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EVALUATION OF THE DEMANDS FOR MICHIGAN'S SALMON AND STEELHEAD SPORT FISHERY OF 1970 [1]

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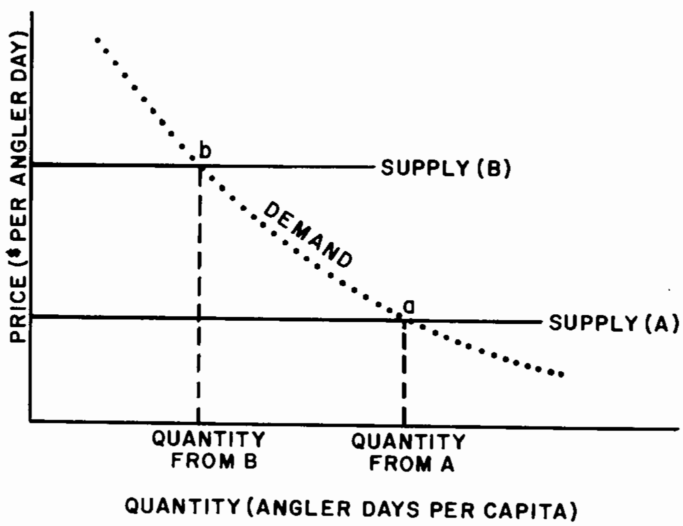

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SUMMARY AND CONCLUSIONS

This study was undertaken to quantify the benefits of Michigan's salmon and steelhead sports fishery. An estimate of the all-or-none value of the entire fishery was the primary goal, although a model was also constructed to evaluate how potential changes in the nature and/or location of the fishery would change anglers' benefits. The all-or-none value is most useful in evaluating a decision of whether or not to have such a fishery, whereas the other values are more useful in evaluating alternative stocking plans or other management decisions. In addition, the study (1) determined which attributes of the fishery anglers apparently find most important, (2) analyzed the willingness of anglers to substitute one kind of angling for another, (3) examined the costs to anglers of angling, and (4) examined other aspects of angler preferences, or demands.

The maximum net all-or-none value of salmon-steelhead angling to anglers is nearly $30 million per year (in 1970). This means they would be willing to pay the state (or other resource owner) a maximum of that amount, if necessary, to prevent the total loss of the opportunity for salmon-steelhead angling. The exact value depends strongly upon the assumptions made about the availability of other kinds of angling.

The most important kind of non-salmon-steelhead fishery affecting the value of salmon-steelhead angling is the Great Lakes lake trout fishery. It was found to be strongly complementary to salmon-steelhead angling. If the lake trout fishery were not available, the value of the salmon-steelhead fishery would be about $20 million, whereas if the lake trout fishery remains as available as it is now, the value of the salmon-steelhead fishery would be about $30 million. In either case, since the annual cost to the state of the anadromous fishery is only about $1.6 million (Ellefson, 1973), it is clear that the fishery is highly beneficial to anglers.

Two attributes of salmon-steelhead angling seemed to describe its character fairly adequately: (1) the salmon-steelhead species mix and (2) the respective catch rates of the steelhead and salmon species. Each "character" of angling is a different kind of angling to at least some anglers, just as each make and model of automobile is a different kind of automobile. Some refinements in salmon-steelhead angling character description may be made by including attributes such as (1) urban or non-urban angling environment, (2) publicity, (3) early or late salmon migration, (4) the nature of the streams in which the fish migrate, and (5) the availability of complementary types of recreation.

As expected, anglers apparently prefer salmon-steelhead angling with higher catch rates to that with lower catch rates. This is indicated by three factors: (1) the demand is greater for the former, (2) anglers are quite willing to switch from lower-catch-rate angling locations to high-catch-rate locations, but not vice-versa, and

(3) a stronger positive relationship between personal income per capita in the angler's origin county and the demand for higher-catch-rate angling. Other conclusions about salmon-steelhead anglers are: (1) they consider inland trout angling[2] as roughly equivalent to salmon-steelhead angling, (2) they strongly prefer high-catch-rate salmon-steelhead angling to other game fish angling (bass, muskellunge, walleye and pike), and (3) they even more strongly prefer high-catch-rate salmon-steelhead angling to perch-panfish angling, particularly during summer.

The few examples explored in a simulation model seem to indicate that a general statewide increase in stocking efforts would have much greater benefits than costs (assuming a direct relationship between stocking and catch rates). The value of each particular change in catch rate at a particular location depends greatly upon the kinds of angling available at nearby locations and the number of people living nearby. Therefore, greater benefits would result from increases in catch rates at particular locations than from a general statewide increase. The modeling capability developed in this study permits examination and evaluation of many such fish stocking options and locations, singly or in combination.

Further analysis of hypothetical alternatives in the simulation model would be highly useful in determining a more nearly optimum management plan. For example, the simulation model developed in this study shows that further investment in chinook stocking in the highly populated counties adjacent to southern Lake Michigan would be highly beneficial. Similarly, reducing the chinook stocking in counties adjacent to central Lake Michigan below 1970 levels would not appear advantageous.

The average all-or-none value of salmon-steelhead angling is $10 to $15 per angler day, but this analysis makes it clear that every increase or decrease in angler days should not be evaluated at $15 per angler day or any other fixed figure. In general, changes in angler days that are the indirect result of changes elsewhere (e.g., increased angling effort at stream A caused by pollution in stream B) should be given zero value. Otherwise, angler days may be valued between zero and $20, or even $30 or more per angler day, depending upon the above circumstances and other factors. The simulation technique could quantify such values in many situations.

It is recommended that further modeling of this type be carried out for Michigan's fisheries resources because of a high potential usefulness for fisheries management and planning. With sufficient data acquisition and analysis, computerized simulation models could become highly accessible and easily used management tools.

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[2] Not including steelhead or Great Lakes lake trout angling.

INTRODUCTION

There is little question that Michigan's salmon and steelhead sport fishery is extremely valuable to anglers. The fact that about 2 million angler days are annually provided by the fishery at a direct cost to state government of only $1.6 million on an annual basis is sufficient to conclude that the welfare of the anglers is greater with the fishery and the cost than without both. The question of whether or not to provide the fishery is disputed little.

Much more critical and difficult questions are: At what level of intensity should the anadromous fishery be developed at the expense of other fisheries developments? In what proportions should each fish species be developed? At which locations? Once these are determined, what is the best overall level of fisheries management in Michigan?

This analysis was undertaken to quantify the benefits of the anadromous fishery, for the purposes of estimating the efficiency of the programs and the prospects and desirability of changes in the program. Such evaluations should help guide fisheries resource management toward a social optimum. During the analysis, additional information was generated about (1) the cost to anglers of angling, (2) the attributes of angling that anglers consider important and (3) the willingness of anglers to substitute one kind of angling for another.

To make such evaluations, many complexities and interrelationships must be explicitly recognized and dealt with. There is no singular value of salmon-steelhead angling. Each angling site may have a different value depending upon the relative locations of the available alternatives, the relative location of the population, the costs to users involved (particularly the time and money costs of transportation), and the characteristics of the particular kind of salmon-steelhead angling. Overriding all of these factors is the fact that there are many kinds of values one may wish to calculate, such as the all-or-none value, various kinds of marginal values, or the net value of a given change in angling characteristics at a given location. These considerations complicate the analysis, the nature of the results, and the nature of the questions that must be asked to obtain desired results. Despite the complexities, the discussion of methodology and theory will be kept as brief as possible. A more thorough discussion is available in Talhelm (1971).

This analysis is really a series of analyses, each of which builds upon the previous analyses. They are presented here as six semi-independent reports, designated as sections, on different aspects of the evaluation. The first section is a discussion of the nature of the demand and supply of angling and the significance of those concepts to management decisions. The second section presents the "price equations," which describe the cost of angling as related to travel distance and other factors. The price equations are used in measuring the supply of angling. Section three on "angling quality" examines several attributes of salmon-steelhead angling and describes the different kinds of angling in terms of those attributes. Each unique set of attributes describes a different kind, or "character," of salmon-steelhead angling. This concept makes it possible to estimate the demand for each "character" of angling. The fourth section utilizes all of the preceding information to estimate and analyze the demand for each "character" of anadromous angling, and the willingness of anglers to substitute one kind of angling for another. Fifth, using the demand analysis, the values of various angling resources are determined under specific circumstances. Included in this last full section is the description of a simulation model which permits evaluation of many hypothetical changes in the fishery at particular locations. A sixth and final section presents some concluding observations.

I. DEMAND AND SUPPLY OF ANGLING

Demand

During late summer and fall, the Manistee area of Michigan is noted as one of the "best" locations for salmon-steelhead angling in the Great Lakes area. By virtue of public access sites the waters are open to all persons. Yet on a per-capita basis, residents of the local area go salmon-steelhead angling much more frequently than others from, say, southeastern Michigan. Southeastern Michigan residents fish for salmon-steelhead less than local residents primarily because of the higher costs in time and money imposed by the greater travel distances required, and to a lesser extent, because alternative kinds of angling are less costly (i.e., "more available") than salmon-steelhead angling to residents of southeastern Michigan. For example, walleye angling in Lake St. Clair is close to southeastern Michigan residents.

The demand for angling is the schedule relating the cost of angling and the amount of angling participation,[3] as illustrated in Figure 1. The cost of angling includes both the money and the time resources required of the angler, evaluated in terms of dollars. Because salmon-steelhead angling participation rates may be influenced by the availability of alternative kinds of angling (such as walleye angling), an unbiased demand curve may be constructed only by holding constant the availability of alternatives. It is important that our demand curve be purely a relationship between the "price" (i.e., the time and money costs to users) of a particular kind of angling and the participation rate in that kind of angling; all other significant factors should be held constant.

A pure price-quantity relationship illustrates the willingness of anglers to exchange their resources for angling. Money itself is practically worthless unless it can be exchanged for market goods. Dollars, then, are

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[3] A formal definition of demand is: a schedule relating the maximum quantity of a good which would be purchased at each given price, during a given period of time, other things being equal.

more or less abstract "tickets" that may be traded for market goods of all kinds. Thus, a demand curve for angling illustrates the voluntary rate of exchange between "all other goods" (measured in terms of dollars on the price axis) and angling; it illustrates the total preference for angling relative to other goods.

It is also important that the kind of angling be carefully specified, so we know exactly what relationship is being examined. The particular kinds of salmon-steelhead angling will be discussed later.

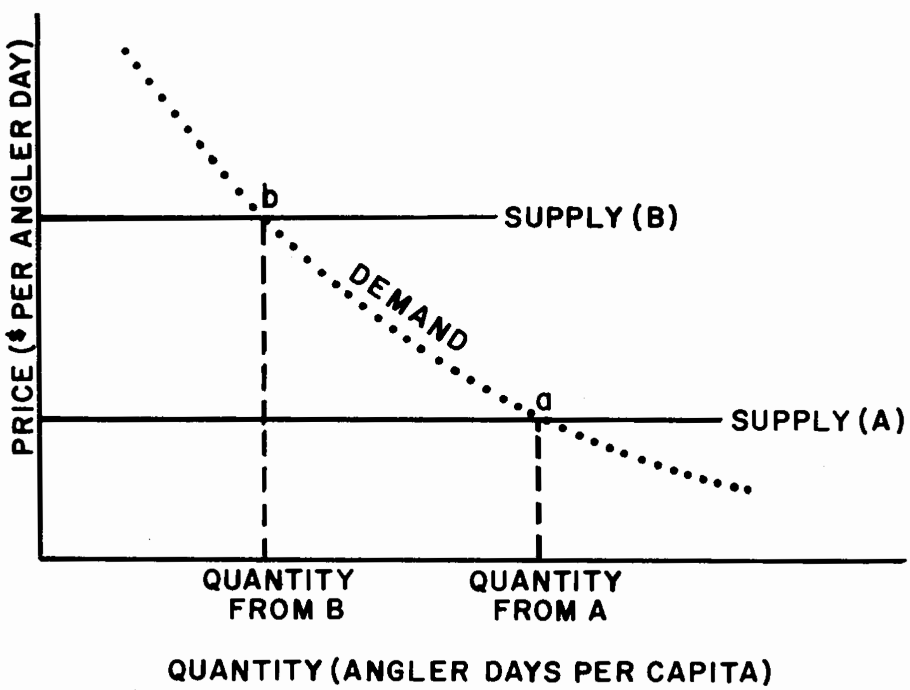

Figure 1.--Supply curves for anglers residing at hypothetical locations A and B, quantities (per capita) of angling by residents of A and B, and the demand curve that might be traced by points such as a and b.

Supply

The supply of a good is the relationship between the prices paid for it and the quantities that producers make available for purchase. Usually manufacturers, suppliers, or speculators will produce or make available more of a good if prices are higher. For example, if farmers feel the price of corn will be high relative to other crops, they will plant more corn. Supply, then, is a price-quantity relationship for any good, which in general shows that if a higher price is offered, more of the good will become available.[4] This is illustrated by curve A in Figure 2. This concept is important to us because it shows the "ability" of resources to produce the good. Since dollars are abstract representations of resources (i.e., the resources people will trade for dollars), the supply relationship generally shows the amount of resources that must go into the production process to make a good available for purchase.

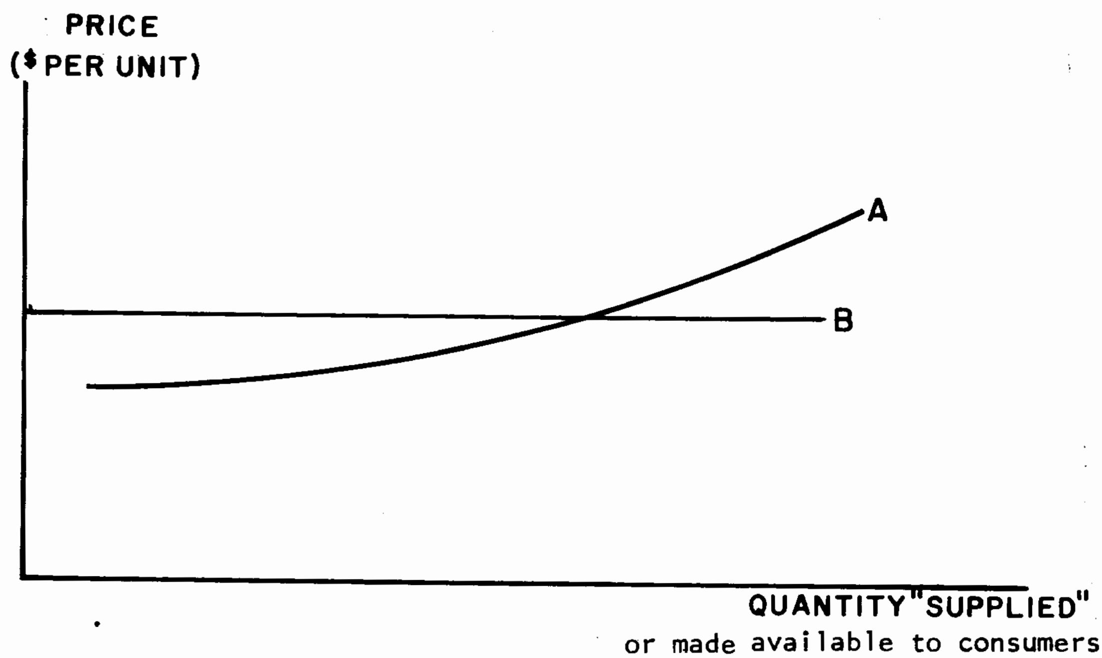

Figure 2.--Usual supply curve (A), and supply "curve" for angling with a given travel distance requirement (B).

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[4] A formal definition of supply consistent with our definition of demand is: the minimum prices at which given quantities of the good will be forthcoming, over a given length of time, other things being equal.

The supply of angling to anglers is the relationship describing the amount of angling available to anglers at each price. In one sense angling is supplied by natural or artificial fish propagation, and in another sense it is supplied by the angler when he allocates his time and money to travel to a particular fishing site to go fishing. The former might be called the "supply of angling potential," whereas the latter might be called the "supply of angling effort." In any one year the potential for angling for anadromous fish is predetermined by biological factors and previous management activities.

Our present interest is in the latter: the short-term relationship between angling effort and the cost to anglers of producing that angling. In any one year the only costs related to the amount of angling are the costs to anglers of participation.

The major time and money resource costs for angling are for (1) time and money for travel, (2) equipment and boating, (3) angling time, and (4) food and lodging. For a given travel distance, anglers may participate in (or produce) a large number of angling trips at a constant cost per trip. Trip cost varies directly with travel distance. This means that anglers may supply themselves with angling at a "price" (i.e., the costs they must pay per day) that varies little as the quantity of angler days varies, and is primarily determined by the required travel distance. Therefore, for any given travel distance the price-quantity supply relationship is a horizontal line (i.e., a constant price per day) illustrated by supply "curve" B in Figure 2. As the travel distance required for angling increases, the price to anglers also increases. Thus, anglers living at a more distant location would have a higher supply "curve"; otherwise known as a smaller or lesser supply.

There are two important implications of this concept of the supply of angling: First, for anglers residing at any given location, such as a county, the supply of a particular kind of angling may be described by specifying only the "price" to those anglers for that kind of angling. Since the distance from each county to the location where a particular kind of angling may be found is different, the price (and therefore the supply) of that angling is different for each county. This is significant to us because our supply curve indicates the resources anglers must invest if they wish to participate in that kind of angling. It is a precise measure of the availability of a kind of angling in terms of market resources.

The second important implication is that because supply is completely "defined" or known, and because the observed quantity of angling is at the intersection of the demand and supply curves, the demand curve may be statistically estimated. For example, Figure 1 illustrates the demand function for a kind of angling, supply curves for a nearby (A) and a distant (B) county, and the quantities of angling from these counties. The supply curves and the quantities of angling may be determined from surveys of anglers, and those two values are points a and b in Figure 1. Points a and b and others like them trace out the demand function.

In statistically estimating the shape of a demand curve, the prices (supplies) of other kinds of angling may also be included to correct for any hidden influences they may have on the quantity of angling actually observed. For example, the amount of salmon-steelhead angling by southeastern Michigan residents may be influenced by the close proximity of walleye angling in Lake St. Clair, and people in other parts of the state may be influenced by other such angling opportunities. The demand equation for salmon-steelhead angling can easily be statistically corrected for such influences by including the prices of such alternatives as independent variables. This not only corrects for such influences, but describes how salmon-steelhead angling is influenced by alternative opportunities.

This analytical framework differs somewhat from the "Hotelling-Clawson" approach used by Ellefson (1973) with the same data. That method does not correct for, or otherwise analyze, the influence of alternatives on the demand for salmon-steelhead angling. The similarities and differences of these analyses are discussed further in the same publication by Talhelm and Ellefson (1973a), and Talhelm (1973b), and elsewhere by Talhelm and Ellefson (1973b). Thorough descriptions of the various methods and current literature on evaluation of recreation resources may be found in Talhelm (1970), Clawson and Knetsch (1966), and Pearse and Bowden (1969).

II. PRICE EQUATIONS

A unit of recreation is most appropriately defined as a unit of time spent in the recreation activity. Here the unit is the angler day, defined as any part of a day in which an angler fished. Angling hours would be a more accurate measure, but angler days was a more practicable unit.

The principal variables determining total anglers costs are (1) fees, equipment costs and other direct costs, (2) the monetary costs necessary for transportation, food and lodging, and (3) the value of time spent to facilitate the angling and transportation. The total time allocated for a trip is determined by the consumer, but the monetary and time costs of transportation are primarily a function of residence and resource location ("origin" and "destination"). Direct costs are a function of the type of recreation consumed.

The value of an individual's leisure time is approximated by his wage rate or potential wage rate, as shown by rigorous analysis (beyond the scope of this paper) by Becker (1965) and Talhelm (1971). The basic reasoning is that the wage rate represents a quantifiable rate of exchange between "other goods" (i.e., money) and non-work time.[5] A weighted average time value, based on reported incomes on a questionnaire sent to fishing license holders, was used in this analysis.

An important element in measuring supply is a "price" equation. The price equation used here expresses the price of recreation (dollars

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[5] It is generally recognized that any individual's wage rate on a given date may not approximate his current marginal value of non-work time because of imperfections in the labor market. However, current economic thought, as reported in professional journals, lead by Becker's analysis, recognizes that wages are at least general approximations of the value of non-work time, although a few economists feel otherwise. One has many ways of exchanging leisure time for goods and services, such as "do-it-yourself" projects, but wage rates are common, relatively pure, easily measurable exchanges. Schultz (1972) reported that Becker's analysis of the value of time is a significant advance in economic thought because it permits more complete understanding and analysis of the value of time. Nelson (1968) argues that the value of leisure time varies so much that the wage rate is a poor approximation. The counter argument is that individuals may often make many kinds of adjustments to smooth out the variations.

per angler day) as a function of distance. For each sampling period [6] separate equations were estimated for salmon-steelhead angling and "other angling," and for residents and non-residents of Michigan. Coefficients in the equation represent travel speed (assumed here at 50 mph), time value and the various monetary expenses. [7] The price equations were used to estimate the supply "curves" (i.e., prices) for angling at any site in Michigan for individuals living at any location. Figures 3, 4, and 5 illustrate the price equations used in this analysis. Further details are available in the Appendix.

The absolute levels of the prices are fairly insignificant in this kind of analysis. The important aspect of prices is their changes as distance changes. It is from the price differences that we determine how anglers react to actual and simulated changes in supply. The most

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[6] Period I: January through April 24, 1970; Period II: April 25 through August 1970; Period III: September through December 1970. The data used are the same used by Ellefson in his report and in Ellefson and Jamsen (1971a, 1971b and 1971c) and Jansen and Ellefson (1970, 1971b and 1971c).

[7] The anglers surveyed reported for each survey period the number of days fished at each location (reporting water body used and nearest town). For each location fished they also reported their expenditures in the area fished and while traveling. It is assumed that they included only those expenses incurred for the purposes of angling, so all expenses were attributable to the angling effort. This could lead to a slight exaggeration of costs if some expenses were incurred partially for other purposes; for example, travel costs incurred partially for visiting relatives and that part of food costs that would have been incurred at home anyway. Since anglers did not report the amount of time or the number of trips involved in the angling at each location, several assumptions were necessary to calculate the time cost of angling: (1) travel distances were the minimum mileage from county to county using major population centers as centroids, (2) only one trip was taken to each reported location, (3) travel reported was undertaken only for the purpose of angling, (4) each angler day involved 6 hours of the angler's time in addition to the travel time, and (5) the monetary value of the time was equal to total annual family income divided by 2080 hours (i.e., 40-hour work week) per year. Assumptions 1 and 2 tend to under-report the costs, whereas 3 and 5 (and the above assumption about monetary costs) tend to over-report the costs. The resulting figures may not be completely unbiased, but they are the best presently available.

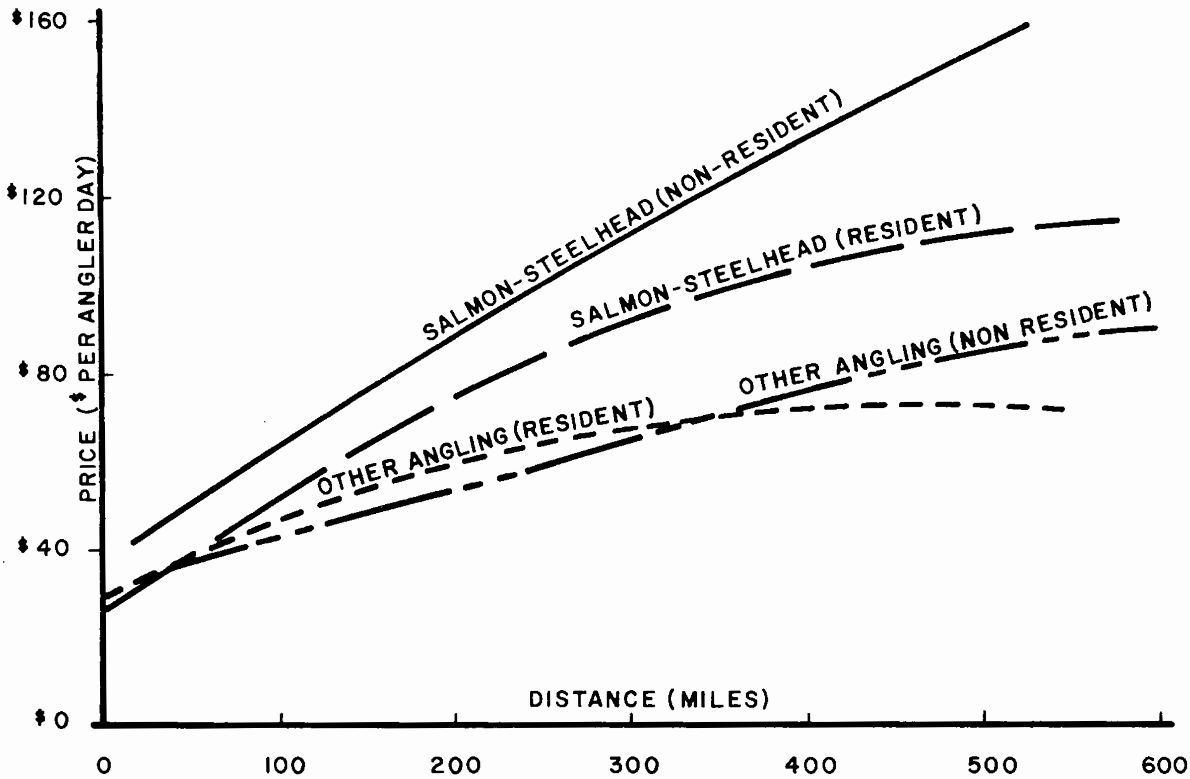

Figure 3.--Price Equations, Period I, illustrating the user cost of angling as related to travel distance

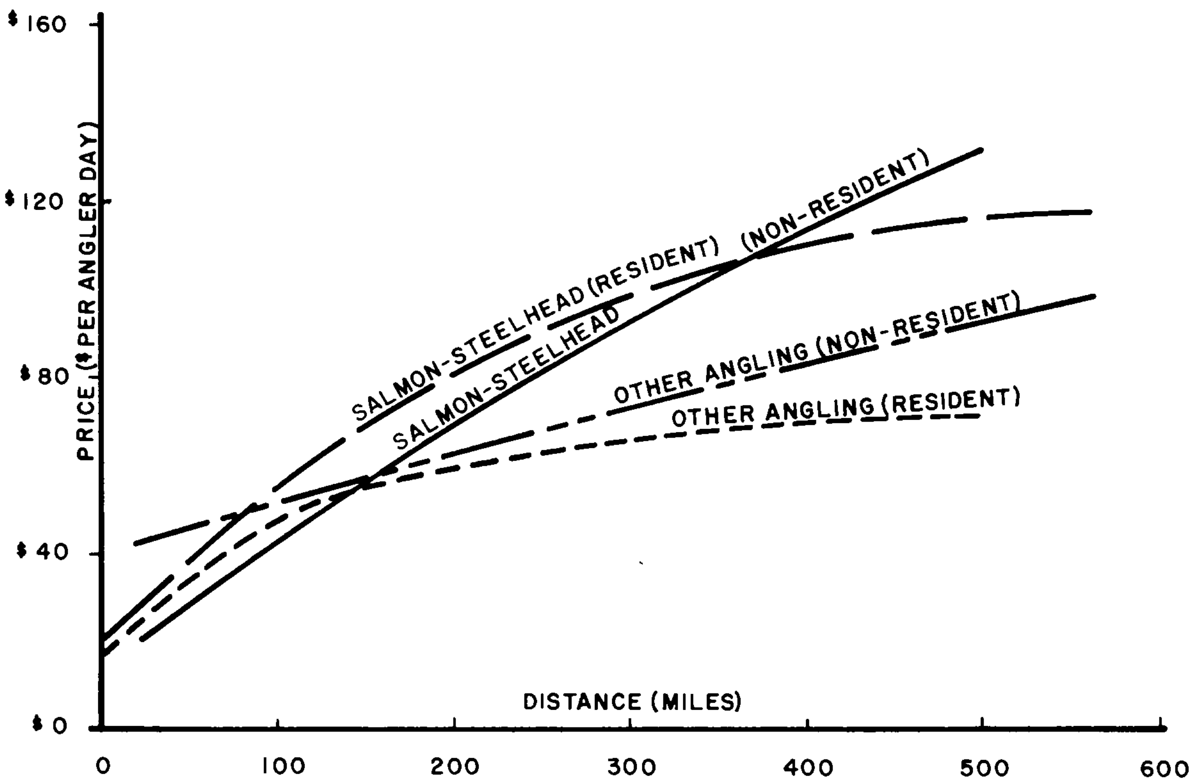

Figure 4.--Price Curves, Period II, illustrating the user cost of angling as related to travel distance.

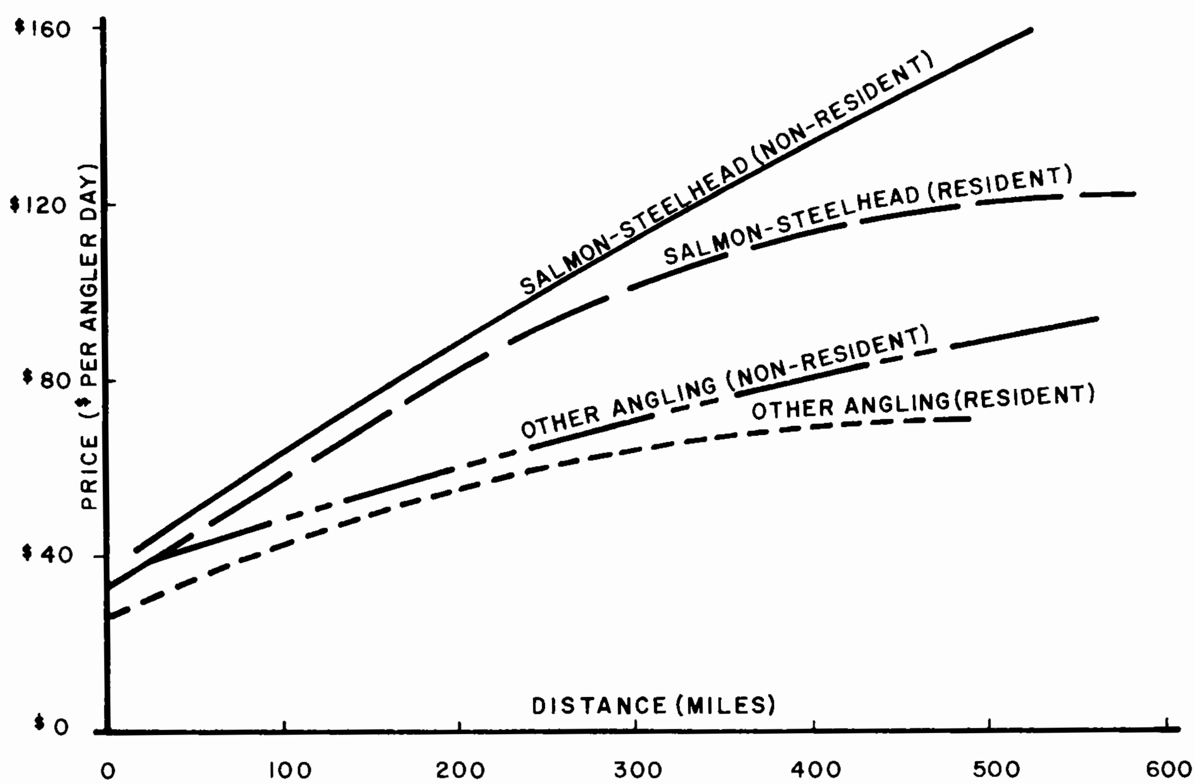

Figure 5.--Price Curves, Period III, illustrating the user cost of angling as related to travel distance.

important costs, therefore, are the money and time costs of travel; the other money and time costs are approximately the same for all anglers.

III. ANGLING QUALITY [8]

It is widely recognized that angling experiences vary in "quality." Usually that notion carries with it some connotation of value judgment and of a dichotomy between "high" quality angling and "low" quality angling. However, upon closer inspection, we find that different anglers have different notions of quality: what is high quality for one is low quality for another.

A more basic concept is that different angling resources have different attributes, and that these attributes are of different importance to various anglers. Different combinations of such attributes as species combination, catch rates, fish size, and angler crowding may be used to define the various kinds of angling. Hereinafter, references to "angling character" refer to angling with a particular set of characteristics and carries no implications of value judgment. It is felt that "angling character" should replace the term "angling quality," since it can clearly refer to the qualitative characteristics of angling.

Each attribute (e.g., catch rate) is divided into a few levels, such as high, moderate and low catch rate. Each permutation of attribute levels describes one "character" or variety of angling. For example, the character of angling available at one site could be described by the following permutation of attributes: moderate catch rate of steelhead trout, no other species of fish available, size distribution of fish caught skewed toward large fish, and high level of angler "crowding."

Different characters of salmon-steelhead angling or other recreation may be treated as separate but related goods, analogous to different makes and models of automobiles. The key point is that with sufficient enumeration

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[8] Further discussion of the procedure for measuring and evaluating recreation quality may be found in Talhelm (1973).

of attributes, all of the kinds of angling that various anglers seek will be placed into separate and distinct categories. In purchasing an automobile, one considers the various makes and models (each of which may be described by a set of attributes, such as make, model, accessories, expected future service, etc.) and their prices before making a choice. Few will knowingly pay more than necessary for an auto with a given set of characteristics. Through a similar process, one chooses a recreation site by selecting the most convenient site having the attributes important to him, considering the availability of sites having other attributes. If angling character is adequately defined, we will find that few persons will knowingly pay a higher price (in time and money costs) than necessary to reach a recreation site of a given character: They will go to the nearest site of that character, assuming perfect knowledge. If anglers go farther than necessary to reach a given character, then either (1) they lack knowledge of other existing sites, (2) they have other purposes for their trips (and since part of the travel is for other purposes, the costs attributable to angling might be lowest at a farther site), or (3) the listing of attributes is faulty, with some having been omitted.

This decision-making model permits analysis of two important aspects of user behavior toward angling. First, since one selects only the most convenient site having the set of attributes he desires, we may determine which set of attributes users apparently find most important in differentiating between sites. Second, since the availability of sites may be expressed in terms of the cost of traveling to and using a site, an economic analysis may examine both the importance of angling to users (relative to other goods) and the rates that users are willing to exchange angling of one character for another.

To determine the most descriptive set of attributes, we must first determine where users go in relation to the recreation locations available. By reclassifying the choices available using different attributes, various sets of attributes may be tested. If a set of attributes adequately describes the various characters of recreation available, the users have few reasons not to travel to the most convenient site of any given character. Therefore, the most descriptive set of attributes may be determined by finding the set for which the greatest proportion of users fit the hypothesized pattern (i.e., they go only to the nearest site of any given character). Again, the only two factors that would confound this search for the most descriptive attributes are (1) lack of knowledge on the part of the users, and (2) the fact that some users have more than one reason for their travel.[9] The latter users could be separated from the analysis, but were not in this case.

For fisheries management purposes, the two most important attributes of salmon-steelhead angling are (1) species combination (steelhead trout, coho salmon, and chonook salmon in various combinations) and (2) catch rates of each, because those characteristics are subject to manipulation through stocking activities. The initial character definition of Michigan's salmon-steelhead angling used here was a combination of these two attributes, as shown in Table 1.

Because of the nature of the angling participation data, all angling effort was attributed to the county in which it took place. The angling character was determined from the angling attributes of the county as a whole. The catch rate for each species was classified as: 0--not available, 1--low catch rate (significantly lower than average), 2--moderate or average catch rate (middle range of catch rates), or 3--high catch rate (significantly higher than average). Since there are three species and four catch rates, there are $4^3 = 64$ possible permutations. These were determined for each of the three periods of 1970 and for the whole year.[10]

In Table 1 and elsewhere, the combination of species and catch rates, which defines the character for each county, is shown by a three-digit number, such as 2-3-0 in the column headed "angling characteristics code." The first digit in the example above (2) represents the catch rate of steelhead (s), the second (3) represents coho salmon (c), and the third

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[9] There is another factor that could confound the investigation: If the number of alternatives is small, a classification scheme could identify a number of seemingly unique recreation locations. For each unique location there is no opportunity to observe whether people go farther than necessary to reach a location of that character. In such cases there would be little basis for selecting between alternative classification schemes.

[10] See the Appendix for further information.

Table 1.--Total angler days and angler days excluded from regression, by character, for the initial character definitions

Period I			Period II			Period III			Angling characteristics code (s-c-k)	Equation No. for year
Equation	Total	Excluded	Equation	Total	Excluded	Equation	Total	Excluded		
1	150	0	1	750	750	1	0	0	0-0-0	1
2	11,610	5,670	2	17,340	450				1-0-0	2
3	7,950	0	3	28,050	0				2-0-0	3
4	1,950	0				2	155,010	0	3-0-0	4
						3	300	0	0-1-0	5
						4	2,430	1,530	1-1-0	6
						5	18,390	2,250	2-1-0	7
						6	11,070	0	0-2-0	8
						7	2,400	0	1-2-0	9
						8	22,860	4,560	2-3-0	10
						9	0	0	0-0-1	11
5	0	0	4	0	0				0-1-1	12
6	32,370	5,670	5	4,230	930	10	9,870	2,130	1-1-1	13
7	16,710	6,900	6	29,340	1,710	11	4,650	0	2-1-1	14
8	48,150	9,750	7	11,010	6,210	12	600	0	3-1-1	15
			8	2,280	0				0-2-1	16
			9	57,240	4,470	13	6,930	0	1-2-1	17
			10	95,370	19,560	14	60,930	8,010	2-2-1	18
			11	54,450	4,080	15	12,720	1,740	3-2-1	19
			12	20,760	2,400				2-3-1	20
						16	8,670	720	3-3-1	21
			13	28,020	0				1-1-2	22
						17	3,600	0	3-1-2	23
9	22,350	600	14	30,300	16,860				1-2-2	24
10	26,850	300	15	109,200	0	18	239,160	53,460	2-2-2	25
			16	159,390	7,800				2-3-2	26
						19	56,220	0	3-3-2	27
						20	47,400	0	1-2-3	28
			17	67,200	0	21	73,410	0	2-2-3	29
						22	10,950	0	3-2-3	30
11	3,000	0							1-3-3	31
12	6,750	0				23	204,510	4,080	2-3-3	32
			18	21,480	0				3-3-3	33
Totals	177,840	28,890	--	736,410	65,220	--	952,080	78,480	-----	--

(0) represents chinook or king salmon (k). Thus, 2-3-0 represents a character in which the catch rate of steelhead is moderate, the catch rate of coho is high, and there are no chinook. As Table 1 shows (under "equation number"), only 33 of the 64 possible permutations existed during 1970. Only 12, 18, and 23 permutations appeared in the three periods, respectively, with many permutations appearing during more than one period.

Specific procedure

It was decided to allow a correction factor in the distance calculations used for determining which county was the nearest for each character. The reasons for this allowance are: (1) the county to county distances used do not precisely represent travel distances for angling trips, (2) road character varies, (3) anglers lack perfect knowledge, (4) borderline locations exist which could be reported as angling in more than one county, and (5) the fact that the additional cost of a slight additional distance would be negligible to an angler deciding between angling locations. The procedure was: If anglers from an origin county traveled a distance (to a destination county) that was within 20 miles or 20% (whichever was greater) of the distance to the nearest county that has the same angling character, they were treated as if they had traveled to the closer county. Otherwise they were excluded from the subsequent regression analysis for the demand equations, to be described below. For example, during Period I, Allegan, Ottawa and Antrim counties, among others, all had low catch rates for all three species (1-1-1). From Barry County the distance to those three counties is 48 miles, 67 miles, and 174 miles, respectively, with Allegan at 48 miles being the nearest county having character 1-1-1. In our analysis, then, Barry County anglers who went to Ottawa County were assumed to have gone only 48 miles (to the closest county of character 1-1-1) even though Ottawa County is 19 miles more distant than Allegan County. Thus, the amount of angling from Barry County at character 1-1-1 would be the sum of the angling by Barry County residents at Allegan and Ottawa counties, plus that at any other counties having character 1-1-1 within 68 miles of

Barry County. On the other hand, angling from Barry County at all remaining counties with character 1-1-1, such as Antrim County, was excluded from further analysis. The "number excluded" represents those angler days at locations more distant than the closest possible location; in other words, the number who traveled farther than "necessary."

Judging the classification scheme

The magnitude of the number excluded may be used to judge the adequacy of the group of attributes used in the analysis. A large percentage of exclusion would probably indicate that a large proportion of the anglers have some reason for incurring additional expenses. The hypothesis that the enumeration of attributes was sufficient to categorize all characters of angling would thus be judged inadequate; anglers apparently feel that locations classified as being the same are significantly different.

Considering the fact that all trips were assumed to be only for the purposes of angling (i.e., no one went to a particular location because he had a cottage, friends or relatives, or other recreation or business there), the two attributes appear to explain a very large amount of the effort. The overall levels of angler days excluded for the three periods are 16%, 9% and 8%, respectively. In some cases there were only a small number of counties with a particular character category, so it was unlikely, and sometimes impossible, that anglers would go father than necessary to reach that character. The Appendix has a list of the counties and their character classifications.

The characters as defined here are characters of salmon-steelhead angling, whereas spring and summer angling (and perhaps much of the fall angling) might better be classified as salmon angling or steelhead angling. During those times anglers usually fish for one or the other on any given day, but not for both. However, the questionnaire with which angling effort statistics were gathered asked only for the total amount and location of salmon and steelhead angling, with no provision to distinguish between the two. For this reason, the data had to be analyzed only in terms of salmon-steelhead angling. Separate statistics on angling effort for salmon and for steelhead would probably have permitted a simpler, more meaningful classification and analysis. The number of angling characters could have been reduced to a few for salmon and a few for steelhead angling. Future data collection should proceed with this in mind.

Subdivision of characters

Since the number of angler days excluded is a good indication of the adequacy of the definitions of the characters, instances in which a large percentage of the total angler days for a particular character were excluded, were investigated further to determine possible explanations. In each case, plausible explanations were found, and the number of angler days excluded was considerably diminished by subdividing those characters according to the additional attributes (Table 2). Undoubtedly, the amount of angler days excluded in other characters could also be diminished by a similar procedure. This process sheds more light on the attributes that define angling character. In particular, publicity, timing of the salmon run, and the kinds of streams in which the fish run were found to be of some importance in defining angling character. Urban or non-urban environment and the availability of complementary types of recreation were also of some importance.

IV. DEMAND ANALYSIS

Perhaps the heart of an economic analysis such as this is the demand analysis. Demand equations as estimated here indicate the rates at which people are willing to exchange their resources for the various characters of angling (measuring their total preference for each character relative to other goods), holding constant the availability of other characters of angling and some other factors. The equations also indicate (1) the willingness of people to give up angling of one character in exchange for angling of the other characters, and (2) the extent to which their preference for one character of angling is affected by the presence of other characters

Table 2.--Subdivisions of character definitions for more complete character description, with total angler days, and angler days excluded

Period	Quality	Total angler days	Angler days: Previously excluded	Angler days: Total after subdivision	Angler days: Excluded after subdivision	Additional character component
1	1-0-0	11,610	5,670	11,310	600	Rural angling environment
				300	0	Urban angling environment
1	2-1-1	16,710	6,900	11,460	450	Many small, coldwater rivers
				5,250	0	Few small, coldwater rivers
1	3-1-1	48,150	9,750	27,150	0	Low publicity
				21,000	0	High publicity
2	3-1-1	11,010	6,210	7,710	0	Moderate weather
				3,300	0	Cool weather
2	2-2-1	95,370	19,560	32,430	3,000	Little complementary recreation opportunity
				62,940	750	Much complementary recreation opportunity
2	1-2-2	30,300	16,860	19,350	0	Non-urban angling environment
				10,950	0	Urban angling environment
3	2-3-0	22,860	4,560	7,170	0	Normal time for salmon-steelhead run
				15,690	0	Early salmon-steelhead run
3	2-2-2	239,160	53,460	184,170	22,470	Typical streams for migration
				54,990	0	Short stream for upstream migration

of angling. Thus the demand equations should indicate the relative preferences of anglers for the various characters of angling, the relative substitutability of one character for another, and how well the characters of angling complement each other. The findings tend to confirm some commonly held ideas of angler behavior and give these ideas quantified expression.

Since the procedures for estimating demand curves are not important for the purpose of this paper, they are presented only very briefly to give the reader some idea of the process. The demand equations are quite complex because of the number of characters that must be examined simultaneously. The relationship between characters of angling are examined in more detail because of their management implications.

Further analysis of the demand equations is necessary to estimate the total worth of the fishery to anglers, and to evaluate angler preferences (in terms of dollars and in terms of angler days) for changes that would be brought about by changing fish catch rates or by adding or eliminating any locations to or from the fishery. This further analysis is presented in Section V.

Procedures

Recall that demand is the relationship between price and angler days representing the willingness of users to exchange resources for angling. Supply is the relationship between price and angler days representing the resources anglers must give up to "produce" angling. In other words, demand is the preference for angling and supply is the availability of angling. The rate of participation (angler days per capita) is determined by the interaction of supply and demand.

The supply "curve" of angling for a particular county of origin equals the corresponding price of angling, because that is their cost of "going fishing." If characters are adequately defined, then any two sites of the same character are nearly perfect substitutes (perfect substitutes are by definition the same good). Therefore (for the purposes of demand analysis), instead of having several prices for a single angling character (such as 1-1-1) that is found in several locations, the price (or supply) of any character of angling is defined as the least expensive price of that character.[11]

For any county of origin, the "quantity of angling of any character" is defined as: (1) the quantity of angling (per 1,000 residents) at the closest county having that character of angling, plus (2) the angling at any other counties within 20 miles or 20% of the minimum distance that have the same angling character. The quantity of angling as used here is the same as that used in the previous section where a correction factor was allowed in distance calculations.

In sum, each county provides one observation of a set of prices (one for each character of salmon-steelhead angling) and a corresponding set of quantities of angling (one quantity for each character). The prices used are those calculated with the "price equations." Other variables observed for each county were (1) the minimum price of Great Lakes lake trout angling of at least a moderate catch rate, (2) the minimum price of other trout angling of at least moderate catch rate (none available in Period I), (3) the minimum price of other game fish angling (bass, northern pike, walleye and muskellunge) of at least moderate (general) catch rate, (4) the minimum price of perch or panfish angling of at least moderate catch rate, and (5) income per capita. The demand equations were estimated using regression analyses in which the angler days per 1,000 residents for a particular character of salmon-steelhead angling is a function of the price of all other characters, and the five other variables. A "log-log" equation form was used, with all variables being the natural logarithm (ln) of the original variable.[12]

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[11] Recall that the definition of supply was "the minimum prices at which given quantities . . . of the good will be forthcoming . . ."

[12] There were many valid observations in which, for a given origin county, no use was observed for several of the characters of angling, particularly those having high prices. Therefore two exceptions were made to the above variables: (1) the value 1.0 was added to each quantity, since the logarithm of zero is undefined, and the logarithm of 1.0 is zero, and (2) since zero use was commonly observed at high prices, the demand curve may lie along the price axis, so an additional variable--the square of the logarithm of the price of the character under consideration--was added to each equation. The latter allows a more realistic curvilinear log-log equation.

Equation (1) is a typical demand equation which illustrates the nature of the demand functions:

$$\begin{aligned} \ln Q_3 = {} & 6.5 + .2 \ln P_2 - 2 \ln P_3 + .2 (\ln P_3)^2 - 1.1 \ln P_4 \\ & + .3 \ln P_5 + .3 \ln P_6 - .6 \ln P_7 - 2.5 \ln P_8 \\ & + .2 \ln P_9 + 1.2 \ln P_{10} + .6 \ln P_{11} + 1.6 \ln P_{12} \\ & - .2 \ln P_{lt} + .7 \ln P_{gf} - .6 \ln P_{pf} + .03 \ln I \end{aligned} \tag{1}$$

It is demand for character 2-0-0 (i.e., moderate steelhead catch rate, no coho or chinook), Period I (equation number 3 in Table 4). Table 3 explains the variables in equation (1). The antilog of equation (1) is equation (2):

$$\begin{aligned} Q_3 = {} & e^{6.5} P_2^{.2} P_3^{-2} P_3^{.2 \ln P_3} P_4^{-1.1} P_5^{.3} P_6^{.3} P_7^{-.6} \\ & P_8^{-2.5} P_9^{.2} P_{10}^{1.2} P_{11}^{.6} P_{12}^{1.6} P_{lt}^{-.2} P_{gf}^{7} P_{pf}^{-.6} I^{.03} \end{aligned} \tag{2}$$

Note that the antilog of $.2 (\ln P_3)^2$ was taken in such a way that the two coefficients of P_3 could be added, so

$$P_3^{-2} P_3^{.2 \ln P_3} = P_3^{-2 + .2 \ln P_3}$$

Table 3.--Variables in Equation (1) (the Demand for 2-0-0)

Variable	Explanation
$\ln Q_3$	Natural logarithm of: quantity of angling per 1000 capita, plus one; character 2-0-0*
$\ln P_2$	Natural logarithm of: price of angling character 1-0-0
$\ln P_3$	Natural logarithm of: price of angling character 2-0-0
$(\ln P_3)^2$	Square of $\ln P_3$
$\ln P_4$	Natural logarithm of: price of angling character 3-0-0
$\ln P_5$	Natural logarithm of: price of angling character 0-1-1
$\ln P_6$	Natural logarithm of: price of angling character 1-1-1
$\ln P_7$	Natural logarithm of: price of angling character 2-1-1
$\ln P_8$	Natural logarithm of: price of angling character 3-1-1
$\ln P_9$	Natural logarithm of: price of angling character 1-2-2
$\ln P_{10}$	Natural logarithm of: price of angling character 2-2-2
$\ln P_{11}$	Natural logarithm of: price of angling character 1-3-3
$\ln P_{12}$	Natural logarithm of: price of angling character 2-3-3
$\ln P_{lt}$	Natural logarithm of: price of lake trout angling
$\ln P_{gf}$	Natural logarithm of: price of game fish angling (bass, pike, walleye, musky)
$\ln P_{pf}$	Natural logarithm of: price of perch-panfish angling
$\ln I$	Natural logarithm of: income per capita in county of residence

* 2-0-0 means moderate catch rate for steelhead, none for coho, and none for chinook; 1-0-0 means low for steelhead, none for coho or chinook, etc.

Elasticities and their interpretation

Because of the log-log format, each coefficient in equation (1) is an "elasticity," representing the ratio of the percentage change in Q_3 to the percentage change in the price variable. For example, the coefficient of ln P_4 (character 3-0-0) is -1.1, so the elasticity of Q_3 with respect to P_4 is -1.1. Therefore we know that if P_4 were to increase 10% then Q_3 would decrease 11%, a ratio of -1.1 to 1.

A positive cross-price elasticity indicates a substitution between the two characters. For example, as angling of character Number 10 (2-2-2) becomes less expensive (more available to anglers), anglers go to character Number 3 (2-0-0) less, as indicated by a cross-price elasticity of 1.2. In other words, a price decrease of 10% for 2-2-2 causes 12% less angling at 2-0-0, apparently because anglers switch from 2-0-0 to 2-2-2 when the opportunity presents itself. The higher the value of a positive elasticity, the more willing they are to give up one for the other, probably because either (1) the anglers consider the characters to be good substitutes for each other, so they go to the least expensive of the two, or (2) character 2-2-2 is preferred to 2-0-0, so anglers switch when the opportunity presents itself. This is explained more thoroughly in the Appendix.

A negative cross-price elasticity indicates a complementary relationship between the two characters. For example, as the price of character Number 9 (3-1-1) decreases (becomes more available), the quantity of angling of character number 3 (2-0-0) increases. A common example of complementary goods is the case of hot dogs and hot dog buns. As the price of hot dogs decreases, the quantity of hot dog buns purchased increases (holding constant the price of buns and other factors). In this study it was found that lake trout angling is generally complementary to the various characters of salmon-steelhead angling. Lake trout and salmon are often found together in the Great Lakes, so many anglers fish for both concurrently. When lake trout are more available there is often more salmon angling.

Negative elasticities between characters of salmon-steelhead angling (as opposed to negative elasticities between salmon-steelhead angling and angling for other species), may have a similar interpretation, but there is an important difference. During any of the three sample periods, each county was assigned only one salmon-steelhead angling character category based upon the catch rates observed there. Each county also was assigned a character for lake trout angling, other trout angling, game fish angling and perch-panfish angling; each was based upon catch rates. It is possible for salmon-steelhead angling and lake trout angling to be available in the same county at the same time, but it is not possible for two different characters of salmon-steelhead angling to be available in the same county at the same time. Each county has only one set of salmon-steelhead catch rates at one time. At best they must be in adjacent counties. It would be extremely difficult for anglers to fish in both counties (for both characters) at the same time, so the above interpretation of complementary characters of angling may not be entirely correct with respect to salmon-steelhead angling.

A better interpretation of the negative elasticity between characters of salmon-steelhead angling is the following: If a character of angling that is generally considered inferior (e.g., because of low catch rates) is near to a given origin, it has a low price for anglers at that origin. Because of this, the anglers might increase their use of alternative (preferred) characters of salmon-steelhead angling. For example, if angling character 0-1-1 (no steelhead, low catch rates for coho and chinook) is considered inferior and if the angling at county Y is character 0-1-1, then residents of Y would likely avoid angling in that county and increase their angling in other counties. Thus there would be a negative relationship between the price of character 0-1-1 and the quantity of angling of other characters: The demand equations for superior characters would have negative cross-price elasticities for character 0-1-1 since it is inferior, and the demand equation for 0-1-1 would have positive cross-price elasticities for the other, superior, characters.

Therefore, the most valid interpretation of cross-price elasticities between characters of salmon-steelhead angling is: a <u>negative</u> cross-price elasticity indicates that the character corresponding to the price is probably a relatively inferior kind of angling, or, less likely, that it is complementary to the character for which the equation is estimated; and a positive cross-price elasticity probably indicates that that character is a substitute for the character for which the equation is estimated, probably either an equivalent or a superior kind of angling.

General relationship observed between characters

Tables 4, 5, and 6 list the elasticities in the various equations for the three periods, respectively. In general, those characters with higher catch rates appear to be relatively superior, and those with lower catch rate inferior. Lake trout angling in the Great Lakes generally is complementary to salmon-steelhead angling. "Other trout" angling is generally a substitute for higher-catch-rate salmon-steelhead angling and a complement to lower-catch-rate salmon-steelhead angling, particularly in Period III when salmon and steelhead enter the trout streams. "Game fish" angling generally is complementary or inferior to high-catch-rate salmon-steelhead angling and a substitute for the other characters. In Period III, game fish angling generally appears to be particularly complementary or inferior to salmon-steelhead angling with high catch rates for chinook. Perch-panfish angling is generally complementary or inferior to higher-catch-rate salmon-steelhead angling and a substitute for the lower-catch-rate salmon-steelhead angling, particularly in Period II.

From these relationships, we may conclude that (1) anglers fish jointly for salmon-steelhead and Great Lakes lake trout, so the presence of one enhances desirability of angling for the other; (2) salmon-steelhead anglers consider "other trout" angling as roughly equivalent to salmon-steelhead angling, and will go to a location with low catch rates for salmon-steelhead if trout are also available, particularly in Period III; (3) salmon-steelhead anglers consider other game fish angling as inferior (or perhaps complementary) to high-catch-rate salmon-steelhead angling (particularly steelhead angling), and roughly equivalent or superior to the lower-catch-rate salmon-steelhead angling; (4) in Period III salmon-steelhead

Table 4.--Matrix of coefficients for Period I

Explanation: For each pair of coefficients, the upper coefficient is the cross-price elasticity in the demand equation for the character listed at the top of the column, whereas the lower coefficient is the cross-price elasticity in the demand equation for the character listed at the end of the row. For example, -0.8 is the cross-price elasticity for 2-0-0 in the equation for 1-0-0, and 0.2 is the cross-price elasticity for 1-0-0 in the equation for 2-0-0. The symbols S, I, + and - mean the following: Reading across the rows, "S" means the character in the row is considered superior to the character in the column, "I" means the row character is inferior to the column character, "+" means they are substitutes for each other, and "-" means they are "complementary." Tables 5 and 6 are similar.

		2 (1-0-0)	3 (2-0-0)	4 (3-0-0)	5 (0-1-1)	6 (1-1-1)
(1-0-0)	2	*	S	S	S	S
(2-0-0)	3	-0.8 0.2	*	-	+	I
(3-0-0)	4	-0.7 0.3	-1.1 -0.3	*	S	I
(0-1-1)	5	-0.1 --	0.3 --	-0.1 --	*	I
(1-1-1)	6	-0.6 0.2	0.3 -0.3	0.1 -0.8	-- -0.1	*
(2-1-1)	7	0.9 0.8	-0.6 1.2	0.4 0.01	-- -0.1	0.9 0.4
(3-1-1)	8	0.1 0.7	-2.5 1.5	0.02 -0.5	-- -2.2	-1.0 0.4
(1-2-2)	9	0.2 0.6	0.2 0.1	0.2 -0.01	-- -0.5	1.2 0.02
(2-2-2)	10	-0.5 -0.1	1.2 0.8	-0.2 0.9	-- 0.3	0.4 -0.1
(1-3-3)	11	1.2 -0.3	0.6 0.6	0.1 0.4	-- -0.5	0.2 0.2
(2-3-3)	12	0.7 0.01	1.6 -0.5	-0.4 0.1	-- -0.5	1.5 -0.4
	Lake Trout	-1.1	-0.2	0.4	--	-1.0
	Game Fish	-0.9	0.7	-1.1	--	-3.0
	Panfish	0.5	-0.6	0.3	--	1.3
	Income	0.3	0.03	0.1	--	0.4
	R^2	0.26	0.35	0.32	--	0.31

Table 4.--(concluded)

7 (2-1-1)	8 (3-1+1)	9 (1-2-2)	10 (2-2-2)	11 (1-3-3)	12 (2-3-3)
+	+	+	-	I	+
S	S	+	+	+	I
+	I	I	S	+	S
I	I	I	+	I	I
+	S	+	I	+	I
*	-	-	-	S	S
-1.6 -0.4	*	S	S	I	+
-0.7 -0.3	-0.6 0.1	*	-	I	-
-0.6 -1.9	-0.1 0.4	-0.3 -1.0	*	-	I
-0.1 0.2	0.5 -0.5	0.5 -0.3	-1.2 -0.3	*	-
-0.5 0.7	3.4 0.3	-0.1 -0.7	0.4 -0.5	-0.1 -0.8	*
1.0	-2.0	-1.0	0.5	-0.2	-0.6
0.7	0.7	0.4	-1.5	0.9	0.1
0.1	-0.5	-0.1	1.3	0.3	-0.1
0.02	0.8	0.4	1.9	0.1	0.5
0.25	0.60	0.66	0.52	0.68	0.35

Table 5.--Matrix of coefficients for Period II
(See Table 4 for explanation.)

		2 (1-0-0)	3 (2-0-0)	4 (0-1-1)	5 (1-1-1)	6 (2-1-1)	7 (3-1-1)	8 (0-2-1)
(1-0-0)	2	*	-	S	-	+	S	+
(2-0-0)	3	-1.6 -1.3	*	I	-	I	-	+
(0-1-1)	4	-1.0 --	2.0 --	*	+	I	+	I
(1-1-1)	5	-0.5 -0.3	-0.3 -0.6	-- 0.9	*	I	-	-
(2-1-1)	6	0.1 0.1	0.02 -0.2	-- -1.1	0.5 -0.2	*	+	S
(3-1-1)	7	-0.5 1.7	-0.04 -1.5	-- 0.3	-0.03 -0.8	0.3 0.5	*	S
(0-2-1)	8	0.2 0.2	0.6 0.1	-- -0.04	-0.9 -0.3	-0.6 0.2	-0.4 0.1	*
(1-2-1)	9	1.0 -0.9	1.0 0.7	-- -0.8	0.5 -0.5	0.2 0.6	-0.2 -0.5	1.2 2.4
(2-2-1)	10	0.1 0.3	0.3 2.5	-- -1.6	1.4 -0.9	-0.5 -1.0	-1.6 -1.5	0.6 1.9
(3-2-1)	11	-0.2 -0.5	-0.6 0.6	-- -0.5	-0.7 -1.6	1.5 0.6	0.1 0.4	-0.7 -1.8
(2-3-1)	12	0.3 -1.3	0.05 0.2	-- 0.6	-0.3 -0.4	0.6 0.1	1.1 1.5	-0.02 0.3
(1-1-2)	13	-0.4 -0.7	-0.4 0.9	-- -0.6	-0.3 -0.5	0.0 0.2	-1.8 -0.8	0.5 1.4
(1-2-2)	14	-0.1 0.1	-0.02 1.2	-- -0.6	0.5 -1.1	1.8 -0.1	0.3 -1.3	-0.04 -3.0
(2-2-2)	15	-5.2 0.5	-1.3 -1.2	-- 1.7	1.0 -0.4	-0.9 0.4	1.1 -0.5	0.7 2.2
(2-3-2)	16	-3.2 3.8	-1.8 -1.2	-- -4.7	-0.1 -1.0	-1.2 -0.01	-0.5 -2.0	0.1 -4.3
(2-2-3)	17	1.7 1.5	1.7 1.2	-- -1.2	0.2 -1.1	1.0 0.4	2.4 -1.4	-0.4 -2.5
(3-3-3)	18	6.9 -0.5	6.5 -0.01	-- -0.1	-0.03 -0.6	-0.3 0.3	-2.1 -0.5	0.2 -0.5
	Lake Trout	-1.3	-1.0	--	1.2	-0.1	0.9	-1.3
	Other Trout	-0.8	0.5	--	0.5	-1.4	0.5	0.2
	Game Fish	1.0	0.6	--	-0.6	0.1	-0.5	0.8
	Panfish	-0.1	-0.7	--	0.7	-0.5	-0.7	-0.5
	Income	0.3	-0.1	--	-0.9	1.9	0.8	-0.3
	R^2	0.47	0.61	--	0.33	0.67	0.44	0.58

Table 5.--(concluded)

9 (1-2-1)	10 (2-2-1)	11 (3-2-1)	12 (2-3-1)	13 (1-1-2)	14 (1-2-2)	15 (2-2-2)	16 (2-3-2)	17 (2-2-3)	18 (3-3-3)
I	+	-	I	-	S	S	S	+	I
+	+	S	+	S	S	-	-	+	+
I	I	I	+	I	I	+	I	I	I
I	I	-	-	-	I	I	-	I	-
+	-	+	+	+	+	S	-	+	S
-	-	+	+	-	I	I	-	I	-
+	+	-	S	+	-	+	I	-	I
*	I	+	S	I	S	S	S	S	+
1.22 -0.03	*	I	S	I	+	S	+	-	S
0.5 0.01	1.9 -2.1	*	-	S	+	I	-	I	S
-0.6 0.8	-2.2 2.4	-0.5 -0.3	*	S	+	S	I	+	+
1.4 -0.7	9.9 -0.4	-0.6 0.4	-2.4 0.5	*	+	S	S	+	+
-0.2 2.1	1.2 0.8	1.2 0.4	1.5 1.0	1.2 0.5	*	I	I	I	-
-0.7 1.4	-5.8 1.1	0.3 -1.3	-1.7 0.1	-4.1 0.4	0.5 -0.6	*	-	S	+
-0.1 1.4	6.8 1.3	-1.6 -0.8	1.6 -0.4	-1.4 3.1	1.1 -0.4	-0.4 -0.7	*	+	I
-1.3 2.1	-10.8 -0.1	4.4 -0.2	0.3 0.5	2.6 6.4	0.4 -0.4	-0.0 1.2	0.7 2.5	*	S
0.8 0.5	-1.5 0.4	-0.9 0.2	1.1 0.4	1.8 0.6	-2.4 -0.4	4.6 0.8	5.0 -3.0	-2.3 2.3	*
-2.1	-3.1	0.1	-2.7	-0.6	-3.4	-1.4	-3.1	-4.1	-1.7
0.5	-1.0	0.6	-0.1	-0.9	-0.5	0.6	-1.0	1.2	-0.4
-0.1	1.0	-1.7	0.6	-0.2	0.9	0.4	0.2	1.2	-0.3
0.5	-0.7	-0.6	-0.7	0.3	0.4	-1.0	0.5	-1.7	-0.4
-0.6	1.8	1.7	1.7	0.7	-0.2	-0.2	0.5	2.2	1.7
0.64	0.69	0.64	0.51	0.43	0.50	0.78	0.58	0.51	0.53

Table 6.--Matrix of coefficients for Period III
(See Table 4 for explanation.)

		2 (3-0-0)	3 (0-1-0)	4 (1-1-0)	5 (2-1-0)	6 (0-2-0)	7 (1-2-0)	8 (2-3-0)	9 (0-0-1)	10 (1-1-1)	11 (2-1-1)
(3-0-0)	2	*	S	-	S	S	I	I	+	S	I
(0-1-0)	3	-1.6 0.05	*	+	I	+	-	-	S	+	I
(1-1-0)	4	-1.1 -0.1	0.1 0.4	*	I	I	+	S	+	-	+
(2-1-0)	5	-0.7 0.8	0.04 -0.5	0.2 -1.1	*	I	+	-	S	+	-
(0-2-0)	6	-0.9 0.7	0.03 0.1	0.01 -0.7	0.5 -0.6	*	I	I	S	+	I
(1-2-0)	7	1.3 -0.6	-0.02 -0.6	0.6 1.4	1.3 0.1	0.4 -0.5	*	-	S	S	+
(2-3-0)	8	0.1 -0.8	-0.04 -2.6	-0.1 1.4	-0.7 -0.7	2.0 -0.8	-0.3 -1.0	*	S	I	+
(0-0-1)	9	2.3 --	-0.2 --	0.3 --	-1.0 --	-0.3 --	-0.4 --	-0.7 --	*	+	I
(1-1-1)	10	-0.8 0.5	0.1 0.3	-0.4 -0.7	1.6 0.2	0.1 0.4	-0.3 0.5	1.4 -0.5	-- 1.8	*	S
(2-1-1)	11	1.7 -1.1	0.02 -0.9	0.2 1.4	-0.2 -0.9	0.3 -1.6	0.7 3.4	0.5 1.1	-- -0.6	-0.1 0.1	*
(3-1-1)	12	-0.05 0.1	-0.1 0.3	0.6 0.8	-2.2 0.1	-0.5 0.02	0.01 0.3	-1.6 0.3	-- 0.3	-0.6 -0.02	-1.1 -0.4
(1-2-1)	13	-3.3 -0.2	-0.2 -1.0	-0.5 0.5	-2.8 0.1	-0.4 -0.3	0.6 0.6	1.0 0.2	-- 0.6	0.3 -0.3	1.1 -0.6
(2-2-1)	14	-0.7 0.9	-0.7 -2.1	0.2 3.2	-0.3 -0.1	0.7 -0.4	-0.2 0.5	-1.8 2.3	-- -0.1	0.9 0.1	0.6 -3.2
(3-2-1)	15	1.2 0.7	-0.3 0.3	1.0 -1.3	0.9 -1.1	1.0 -0.8	-0.8 -0.5	0.2 0.01	-- 1.9	0.5 -1.0	-0.4 1.3
(3-3-1)	16	-0.6 0.8	0.4 -0.2	0.2 -0.6	6.0 -0.1	1.1 0.6	-0.6 -1.2	-0.1 -0.6	-- 0.6	0.8 -0.1	0.2 0.3
(3-1-2)	17	-0.8 1.7	-0.03 -0.2	-0.6 -0.9	-1.7 0.7	-2.2 -0.9	0.9 0.7	2.3 0.1	-- -0.3	0.3 0.2	1.9 -0.6
(2-2-2)	18	-0.3 1.7	0.1 -0.7	-0.1 -8.7	3.1 -0.1	-0.2 -0.2	0.1 0.3	0.7 1.7	-- 2.6	0.5 -0.6	0.4 -2.5
(3-3-2)	19	3.2 0.5	0.05 -1.5	1.4 -4.0	5.5 -0.6	-0.7 -0.9	-1.7 -4.6	0.1 1.0	-- 2.0	-0.3 -0.1	-0.8 -1.8
(1-2-3)	20	0.3 -2.0	-0.2 0.6	0.1 0.2	-0.2 -0.1	-1.6 0.02	0.5 1.5	-0.2 -0.1	-- -0.4	0.9 -0.1	-0.2 -3.1
(2-2-3)	21	0.3 -1.1	-0.2 -0.2	-0.03 -0.7	-5.5 -0.7	-0.9 -0.6	-0.1 2.9	0.8 0.7	-- -0.7	-1.9 0.9	-0.9 -3.0
(3-2-3)	22	-2.8 -0.8	0.04 -1.7	-0.4 3.3	1.0 -0.1	-0.4 -0.9	0.8 -3.5	1.5 0.4	-- -0.4	0.1 0.04	0.6 0.6
(2-3-3)	23	-0.6 0.9	-0.02 -1.4	0.1 -5.6	-2.7 0.3	-0.1 -0.4	2.0 -0.04	1.1 0.8	-- 0.9	0.2 0.8	2.2 3.3
	Lake Trout	-0.3	-0.1	-0.5	-3.9	0.5	-0.6	-1.7	--	-0.4	-2.2
	Other Trout	0.2	-0.02	-0.2	0.5	0.01	-0.01	1.3	--	-1.1	0.03
	Game Fish	0.3	-0.02	0.6	1.4	0.5	0.01	-0.9	--	0.2	0.2
	Panfish	-1.1	0.02	-0.8	-2.1	-0.1	-0.2	0.4	--	0.1	-1.3
	Income	0.7	0.1	0.1	-0.5	-0.03	0.1	-0.7	--	-0.7	-0.9
	R^2	0.68	0.12	0.29	0.35	0.85	0.50	0.65	--	0.59	0.58

Table 6.--(concluded)

12 (3-1-1)	13 (1-2-1)	14 2-2-1)	15 (3-2-1)	16 (3-3-1)	17 (3-2-1)	18 (2-2-2)	19 (3-3-2)	20 (1-2-3)	21 (2-2-3)	22 (3-2-3)	23 (2-3-3)
S	-	S	+	S	S	S	+	I	I	-	S
S	-	-	S	I	-	I	I	S	-	I	-
+	S	+	I	I	-	-	I	+	-	S	I
S	S	-	I	I	S	I	I	-	-	I	S
S	-	I	I	+	-	-	-	S	-	-	-
+	+	S	-	-	+	+	-	+	S	I	I
S	+	S	+	-	+	+	+	-	+	+	+
+	+	I	+	+	I	+	+	I	I	I	+
-	I	+	I	I	+	I	-	I	S	+	+
-	I	I	S	+	I	I	-	-	-	+	+
*	+	I	+	S	-	-	-	+	S	-	I
0.1 0.4	*	+	I	S	I	S	S	+	+	S	I
0.6 -0.3	0.2 4.0	*	-	+	+	+	-	S	-	-	+
0.3 2.3	0.2 -0.9	-0.2 -2.8	*	-	+	I	I	I	I	S	-
-0.1 0.1	-0.2 2.5	1.9 0.1	-1.3 -0.02	*	-	I	I	I	-	I	+
-0.5 -0.5	0.1 -0.2	0.6 1.2	2.7 1.5	-0.9 -1.0	*	-	S	S	S	S	I
-1.0 -1.7	-0.2 5.6	1.1 1.0	2.2 -0.03	0.4 -8.4	-0.9 -0.9	*	+	I	S	+	I
-0.6 -0.6	-0.7 2.5	-3.0 -2.1	1.9 -0.1	0.1 -6.6	-0.7 0.1	6.6 1.3	*	I	+	I	+
0.1 0.04	0.5 1.5	-0.7 0.7	0.5 -0.8	2.4 -0.2	-0.2 2.1	6.3 -0.6	.4 -0.1	*	+	S	I
-0.2 0.2	0.9 4.3	-3.9 -0.8	2.8 -0.04	-4.1 -4.9	-1.0 0.9	-5.6 0.5	1.2 2.9	0.9 1.9	*	S	+
-0.1 -4.6	-1.0 2.0	-1.3 -1.3	-0.4 0.4	0.01 -1.3	-0.0 0.5	1.4 1.2	3.7 -1.1	-0.01 0.9	-1.6 0.8	*	+
0.6 5.2	0.5 -4.5	4.1 2.3	-2.6 -2.3	1.1 0.4	0.6 -0.9	6.9 -2.0	7.0 7.8	1.2 -1.2	1.5 3.6	0.0 1.6	*
0.1	-0.5	-0.2	1.0	0.4	0.04	-3.9	-0.3	-0.8	-0.1	-0.3	-0.9
0.3	-0.2	0.1	0.3	0.1	0.2	3.5	1.4	0.6	-0.03	-0.3	2.2
-0.1	0.9	0.1	0.8	-0.4	-0.3	0.2	-1.9	-0.6	-2.4	-0.7	-1.5
0.02	0.1	-0.5	-1.0	0.4	0.2	-1.3	0.6	-0.2	0.6	0.02	-1.9
0.3	0.1	1.0	0.4	0.5	-0.4	1.9	0.0	1.1	1.1	0.5	-0.6
0.36	0.47	0.66	0.52	0.54	0.54	0.73	0.67	0.50	0.67	0.41	0.54

anglers consider game fish angling strongly inferior (or complementary) to chinook angling; and (5) salmon-steelhead anglers consider perch-panfish inferior (or perhaps complementary) to high-catch-rate salmon-steelhead angling and roughly equivalent (or superior)[13] to other salmon-steelhead angling, particularly in Period II.

Income elasticity provides another indication of anglers' evaluations of superior or inferior kinds of angling. As people have more resources to spend (hence have more choices available), they select more of the preferred goods. Most such preferred goods are known as "normal" goods, but those with the strongest positive income elasticity are usually known as "luxury" goods. Goods with negative income elasticities are known as "inferior" goods. Thus a positive relationship indicates a "normal" or "luxury" good. In Period I, the demand for each character of salmon-steelhead angling is positively related to the income per capita in the angler's county of residence (Table 4). This is particularly true for characters with higher salmon catch rates. In Periods II and III, salmon-steelhead angling at locations with the higher catch rates, particularly high chinook catch rates, is positively related to county income, whereas angling at locations with low catch rates is negatively related to county income (Tables 5 and 6). Thus, we may conclude that high-catch-rate salmon-steelhead angling is a "normal" or even a "luxury" good. However, this conclusion is uncertain for two reasons: (1) no direct relationship was calculated between anglers' incomes and their participation rates, and (2) the average income reported by Michigan anglers is very similar to the statewide average.

Relationships between the characters of salmon-steelhead angling are somewhat more complex. The most significant generalization supported by the data is that high-catch-rate salmon-steelhead angling is generally superior to low-catch-rate salmon-steelhead angling--the higher the catch rates, the more superior the angling. Other conclusions are too specific and numerous to list here. However, biologists and planners who wish to gain more insight about the interrelationships should read the section in

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[13] Probably not superior to salmon-steelhead angling, except in Period I (winter), because the positive elasticities are of too low a magnitude in Periods II and III.

the Appendix about relationships between characters, then peruse the symbols and elasticities in Tables 4, 5 and 6 and Appendix Table A-3.

Note that because the equations are statistical estimates, and even the angling origin/destination data upon which the equations are based are themselves estimates, the relationship of any estimated coefficient to the true coefficient is questionable. The general relationships, however, are presumed to be valid.

Comparing levels of demand

We have seen that the income elasticities and the various cross-price elasticities indicate which kinds of angling salmon-steelhead anglers consider superior or inferior, and indicate complementarity or substitutability. Three other important attributes of the demands for the various characters are indicated by (1) the sums of the cross-price elasticities, (2) the location of the demand curves, and (3) the shape of the demand curves. The sum of the cross-price elasticities and the location of the demand curve (i.e., to the right or left of other demand curves) are both indications of whether a character is generally inferior or superior to the other characters. The former indicates the willingness of anglers to substitute other characters, and the latter indicates the willingness of anglers to pay for a character. The shape of the demand curve and the sum of the cross-price elasticities are both indications of how unique a particular character is in relation to the others. More detailed explanations are given in Appendix C, together with explanatory data and figures. Upon closer inspection of the information in Table C-4 and Figures C-2 through C-4, much detailed information of value to the biologist or planner is available. In general, these data further support the conclusions made above. Because of the large amount of detailed information and conclusions that may be drawn, further discussion will not be presented here.

Combining the three periods

Table 1 (above) illustrates the various salmon-steelhead angling characters and the periods in which they exist. There are 33 characters that exist at some time during the year in Michigan. Any character that is not available in Michigan during one of the periods may be available in some other location in North America, or at least an equivalent character can be assumed to be available somewhere. If it is available, an angler may wish to supply himself with it at a high supply price. For example, he could travel to the Washington coast for certain kinds of salmon-steelhead angling. To simulate the extreme supply price of the "unavailable" characters (in the periods for which they are not available), a value of 5.5 [14] was assumed for "ln P," equivalent to $244.70 per angling day, including the value of the time involved. In addition, because the three sampling periods involved different numbers of days and seasonal differences, dummy variables for "period" were also used. Demand equations were then estimated for several of the characters, the results of which are shown in Table C-3. Some of the less important demand equations were not estimated.

The results from these equations may be more representative of the true relationship because more observations and wider variations in prices were used in the regressions.

V. VALUE DETERMINATION

The meaning of total value

The demand schedule for any kind of angling indicates the willingness of anglers to exchange their resources (measured in terms of dollars) for various amounts of that kind of angling. From the demand schedule and the knowledge about the present costs to anglers (based upon travel distance), we may predict (1) any additional amounts anglers would be willing to pay if additional costs were imposed upon them, (2) any savings

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[14] From the price equation the logarithm of the price of angling for non-residents living 1,000 miles away is approximately 5.4.

to anglers from reductions in their present costs, and (3) the change in the amount of angling that would accompany any change in angling costs or availability. Such changes in angling costs may result either from additional costs (or savings) imposed upon anglers, such as changes in license fees, user fees, transportation costs, etc.; or from a change in travel costs resulting from a change in the location of the angling. In either case, an increase in costs represents a decrease in supply (i.e., a shift in the supply schedule) and some loss of angling, whereas a decrease in costs represents an increase in supply and some increase in angling.

Therefore, with the proper analysis, we may estimate anglers' willingness to pay (beyond their present costs) to prevent a decrease in supply or to promote an increase in supply. Since the demand schedule measures social preferences, willingness-to-pay may be estimated in such a way that it summarizes social preferences in given circumstances.

The total value of the 1970 salmon-steelhead sport fishery is the maximum net willingness of anglers to pay, over and above their present angling costs, either to prevent the loss of the existing fishery, or, conversely, to promote the gain of the existing fishery if one didn't already exist. This kind of value is sometimes referred to as the net "all-or-none" value of a good, meaning a value comparison between the presence of a good and the absence of the good. It represents an evaluation of an "all-or-none" choice for society. The value is also called "consumer's surplus," referring to the fact that the value is net of the price actually paid.

An all-or-none value measures the total benefits to buyers of having the opportunity to purchase a good as opposed to not having that opportunity. The all-or-none value of the fishery, or any other kind of good, could almost certainly never be recovered by the state or anyone else. For most practical purposes, such an all-or-none value is imaginary. It is never found in a real market situation, and the concept has limited usefulness. Only a perfectly discriminating monopolist could collect that amount by collecting every increment in willingness to pay as price increased to the maximum possible. Geometrically it is equivalent to the entire area under the demand curve and above the price at which the supply curve intersects the demand curve.

In the real world, only one or, at most, a few different prices could be charged to anglers at various locations and times. The most revenue a real owner (or controller) of the salmon-steelhead fishery could recover from anglers is probably about one-half to one-third of the maximum willingness to pay. This value, minus the cost of administering such charges, would be the market value of control over fishing rights. The total amount an owner can recover from anglers is equivalent to the sales revenue from any market good, such as automobiles or apples. For example, the all-or-none value of water is extremely high, since without it we would be dead; but its sales value is low because it is so easily attainable. The all-or-none value of the fishery gives little insight about whether the level of development of the fishery is the most appropriate one, or whether the anadromous program should be increased or decreased in any or all locations. The simulation model discussed later should help evaluate those questions. Just as the cost of shopping is not included as part of the sales price of automobiles or apples, the present costs to anglers of angling, with the exception of license fees, are not included as any part of the willingness of anglers to pay an owner for angling. The shopping and angling costs are important to shopper behavior and angler behavior (we use them for calculating demand), but are eliminated in calculating all-or-none value.

If a decision-maker is faced with an all-or-none choice--either provide the opportunity to "purchase" a good or provide no opportunity--the most appropriate value to use would be the all-or-none value. For lesser choices, however, the revenue that could actually be recovered by an owner would usually be a more realistic value, since almost all goods are allocated on that basis in this country by private enterprise.

The all-or-none value was calculated in this analysis, and by Ellefson in his analysis, because in a real sense it evaluates the net worth to society of having the good. All-or-none values may also be used in comparison with other values calculated in a similar manner to judge between mutually exclusive choices of resource utilization.

Calculated total value

As mentioned earlier in the discussion of the demand and supply of angling, some assumption must implicitly or explicitly be made regarding the prices of alternative kinds of recreation. In this case the most important alternative kinds of recreation are the other kinds of angling available.

Using the demand equations that were separately estimated for each period, the all-or-none value was calculated under two different assumptions. One calculation produced a crude estimate of \$30 million per year, assuming that all other fisheries continue to exist in their present form at their present costs. The other calculation estimated the maximum net willingness for anglers to pay for salmon-steelhead angling in each period, assuming that all prices (including prices for non-salmon-steelhead angling) increase simultaneously (Table 7). In other words, all prices were simultaneously raised by increments, and the incremental revenue that would be forthcoming from the price increases [15] was totalled. The total value was estimated at about \$23 million.

The total value of \$30 million was estimated under the assumption that none of the prices for (1) lake trout angling, (2) other trout angling, (3) game fish angling, and (4) perch-panfish angling changed in any way as the prices of salmon-steelhead angling were increased. It might seem that since the other kinds of angling remain available to salmon-steelhead anglers, they would switch to them as salmon-steelhead prices increase. If this happened, anglers would be less willing to pay for salmon-steelhead angling, so the net value would be below \$23 million. Instead, the calculated willingness-to-pay was about three times greater than that. The reason is that in the price ranges observed, lake trout angling and some others are complementary to salmon-steelhead angling: If those kinds of angling are more available (lower prices) they increase the demand for salmon-steelhead angling, causing anglers to be more willing to pay to prevent the loss of the salmon-steelhead fishery. It seems realistic under such circumstances to have some increases in the net willingness to pay, but the observed increase seems unrealistically high. The most likely reason for the high

[15] Including an approximation of consumers' surplus.

Table 7.--Maximum total value* of the salmon-steelhead fishery to anglers, 1970, assuming all prices are increased simultaneously

Period	All anglers		Michigan residents only	
	Uncorrected value	Corrected value	Uncorrected value	Corrected value
I	$2,458,377	$2,851,717	$1,834,840	$2,128,414
II	3,803,692	4,146,024	3,298,398	3,595,254
III	15,237,252	16,456,232	10,619,420	11,468,974
Total	21,499,321	23,453,973	15,752,658	17,192,642

* Because some angler days were excluded from the demand equation regressions, the values were increased by a percentage equivalent to the percent of angler days excluded to obtain the "corrected" value.

estimate is that the simulated price increases exceeded any price combinations actually observed. An "educated guess" of the "most realistic" value of the salmon-steelhead fishery, holding constant the availability of all other kinds of angling, is about $30 million.

Whenever predictions are attempted beyond the range of observed values, unrealistic results may be forthcoming. If the value were to be calculated again, but increasing the price of lake trout angling along with the prices of salmon-steelhead angling, a different and perhaps more realistic value would result. Also, if the demand equations for the entire year were to be used instead of the demand equations for the separate periods, more realistic answers might be produced because those equations are based upon a wider variety of price observations. Another way of getting even more realistic results would be to combine observations over several years, giving a dynamic cross-section analysis with a much wider variety of situations and prediction capability.

As mentioned earlier, the implicit assumptions made in Ellefson's analysis are uncertain, but they are probably similar to the assumption that all prices rise except those of game fish angling and panfish angling, including rises in the prices of lake trout angling, and some slight rise in other trout angling prices. Using these assumptions in this analysis would probably result in a value to Michigan residents only of about $20 million, which is similar to Ellefson's results when he corrected them for the value of time.

Perhaps the most important point of this analysis is that "the value" of the salmon-steelhead sport fishery depends to a great extent upon the assumptions used about the availability of alternatives. Perhaps the "most correct" value of the 1970 fishery is one in the neighborhood of the $30 million per year that would be calculated holding the availability of all other kinds of angling constant. All other value estimates are confused by other factors.

Value of incremental changes

If a change in the stocking rates of steelhead, coho, or chinook, or if some other factor caused a change in the catch rate(s) of salmon or steelhead at a location, by definition it would change the character of angling there. Such a change would be an incremental change in the supply of salmon-steelhead angling, and would be evaluated differently than an all-or-none choice.

Even one such change in character at one location can set off a series of changes that are difficult to evaluate without a computer-based simulation model. Suppose the change was an increase in a steelhead stocking rate that changed the catch rates in Period I at county X from 2-0-0 to 3-0-0 (i.e., moderate steelhead catch rate to high catch rate, with no salmon available). For anglers living in county X, and likely for some others, too, 2-0-0 becomes less available and 3-0-0 becomes more available. This should be interpreted as a decrease in the supply (increase in price) of 2-0-0 and as an increase in the supply (decrease in price) of 3-0-0. The demand for each character is a price-quantity relationship so although the demand for each does not change as its availability changes, the amount of angling--the quantity demanded--does change as the prices change, as shown in Figure 4.

In addition, another important change takes place: The demand curve for the new character shifts.[16] Any demand curve is (or should be) constructed holding constant the prices of alternatives. In this example, the price of 2-0-0 changes from its original price, causing anglers to reevaluate their preferences. This reevaluation shifts the whole demand curve for 3-0-0, and may significantly change the amounts of angling at various locations, but does not in itself normally[17] change the value of angling in any way. In the demand for character 3-0-0, the cross-price elasticity of 2-0-0 is -0.3, so if the price of 2-0-0 increases 10%, the quantity of angling of character 3-0-0 would decrease 3%. This shift in the demand curve is illustrated in Figure 4b. Again, this 3% change in the amount of angling would not indicate any value change.

The net change in value to anglers from county X may be evaluated in a two-step process. First, the loss to anglers due to the reduction in supply of character 2-0-0, equal to the shaded area in Figure 4a, may be calculated; and second, after the demand for character 3-0-0 has shifted, the gain to anglers due to the increase in supply of character 3-0-0, equal to the shaded area in Figure 4b, may be calculated. The net value change is the gain minus the loss.

Such changes in the availability of characters 2-0-0 and 3-0-0 at county X may or may not change the supply of character 2-0-0, character 3-0-0, or both at other counties. Whether or not anglers at other locations

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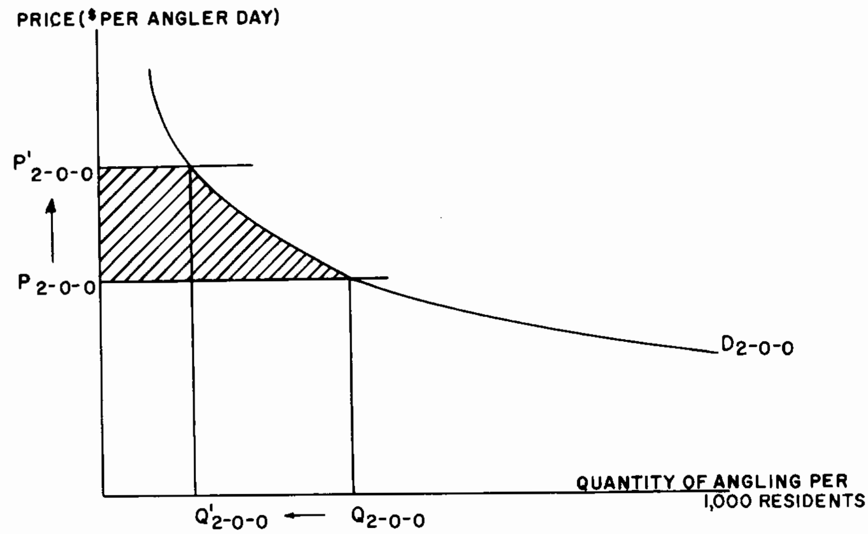
[16] The demand curve for the other character (2-0-0) shifts also, but that shift is not important in the evaluation. It only indicates the change in consumer preferences as a result of the increase in supply of the new character, and does not change the value of the angling resources. The demand for all other characters change, too, with a similar insignificant effect on value. However, the quantity demanded of many characters may be altered significantly.

[17] Unless it changes the character of angling at some location (e.g., by changing crowding levels).



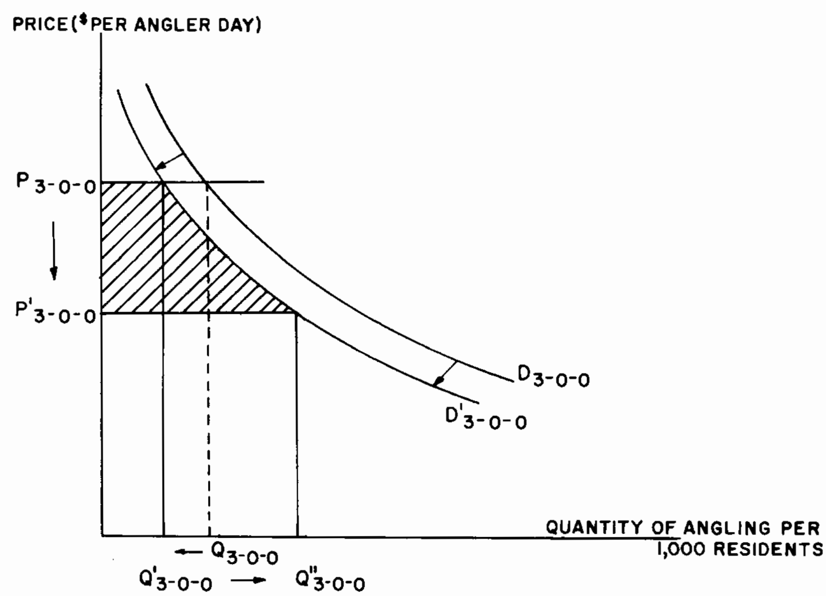


Figure 4.--Illustration of the change in value brought about by a change in the character of angling at a particular location, evaluated for anglers residing at that location.

(Upper) Loss in value due to reduction in supply (increase in price) of character 2-0-0. The quantity of angling is reduced from Q to Q' as the price increase.

(Lower) Shift in the demand for character 3-0-0 (brought about by an increase in P_{2-0-0}) decreases the amount of angling from Q to Q'. The shaded area indicates the increase in value due to an increase in the supply (lower price) of character 3-0-0. The quantity of angling increases from Q'to Q" as the price decreases.

experience changes in supply depends upon the locations of the other counties and the locations of other places where these characters are available. Recall that the price (or supply "curve") is determined only by the nearest location of a given character. The total value of increased steelhead stocking must be determined by evaluating the gain and loss to anglers in each origin, so it should be apparent that the more available character 2-0-0 or 3-0-0 is, the smaller will be the loss or gain, respectively. Also, the availability of substitutes or complements can have a great effect upon the magnitude of that gain or loss.

The set of demand equations, together with information about the existing locations of the various characters, makes it possible to simulate many hypothetical changes in character. Such simulations could be used to estimate the value of possible management schemes and their effect upon the number and distribution of angler days.

The resulting values may be interpreted as the maximum all-or-none value to anglers of the incremental change in supply. This value differs somewhat from the all-or-none value of the whole fishery. Since the calculations for an incremental change are based upon locational advantages of various "market" areas, the values could largely be recovered by a monopolist discriminating among users based upon their place of residence. Even without discrimination much of the value of such a change could likely be collected by an owner. Therefore, the all-or-none value of an incremental change in salmon-steelhead angling character would usually be the best value to use in evaluating such changes.

The main limitations to such simulations are (1) any character not included in the demand equations may not be used in the simulations, and (2) if the simulation creates combinations of prices unlike those actually observed, the resulting estimates may be unrealistic. These limitations may be overcome by obtaining as many observations under as great a variety of circumstances as possible. For example, the demand equations estimated for the entire year are probably more reliable for simulating changes than the equations estimated independently for each season. Data collected and analyzed over a number of years or over a wide geographical area would be better. It is also possible, if necessary, to assume a set of coefficients and proceed from there.

For purposes of illustration, several simulations were tried using the equations estimated separately for the three periods as shown in Table 8. Some of the results seem unrealistic,[18] but the general nature of the figures seem to be reasonable in most cases. Some of the points made above are illustrated by these examples. Part b of Table 8 illustrates that as several counties are changed to character 3-1-2, each gain due to the increase in supply of 3-1-2 is less than the previous gain. The value of changing Kent County to character 1-2-3 (by increasing the catch rate of chinook) is positive under existing circumstances, but negative if some nearby counties also have high catch rates of chinook. In general, the rarer any character is the more valuable would be an additional unit of that character, and vice versa. The changes in the amount and distribution of angling effort resulting from simulated changes in catch rates could have also been estimated while estimating value changes, but were not included in this brief analysis.

Conclusions that may be tentatively drawn from these few simulations (assuming that increase in stocking will increase catch rates) are: (1) that in general, increases in stocking rates appear to have high benefits --much higher than the costs of increasing the stocking, (2) additional stocking of certain species at certain locations would have even greater benefits than general increases in stocking, and (3) stocking rates for certain species at some locations may be reduced without important losses in benefits. It is apparent that further work with the simulation model would be helpful in prescribing a more optimum stocking plan. This would seem to be true not only for the anadromous fishery, but for other fisheries as well.

These conclusions should be qualified by two other considerations. First, because of the uneven distributions of angling effort and biological

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[18] One reason for unrealistic results is that there was only one county observed of character 3-1-2 (Houghton County) and, given the sparse data for that county, the misleading results are understandable. Similar problems exist in some other examples given. Such problems may be overcome by expanding and refining the data base used in estimating the demand equations.

Table 8.--Evaluations of simulated character changes at given central and southern Lake Michigan locations (evaluated for Michigan residents only) using equations independently estimated for each season

(s-c-k represent steelhead, coho and chinook, respectively)

Michigan county	Period	Old character s-c-k	Simulated character s-c-k	Loss	Gain	Net value of change
a. Independent changes						
Muskegon	3	2-2-3	2-3-0	$275,177	$1,399,494	$1,124,317
Muskegon	3	2-2-3	3-3-1	275,177	0	-275,177
Muskegon	3	2-2-3	3-2-1	275,177	6,660,167	6,384,990
Muskegon	3	2-2-3	2-2-1	275,177	14	-275,163
Allegan	2	0-2-1	1-1-2	5,846	1,548,164	1,542,318
Berrien	3	1-2-3	1-2-1	61,038	8,623	-52,415
Kent	3	1-2-1	1-2-3	51,383	465,499	414,116
b. Series of changes, assuming each change becomes "permanent" in the order given						
Newaygo	3	2-2-3	3-1-2	2,162,144	8,637,675	6,475,531
Ottawa	3	3-3-1	3-1-2	158,608	5,999,860	5,841,252
Van Buren	3	3-3-1	3-1-2	331,124	1,825,112	1,503,988
Kent	3	1-2-1	1-2-3	7,755	332	-7,423
Mason	3	2-2-2	2-2-1	972	1,039,146	1,038,174
Manistee	3	2-3-3	2-3-0	27,415	9,121	-18,295

conditions, the degree of management effort required to produce a significant change in salmon or steelhead catch rates varies considerably throughout Michigan. Management costs and feasibility are equally as important in determining the distribution of management effort as the values produced: Management effort should be allocated so as to produce the maximum benefits with a given amount of resources. Second, the values of alternative activities of the Department, particularly fisheries management for non-anadromous species, have not been determined. Such evaluations may indicate that greater or lesser benefits are produced by other programs, so the Anadromous Program should be decreased or increased to shift resources to or from other programs. Moreover, the budget for any program should be increased when it can be shown that the benefits to the public would be increased more than the costs to the public, as appears to be the case in the Anadromous Program.

VI. CONCLUDING OBSERVATIONS

It has been demonstrated how a demand analysis may provide several kinds of useful information to fisheries resource managers and planners: (1) a description of a fishery in terms of the attributes of the fishery that are most important to anglers, (2) descriptions of the relationships between various fisheries, (3) descriptions of the interrelationship between the various characters ("qualities") of certain fisheries, including the relative preferences for various characters, (4) an estimate of the total "all-or-none" value of the fishery, and (5) capability of evaluating many hypothetical changes in the resource to determine both the resulting changes in the value of the resource to anglers and the resulting changes in the patterns of angling pressure at various locations. Such information is useful in formulating fisheries management programs, comparing the benefits of one fisheries program to another, and comparing fisheries management to other governmental activities.

The analysis suggests several factors that should be taken into consideration when evaluating the kinds of recreation that might be provided at various locations. First, the rarer any kind of recreation is, the more valuable an additional unit of that kind would be to the users, or conversely, the more available any kind is, the smaller the value of an additional unit. Second, different people have different preferences, so each different kind of recreation may be viewed as serving a different segment of the population. Third, since one of the primary costs of recreation is the cost of transportation, each unit of a kind of recreation (e.g., each county that has a particular character of salmon-steelhead angling) serves a fairly unique geographic market area. Each angler belongs to the market area of the closest unit of a kind of recreation, so the size of each market area depends upon the locational advantage of the unit. Fourth, the larger the population of the market area, and the closer the population is to the recreation, the greater is the value. All of these considerations and others are included in the simulation procedures.

The average all-or-none value of salmon-steelhead angling is $10 to $15 per angler day, but it should be abundantly clear that every increase or decrease in angler days should not be evaluated at $15 per angler day or any other fixed figure. In general, changes in angler days that are the indirect result of change elsewhere (e.g., increased angling effort at stream A caused by pollution in stream B) should be given zero value. Otherwise, angler days may be valued up to as high as $20 or $30, or more, depending upon the above circumstances and other factors. The simulation techniques could quantify such values in many situations.

The primary limitation to such a demand analysis is the large volume of required data. The more complete the data, the more realistic will be the analytical results. However, once sufficient data are acquired the simulation model may be easily kept in a current, readily accessible form for several years. The equations would probably need to be re-estimated with new data (perhaps even using less data) only about every 5 years, assuming no major changes take place in the fisheries resource or angler preferences. Additional work of this nature is highly recommended. Computerized simulation models could become highly accessible and easily used management tools. Easily available assessments of the values of potential changes and the resulting shifts in angling effort would be quite helpful in fisheries management and planning.

APPENDIX

Price equations

Appendix Figure A-1 illustrates the effect of including the number of angling days per trip as a separable item: Price (\$/angler day) was estimated as a function of $\frac{1}{\text{angler days}}$, $\frac{\text{distance}}{\text{angler days}}$, and $\frac{1}{\text{distance x angler days}}$.

The reasoning is that total cost of angling is a function like equation (1) for any period, residence, and angling type. The cost per angler day may be

$$\text{Total cost} = a + b_1 \text{ distance} + \frac{b_2}{\text{distance}} + b_3 \text{ angler days} \qquad (1)$$

determined by dividing each item by the number of angler days, resulting in the equations illustrated in Figure A-1. Note that the slope of the cost curves decreases in proportion to $\frac{1}{\text{angler days}}$ as angler days increase. However, up to a certain distance, this implies an increase in the cost per angler day, since anglers who travel short distances would not normally incur overnight expenses unless they stayed for more than one day.

Appendix Table A-1 presents the actual price equations used in the analysis. The percent of the variability accounted for in the equations (R^2) is only about 20%. However, the equations are considered valid because there is a strong theoretical basis for the equation format. The shapes of the curves are as hypothesized. One reason for a low R^2 could be the large inherent variability in individual angler-expenditure patterns.

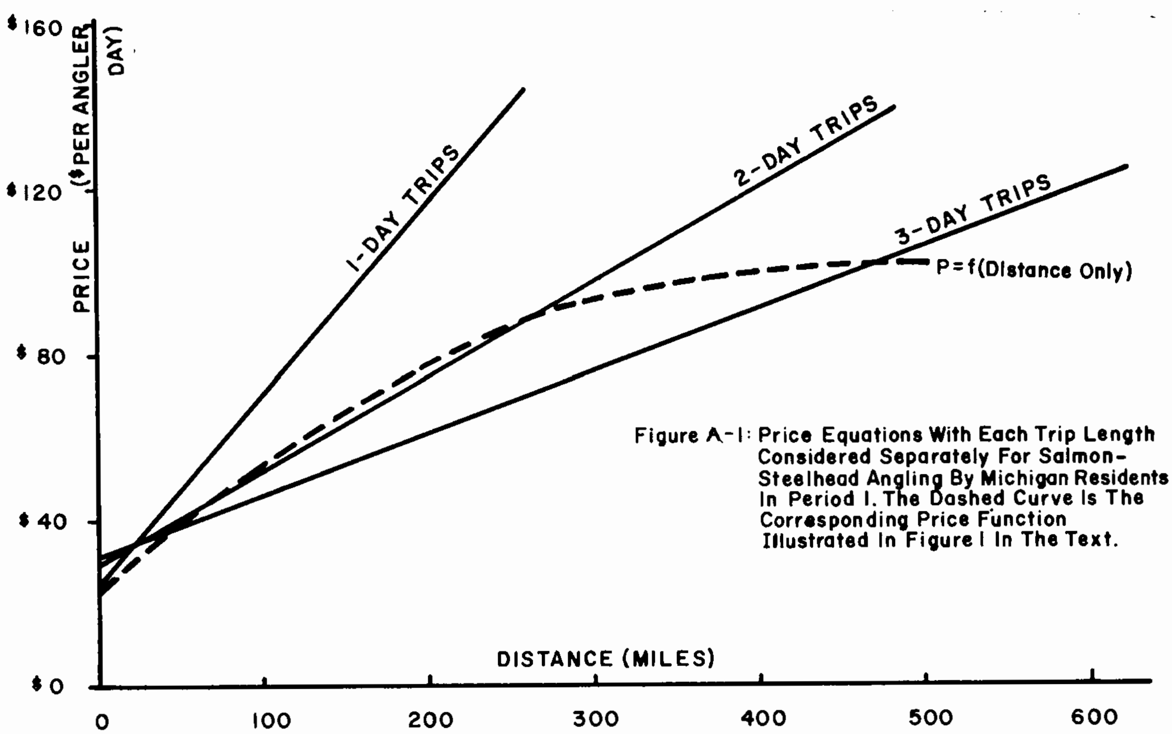

Figure A-1: Price Equations With Each Trip Length Considered Separately For Salmon-Steelhead Angling By Michigan Residents In Period I. The Dashed Curve Is The Corresponding Price Function Illustrated In Figure I In The Text.

Appendix Table A-1.--Price equation coefficients

Factor	Residents: Salmon-steelhead	Residents: Non-salmon-steelhead	Non-residents: Salmon-steelhead	Non-residents: Non-salmon-steelhead
Constant	18.2796	24.3168	101.293	14.2167
Distance	.31078	.19381	.29347	.15856
$(\text{Distance})^2$	-.000259	-.00021	-.000098	-.000074
ln (distance + 1)	-.69195	.50715	-1.0942	-2.4193
Period	7.9863	3.9661	-81.0805	28.6758
$(\text{Period})^2$	-.91768	-1.1512	20.0757	-6.2858
R^2	.224	.223	.200	.188

Catch rates

Appendix Table A-2 illustrates the character of each county in each period. Catch rate classifications were made by biologists familiar with the 1970 salmon-steelhead fishery, in conjunction with the average catch per day as reported by anglers in response to the survey.

Appendix Table A-2.--Summary of angling character in each county in each of the three periods

County	Period I	Period II	Period III
	s-c-k	s-c-k	s-c-k
1. Alcona	1-1-1	3-1-1	3-1-1
2. Alger	1-3-3	2-2-1	2-2-2
3. Allegan	1-1-1	0-2-1	1-1-1
4. Alpena	2-1-1	2-1-1	2-2-2
5. Antrim	1-1-1	2-2-1	1-1-0
6. Arenac	2-1-1	1-0-0	3-2-1
7. Baraga	2-2-2	3-2-1	3-2-1
8. Barry	0-0-0	0-0-0	0-0-0
9. Bay	0-1-1	0-1-1	0-1-0
10. Benzie	2-1-1	2-3-2	3-3-2
11. Berrien	1-2-2	1-2-1	1-2-3
12. Branch	0-0-0	0-0-0	0-0-0
13. Calhoun	0-0-0	0-0-0	0-0-0
14. Cass	0-0-0	0-0-0	0-0-0
15. Charlevoix	1-1-1	1-1-2	2-2-2
16. Cheboygan	2-1-1	1-1-1	1-2-0
17. Chippewa	1-1-1	2-1-1	2-1-0
18. Clare	0-0-0	0-0-0	0-0-0
19. Clinton	0-0-0	0-0-0	0-0-0
20. Crawford	0-0-0	0-0-0	0-0-0
21. Delta	1-2-2	2-1-1	2-3-0
22. Dickinson	0-0-0	0-0-0	0-0-0
23. Eaton	0-0-0	0-0-0	0-0-0
24. Emmet	3-1-1	2-3-1	2-3-3
25. Genesee	0-0-0	0-0-0	0-0-0
26. Gladwin	0-0-0	0-0-0	0-0-0
27. Gogebic	1-1-1	1-2-1	1-1-1
28. Grand Traverse	2-3-3	2-2-3	2-2-2
29. Gratiot	0-0-0	0-0-0	0-0-0
30. Hillsdale	0-0-0	0-0-0	0-0-0

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Appendix Table A-2, continued.

County	Period I s-c-k	Period II s-c-k	Period III s-c-k
31. Houghton	3-0-0	2-2-1	3-1-2
32. Huron	0-0-0	1-1-1	0-0-1
33. Ingham	0-0-0	0-0-0	0-0-0
34. Ionia	0-0-0	0-0-0	0-1-0
35. Iosco	2-2-2	3-2-1	2-2-2
36. Iron	0-0-0	0-0-0	0-0-0
37. Isabella	0-0-0	0-0-0	0-0-0
38. Jackson	0-0-0	0-0-0	0-0-0
39. Kalamazoo	0-0-0	0-0-0	0-0-0
40. Kalkaska	0-0-0	0-0-0	0-0-0
41. Kent	1-0-0	0-0-0	1-2-1
42. Keweenaw	1-0-0	2-1-1	3-0-0
43. Lake	2-0-0	1-0-0	2-2-2
44. Lapeer	0-0-0	0-0-0	0-0-0
45. Leelanau	1-1-1	2-2-1	2-2-1
46. Lenawee	0-0-0	0-0-0	0-0-0
47. Livingston	0-0-0	0-0-0	0-0-0
48. Luce	1-1-1	3-1-1	2-1-0
49. Mackinac	2-0-0	2-2-1	2-1-1
50. Macomb	0-0-0	0-0-0	0-0-0
51. Manistee	3-1-1	2-3-2	2-3-3
52. Marquette	1-2-2	2-2-1	2-2-1
53. Mason	2-2-2	3-3-3	2-2-2
54. Mecosta	0-0-0	0-0-0	0-0-0
55. Menominee	0-0-0	1-1-1	0-2-0
56. Midland	0-0-0	0-0-0	0-0-0
57. Missaukee	0-0-0	0-0-0	0-0-0
58. Monroe	0-0-0	0-0-0	0-0-0
59. Montcalm	0-0-0	0-0-0	0-0-0
60. Montmorency	0-0-0	0-0-0	0-0-0
61. Muskegon	1-1-1	2-2-2	2-2-3
62. Newaygo	1-0-0	2-0-0	2-2-3
63. Oakland	0-0-0	0-0-0	0-0-0
64. Oceana	3-1-1	1-2-2	2-2-1
65. Ogemaw	1-0-0	0-0-0	1-1-0
66. Ontonagon	2-1-1	2-1-1	2-1-0
67. Osceola	0-0-0	0-0-0	0-0-0
68. Oscoda	0-0-0	0-0-0	0-0-0
69. Otsego	0-0-0	0-0-0	0-0-0
70. Ottawa	1-1-1	1-2-2	3-3-1

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Appendix Table A-2, concluded.

County	Period I s-c-k	Period II s-c-k	Period III s-c-k
71. Presque Isle	1-1-1	1-2-2	3-2-3
72. Roscommon	0-0-0	0-0-0	0-0-0
73. Saginaw	0-0-0	0-0-0	0-0-0
74. St. Clair	1-1-1	1-1-1	1-1-1
75. St. Joseph	0-0-0	0-0-0	0-0-0
76. Sanilac	0-0-0	1-1-1	1-1-1
77. Schoolcraft	1-1-1	2-3-1	2-3-0
78. Shiawassee	0-0-0	0-0-0	0-0-0
79. Tuscola	0-0-0	0-0-0	0-0-0
80. Van Buren	1-2-2	1-2-1	3-3-1
81. Washtenaw	0-0-0	0-0-0	0-0-0
82. Wayne	0-1-1	0-0-0	0-1-0
83. Wexford	0-0-0	0-0-0	0-0-0

APPENDIX DISCUSSION

Relationships between characters of salmon-steelhead angling

The relationships between the characters of salmon-steelhead angling require some interpretation beyond that given in the text. The cross-price elasticities in Tables 4, 5, 6, and A-3 indicate inferior-superior relationships, good substitutes and good complements. If the pairs of coefficients have opposite signs, the respective characters may have an inferior-superior relationship in which the character of the equation having the positive coefficient is apparently inferior to the other character. For example, the first set of coefficients in the upper left corner of Table 6 (Period III) indicates such a relationship: Equation 3 (the demand for 0-1-0, now 3) has a positive cross-price elasticity (0.05) for character 3-0-0, while equation 2 (the demand for 3-0-0) has a negative cross-price elasticity (-1.6) for character 0-1-0. Each elasticity indicates that 3-0-0 is superior to 0-1-0. A similar but more extreme example is found in Table 6 (Period III): Equation 4 (the demand for 1-1-0) has a cross-price elasticity for character 3-3-2 of 1.4, indicating that 3-3-2 is superior to 1-1-0, while equation 19 (the demand for 3-3-2) has a cross-price elasticity for character 1-1-0 of -4.0, indicating that 1-1-0 is inferior to 3-3-2. In other words, salmon-steelhead anglers apparently consider character 3-3-2 superior to 1-1-0, because as 1-1-0 becomes more available anglers switch to 3-3-2, but as 3-3-2 becomes more available anglers turn away from 1-1-0. A case in which both elasticities are positive, such as characters 2-3-3 and 3-3-2 in Period III, indicates that the anglers apparently consider the two goods to be substitutes for each other, and perhaps make little distinction between the two. A case in which both elasticities are negative, such as characters 2-2-3 and 3-3-1, indicates that anglers apparently either find the two incompatible or find that angling at one location is complemented by angling at the other, because the increased availability of one is associated with an increase in angling at both characters.

These interpretations of elasticities are shown in the upper right-hand portions of the tables by four symbols: S, I, + and -. Reading across the row, "S" means the character in the row is superior to the character in the column, "I" means the row character is inferior to the column character, "+" means they are substitutes for each other, and "-" means they are "complementary." For example, the figures in Table 4 indicate that 1-0-0 is superior to 2-0-0, 3-0-0, 0-1-1 and 1-1-1, a substitute (or equivalent) for 2-1-1, 3-1-1, 1-2-2 and 2-3-3, a complement to 2-2-2, and inferior to 1-3-3. Some of these relationships between characters of salmon-steelhead angling seem inconsistent. The most likely reason is that the data were insufficient for accurate estimates in each case. However, the general trends indicated by the data seem to be as expected.

Comparing levels of demand

The general form of each demand curve is illustrated in equation (2), where

$$Q_i = e^a P_1^{b1} P_2^{b2} \ldots P_i^{b_i} P_i^{b_i \ln P_i} \ldots P_m^{bm} I^{bm+1} \qquad (2)$$

the b_i are the coefficients of the prices of angling of the respective m characters, "a" is the constant and "b_{m+1}" is the income coefficient. Mathematically, if any of the P_i are equal, their respective coefficients (b_i) may be added without changing the result (i.e., $P_2^{b2} P_3^{b3} = P_2^{b_2+b_3}$ if $P_2 = P_3$). To illustrate the basic nature of the demand equations, the coefficients of all of the prices except the character for which the demand curve was estimated were summed, changing the equation form from (2) to (3), where $\sum_1^m b_j$ is the sum of all price coefficients except those of P_i and P_j

$$Q_i = P_i^{b_i} \quad P_i^{b_i \ln P_i} \quad P_j^{\sum_1^m b_j} \quad I^{b_{m+1}} e^a, \text{ where } j \neq i \qquad (3)$$

is a representative constant price equal to all other prices. The coefficients b_i, b_i, $\sum_1^m b_j$, b_{m+1}, and a, respectively, are illustrated for all equations in Table A-4. The sum of coefficients ($\sum_1^m b_j$) illustrates the general relationship of the demand for the character for which the equation was estimated (character "i") to the other characters.

The prices of non-salmon-steelhead angling are generally lower than those of salmon-steelhead, so the assumption that all prices are equal may be slightly unrealistic: "$\sum_1^m b_j$" may be significantly higher or lower because of the greater than average prices attributed to the non-salmon-steelhead angling. A negative value of "$\sum_1^m b_j$" indicates that as the other kinds of angling are more available, anglers switch to character "i", meaning that the other characters are generally inferior to (or complementary to) character "i". In other words, character "i" is apparently superior when "$\sum_1^m b_j$" is negative. A positive value of "$\sum_1^m b_j$" indicates willing substitution between "i" and the others, meaning that the others are equivalent or superior to "i"; character "i" would be equivalent or inferior.

Appendix Table A-3.--Combined matrix coefficients, periods I, II and III

		2 (1-0-0)	3 (2-0-0)	4 (3-0-0)	5 (0-1-0)	6 (1-1-0)	7 (2-1-0)	8 (0-2-0)	9 (1-2-0)	10 (2-3-0)	11 (0-0-1)	12 (0-1-1)	13 (1-1-1)	14 (2-1-1)	15 (3-1-1)	16 (0-2-1)
(1-0-0)	2	*	+	+	√	√	-	√	+	+	√	√	+	+	+	√
(2-0-0)	3	-- 0.3	*	-	-	+	S	-	-	S	+	+	-	S	I	-
(3-0-0)	4	-- 0.4	-0.6 -0.1	*	-	+	S	-	I	I	+	-	I	+	-	+
(0-1-0)	5	-- --	-0.4 --	-2.2 --	*	√	-	√	-	+	√	√	-	+	-	√
(1-1-0)	6	-- --	0.1 --	0.3 --	-- --	*	-	√	-	+	√	√	-	+	+	√
(2-1-0)	7	-- -0.2	-0.2 0.3	-0.5 0.1	-- -0.9	-- -0.6	*	+	S	-	+	-	+	-	I	+
(0-2-0)	8	-- --	-0.1 --	-0.4 --	-- --	-- --	0.4 --	*	-	-	√	√	-	-	-	√
(1-2-0)	9	-- .01	-0.6 -0.1	2.0 -0.1	-- -0.5	-- -0.8	-1.5 0.4	-- -0.2	*	-	-	-	-	+	-	-
(2-3-0)	10	-- .01	-0.1 0.1	0.2 -0.1	-- 1.6	-- 0.2	-0.5 -0.5	-- -1.2	- .04 -0.3	*	+	-	I	+	S	-
(0-0-1)	11	-- --	0.2 --	2.7 --	-- --	-- --	0.7 --	-- --	-0.4 --	0.1 --	*	√	+	-	-	√
(0-1-1)	12	-- --	0.1 --	-0.3 --	-- --	-- --	-0.1 --	-- --	-0.1 --	-0.1 --	-- --	*	-	-	-	√
(1-1-1)	13	-- 0.3	-0.1 -0.2	0.1 -0.4	-- -0.1	-- -0.1	0.1 0.3	-- -0.2	-0.1 -0.1	.1 -0.6	-- 0.8	-- -0.1	*	+	-	-
(2-1-1)	14	-- 0.5	-0.3 0.4	0.2 0.4	-- 0.2	-- 0.5	-0.2 -1.0	-- -0.5	0.1 0.3	0.2 0.9	-- -0.9	-- -0.2	0.3 0.1	*	S	+
(3-1-1)	15	-- 1.1	0.0 -0.5	-0.3 -0.9	-- -0.2	-- 1.5	0.1 -0.4	-- -0.2	-0.1 -1.1	-0.3 0.1	-- -1.1	-- -1.3	-0.4 -0.2	-0.5 0.1	*	+
(0-2-1)	16	-- --	-1.7 --	0.9 --	-- --	-- --	0.1 --	-- --	-0.0 --	-0.3 --	-- --	-- --	-0.4 --	0.5 --	1.6 --	*
(1-2-1)	17	-- -0.1	1.2 0.2	-0.7 0.2	-- -0.6	-- 0.4	-0.1 -0.1	-- -0.04	-0.04 -0.01	0.2 -0.2	-- 0.3	-- -0.4	0.3 -0.2	0.1 0.2	-0.7 -0.2	-- 1.4
(2-2-1)	18	-- -0.5	-0.2 0.1	- 0.6 0.4	-- -1.0	-- 1.0	0.3 0.1	-- -0.2	-0.1 0.5	-0.4 0.9	-- -0.4	-- -0.4	0.8 -0.3	0.4 -0.2	-0.9 -0.5	-- -2.2
(3-2-1)	19	-- -0.4	-0.2 -0.4	0.6 -0.6	-- -0.4	-- 0.7	0.3 -1.6	-- -1.5	-0.1 -0.7	-0.01 .02	-- 0.9	-- 0.2	0.1 -0.6	0.8 0.6	1.3 0.6	-- -1.2
(2-3-1)	20	-- -0.1	-0.2 -0.7	-0.1 0.03	-- 0.1	-- -0.5	-0.3 0.3	-- .03	0.1 -0.2	0.4 -0.3	-- 0.1	-- .03	-0.2 -0.3	1.0 0.2	0.3 0.9	-- 0.7
(3-3-1)	21	-- -0.1	-0.2 0.1	-3.2 0.2	-- 0.1	-- -0.7	0.5 0.1	-- .04	-0.2 0.1	0.3 -0.1	-- 0.2	-- 0.1	-0.2 -0.02	1.3 -0.2	0.3 0.1	-- -0.2
(1-1-2)	22	-- --	0.9 --	0.7 --	-- --	-- --	1.1 --	-- --	-0.02 --	-0.5 --	-- --	-- --	1.3 --	1.2 --	-0.2 --	-- --
(3-1-2)	23	-- -0.2	0.9 0.2	-0.8 0.5	-- .02	-- -0.5	-1.6 0.4	-- -0.6	-0.5 -0.1	0.3 0.1	-- -0.2	-- 0.1	1.2 0.1	.01 -0.2	0.5 -0.03	-- .01
(1-2-2)	24	-- 0.4	-0.1 0.5	-0.1 -0.2	-- -0.6	-- 0.2	-0.1 0.3	-- -0.1	0.1 -0.1	0.1 -0.1	--	-- -0.6	0.4 -0.3	-0.8 -0.1	-0.2 -0.4	-- -0.8
(2-2-2)	25	-- 0.6	0.3 0.7	-0.03 1.4	-- 0.6	-- -10.5	0.4 -0.4	-- -0.3	-0.02 2.2	-0.6 1.2	-- 1.6	-- -0.2	0.3 -0.3	0.1 -0.6	-0.5 0.3	-- -2.4
(2-3-2)	26	-- 0.6	2.3 -0.1	1.2 -0.6	-- -0.3	-- 1.4	1.8 -0.01	-- -0.2	-0.2 -1.4	-0.4 -0.3	-- 0.8	-- -0.8	0.3 -0.6	0.8 0.3	-0.5 -0.3	-- -4.4
(3-3-2)	27	-- -0.6	-0.1 -0.1	2.6 0.3	-- -1.2	-- -5.9	1.4 -0.9	-- -1.4	-0.5 -2.1	-0.6 0.9	-- 1.2	-- 0.1	-0.3 -0.1	0.2 -0.2	-1.2 -0.4	-- -1.0
(1-2-3)	28	-- 0.1	0.5 -0.1	2.5 -0.2	-- 0.6	-- -0.6	0.7 -0.3	-- 0.5	.01 0.3	-1.0 -0.5	-- -0.5	-- .02	1.0 .03	-1.0 -0.1	.01 .02	-- -0.2
(2-2-3)	29	-- -0.2	-0.9 0.5	-1.2 -0.00	-- -0.1	-- -1.7	-2.1 -0.5	-- -0.5	0.7 1.3	0.9 0.4	-- 0.3	-- -0.2	-1.0 -0.1	-1.4 -0.4	1.5 -0.3	-- -2.5
(3-2-3)	30	-- .02	-0.04 0.2	-2.4 0.1	-- -1.1	-- 1.6	1.0 0.7	-- -0.8	0.1 -3.2	0.8 1.1	-- .03	-- .00	-0.1 .03	0.6 0.1	0.1 -0.5	-- -0.3
(1-2-2)	31	-- --	1.1 --	-0.1 --	-- --	-- --	.14 --	-- --	0.2 --	.05 --	-- --	-- --	0.5 --	0.9 --	0.7 --	-- --
(2-3-3)	32	-- 0.2	1.1 -0.1	-0.5 0.2	-- -1.4	-- -2.1	.04 0.5	-- -0.3	0.2 -2.8	0.3 0.6	-- 0.9	-- -0.3	1.0 -0.00	0.5 0.2	1.6 0.9	-- 1.3
(3-3-3)	33	-- 0.1	-0.8 0.3	-1.0 -0.2	-- -0.03	-- 0.2	-0.9 0.1	-- -0.1	-0.1 0.2	0.1 -0.03	-- .02	-- -0.1	-0.3 -0.2	-0.5 -0.02	-0.7 -0.2	-- -0.5
	Lake Trout	--	-0.5	0.5	--	--	-0.5	--	-0.1	-0.2	--	--	-1.0	-0.7	-0.5	--
	Other Trout	--	0.4	0.2	--	--	0.4	--	0.1	0.5	--	--	-0.2	-0.9	0.1	--
	Game Fish	--	-0.1	-0.4	--	--	0.1	--	-0.1	-0.1	--	--	-1.0	0.4	-0.3	--
	Panfish	--	-0.4	-0.3	--	--	-0.5	--	.02	.01	--	--	0.9	-0.7	0.1	--
	Income	--	0.1	0.1	--	--	-0.04	--	2.4	-0.1	--	--	-0.3	0.1	1.0	--
	R^2	--	.34	.68	--	--	.25	--	.42	.64	--	--	.32	.34	.49	--

Appendix Table A-3 (concluded)

17 (1-2-1)	18 (2-2-1)	19 (3-2-1)	20 (2-3-1)	21 (3-3-1)	22 (1-1-2)	23 (3-1-2)	24 (1-2-2)	25 (2-2-2)	26 (2-3-2)	27 (3-3-2)	28 (1-2-3)	29 (2-2-3)	30 (3-2-3)	31 (-3-3)	32 (2-3-3)	33 (3-3-3)
-	-	-	-	-	√	-	+	+	+	-	+	-	+	√	+	+
+	S	-	-	S	+	+	S	+	I	-	I	S	S	+	I	S
S	S	I	S	S	+	S	-	S	I	+	I	-	S	-	S	I
-	-	-	+	+	√	+	-	+	-	-	+	-	-	√	-	-
+	+	+	-	-	√	-	+	-	+	-	-	-	+	√	-	+
-	+	I	S	+	+	S	S	I	I	I	I	-	+	+	+	S
-	-	-	+	+	√	-	-	-	-	-	+	-	-	√	-	-
-	S	-	I	S	-	-	I	S	-	-	+	+	I	+	I	S
I	S	S	I	I	-	+	I	S	-	S	-	+	+	+	+	I
+	-	+	+	+	√	-	+	+	+	+	-	+	+	√	+	+
-	-	+	+	+	√	+	-	-	-	+	+	-	+	√	-	-
I	I	I	-	-	+	+	I	I	I	-	+	-	S	+	I	-
+	I	+	+	I	+	I	-	I	+	I	-	-	+	+	+	+
-	-	+	+	+	-	I	-	S	-	-	+	I	I	+	+	-
+	-	-	+	-	√	+	-	-	-	-	-	-	-	√	+	-
*	+	S	-	+	-	I	S	S	S	+	S	S	+	-	I	+
0.7 1.5	*	I	S	+	+	S	+	I	+	-	-	-	-	-	+	S
-0.01 0.3	1.2 -1.5	*	I	S	-	+	+	I	-	S	I	+	I	-	-	+
-0.1 -0.1	-0.8 1.1	0.2 -0.1	*	-	-	-	I	-	I	+	I	S	S	+	I	+
1.0 0.2	5.7 .01	-3.6 0.1	-0.2 -0.2	*	+	-	-	I	I	I	+	-	-	-	-	-
-0.2 --	6.7 --	-1.3 --	-1.0 --	0.9 --	*	-	+	+	+	-	-	+	-	√	+	+
0.3 -0.05	-0.2 0.3	2.8 0.2	-0.01 -0.2	-0.3 -0.8	-- -0.00	*	S	-	S	-	S	S	-	-	I	S
-0.02 0.9	0.6 0.3	0.7 0.3	0.3 -0.3	-0.1 -0.4	-- 1.7	-0.01 0.3	*	I	+	+	I	S	+	+	I	-
- .03 2.6	0.1 -0.5	0.3 -0.8	-0.3 -0.1	0.1 -6.9	-- 2.0	-0.0 -0.1	.00 -0.7	*	I	+	+	S	I	+	I	-
0.7 1.5	4.2 1.0	-1.3 -1.5	1.5 -0.7	1.2 -2.0	-- 3.0	-0.04 2.3	1.1 0.2	3.8 -0.02	*	-	I	I	I	+	I	I
-- 0.3	-0.02 -1.1	-0.3 0.6	0.3 1.0	1.0 -4.6	-- -1.2	-0.1 -0.9	0.2 0.4	9.0 0.4	-1.3 -1.5	*	S	+	I	-	+	I
-0.9 0.2	-1.6 -0.01	1.6 -0.1	0.9 -0.00	1.3 1.0	-- -0.1	-0.2 0.3	1.1 -0.01	3.9 .02	1.6 -0.1	-0.7 0.2	*	+	-	+	-	S
-0.2 1.5	-5.7 -0.7	3.7 0.4	-0.6 .02	-1.4 -2.6	-- 4.6	-0.1 0.2	-0.7 0.1	-2.0 0.4	0.3 -0.1	2.5 4.1	0.2 2.2	*	S	+	I	+
0.2 0.2	-1.2 -0.2	0.4 -0.1	-0.4 0.3	-0.1 -0.2	-- -0.4	-0.1 -0.6	.04 0.2	0.1 -0.2	0.8 -0.6	3.5 -0.4	-0.02 -0.1	-1.5 0.9	*	-	+	I
-0.5 --	-0.2 --	-0.2 --	0.4 --	-0.1 --	-- --	-0.3 --	0.6 --	.04 --	0.9 --	-0.5 --	0.2 --	0.4 --	-0.2 --	*	+	+
0.3 -0.4	1.8 0.7	-0.3 -0.6	0.2 -1.0	-0.02 -1.5	-- 0.4	0.2 -1.0	0.4 -0.9	1.9 -0.7	1.0 -0.6	1.0 1.1	-0.01 -0.1	0.8 -0.3	0.3 2.3	-- 0.1	*	+
0.6 0.2	-0.5 0.3	0.2 0.1	0.4 .03	-0.5 -1.0	-- 0.5	-0.03 0.3	-1.2 -0.03	-1.6 -0.01	5.1 -1.5	0.5 -0.3	-0.01 0.8	0.8 0.8	0.1 -0.03	-- 0.3	1.1 0.2	*
0.2	-1.4	0.3	-1.0	0.04	--	-0.1	-1.3	-2.0	-1.1	0.1	-0.1	-1.4	-0.03	--	-0.2	-0.5
-1.0	-0.3	0.5	0.1	0.1	--	0.2	-0.1	2.0	-0.3	0.4	0.2	0.6	0.2	--	0.8	-0.2
0.2	0.4	-0.6	0.1	-0.00	--	-0.3	0.3	-0.2	-0.3	-0.6	-0.02	-0.4	-0.1	--	-0.7	-0.1
0.4	-1.2	-0.4	-0.5	.01	--	0.1	-0.3	-1.0	-0.6	.01	-0.1	-0.9	-0.1	--	-0.1	-0.3
-0.1	1.2	1.0	0.7	0.1	--	-0.1	0.2	1.0	0.02	0.2	0.2	0.8	0.1	--	0.1	0.4
.55	.61	.53	.41	.35	--	.43	.45	.64	.61	.69	.47	.52	.34	--	.59	.50

Appendix Table A-4.--Equation coefficients of summarized demand equations

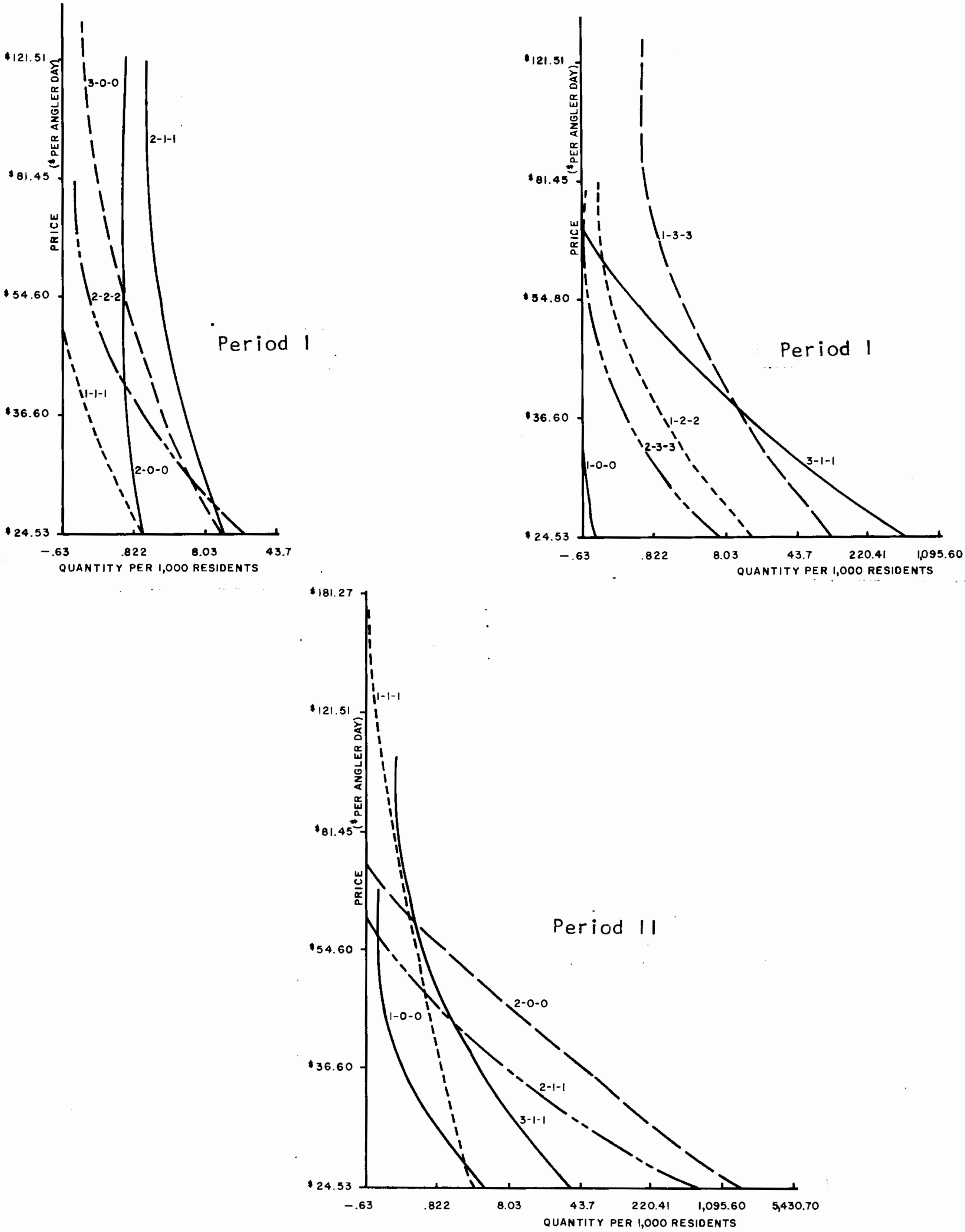
Angling characteristics s-c-k	Equation	ln P	ln P^2	$\sum_{1}^{m} b_j$	I	Constant
Period I						
1-0-0	2	-3.55	0.45	-1.28	0.28	9.18
2-0-0	3	-2.00	0.23	-0.47	0.03	6.45
3-0-0	4	-9.70	0.98	-0.27	0.10	23.92
0-1-1	5	0.00	0.00	0.00	0.00	0.00
1-1-1	6	-8.32	0.82	-0.50	0.42	17.67
2-1-1	7	-7.99	0.87	0.62	0.02	16.44
3-1-1	8	-27.22	2.74	0.94	0.76	55.40
1-2-2	9	-21.47	2.47	-0.42	0.36	45.09
2-2-2	10	-24.31	2.80	-1.24	1.90	42.31
1-3-3	11	-18.51	1.98	0.25	0.08	41.85
2-3-3	12	-24.45	2.93	-2.35	0.49	56.06
Period II						
1-0-0	2	-27.69	3.45	-3.54	0.29	67.42
2-0-0	3	-17.39	1.27	5.87	-0.06	25.96
0-1-1	4	0.00	0.00	0.00	0.00	0.00
1-1-1	5	-3.68	0.30	0.99	-0.88	12.87
2-1-1	6	-40.96	4.50	-1.40	1.85	82.64
3-1-1	7	-20.77	2.30	-1.10	0.76	45.15
0-2-1	8	-8.84	0.83	1.41	-0.27	18.47
1-2-1	9	-24.70	2.70	0.87	-0.55	55.98
2-2-1	10	-46.69	5.51	-4.60	1.79	101.84
3-2-1	11	-57.27	6.60	-4.33	1.71	127.05
2-3-1	12	-0.61	-0.24	1.44	1.75	-13.72
1-1-2	13	-40.35	4.50	-1.54	0.73	89.93
1-2-2	14	-14.07	1.85	-2.93	-0.23	40.11
2-2-2	15	-23.69	1.82	6.40	-0.20	41.53
2-3-2	16	-80.66	8.87	-3.62	0.52	192.48
2-2-3	17	-28.44	2.52	3.20	2.18	42.89
3-3-3	18	-22.79	2.72	-3.11	1.74	45.52

(continued next page)

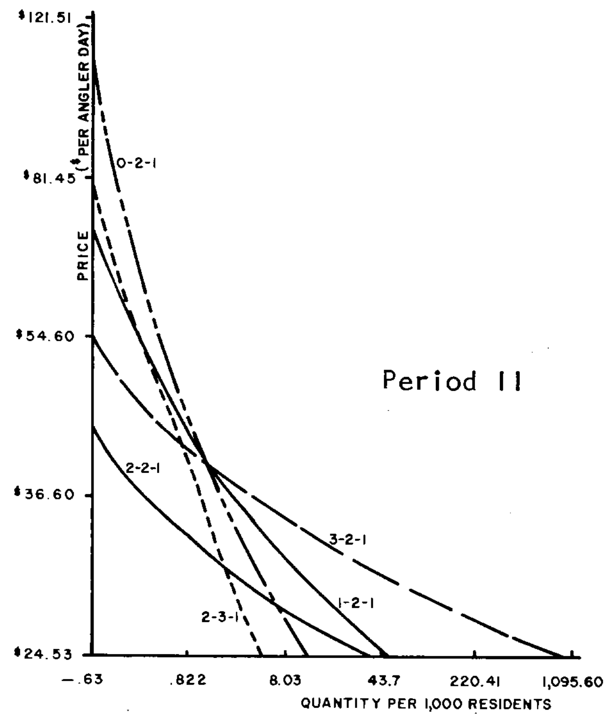
Appendix Table A-4, concluded

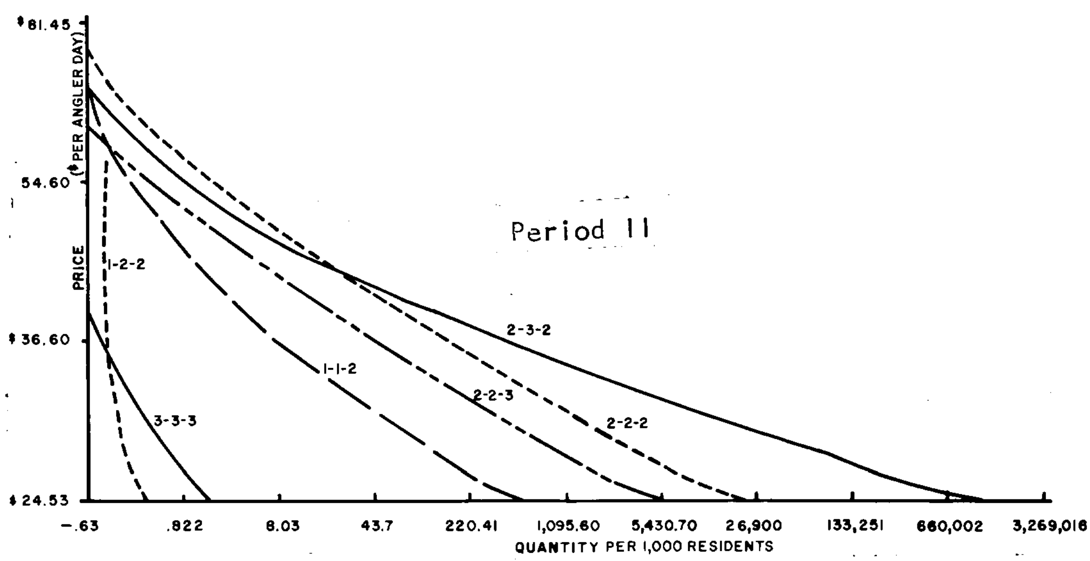
Angling charac- teristics s-c-k	Equa- tion	ln P	ln P^2	$\sum_{1}^{m} b_j$	I	Constant
Period III						
2-2-3 *	2	-43.36	4.99	-4.59	0.72	107.60
0-1-0	3	-0.18	0.03	-0.24	0.07	0.73
1-1-0	4	-6.05	0.41	2.29	0.10	7.14
2-1-0	5	-0.18	0.10	-2.50	-0.50	12.85
0-2-0	6	-39.48	4.07	-1.13	-0.03	102.09
1-2-0	7	-32.86	3.43	0.33	0.10	74.96
2-3-0	8	-26.16	2.69	-0.66	-0.69	70.43
0-0-1	9	0.00	0.00	0.00	0.00	0.00
1-1-1	10	-7.72	0.63	2.67	-0.75	14.88
2-1-1	11	-38.60	3.86	1.19	-0.90	94.41
3-1-1	12	4.98	-0.70	1.39	0.30	-16.29
1-2-1	13	-10.41	1.11	0.66	0.06	21.05
2-2-1	14	-27.34	2.49	3.14	1.01	50.09
3-2-1	15	-11.46	0.80	4.95	0.40	9.18
3-3-1	16	-7.62	0.62	1.88	0.45	10.20
3-1-2	17	-34.48	3.46	-0.38	-0.40	90.78
2-2-2	18	-21.55	1.89	3.35	1.94	25.99
3-3-2	19	-42.60	4.54	-2.27	0.00	109.33
1-2-3	20	-21.64	2.26	0.15	1.13	40.31
2-2-3	21	-27.25	2.70	0.55	1.08	54.71
3-2-3	22	-26.58	3.42	-6.87	0.50	75.85
2-3-3	23	-20.50	1.26	7.40	-0.62	34.85

* Newaygo County.

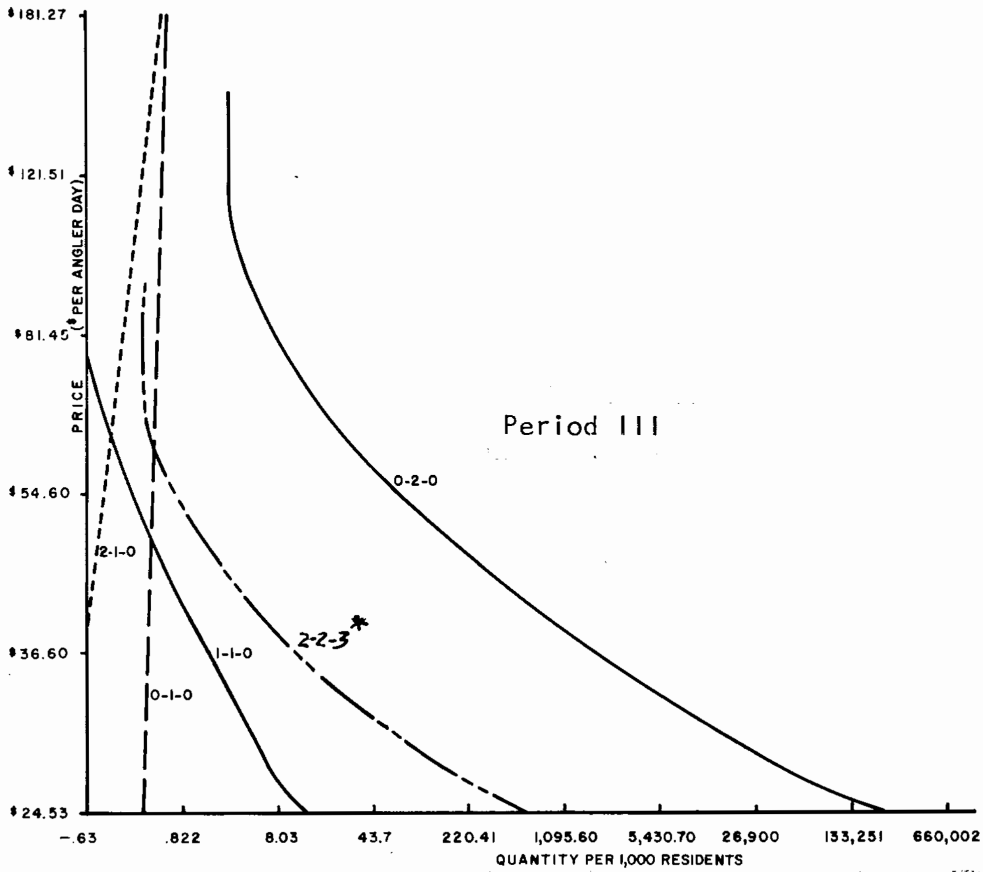


Appendix Figure A-2.--Demand curves for some of the characters of salmon-steelhead angling, based upon the demand equations independently developed for the three periods.

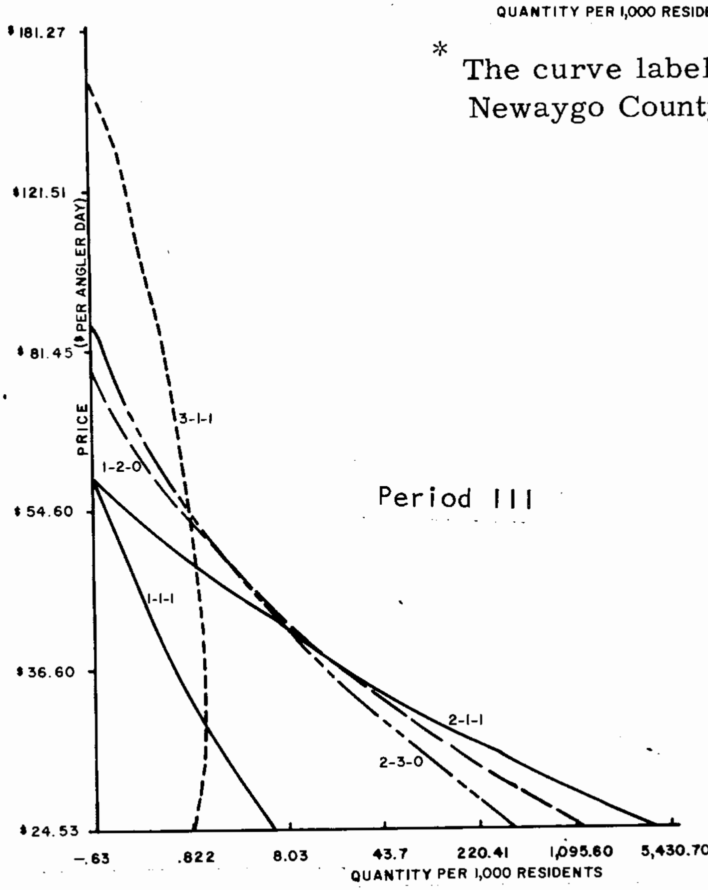




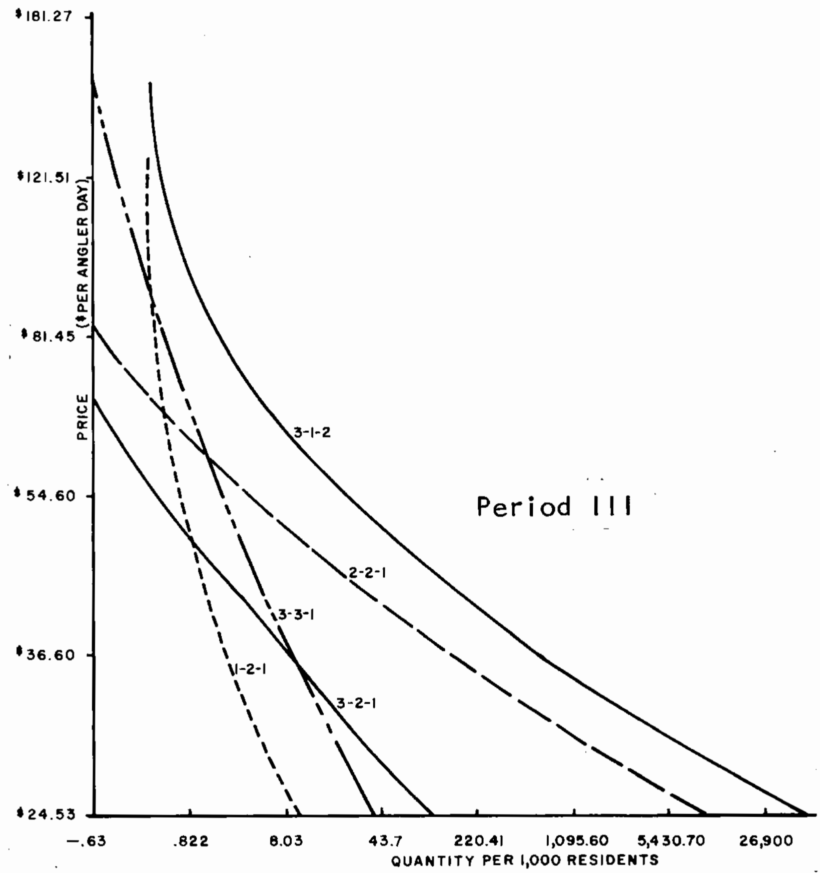
Appendix Figure A-2 (continued)

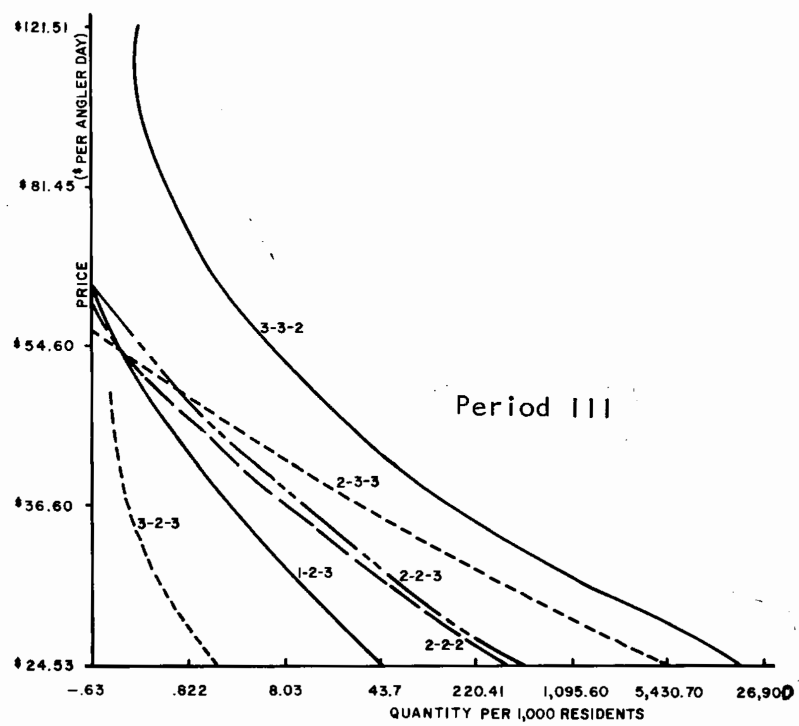


* The curve labeled 2-2-3 is for Newaygo County only.



Appendix Figure A-2 (continued)





Appendix Figure A-2 (concluded)

Assuming that $\ln P_j = 4.2$ and $\ln I = 7.9$ (approximate mean values)[19] the equations were evaluated as illustrated in Figure A-2. In general, the farther to the right a demand curve is, the "greater" the demand for that character. Another generality is that the steeper the demand curve, the less willing are the anglers to reduce their amount of angling as the price of that character increases (i.e., the "price elasticity" of demand[20] is relatively low; the absolute value of the elasticity is small). A negative general cross-price elasticity $(\sum_{1}^{m} b_j)$ and a generally high level of demand would imply that the character (i) is highly preferred by a large number of anglers to other qualities. If, in addition, the price elasticity of demand were low, we would know that anglers are quite dedicated to that particular character of angling. A high level of demand and a positive cross-price elasticity would indicate that anglers readily accept that character, but readily substitute other characters if they are available.

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[19] The mean "$\ln P_j$" for characters of salmon-steelhead angling is about 4.2, but the mean "$\ln P_j$" for non-salmon-steelhead angling is only about 3.6. Thus some of the demand curves may be farther right or left than if they had been evaluated at 3.6 for those kinds of angling.

[20] The price elasticity of demand in these equations is

$$b_i - b_i' \ln P_i \ .$$

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