were made for each of the four sizes of boats for two cases: 100 percent mackerel fishing, and 50 percent mackerel, 50 percent anchovy fishing. The $100,000 gross revenue cases shown in table 22 of Perrin and Noetzel were recomputed. If landings increased in each case by 10 percent, gross revenue would be $108,841 and $108,876 respectively. As can be seen, crew shares, profits, and return on investment would all increase significantly on each vessel whose catch increased by at least the average increase of the whole fleet. A vessel which did not increase catch, naturally would experience a decline in total revenue because the same catch would be sold for a lower price per pound.

The fact that profits can go up by increasing the amount sold should be of major interest to canners. Table 1B shows that gross profits increase at higher amounts sold for the canners as well. Although the profit picture of canners cannot be analyzed as was done for the vessels, it is highly likely that net profit would also increase. An analysis similar to the one done by Perrin and Noetzel should be done at the canners level. If net profit increases with sales increases, then catch quotas should be liberalized.

The effect of the elasticity on profits is a two-edged sword. The relationship also works in reverse in that a decrease in landings decreases total profits and in this case net profits. This probably explains a good share of the difficulty the fleet presently finds itself in.

Conclusions

It has been demonstrated by the Perrin and Noetzel paper that there can be profits in the wetfish fishery given sufficient volume of landings. This paper shows that increasing the catch, in contrast to increasing the supply of many food products, will increase total revenue to the fleet and net revenue to any vessel which increases its catch by a percentage equal to or greater than that by which total fleet catch is increased. Therefore, there is considerable hope for a profitable fishery. Rising population and income on the other hand, probably will not cause any growth in the market.

One final note. Except for canned tuna and the luxury shellfish, the only fish products that have made significant advances in per capita consumption in the U.S. during the past two decades are those with new product forms—the convenience items. These are fish sticks and portions, breaded frozen shrimp, and other shellfish with shell removed and highly processed. The losers are the smoked, cured, many canned items (except tuna), and the traditional fish market forms. I am not suggesting what might be done to improve the market form of the wetfish fleet. It does present a problem and room for someone to generate and test some ideas.

REFERENCE

Perrin, William F. and Bruno G. Noetzel, 1970. Economic Study of the San Pedro Wetfish Boats. *Fishery Industrial Research*, 6(3): 105–138.