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DEFINING ANGLING QUALITY AND ESTIMATING THE DEMAND FOR MICHIGAN'S 1976 GREAT LAKES SALMONID AND NON-SALMONID SPORT FISHERIES

By

Charles Sheldon Korson

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ABSTRACT

DEFINING ANGLING QUALITY AND ESTIMATING THE DEMAND FOR MICHIGAN'S 1976 GREAT LAKES SALMONID AND NON-SALMONID SPORT FISHERIES

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Angler demand and values are largely dependent upon the "quality" provided. Consumers apparently select any product, a particular dinner wine for example, based on some set of attributes distinguishing it from other similar products (wines). Anglers apparently have a similar classification system to distinguish between various fishing sites, based on similar sets of characteristics or attributes. If anglers believe the important attributes of any two sites are the same, they will usually visit only the more convenient site. This principle was used to define the different kinds of Great Lakes salmonid and non-salmonid angling (respectively) available in Michigan, based upon seasonal surveys of 1976 angling. The results indicated that catch rate and species composition were apparently the most important attributes to Great Lakes open-water anglers. Anglers fishing for anadromous fish consider catch rates, lake throughways, publicity, and regulations of primary importance. This technique of product enumeration provides the basis for intensive

demand and supply analysis. Instead of estimating the much more general demand for salmonid fishing as a whole, the demand for each different component is studied separately, producing much more precise estimates of angler behavior.

Dedicated to

my parents

ACKNOWLEDGMENTS

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Most importantly, much of the credit for my present accomplishments goes to my mother and father. I cannot adequately express my thanks and appreciation for their undying moral support, encouragement, confidence in my ability, and financial assistance. I feel very fortunate to have parents as dear as mine, and who always respected

my decisions and stood behind me throughout my educational career.

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I. INTRODUCTION

Overview

Over the last thirty years, society has placed increasingly heavy demands on the recreational use of our renewable natural resources. All areas of public recreation--fisheries, wildlife, national parks and forests, water-based resources, and many more--have in some way been affected by this preoccupation with outdoor recreation. This is especially true of Michigan's public resources, where recreational activity has expanded on all fronts. One such area of public recreation showing considerable growth in interest over the last decade has been Great Lakes sport fishing activities. Michigan's sport fishing industry is highly esteemed as one of the most popular forms of outdoor recreation available to the public.

With current emphasis being placed on continually improving and developing opportunities for sport fishing, managers and planners must make more crucial decisions about the proper and intelligent use of the public's sport fishery resources. Questions regarding the direction and efficiency of public programs must be raised to determine if limited public monies are properly invested for the greatest public good. Not only does this require assessing the biological and physical tradeoffs between various management and development plans, but it also necessitates assessing the desires of people for alternative recreation uses.

Resource economists have commonly addressed the question of social preferences within the context of demand models for outdoor recreation. Demand functions express the willingness of users to exchange their personal resources for the type of recreation in question. In addition, they estimate the expected use and recreation benefits associated with the planned development of various sites for recreational activities (Dwyer, et al., 1977). These kinds of information help decide which alternative public investment decisions secure the greatest return to society, thus maximizing social welfare. The primary management goals of operational efficiency and a social optimum are attainable with further development of reliable economic evaluations.

One aspect of social choice which has become more important as increasing pressure is put on recreational resources is understanding the exact nature of peoples demands for recreational opportunities. What is it about a recreation site or facility that attracts user interest? Should certain features be developed at the expense of others which are somewhat less important to some users? Such questions can be answered more easily by determining how the "quality" of a recreation experience affects an individual's demand for outdoor recreation.

It is widely recognized that site quality varies considerably. People presumably select a particular recreation site based on certain characteristics or attributes which are most important to them. Important attributes for a salmon fishing experience may include the species of salmon, success rate, fish size, shoreline access, stream or lake fishing, crowding, special regulations, and other factors. However, the problem is determining just which attributes people use to distinguish between alternative recreation sites. Managers, policymakers, and administrators would benefit by knowing which of these attributes are most important as a guide to better resource allocation.

Quality evaluation frequently is unreliable when differences between sites are based on some arbitrary quality rating system. Personalized judgments may not reflect individuals tastes and preferences. The major goal of this study is to utilize a more satisfactory product classification approach for determining which recreation sites are alike or different, for the purpose of estimating the demands for Michigan's Great Lakes sport fishery resources.

The primary objectives are to:

(1) Group angling sites into various specific kinds (products) of angling recreation according to the attributes of angling that anglers

apparently consider most important. This is very similar to a biological taxonomy where several levels of aggregation exist and there is some degree of personal interpretation (Talhelm, 1978b);

(2) Develop separate product classification schemes for Michigan's Great Lakes open-water salmonid, open-water non-salmonid, and anadromous salmon-steelhead sport fisheries;

(3) Estimate the demand for each of the specific component angling products by integrating the angling classification systems into an intensive supply and demand model.

These separate but related analyses will generate useful information on:

(a) angling supply: the prices or costs of the respective component products to anglers;

(b) and the willingness of anglers to substitute one kind of angling for another.

These demand equations, together with knowledge of present angler costs, serve as the basis for estimating values to anglers of alternative sport fishing management programs in Michigan. Specifically, equations may be used in a simulation model to estimate (1) the net social welfare or benefits of sport fishing accruing to the public, and (2) more importantly, the changes in participation levels and benefits caused by changes in angling quality at certain locations. This will be useful for evaluating the efficiency and the prospects and desirability of many alternatives (Talhelm, 1973b). Future research will utilize the information provided in this study to estimate the net benefits of salmonid and non-salmonid sport fishing programs.

This research is one phase of an overall project (sponsored in part by the Michigan Sea Grant Program) to document fisheries values for Michigan's Great Lakes. It is anticapted that this study partially fulfills one of the major project goals:

> to provide information needed for selecting optimal utilization of Great Lakes fisheries by documenting the benefits, costs and other impacts of potential management strategies.[1]

The remaining portion of this introduction contains a brief capsule on the valuation and history of Great Lakes fishery resources. The thesis then proceeds with a short review of the literature dealing with recreation demand and its relationship to quality evaluation (Chapter II). Chapter III will discuss the theory behind the definition of angling quality and supply and demand. Chapter IV explains the specific procedures for the research. The results and discussion sections are combined in Chapter V.

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[1]Taken from a report on the 1975-76 Sea Grant Program in fisheries economics and marketing (Talhelm, 1975).

Great Lakes Fishery Resources--Values and History

The Great Lakes[2] are recognized as supporting one of the outstanding fresh-water sport fisheries in the world. On the other hand, the concomitant regulation of commercial fishing has caused the once thriving commercial fishing industry to become increasingly depressed. Nowhere is this trend more prominent than in Michigan, where 41% of the total Great Lakes water area lies within state boundaries (Figure 1). As a result, Michigan is provided with 3,200 miles of coastline from which sportfishing and commercial fishing may be pursued.

The success of sportfishing in Michigan is attributable to a number of factors. Primary among them is recognition by the Department of Natural Resources (DNR) that sportfishing is much more valuable to the public than commercial fishing, both in terms of social welfare (value) and in terms of the positive economic impact on the state.

Various studies have documented the values accruing to the public for Michigan's Great Lakes sport fishery resources. Talhelm (1973b) and Ellefson (1973) estimated that the 1970 anadromous salmon-steelhead program produced net "social" benefits of approximately $24 million for licensed Michigan residents in 1970. This is to say that anglers would have been willing to contribute or pay this

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[2]With a water surface area of about 95,000 square miles and over 9,000 miles of shoreline.

Figure 1. The Great Lakes and the 83 counties of Michigan (the names of each county are given in Table 1).

Table 1. The Names of the Counties in Michigan

Number	County	Number	County	Number	County
1	Alcona	36	Iron	71	Presque Isle
2	Alger	37	Isabella	72	Roscommon
3	Allegan	38	Jackson	73	Saginaw
4	Alpena	39	Kalamazoo	74	St. Clair
5	Antrim	40	Kalkaska	75	St. Joesph
6	Arenac	41	Kent	76	Sanilac
7	Baraga	42	Keweenaw	77	Schoolcraft
8	Barry	42	Lake	78	Shiawassee
9	Bay	44	Lapeer	79	Tuscola
10	Benzie	45	Leelanau	80	Van Buren
11	Berrien	46	Lenawee	81	Washtenaw
12	Branch	47	Livingston	82	Wayne
13	Calhoun	48	Luce	83	Wexford
14	Cass	49	Mackinac		
15	Charlevoix	50	MaComb		
16	Cheboygan	51	Manistee		
17	Chippewa	52	Marquette		
18	Clare	53	Mason		
19	Clinton	54	Mecosta		
20	Crawford	55	Menominee		
21	Delta	56	Midland		
22	Dickinson	57	Missaukee		
23	Eaton	58	Monroe		
24	Emmet	59	Montcalm		
25	Genesee	60	Montmorency		
26	Gladwin	61	Muskegon		
27	Gogebic	62	Newaygo		
28	Grand Traverse	63	Oakland		
29	Gratiot	64	Oceana		
30	Hillsdale	65	Ogemaw		
31	Houghton	66	Ontonagon		
32	Huron	67	Osceola		
33	Ingham	68	Oscoda		
34	Ionia	69	Otsego		
35	Iosco	70	Ottawa		

amount in 1970 to prevent the total loss of salmon-steelhead angling opportunity. The total all-or-none value for Michigan's entire Great Lakes sport fishery is estimated at around $250 million per year in current dollars (Talhelm, 1979).

Michigan's sport fishery has also exerted a considerable economic impact on the state's economy. Some $20 million was spent for 1970 Great Lakes salmon-steelhead angling activities by licensed and unlicensed anglers (Talhelm, 1979). Ellefson (1973) estimated that 60% of the $15.5 million in licensed fisherman expenditures for 1970 salmon-steelhead fishing were made at or near the location fished. The remaining $6.1 million was spent for goods or services en route to a site. The anadromous fishery was responsible for anglers' spending $400 thousand and for providing 21.5 full-time equivalent jobs in the Grand Traverse area of Michigan in 1970 (Kapetsky and Ryckman, 1973). The current total economic impact of Michigan's entire sport fishery for Great Lakes fish is estimated at $200-300 million annually (Talhelm, 1979).

The estimated values of Michigan's commercial fishing industry have all been considerably lower than those for sportfishing. The total economic impact is estimated at only around $16-20 million annually (Talhelm, 1979). Fogle (1973) reported the 1971 dockside value for the entire commercial catch as $2.7 million. The social surplus or net all-or-none value for Michigan's 1976 commercial fishery was estimated at slightly more than $2.6 million (Ghanbari, 1977).

The DNR saw the potential benefit to society of expanding sportfishing programs. As a result, commercial fishing operators were subjected to stricter regulations in an attempt to maintain a more limited but economically viable commercial fishing industry. Over the last ten years, the DNR has been restricting the species, locations and methods of harvest, and reducing the number of licensed commercial fishermen. By 1976, commercial operators numbered less than 150 while the number of sport fishermen had risen to some 1.2 million (Talhelm, 1979).

Sport fishing is an extremely popular recreational activity in Michigan. The total Great Lakes sport harvest is estimated to be about three times (by weight) the present commercial catch (Talhelm, 1979). Anglers enjoy diverse angling opportunities from among a wide variety of gamefish populations, including abundant stocks of salmon, lake trout, steelhead, yellow perch, walleye, bass, pike, and others. However, prior to the mid-1960's and the institution of a salmonid program, the existence of a sport fishing program was seriously threatened. Stocks of many of these fishes had become severly depleted due to a number of biological and man-induced factors.

Primary among them was the invasion of the sea lamprey and alewife, apparently through the Welland Canal in the mid-1930's. Lake trout and other important stocks were almost exterminated by extensive sea lamprey depredations. By 1950, the lake trout fishery on Lakes Michigan and Huron was gone, and by 1962 the Lake Superior fishery was closed (Borgson and Tody, 1967). Disruption of predator-prey equilibriums permitted smelt and especially alewife to rapidly explode into superabundance on Lakes Michigan and Huron beginning in 1955. Alewife further impacted stock levels by devastating small market fish like herring, chubs, perch, and recreational fish such as walleye and smallmouth bass (Tainter and White, 1977). In addition, alewife posed a threat to the spawning success of other species, and became a public nuisance when dead fish accumulated on beaches and in harbor areas. Once other fish populations were seriously depleted, commercial fishermen began harvesting smaller, less valuable species. By the mid-1960's, stocks of important commercial and recreational species had declined to dangerously low levels. Because fish stocks were so limited, the number of commercial fishermen fell from 1,100 in 1950 to approximately 300 in 1969 (Fogle, 1973).

By the late 1960's, these ecological disruptions were brought under control through effective lamprey control and intensive restocking programs. These facilitated the recovery of populations of lake trout in Lakes Michigan and Huron, and permitted the reestablishment of steelhead, brown, brook, and hybrid (splake) trout. As expected these salmonids preyed on abundant pelagic species to successfully prevent massive die-offs. More importantly, the DNR saw the possibility of utilizing the alewife as forage to produce sport or food fish of maximum interest and value (Tody and Tanner, 1966).

This objective was realized when coho and chinook salmon were first introduced in the middle 1960's. As a result, a highly successful and popular salmonid program has developed in the Great Lakes. Since 1970 the number of angler days spent fishing for Great Lakes salmonids has increased from 2 million to more than 3.3 million. Licensed sportsmen harvested around 23 million pounds of salmonids in 1976 (Jester, 1978 in Talhelm, 1978a).

The resulting introductions and rehabilitation efforts have enabled most other gamefish species to increase their biomass levels as well. As a result of restoring the ecological balance of the Great Lakes, an outstanding and diversified sport fishery has developed in Michigan since the late 1960's. The total sport harvest for the salmonid and non-salmonid fisheries has sharply increased from 1970 through 1976 (Figure 2).[3]

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[3]The 1974 harvest data are from DNR survey raw data reports and may not be accurately represented, but these were the only available catch statistics for this year. Therefore, one should interpret these numbers with extreme caution.

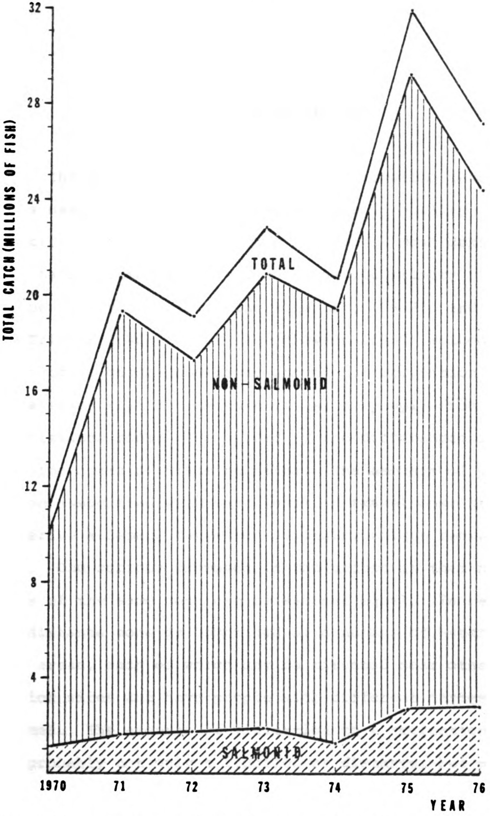

Figure 2. Total sport catch for salmonids and non-salmonids in Michigan's Great Lakes and tributary streams from 1970 thru 1976 (Jameson and Ellefson, 1970, 1971a, 1971b; Jamesen, 1972, 1973, 1974, 1976, 1977; Michigan DNR, 1978).

II. LITERATURE REVIEW

The traditional approaches to estimating demand equations have largely ignored the effects of quality upon the quantities of recreation taken by users. Most demand studies have focused on travel costs as the primary variable influencing visitation. The Hotelling (1949), and later the Trice and Wood (1958) and Clawson (1959) methods defined broad geographic zones around the recreation site, and assumed that the amounts of use by people from increasing distance zones were caused by the differences in money and time costs of visiting sites. The amounts of particicipation associated with each level of travel cost are used to derive a demand curve for a single, unique recreation site. One serious drawback in the method is that not all parts of the same zone can be assumed equal. In reality any distance zone is comprised of a number of heterogeneous areas, each of which may be situated near other recreation sites and have people with different tastes and incomes. The amounts of visitation to a recreation site are probably not only a function of distance, but also of prices of alternative forms of recreation, site characteristics, and other socioeconomic variables.

The difficulty with this early travel cost approach was overcome when various investigators began centering their observations on population centers rather than homogeneous distance zones. This permitted one to consider all aspects of a recreation experience when predicting use and values of recreation resources. Brown, Singh, and Castle (1964); Boyet and Tolley (1966); Merewitz (1966); and Johnston and Pankey (1968) are some who used this method, but without the prices of alternatives. Studies by Talhelm (1972, 1973, 1976); Burt and Brewer (1971, 1974 in Dwyer, et al., 1977); Cesario and Knetsch (1976); Cicchetti, Fisher, and Smith (1976); and Knetsch, Brown, and Henson (1976) extended the revised travel cost procedure by including the influence of substitute resources on recreation use.

An additional dimension of demand which has received more recent attention is that the qualitative characteristics of the site are also influential in determining demand and usage. This is an important concept when considering the prospective use and development of a number of different sites within a similar recreation system. Behavioral studies by Hendee and Potter (1971), More (1973), and Hendee (1974) suggested that an important component of resource management was understanding the qualitative factors that motivate the behavior of recreational users. Talhelm (1973a) indicates that optimal management efforts can be achieved by estimating the demand and supply for different varieties or qualities of recreation. However, the major difficulty is in selecting a variable to repre-snet quality in a way which eliminates the bias encountered when making subjective value judgments.

Only a few demand studies have dealt explicitly with quality where subjective measurements are avoided. Stevens (1962), using a degree of quantitative measurement of the qualitative characteristics of a sports angling experience, included angling success per unit of angling effort as a variable in demand functions. In this way, he estimated the total angling effort for original levels of angling success, and for some reduced success levels brought about by changes in water quality. Cesario (1975) and Cesario and Knetsch (1976) included an index of inherent appeal or quality when specifying demand functions. Instead of subjectively ranking or measuring quality, an arbitrary scale rating the apparent utility or attractiveness of a site was used to reflect the multitude of site characteristics. Johnston and Pankey (1968) evaluated the effects of quality upon total recreation use for seven California reservoirs. Demand functions were estimated by including certain reservoir size characteristics as one of a potential group of independent variables. Wennergren and Fullerton (1972) estimated recreational values attributable to qualitative differences in sites for sixteen Utah counties, but failed to identify the factors contributing to recreation quality.

A different approach to interrelating demand and recreation quality has been developed in a number of studies by Talhelm (1972, 1973b, 1976). A consumer behavioral model is used to partition sites or counties into various kinds or varieties of recreation according to specific site attributes. The assumption is that if any sites are perfect substitutes, users will only go to the least expensive (closer) site. Each variety is considered a different quality or "product" of recreation, analogous to one of the many makes and models of automobiles or other products. With the products defined, the demand and supply for each kind of recreation can be estimated. This permits calculations of amounts of use and benefits to users of each product at each site, and the changes in user benefits and participation levels produced by changes in recreation attributes at specific sites over time.

III. THEORY[4]

1. Demand

A consumer normally responds to changes in the price of a product by either increasing or decreasing his consumption of the good in question. This behavior is traditionally summarized in a demand curve for any market commodity. Generally, a smaller quantity of a good is demanded by consumers at higher prices, and vica-versa. Demand is more formally defined as a schedule of the maximum quantities purchased (per unit of time) at every possible price over a specified period of time, if all other influences on demand remain constant.

The demand for angling recreation is a similar price-quantity schedule, only here price is not determined by typical market forces. Rather the "price" of angling represents the cost of angling in terms of the money and time resources required of the angler for participation in angling activities. Thus, the demand for angling relates the costs (prices) of participation to the amounts (quantities) of participation per angler day. As the price of angling increases, the quantities of use (days) taken by

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[4]This theory was first proposed by Talhelm (1972).

anglers will decrease, _ceteris paribus_. For instance, residents of Detroit commonly fish less for salmon than residents of southwestern Michigan primarily (presumably) because of higher expenses imposed by greater travel distances. In essence, the demand for a particular type of angling is the willingness of anglers to exchange their resources for that kind of angling (Talhelm, 1973b). An angling demand curve illustrates the voluntary rate of exchange between "all other goods" (measured in terms of dollars) and angling--the total preference for angling relative to other goods.

An unbiased price-quantity relationship is estimated by seeing that the values of other factors affecting demand remain unchanged. However, the shapes and positions of demand curves, and therefore, participation rates, are significantly influenced by a number of important factors. An acceptable means for estimating recreational demand curves should take into account such influences as the availability and quality of alternative forms of angling, and the nonhomogeneity of tastes and income in the population (Dwyer, _et al._, 1977). Because of the countless variety of sites within a similar recreational system, it is misleading to consider only one site in isolation from others. To do so could lead to severe overestimates or underestimates of use.

2. Supply

The price producers receive for a good largely determines how much is supplied in the marketplace. Generally, more of a good is made available for sale when prices are higher. Such a price-quantity relationship is represented by the supply curve A in Figure 3. It shows the given quantities of goods which will be forthcoming (per unit of time) at various prices during a specified time period, with other influences on production held constant. In a real sense, supply relfects the "ability" of society to produce a good (Talhelm, 1973b).

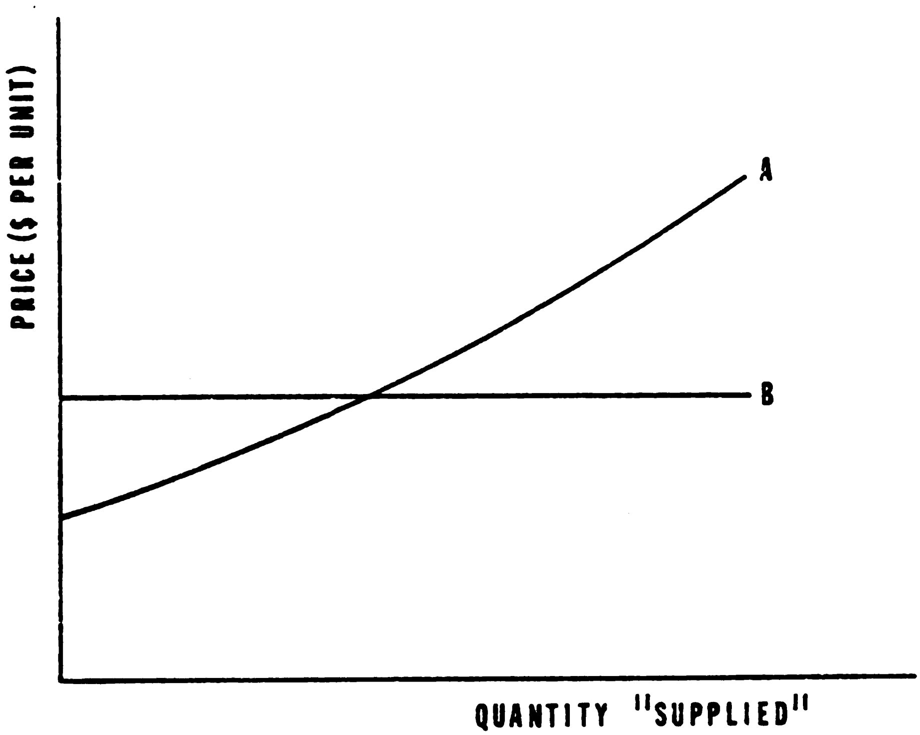

Figure 3. A normal supply curve (A) and a supply curve for angling with a given travel distance requirement (B).

The supply of angling recreation is somewhat different since consumers are in themselves the producers of angling activity. Anglers must trade their personal time and money resources in exchange for participation in angling. The price of obtaining a unit of angling recreation[5] is based on the monetary and time costs of transportation to the site. Thus, the "supply" of angling is a relationship between the costs (price) of going fishing and the amounts of angling available to anglers. This concept is referred to as the "supply of angling effort," since anglers must allocate time and money to travel to a particular angling site (Talhelm, 1973b).

Angling cost or "price" equations may be developed to express the price of angling (in dollars per angler day) as a direct function of distance (mileage) to the various angling sites. In other words, the variability in angler costs is primarily a function of angler residence and angling resource location. The major resource costs required of the angler to produce angling are (1) the operating costs necessary for transportation; (2) the additional monetary costs of food and lodging; (3) the direct expenditures on fees, licenses, and equipment necessary for angling; and (4) the value of time spent to facilitate the angling experience. This last factor is important because visitation rates are not only influenced by monetary costs,

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[5]Here a unit is the angler day, defined as any part of a day in which an angler fished.

but also by the time required to reach a site. A greater travel distance not only increases the time and money costs of travel, but it also reduces the recreation time remaining on a trip (Talhelm, 1972). Time spent angling is at the expense of opportunities which must be foregone, either in alternative forms of recreation or in non-leisure activities. Thus, the value or opportunity cost of time is most appropriately measured by the lowest current wage rate or potential wage rate one could have earned by re-allocating time and effort to more "productive" endeavors.

For a given travel distance, any number of angling trips may be taken at a relatively constant cost per angler day (Talhelm, 1972, 1973b, 1976). Since the variation in trip costs depends on the distance an angler must travel, a perfectly elastic or horizontal angling supply curve is defined for every possible travel distance (Figure 3). Those anglers from more distant locations have higher supply curves (a lesser supply) because of the higher costs of traveling to a particular site. A reduction in travel costs will lower the supply curve because availability is now greater.

This explicit treatment of supply, in conjunction with origin-destination patterns of use, forms the basis for statistically estimating demand equations for various kinds of angling recreation. A point on a demand curve is formed by each of the respective price and quantity observations. Hence, with supply curves (prices) and

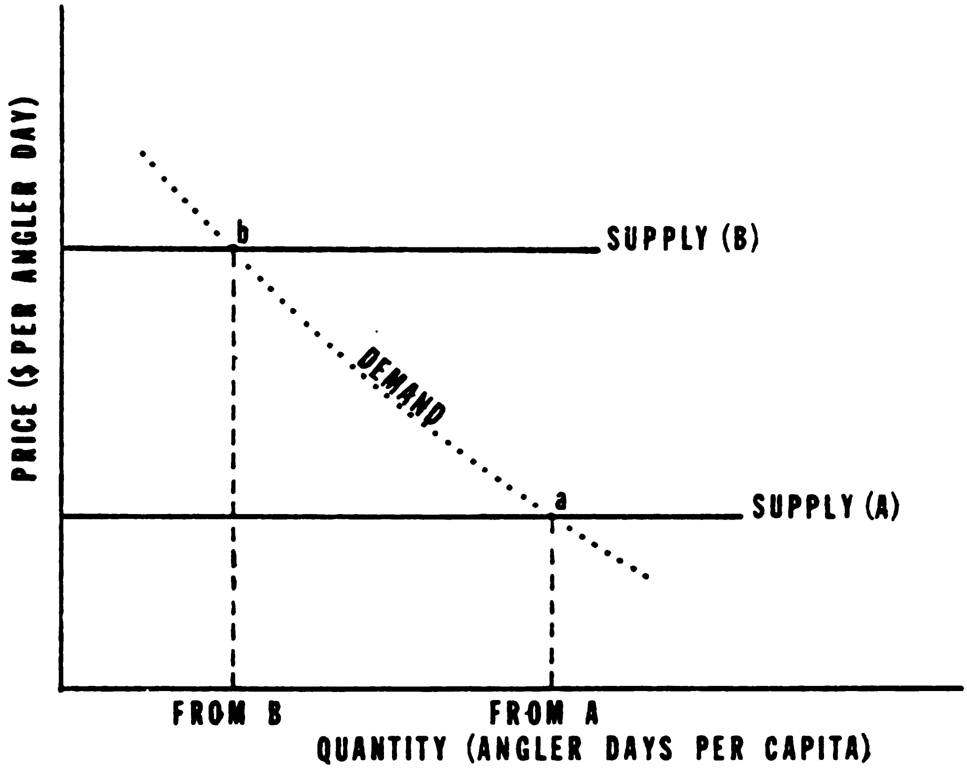

Figure 4. An angling demand curve traced out by supply curves (prices) and quantities of angling for anglers residing at hypothetical locations A and B.

observed use of angling from two hypothetical locations (A and B), a demand function is traced out by points like a and b in Figure 4.

3. Product Classification and Angling Quality

Analysts often assume that people prefer "high" quality over "low" quality angling, where this notion of quality rating implies making individual value judgments to distinguish between various angling sites. However, a site which is "high" quality for one individual may be considered "low" quality by someone with different personal preferences. Clearly when users' tastes vary considerably, there may be no clear consensus regarding how various attributes define recreation quality along a single scale. Even if there were a consensus, how can we judge the relative importance to society of "good" as opposed to "outstanding" recreation?

A more useful concept is that different products have different attributes of varying importance to users. Consumers apparently select a product based on some set of attributes distinguishing it from other similar products. For example, casual wine drinkers may select a dinner wine simply on the basis of wine color: red or white. Others may recognize four specific products by including taste as an additional attribute (Figure 5). Connoisseurs may further distinguish between dinner wines by including such attributes as aroma groupings, major brand, and ageing period. The number of products or permutations become greater as attributes are divided into even finer divisions or details. Any hypothesized set of attributes defines a variety of specific goods within a general product group. Other examples may include the many different cuts of beef, or the many makes and models of automobiles.

In an analogous fashion, angling resources can be characterized by enumerating the most important attributes of the recreation experience. A Great Lakes fishing site might be typified by the probability of catching salmonids, the species mix of salmonids, whether or not it has a pier, the extent to which publicity influences anglers'

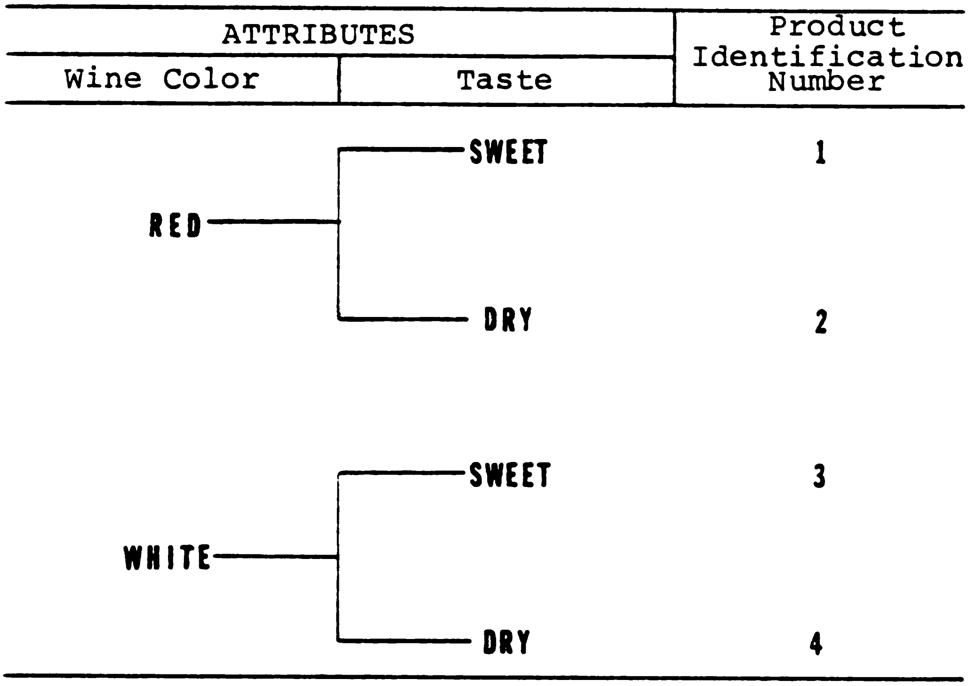

Figure 5. Two attributes defining four specific dinner wine products.

expectations, and other attributes. Each particular permutation of attributes is used to define the different "products" (like the specific dinner wines) of angling recreation. For instance, one specific product may be "high" trout and salmon catch rates, no piers, and "high" publicity; another product may be "high" trout and salmon catch rates, no piers, and "low" publicity. With these three attributes (catch rate, piers, publicity), the differences in angling sites are classified into a multiple product set, where each site corresponds to a particular product and each product is a separate but related good. In this way, a general kind of angling is segmented into its specific component parts.

Certain attributes or combinations of attributes may be hypothesized as being possibly important to anglers in determining where they go to fish. Of course, the problem remains of choosing the best set of angling attributes, and therefore the best classification scheme to define angling quality. Since consumers normally consider the various characteristics and prices of goods before making their choices, anglers should display similar patterns of behavior when deciding among different products of angling recreation. Rational behavior dictates that few will knowingly pay more than necessary for a good with a given set of characteristics. Through a similar process, a definition of angler quality is based on the idea that if anglers feel the angling afforded at any two sites is essentially the same, they will usually visit only the more convenient site. Otherwise, if anglers feel one of the sites is more desirable than the other, some anglers will travel farther or longer to visit that site. The degree to which anglers consider sites to be different is dependent on the magnitude of anglers' willingness to travel farther than necessary to reach a supposedly identical site.

A classification system showing large numbers of anglers traveling farther than necessary, or high levels of "excess" travel, indicates that some sites classified as identical products are actually considered different by many anglers. In this case, the hypothesized attributes do not adequately define the different products of angling available to anglers. An alternative hypothesis would be to reclassify similar sites as different products using a different set of attributes. If a descriptive set of attributes sufficiently defines the various products of angling, then few anglers have reasons not to travel to the closest site of a given product (Talhelm, 1973b). Therefore, the most satisfactory or "best" classification system minimizes "excess" travel within each product category. By analytically trying alternative attribute combinations, the set most consistent with this expected pattern of behavior is found.

As a result of minimizing "excess" travel, few anglers are incurring higher prices (in time and money costs) than necessary to reach an angling site within a particular product category, assuming perfect knowledge. In other words, the supply (price) of an angling product is the minimum (least expensive) price available for a product, since similar products are considered perfect substitutes, and anglers have little reason to go to more distant sites.

Rather than being an arbitrary classification based on *a priori* value judgments, this multiple-product approach depends on actual observations of visitors' choices of angling sites. This consumer behavioral model reduces the bias associated with sentimental choices. However, this type of analysis is subject to the limitations imposed by the lack of perfect knowledge among anglers. These may include (1) the absence of information regarding the attributes of various sites, thus causing users to mistakenly go to less advantageous locations; (2) anglers may have multiple reasons for traveling to sites, such as for alternative forms of recreation, or to visit friends and relatives who reside near angling sites visited; and (3) attributes of sites hypothesized to be important may not be identified properly, especially when attributes are confounded with one another (i.e. catch rate and fish size). These difficulties are inevitable when conducting a discriminant study of this type. Yet it is not necessary that all users' recognize all angling products, just as all wine buyers can't recognize all types of wine; but the greatest proportion must act as if they perceive some difference, in order for analysts to detect the anglers' selection process.

This technique of product definition not only provides insight into angler behavior, but also is useful as the basis for intensive supply and demand analysis. Rather than estimating the general demand for a general product group, such as all Great Lakes salmonid angling, this procedure generates more precise estimates of levels of participation and recreational values by analyzing component products.

IV. METHODS

1. Product Classification Analysis

General Description

Seasonal product classification schemes are developed for three types of sport fishing: Great Lakes open-water salmonid and non-salmonid fishing, and anadromous salmon-steelhead fishing. Specifically, each species group is examined independently for the winter-spring (Period I, January thru May), summer (Period II, June thru August), and fall (Period III, September thru December) angling seasons.[6] Consequently, this study in effect consists of eight separate analyses, one for each type of seasonal fishing. Since the procedural steps for each analysis are virtually identical, only one period and type of fishing will be used as a general example to explain the following methodology. For this purpose, winter-spring angling for Great Lakes salmonids will serve as the model. On occasion, reference to other forms of fishing is necessary when circumstances require reporting certain facts or details. These cases

[6]Summer anadromous angling is not included in the analysis because of the limited number of anadromous angling opportunities available during the summertime. This was reflected by the paucity of data collected for the summer survey of anadromous fishing activities.

will also apply to Period I.

Data Collection

The Department of Natural Resources (DNR) conducted a mail survey of over 40,000 sport fishermen licensed in Michigan about their 1976 seasonal angling activity.[7] The seasonal survey samples were taken from only a very small segment of the licensed sport fishing population: 2% in winter-spring, and 1% each for summer and fall. One sample questionnaire showing the type of information requested from fishermen may be found in Appendix A.[8] Data were gathered on such questions as origin-destination travel patterns, angling effort at various destinations (counties), and numbers of fish of various species caught by anglers. The data were collected and separated into five distinct categories of fishing: (1) Great Lakes salmonid; (2) Great Lakes non-salmonid; (3) anadromous salmon and steelhead; (4) inland trout; and (5) inland non-trout. Within each category, anglers' responses were coded and stored on a permanent computer tape file according to season and type of fishing. A total of 19,109 useable records (responses) were collected for the five types of fishing. Data on

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[7]There are 83 counties available for angling activities.

[8]It should be stated at this point that the nature of the survey asked anglers to report only those species of fish they caught and the effort expended while doing so. Anglers were not asked about the species they actually fished for. This factor is considered when computing catch rate estimates for various species.

specific questions were extracted from each record for use in the product classification analysis.

Input Data and Organization

The relevant data utilized from the period I survey results were as follows: (1) county of residence, (2) site (county) fished; (3) number of days fished in the county; and (4) number of fish of various species caught. Data on catch and effort by species were used to estimate county catch rates for the five types of fishing. Depending on the species category, catch rates were computed for individual species or groups of fishes for each of the 83 counties in Michigan (Table 2). The species comprising inland trout and non-trout fishing were used to compute trout, gamefish and panfish catch rate categories. While not included in the actual classification process, the inland catch rate estimates identify locations for substitute kinds of angling.

Catch rates were calculated by dividing the total catch for a certain species or group of species by the relevant number of angler days fished in a particular county. For each species (or group of species), county effort included only those angler days in which anglers reported catching fish of that species. Otherwise when an angler failed to catch fish, the effort expended by that angler was excluded form the resultant calculations. For example, if in Berrien county, one respondent reported

Table 2. The Individual Species or Groups of Fish Whose Catch Rates are Utilized in the Angling Product Classification Procedure

Type of Fishing		Species
Great Lakes salmonid		1. Lake trout 2. Brown trout 3. Steelhead (rainbow) trout 4. Coho salmon 5. Chinook salmon
Anadromous		1. Steelhead trout 2. Coho salmon 3. Chinook salmon
Great Lakes non-salmonid		1. White bass, crappie 2. Yellow perch 3. Bluegill, sunfish 4. Small and largemouth bass 5. Walleye pike, sauger 6. Northern pike, muskellunge 7. Other (smelt, carp)
Inland Trout		1. Lake trout 2. Rainbow trout 3. Brook trout 4. Brown trout
Inland non-trout	Gamefish:	1. Walleye 2. Bass 3. Pike, muskie
	Panfish:	1. Yellow perch 2. Bluegill, sunfish 3. White bass, crappie 4. Rock bass

catching no fish for one day's effort, and another reported catching two lake trout for two days effort, the catch rate for lake trout is $\frac{2}{2}$ = 1.0 fish per angler day. This is done because of the manner in which the questionnaire was worded, since it is difficult to determine what an angler fishes for in cases where no fish or even if fish are harvested. Aggregate catch rates for various species associations were computed using total catch for the species considered and dividing by aggregate effort.

The remaining sources of input data included information on anglers' residence, angling location, and participation in Great Lakes salmonid angling activities. From these data, origin-destination patterns of total angler effort for each county were generated for period I. In other words, this is the number of angler days spent at the various counties offering salmonid angling opportunities by anglers originating from each location. Anglers origin sites included any one of the following 88 possibilities: all 83 Michigan counties, Wisconsin, Illinois, Indiana, Ohio, plus an additional category reserved for any other origin (i.e. other states, Canada). This origin-destination information was provided as an 88 x 83 matrix and stored on a permanent computer file.

Specific Procedures

The primary purpose of the classification procedure is to determine which attribute or sets of attributes anglers' apparently use to distinguish between various angling sites. Therefore, preliminary work was devoted to compiling a list of potential attributes which might be relevant in the decision-making process. Every county offering salmonid fishing was then inventoried for each of the attributes selected for analysis.

Catch rate attributes were finalized after the reliability and accuracy of the species catch rate estimates were verified by professional fishery biologists. As a result of both the variability in annual angling success and the small seasonal samples, many catch rate estimates for certain counties were somewhat questionable and required adjustments based upon more reliable information. Following confirmation, county catch rate estimates for each individual salmonid species were plotted on standard graph paper. Counties were then separated into various levels or sub-divisions, such as high, moderate, and low catch per unit of effort, on the basis of their relative distribution (Figure 6A).

Many catch rate attributes were generated to test the importance to anglers of specific seasonal hypotheses regarding salmonid species mix. During period I, some anglers may select sites on the basis of the success rates of major species categories, such as the trout and salmon groups. Others may further discriminate within the trout category by considering the catch rates for a certain species or combination of species as being most important

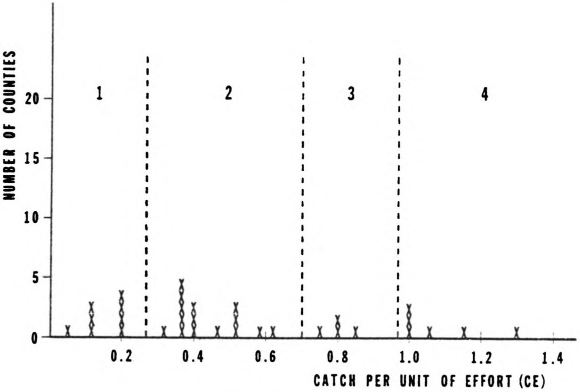

Figure 6. A hypothetical graph showing the catch rates for steelhead at various counties (x). By changing the cut-off points, two different catch rate attributes are created as follows: (A) catch rate levels initially designated as 1 = Low, 2 = Moderate, 3+4 = High; (B) catch rate levels alternatively designated as 1 = Low, 2+3 = Moderate, 4 = High.

to them. For example, anglers may regard steelhead or lake trout catch rates independently, steelhead together with either lake trout or brown trout catch rates, or brown trout and aggregate steelhead/lake trout catch rates. A number of different catch rate attributes were created by first varying and recombining species into various associations (Figure 7). Depending on the species combination and levels of catch rate, the possible permutations for any catch rate attribute range anywhere from a simple 3-way breakdown (for a single species with 3 levels of catch

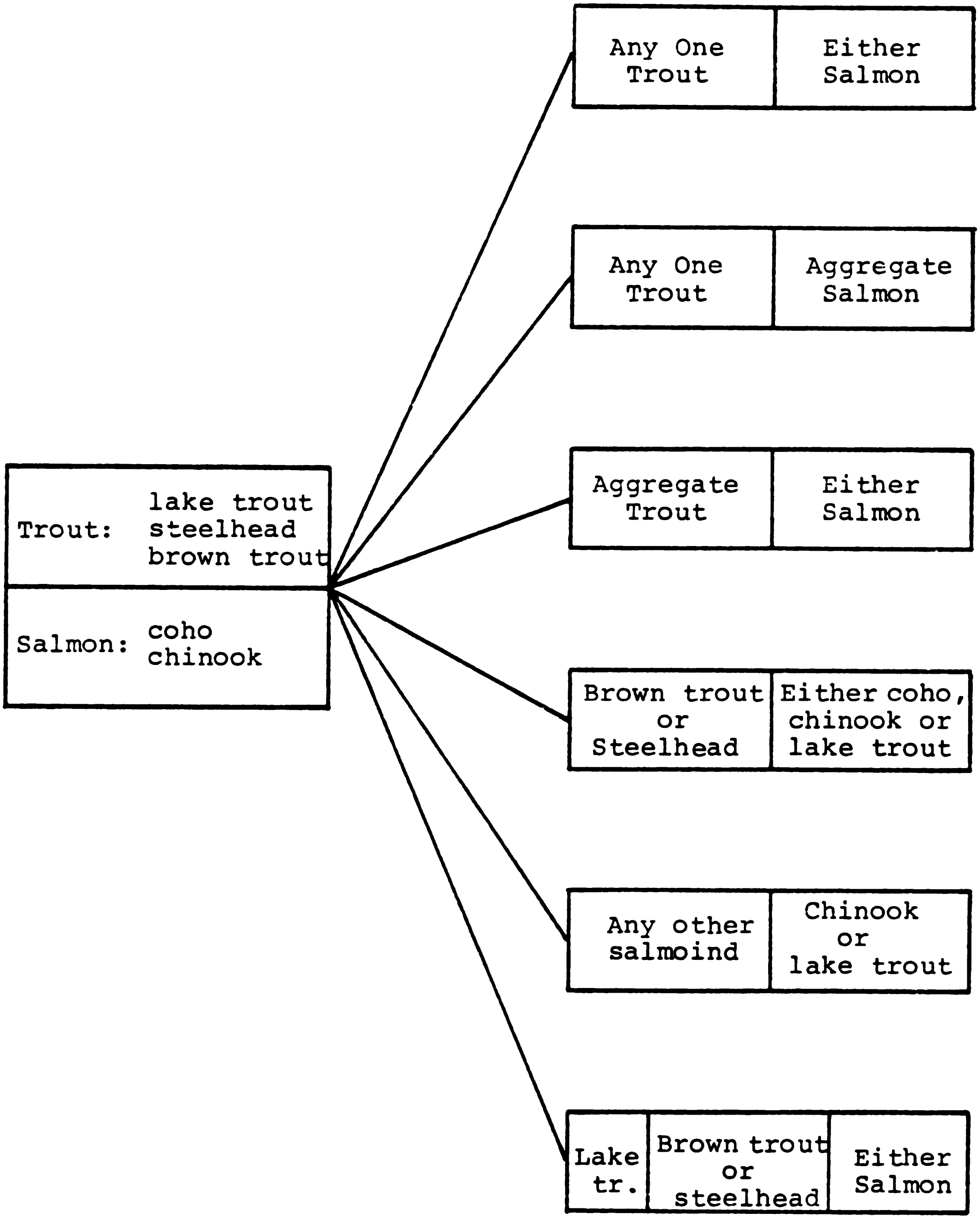

Figure 7. Example of six different catch rate attributes formed by simply varying salmonid species combinations.

rate) to a 27-way system (three species categories each with 3 levels of catch rate). Tables describing the many seasonal catch rate attributes formulated and tested for the three types of fishing may be found in Appendix B.

Secondly, additional catch rate attributes are formed by simply redistributing counties into different levels by changing the arbitrary cut-off points on one or more graphs (Figure 6B). Here the counties in group three (high catch per unit of effort), although somewhat differentiated from moderate catch rate counties (group 2), may not truly be classified as "high" by some anglers. An alternative is to lump these counties into the moderate category, thus forming a different attribute.

Other plausible attributes in addition to catch rate were chosen to more completely describe how anglers discriminate between angling sites. These included such factors as the availability of piers, publicity, and the presence of natural bays. A list with complete definitions of these other attributes utilized for each type of fishing is found in Table 4 of Appendix B. These selections were made on the basis of personal judgment, suggestions by professionals, discussions among fellow students, or remarks by anglers themselves. Many other important factors, such as size of fish, public access, and crowding, were not selected because they are either confounded with other attributes or are difficult to assess on a county-wide basis.

A complete inventory is formed by coding each county according to the level of attributes found there. These results, combined with origin-destination use patterns and price data obtained from various price equations (described below), were then simultaneously integrated into a complex Fortran computer program which generated each classification scheme. Any hypothesis includes a catch rate attribute, and may include one or more of the non-catch rate attributes.

Each hypothesis was judged by examining user travel patterns in relation to the number of specific products generated by the classification procedure. Talhelm (1972, 1973b, 1976) proposed that if each product is properly defined, the magnitude of the number of users traveling "farther than necessary" to reach a more distant but hypothetically identical site will be minimized. Excess travel is minimum in the case where all sites are unique, and maximum when sites are classified as being alike. Therefore, a reasonable criterion is one which minimizes excess travel within categories while using a "small" number of categories.

Instead of measuring excess travel by counting the number of anglers traveling farther than necessary to reach each product, it was decided to measure total excess expenditures incurred by users in traveling to more distant sites. That is, the extra money and value of time spent over and above what users could have incurred to reach a hypothetically identical and less expensive (more convenient) site. The percentage of total excess expenditures indicates the adequacy of each hypotheses. High percentages suggest that (1) a large proportion of anglers have reasons for incurring additional expenses, or (2) a small number of users are traveling much farther than necessary.

All hypotheses were examined for their level of excess expenditures. A number of hypotheses were investigated in detail to determine possible explanations for angler behavior. Attribute combinations and subdivisions (levels) of attributes were varied depending on which alternative hypotheses appeared feasible. For instance, one hypothesis might examine the following attribute for salmonid fishing in period I: any trout and any salmon catch rates. A pattern may emerge whereby a large proportion of anglers are consistently paying high prices to reach one or two particular sites classified as "moderate" catch rate products for both species categories. Apparently, anglers' find these more distant sites sufficiently different to warrant spending excessive amounts of money. Closer inspection of the inventory may indicate that the farther sites offer pier fishing while the closest site does not. Therefore, a second attribute (piers) is tested in combination with catch rates. By testing this alternative hypothesis, the level of excess expenditures is reduced when these counties are separated into a distinct product category ("moderate" catch rates and piers available). Under this new classification scheme, anglers who were originally spending more than necessary for hypothetically identical products are traveling to those same sites, but to different products. Since the new products are only available at these distant locations, by definition, anglers must be traveling to the closest counties for this new product. Therefore, anglers' supply prices are necessarily minimized.

These procedures were followed until a satisfactory hypothesis was discovered. Various hypotheses were compared by plotting them on a graph where one axis has the number of products and the other total excess expenditures (Figure 8). A curved frontier is formed by the most "reasonable" hypotheses for various numbers of products defined. The final selection was made from among a few possibilities for which excess expenditures were low, considering the number of product categories.

2. Price Equations

Price equations were developed to express angler travel costs as a function of travel time and distance (mileage) to the site. Costs attributable to fishing include (1) the estimated value of time, and (2) expenditures on travel, equipment, fees and lodging. The equations used in this study are modifications of those estimated for a study of Michigan's 1970 salmon-steelhead sport fishery

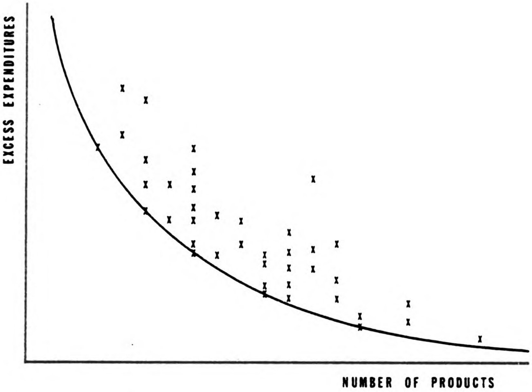

Figure 8. The relative importance to anglers of various angling attributes was judged by examining the excess amounts of money spent in relation to the number of products defined. A curve frontier is formed by the "best" hypotheses and the result of each hypothesis is represented by an "x".

Talhelm, 1973b) and a 1972 inland lake study of boating and angling in Michigan (Talhelm, 1976). Expenditure data for the 1970 equations were obtained from mail survey questionnaires asking anglers to report their expenses traveling and in the area fished. It was assumed that they included only those expenses incurred for the purposes of angling. However, if some expenses were incurred for purposes other than fishing, such as travel costs incurred partially for visiting friends or relatives, then it is likely that 1970 angling costs may be slightly exaggerated.

The angling price equation estimated for the 1972 study was based upon expenditure data collected by means of personal interviews of users. In this way, expenses for the purposes of fishing are determined more precisely. The 1972 equation was considered much more reliable for predicting true angling costs. However, it represented costs for angling on inland lakes rather than angling for Great Lakes fish.

In the 1970 study, separate price equations were estimated for resident and non-resident salmonid and non-salmonid anglers. Upon closer examination of these equations, it was discovered that the resident non-salmonid price curve (plotted from the equation) began to decline at distances greater than 450 miles, implying that angling costs are decreasing with increasing travel distance. Normally one would expect angling costs to continue rising as distance increases. Therefore, to correct this problem and improve the 1970 non-salmonid price equation, the resident costs of non-salmonid angling at distances (in increments of 10 miles) of 0-450 miles were combined with the non-resident costs of non-salmonid angling at distances of 460-1000 miles, and a single 1970 non-salmonid angling cost equation applicable for both residents and non-residents was estimated. This new curve was used as the basis for calculating angling costs in 1976.

For this study, the 1970 price equations are revised to conform in part with the 1972 equation. This involved (1) graphically comparing each 1970 equation estimated for resident and non-resident salmonid and non-salmonid anglers with the 1972 equation; (2) determining any differences between curves by examining the heights and slopes of curves at various travel distances; and (3) incorporating these differences by adding or subtracting specific constants to the 1970 price equations. Because angling costs were probably somewhat overestimated in 1970, the intercepts for the 1970 curves are greater than the intercept value for 1972. Therefore, various constants were subtracted from the 1970 salmonid and non-salmonid price equations. Different constants were subtracted when (1) an origin and distination site happened to be the same; equivalent to zero mileage; or (2) when origin and destination sites are different. The specific constants were 19 and 16 for salmonid fishing and 13 and 16 for non-salmonid fishing, respectively.

In addition, to account for inflation over a four year period (1972-1976), an average rate of inflation applicable to angling expenditures is added to the updated 1970 price equations. Consumer price indices for various items pertinent to recreational activities were gathered to estimate this factor. Angling costs were converted to 1976 dollars by assuming a 50% inflationary rate.

For each sampling period, the various resident and non-resident price equations are illustrated by type of fishing in Figures 9, 10, and 11, respectively. The functional form for these price equations is:

$$P = C + b_1\text{Distance} + b_2(\text{Dist})^2 + b_3\ln(\text{Dist} + 1) \qquad (1)$$

The specific price equation coefficients are shown in Table 3.

Table 3. Price Equation Coefficients for Salmonid and Non-Salmonid Fishing

Factor	Salmonid		Non-Salmonid
	Resident	Non-Resident	Resident and Non-Resident
Distance	.31078	.29347	.105815
$(\text{Distance})^2$	-.000259	-.000098	.0000044
ln(Distance+1)	-.69195	-1.0942	2.84127
Constants:[a]			
Period 1	25.34822	40.2882	23.9028
Period 2	30.58148	19.4348	24.4153
Period 3	33.97938	38.7328	22.6254

[a]The values 19 and 16 for salmonid fishing and 13 and 16 for non-salmonid fishing were subtracted from the specific constants given above to calculate the costs of angling for various travel distances.

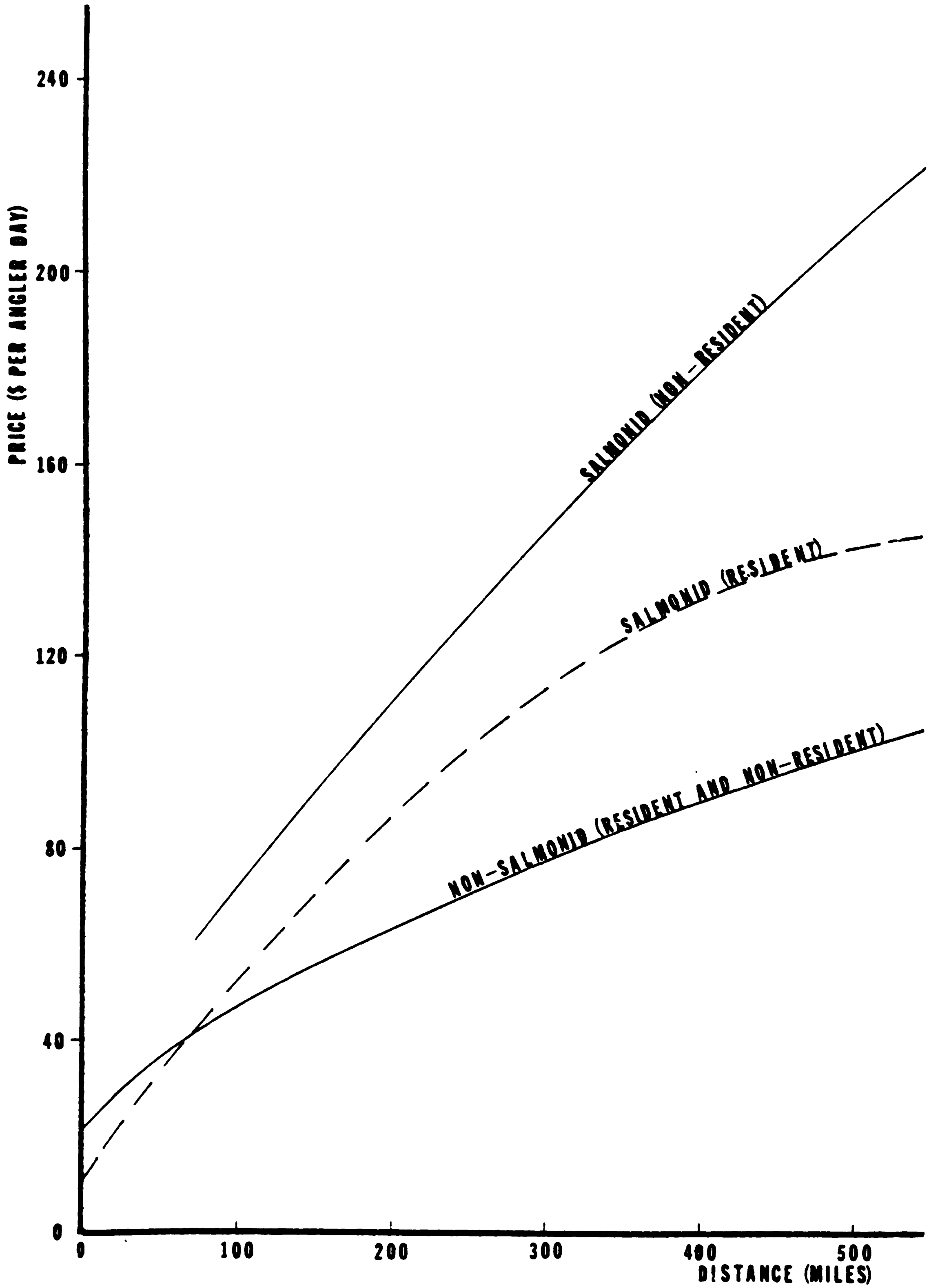

Figure 9. Price curves, winter-spring period, showing the user cost of angling as related to travel distance.

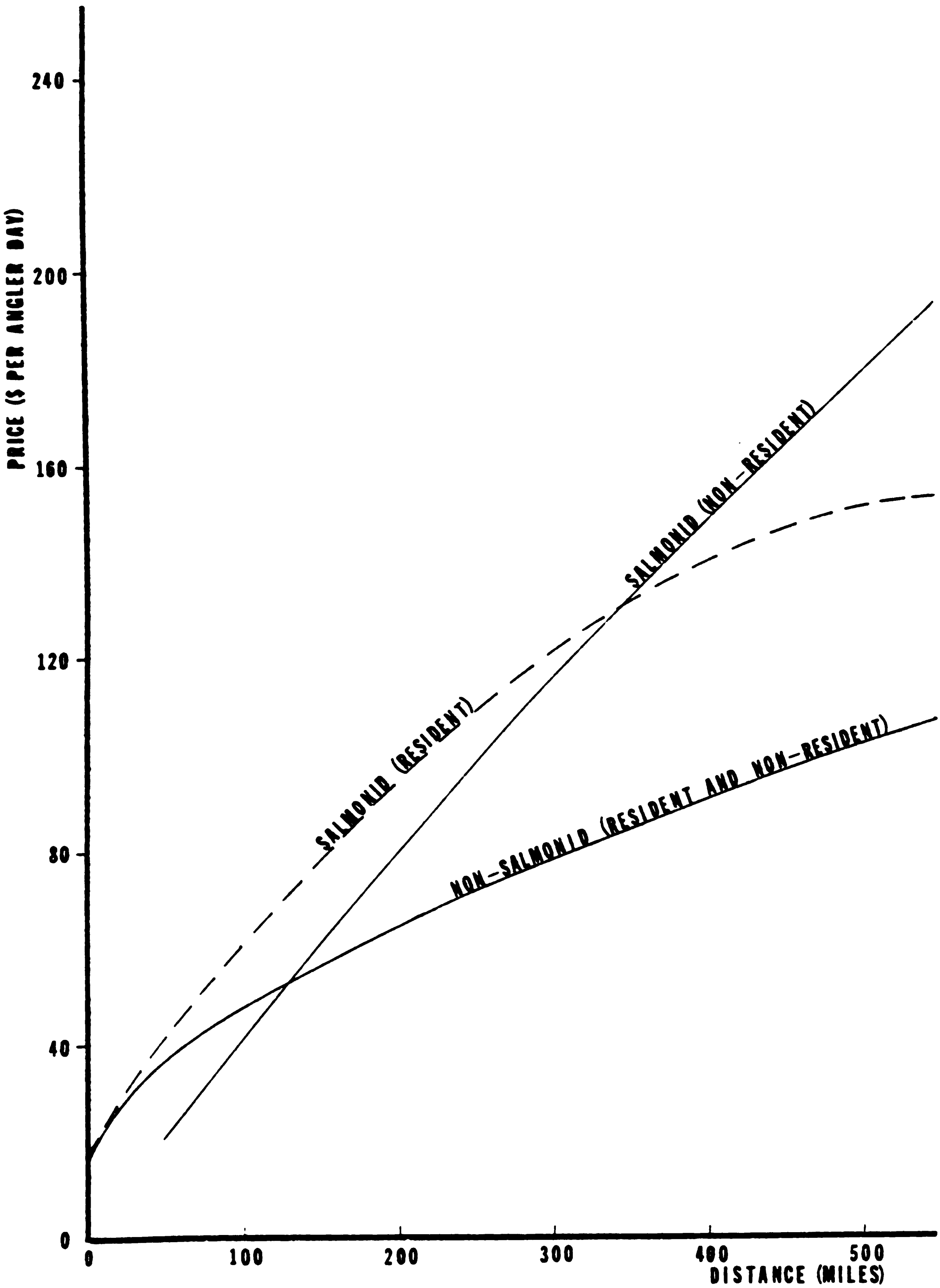

Figure 10. Price curves, summer period, showing the user cost of angling as related to travel distance.

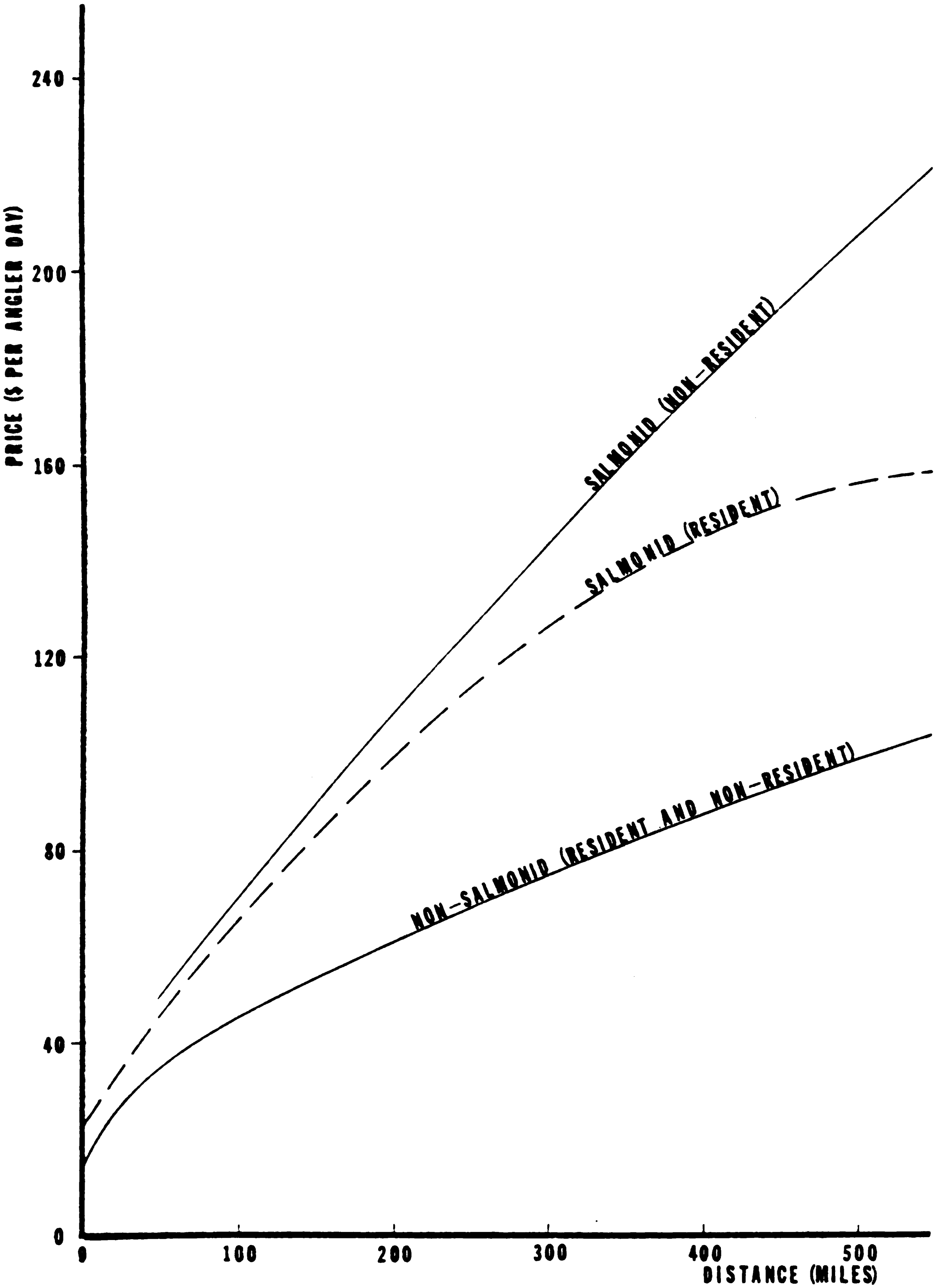

Figure 11. Price curves, fall period, showing the user cost of angling as related to travel distance.

3. Demand Analysis

General Description

The final resource classifications define the specific angling products for which demand is estimated. As mentioned previously, the demand analysis gives the advantage of evaluating consumer preferences for specific components of a general recreational system. As before, demand is analyzed independently for each of the eight types of seasonal fishing. Since the analytical procedures are virtually identical for each demand analysis, the following description is applicable to all eight cases.

Specific Procedures

The initial information required for estimating the demand functions are (1) the number of angler days use of each angling product from every origin, and (2) the corresponding minimum (supply) prices of each product from every origin. In other words, these pairs of data represent the prices and amounts of use (angler days) at the closest county of a particular product for anglers originating from the same location. Each product provides 88 sets of quantities and prices, one set for each origin.

Because only a small percentage of the licensed angling population were sampled in each season, the seasonal user information was adjusted to reflect quantity in terms of the total populations of each origin. Various expansion factors (provided by the DNR) were utilized to estimate the total number of user days consumed by anglers. Specifically, origin user data were multiplied by values of 115.0, 180.0, and 190.0 for periods I, II, and III, respectively. Quantity was subsequently expressed as numbers of angler days per 1,000 capita by dividing total use by the population size of each origin.

For this and other studies (Talhelm, 1973b, 1976), a correction was allowed for calculating the use at the closest counties of a given angling product. The amounts of use at those counties within 20 miles or 20% (whichever is greater) of the minimum distance to a particular angling product were combined with the observed amounts of use for that same product. The reasons for this allowance are (1) county to county distances may not necessarily represent actual road distances for various anglers, and (2) anglers wishing to visit two angling products which are close to each other may find it cheaper to visit both sites together rather than separately, even though one product is slightly farther.

In addition to the preceeding price and quantity variables, observations of the prices of general substitute forms of angling and one socioeconomic variable were accumulated for every origin. These included (1) the <u>minimum</u> price of angling in a county offering at least a "moderate" catch rate for inland trout angling; (2) the minimum price for inland panfish angling (yellow perch, bluegill, crappie) of moderate or better catch rate;

(3) the minimum price for inland gamefish angling (bass, walleye, pike, muskellunge) of moderate or better catch rate; (4) the minimum prices for Great Lakes salmonid, non-salmonid, and anadromous stream angling (respectively) of moderate or better catch rate; and (5) personal income per capita. The prices were determined from the price functions given earlier. The non-salmonid price function was used to calculate the respective prices for inland angling substitutes.

With information from every origin on (1) the prices and quantities of use of each angling product, (2) the prices of various substitutes, and (3) income per capita, demand equations were estimated for each quality of angling. Each demand function is described by the general functional form in equation 2,

$$Q_i = b_0 + b_i/P_i + b_iP_i + b_jP_j + b_kP_k + b_sS \qquad (2)$$

where Q_i represents the number of visits per 1,000 capita at the least expensive location for product i; the independent variables are the minimum available price of product i (P_i), the prices of the other substitute specific products (P_j), the prices of the relevant substitute general angling substitutes (P_k), plus income (S). The four possible forms for this equation are illustrated in Figure 12. The equations were purposely restricted so as to eliminate any possibility of a positively sloped demand curve (Figure 12D).

The demand equations for each specific product were

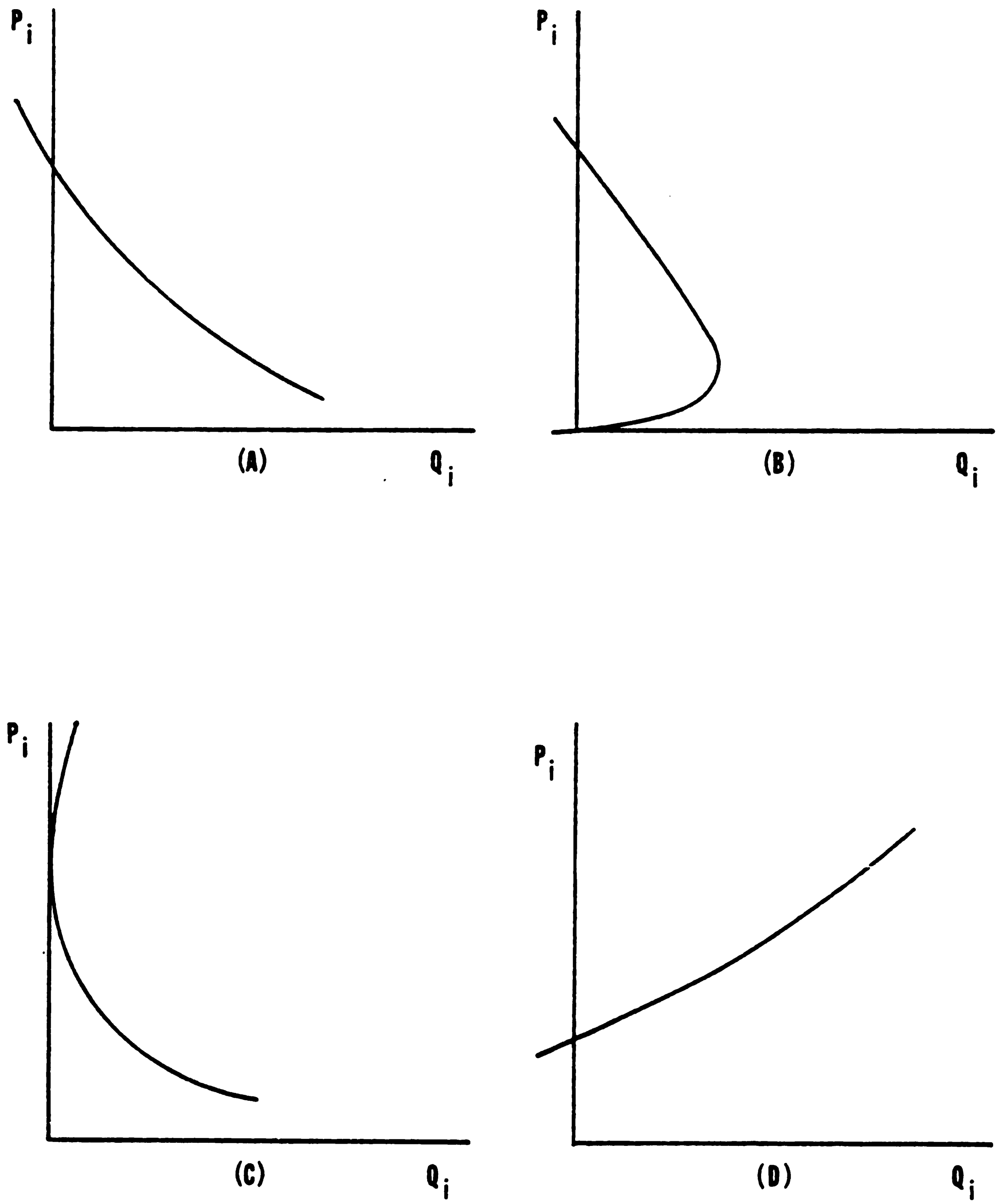

Figure 12. The possible general forms for equation $Q_i = C + bP_i + b'/P_i$: (A) $b < 0$, $b' > 0$; (B) $b < 0$, $b' < 0$; (C) $b > 0$, $b > 0$; (D) $b > 0$, $b' < 0$.

estimated using ordinary least squares regression analyses. Initially, each regression is run using the complete set of price variables possible for a given product. Through a step-wise elimination process, certain variables are progressively omitted when (1) coefficients are negative, or (2) when specific positive coefficients cannot be retained for statistical reasons. These factors are discussed more completely later in this section. Upon eliminating any questionable variables, the regression was rerun and the process repeated until an acceptable demand relationship was found. In this way, a set of demand functions (one for each angling product) is estimated for each of the seasonal types of fishing analyzed.

A typical demand function for period I Great Lakes salmonid angling is represented in equation 3,

$$Q_4 = -55.2 + \frac{1895.4}{P_4} + .20P_4 + .05P_3 + .11P_6 - .001I \quad (3)$$

where, in this case, the estimated quantity of angling consumed (per 1,000 anglers) at product four for a given origin site is a function of the minimum price of product four, the prices of specific substitute products three and six, and county per capita income. Tables giving the demand equations for all of the angling products defined for each seasonal type of fishing are found in Appendix B.

In any demand function, a positive coefficient or cross elasticity of demand indicates substitution between two goods. Two products are considered substitutes when changes in the price of one have a positive effect on the quantity demanded of the other (i.e. $(dx_2/dp_1)p_1/x_2$ is always positive, where x_2 is the quantity of good 2 demanded). For example, as the price of meat increases (p_1), consumers will tend to increase their consumption of poultry or fish (x_2) instead (and decrease the quantity of meat demanded). In the case of equation 3, anglers will go to product four less as the price of product six becomes less expensive (more available to anglers). Higher values for positive coefficients indicate that anglers are more willing to give up one product for another, either because (1) anglers consider the products to be good substitutes for each other, so they visit the least expensive of the two; (2) product six is preferred to four, so anglers switch when the opportunity presents itself; and (3) product four is generally too expensive relative to product six (Talhelm, 1973b).

The rationale for including only those variables with positive coefficients is that specific products in the same general product group are normally substitutes (Talhelm, 1978b). Any negative coefficients, indicating complementarity between products,[9] were eliminated from the regressions because they were difficult to justify due to the nature of the classification scheme. Two angling products might be considered complements if they are located

[9]Two goods are complements when an increase (decrease) in the price of one decreases (increases) the quantity demanded of the other.

directly adjacent to one another, since anglers visiting one product may also find it very convenient to visit a second product which is in close proximity. The only other logical explanation for a negative coefficient would be "learning": the use of site Y whets the appetite for the product at site X (Talhelm, 1978b). However, it is unlikely that quantity of use at site X would increase as a result of a decrease in the price of site Y, since a reduction in price effectively means the complement is located closer to a particular origin.

As mentioned before, several independent variables were eliminated for specific statistical reasons. First, and probably the most fundamentally serious, is a source of measurement error in the dependent variable. Because the sample of user origin information is not very intensive at any single county, the amount of information available for estimating the equations is both limited and subject to some degree of uncertainty. Frequently as few as ten out of 88 origins provided non-zero data points for any one product. The observations of zero use from some origins may also result from statistical error associated with sampling, therefore they cannot be arbitrarely excluded from the regressions. With the liklihood of questionable data, it is difficult to justify supporting some twenty independent variables to explain the total variation in the dependent variable. Secondly, prices are correlated with product categories, either because (1) often a particular product is represented by one unique county or by a group of counties in a unique geographical area, or (2) when products near population centers are separated from those farther away. For example, visualize a situation where a product (say number one) is represented by both Grand Traverse and Leelanau counties in northern Lower Michigan. Moreover, another product (say number two) is located in Berrien county in the extreme southwestern end of Lower Michigan. For those origins in souternmost lower Michigan, the price of product two is always low relative to the price of product one, and vica versa for origins in the northern part of the state. Consequently, when product two is examined as a potential substitute in the equation for product one, a strong substitution effect (high positive coefficient) will be exhibited due to the negative correlation between product prices. Other cases may result in positive interrelationships between product prices. The major multi-collinearity problems were minimized by excluding those variables subject to these statistical pitfalls.

The many demand equations permit generalizations about consumers' revealed preferences for angling activities. By comparing the different product demand curves for a particular seasonal type of fishing, one can assess the relative importance to anglers of various qualities of angling. In general, the nature of the comparative demand for any angling product depends upon (1) the location of the demand curves with respect to one another, and (2) the shapes of the demand curves. Whether a demand curve is to the right or left of other curves indicates anglers' relative preferences for different angling products. The shape of a demand curve is an indication of the responsiveness in quantity demanded to changes in the price of a particular angling product, or what is referred to as the price elasticity of demand. The relative positions of each demand curve was approximated by using an average of the 88 minimum supply prices for each of the final substitutes, including average county per capita income. The demand curves for each seasonal type of fishing are shown in the following chapter.

V. RESULTS AND DISCUSSION

1. Product Classification Analysis

Salmonid Angling in the Great Lakes

A total of 41 counties offered some form of Great Lakes salmonid angling each period. Anglers fishing for salmonids on the Great Lakes appear to find catch rates and species mix the most important attributes. It was decided that a nine-way breakdown describing eight products best identifies winter-spring (Period I) Great Lakes salmonid fishing (Figure 13). For this period the level of "excess expenditures" was 15.3%. Apparently, anglers discriminate primarily between the trout group (steelhead or rainbow, brown and lake trout) and the salmon group (coho and chinook). They seem to be interested in the catch rates of any one or more species within these two groups, and do not distinguish much between the species within the groups. For example, if a particular county has a "high" catch rate for at least one species of trout and "moderate" (but not high) for either coho or chinook salmon, then it falls into the "high" any trout and "moderate" any salmon category (product number 1). If only "moderate" catch rates are found for one or more trout, the county is classed as product number 4. Tables 13-15 in

ATTRIBUTES		Product Identification Number	Number of Counties
Catch Rates			
Any Trout	Any Salmon		
	HIGH	-	-
HIGH	MODERATE	1	2
	LOW	2	5
	HIGH	3	4
MODERATE	MODERATE	4	7
	LOW	5	11
	HIGH	6	1
LOW	MODERATE	7	3
	LOW	8	8

Figure 13. Identification key defining eight different kinds (products) of Great Lakes salmonid fishing during the 1976 winter-spring period.

Appendix B lists the counties corresponding to each of the various products defined for the respective periods and types of fishing. Definitions of all the final catch rate attributes are found in Tables 16-18 of Appendix B.

Alternative attribute combinations which were found to be almost as satisfactory in period I included (1) the availability of pier fishing in conjunction with any trout and any salmon catch rates, and (2) a nine-way breakdown of aggregate trout and any salmon catch rates. Some additional factors tested in combination with various catch rate attributes included the location of a county on a natural bay, the amount of publicity, and urban/non-urban angling environment. Although none of these combinations proved to be as successful as catch rate alone, these factors could be of secondary importance to anglers.

These results are not surprising, in light of the fact that the winter-spring fishery in Michigan provides excellent early spring runs of steelhead off river mouths, and late spring lakeshore runs of brown trout, lake trout, and salmon. Although there are anglers who prefer a certain species of fish and/or areas with bays, the results indicate that the majority of anglers feel and behave differently when fishing for salmonids during the winter-spring season.

The summer (period II) and fall (period III) Great Lakes salmonid fisheries differ somewhat from that of spring. Larger coho and more abundant stocks of chinook are responsible for enhancing salmon fishing opportunities. Good creels of lake trout are caught in summer. Steelhead fishing reaches its peak in late fall, usually after salmon have entered the streams for their annual spawning migrations. For the 41 counties, seven specific products with a level of excess expenditures of 12.3% were identified in period II and eight specific products with 8.7% in period III. During these two periods, anglers were apparently most interested in "any trout" and "aggregate salmon" catch rates (Figures 14 and 15). Other hypotheses which were tested and found somewhat less important indicated that anglers do not differentiate summer lake trout or fall steelhead fishing from their respective species groups, and aggregate catch rates for all fish (hypothesizing that anglers do not differentiate at all between species) were not as satisfactory. In addition, hypotheses testing secondary attributes such as alternative forms of recreation available at sites (complementary recreation), natural bays, pier fishing, and publicity were not as successful as catch rate alone.

Angling for Anadromous Fish in Streams

The winter-spring anadromous fishery in Michigan is based primarily upon the numerous migrating steelhead trout. Upwards of 200,000 steelhead were caught in the many streams and tributaries during their 1976 spawing

ATTRIBUTES		Product Identification Number	Number of Counties
Catch Rates			
Any Trout	Aggregate Salmon		
HIGH	HIGH	1	3
	MODERATE	2	3
	LOW	3	5
MODERATE	HIGH	4	1
	MODERATE	5	5
	LOW	6	15
LOW	HIGH	-	-
	MODERATE	-	-
	LOW	7	9

Figure 14. Identification key defining seven different kinds (products) of Great Lakes salmonid fishing during the 1976 summer period.

ATTRIBUTES		Product Identification Number	Number of Counties
Catch Rates			
Any Trout	Aggregate Salmon		
HIGH	HIGH	1	4
	MODERATE	2	1
	LOW	6	2
MODERATE	HIGH	3	4
	MODERATE	4	7
	LOW	5	6
LOW	HIGH	7	7
	MODERATE	-	-
	LOW	8	10

Figure 15. Identification key defining eight different kinds (products) of Great Lakes salmonid angling for the 1976 fall period.

runs (Michigan DNR, unpublished survey results, January 1-May 31, 1976). Anglers have ample opportunity to pursue steelhead fishing in 52 counties around the state. Figure 16 identifies the nine specific kinds of anadromous angling for period I. The overall level of excess expenditures is 11.5%. It is apparent that (1) steelhead catch rate (3-way breakdown), (2) publicity, (3) natural lake throughways, and (4) fly-fishing regulations (in this order of importance) are the most important attributes used by anglers to differentiate between counties offering winter-spring anadromous fishing.[10] Some additional attributes examined with catch rate included (1) the presence of dams along streams, (2) anadromous stream mileage in a county, (3) size of streams, and (4) availability of land-locked anadromous fisheries. Stream size appears to be the most important secondary attribute.

The fall anadromous fishery is primarily dominated by the spawning migrations of coho and chinook salmon, although in late fall steelhead are also found in streams throughout the state. Thirteen specific products were defined for the 52 counties by the following attributes (in their apparent order of importance): (1) aggregate steelhead and salmon catch rate, (2) natural lake throughways,

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[10]The reader will notice that levels for the fly-fishing attribute were left unlabeled for the majority of angling products. This was done to facilitate perusal of the figure. However, one should understand that each permutation is characterized by unavailability (NO) for this attribute. Similarly, other attribute levels in Figures 17-20 are unlabeled, but they also denote unavailability.

ATTRIBUTES				Product ID Number	Number of Counties
Catch Rate Steelhead	Publicity	Lake Throughways	Fly-fishing Regulations		
HIGH	HIGH	YES		1	3
		NO	YES	2	1
			NO	3	2
	LOW	YES		-	-
		NO		4	9
MODERATE	HIGH	YES		5	1
		NO		6	3
	LOW	YES		7	3
		NO		8	13
LOW	HIGH	YES		-	-
		NO		-	-
	LOW	YES		-	-
		NO		9	17

Figure 16. Identification key defining nine different kinds (products) of Great Lakes anadromous fishing during the 1976 winter-spring period.

(3) snagging regulations, and fly-fishing regulations (Figure 17). For period III, the level of total excess expenditures is 5%. Among the numerous alternative attributes tested, stream size again appeared to be the most successful secondary attribute in combination with catch rate.

These results for anadromous angling may not be surprising to those familiar with salmonid angling opportunities around the state. Anglers' interested in salmon and steelhead may be attracted to areas with lake throughways at or near river mouths of major anadromous streams. This is especially true of the many rivers found in counties located along the eastern shore of Lake Michigan. As salmon and steelhead enter the streams for their annual spawning migrations, they inevitably must pass through these lakes before continuing upstream. Moreover, lakes of this nature provide greater opportunities for boat fishing and an angling environment which differs significantly from that of streams. Since lake throughways are usually protected from strong off-shore winds, they also offer more favorable weather conditions than open-waters for angling activities. While publicity is to some extent influential in any season, it is apparently more crucial in period I. The initial reports of steelhead success are likely to have a greater impact on anglers after anadromous angling activity has been somewhat slower during the winter. Some anglers may be attracted to salmon

ATTRIBUTES				Product ID Number	Number of Counties
Catch Rate / Aggregate Steelhd/Salmon	Lake through	Snagging regulations	Fly-fishing regulations		
VERY HIGH	YES	YES		1	2
		NO		2	2
	NO	YES		3	2
		NO		4	2
HIGH	NO	YES		5	2
		NO	YES	6	1
			NO	7	3
MODERATE	YES	YES		8	1
		NO		9	2
	NO	YES		10	4
		NO		11	12
LOW	NO	YES		12	2
		NO		13	17

Figure 17. Identification key defining thirteen different kinds (products) of Great Lakes anadromous fishing during the 1976 fall period.

snagging areas because little skill is needed while fishing and higher population densities in the fall increases the probability of catching salmonids. The fact that aggregate salmon-steelhead catch rates are important implies that most fall anglers are interested in all species rather than one individual species.

Non-Salmonid Angling in the Great Lakes

A total of 41 coastal counties offer some form of Great Lakes non-salmonid angling activity annually. In period I, ten specific products are identified by (1) aggregate panfish (yellow perch, bluegill, crappie, white bass) and aggregate gamefish (bass, walleye, pike/muskie) catch rates and (2) special bass regulations (Figure 18). The level of excess expenditures is 4%. These particular attributes were selected in lieu of other slightly less important catch rate attributes, namely (1) aggregate panfish and any gamefish, and (2) any panfish and aggregate gamefish catch rates. Other attributes were examined to test such hypotheses as (1) whether yellow perch catch rates were considered important because of this species popularity during the winter ice fishing season, or (2) that yellow perch, walleye, and any other species catch rates may be more important to anglers who exploit the popular walleye and yellow perch fisheries during their spring spawning seasons. However, both of these theories proved less satisfactory for the winter-spring non-salmonid fishery.

ATTRIBUTES				
Catch Rates		Special Bass Regulations	Product ID Number	Number of Counties
Aggregate panfish	Aggregate gamefish			
HIGH	HIGH		1	1
HIGH	MODERATE		2	1
HIGH	LOW		3	1
MODERATE	HIGH	YES	4	3
MODERATE	HIGH	NO	5	1
MODERATE	MODERATE		6	3
MODERATE	LOW		7	3
LOW	HIGH		8	2
LOW	MODERATE		9	6
LOW	LOW		10	20

Figure 18. Identification key defining ten different kinds (products) of Great Lakes non-salmonid fishing during the 1976 winter-spring period.

The wide variety of fish available to non-salmonid anglers in period I may be the reason anglers regard groups or categories of sportfish as more important than individual species. The special bass regulation occurs as a result of bass season opening later (June 17) than normal (May 27) for three Michigan counties: Wayne (Detroit river), MaComb (Lake St. Clair), and St. Clair (St. Clair river) counties. Interestingly, winter-spring survey results indicated that large numbers of bass were caught in these areas. Apparently, either (1) some respondents may have mistakenly reported their early summer bass catches (after June 17) instead of their actual catches for the winter-spring period, or (2) anglers are taking advantage of an excellent smallmouth bass catch and release fishery in these special counties and reporting their catches. Since the existence of higher bass catch rates were verified for these counties, it is feasible that anglers are behaving in the latter fashion. At the same time, the classification revealed that many anglers also tended to avoid the three special counties in order to reach otherwise identical products at some more distant site. Evidently, most anglers are inclined to fish for bass where they may legally retain their catches.

During the summer period, anglers' are apparently primarily concerned with (1) any panfish and aggregate gamefish catch rates and (2) a resort or vacation area factor. Twelve specific products are defined in this classification and the level of total excess expenditures is 3% (Figure 19). The resort factor was selected because a large percentage of anglers were spending in excess of what was necessary for primarily moderate catch rate products in the upper peninsula. In particular, many anglers originating from southern lower Michigan (especially the Detroit area) were avoiding hypothetically identical sites in the lower peninsula in favor of Chippewa, Mackinac, and other counties. Since the upper peninsula is a popular seasonal recreational area with many aesthetic qualities, it is reasonable to conclude that anglers are also spending their vacation time in this resort-like setting. The amenities of a site can significantly influence the decision-making process.

Examples of slightly less satisfactory attributes in period II included (1) aggregate panfish - other (suckers, catfish, whitefish, etc.) and any gamefish catch rates; and (3) any panfish and any gamefish catch rates. Other attributes rejected as being less important suggested that anglers do not differentiate between individual non-salmonid species during the summer. Also, factors such as bays, piers, and publicity were not as successful in combination with catch rate.

A travel pattern similar to period II was found in the fall. In addition to a resort factor, catch rates for yellow perch and "any other species" (bluegill, crappie, bass, pike, walleye) appear to be the most important

ATTRIBUTES			Product ID Number	Number of Counties
Catch Rates		Resort or Vacation Areas		
Any Panfish	Aggregate Gamefish			
HIGH	HIGH		1	1
HIGH	MODERATE		2	2
HIGH	LOW		3	2
MODERATE	HIGH		4	1
MODERATE	MODERATE	YES	5	1
MODERATE	MODERATE	NO	6	6
MODERATE	LOW		7	4
LOW	HIGH	YES	8	2
LOW	MODERATE	YES	9	5
LOW	MODERATE	NO	10	8
LOW	LOW	YES	11	5
LOW	LOW	NO	12	4

Figure 19. Identification key defining twelve different kinds (products) of Great Lakes non-salmonid fishing during the 1976 summer period.

attributes. Twelve specific products with total excess expenditures of 2.2% were defined for period III (Figure 20). Various other catch rate attributes of secondary importance included (1) aggregate panfish and any gamefish; (2) aggregate panfish and aggregate gamefish, and (3) yellow perch, walleye, and any other species catch rates.

These results indicate that anglers apparently do discriminate between species in period III (perch in contrast to the other species). This is probably due to the abundant populations of yellow perch in comparison to other non-salmonid fish stocks. It is plausible that yellow perch becomes the dominant species because of an adaptive capacity for remaining vigorous as water temperatures rapidly cool during the fall. As a result of this tolerance, ice fishermen frequently harvest large creels of yellow perch in winter.

It is evident from each of the preceeding angling classification analyses that catch rate and a particular species mix of fish are the most common and sometimes, as in the case of Great Lakes salmonid angling, the only significant attributes defining angling quality sufficiently. Instances in which other attributes in combination with catch rate, as for anadromous and non-salmonid angling, are used by anglers to differentiate between angling sites indicate the apparent importance of (1) angling sites with the reputation or potential for higher

ATTRIBUTES			Product ID Number	Number of Counties
Catch Rates		Resort or Vacation Areas		
Yellow Perch	Any Other Species			
HIGH	HIGH		1	2
	MODERATE		2	2
MODERATE	HIGH	YES	3	1
		NO	4	1
	MODERATE	YES	5	1
		NO	6	2
	LOW		7	2
LOW	HIGH		8	6
	MODERATE	YES	9	4
		NO	10	8
	LOW	YES	11	7
		NO	12	5

Figure 20. Identification key defining twelve different kinds (products) of Great Lakes non-salmonid fishing during the 1976 fall period.

catch rates (publicity, lake throughways, special bass regulations, snagging), and (2) locations which require a greater degree of skill and effort in catching fish (no snagging, no lake throughways, fly-fishing regulations).

Other product classification studies have shown varied results. Talhelm (1972) found that trout catch rate, stream size, regulations, and in some cases streamside buildings were the most important attributes defining trout angling quality in the southern Appalachians. In a study of Michigan's 1970 salmon-steelhead fishery (Talhelm, 1973b), angling quality was defined primarily by combinations of catch rates of three species of fish: coho salmon, chinook salmon, and steelhead trout. In addition, some other secondary attributes of importance included (1) urban or non-urban angling environment, (2) publicity, (3) early or late salmon migration, (4) the nature of the streams in which fish migrate, and (5) the availability of complementary types of recreation. Finally, an inland lake study of angling in Michigan classified angling sites in terms of (1) lake size, (2) catch rates and species mix of fish, and (3) whether or not a lake has a public entry point (Talhelm, 1976).

2. Demand Analysis

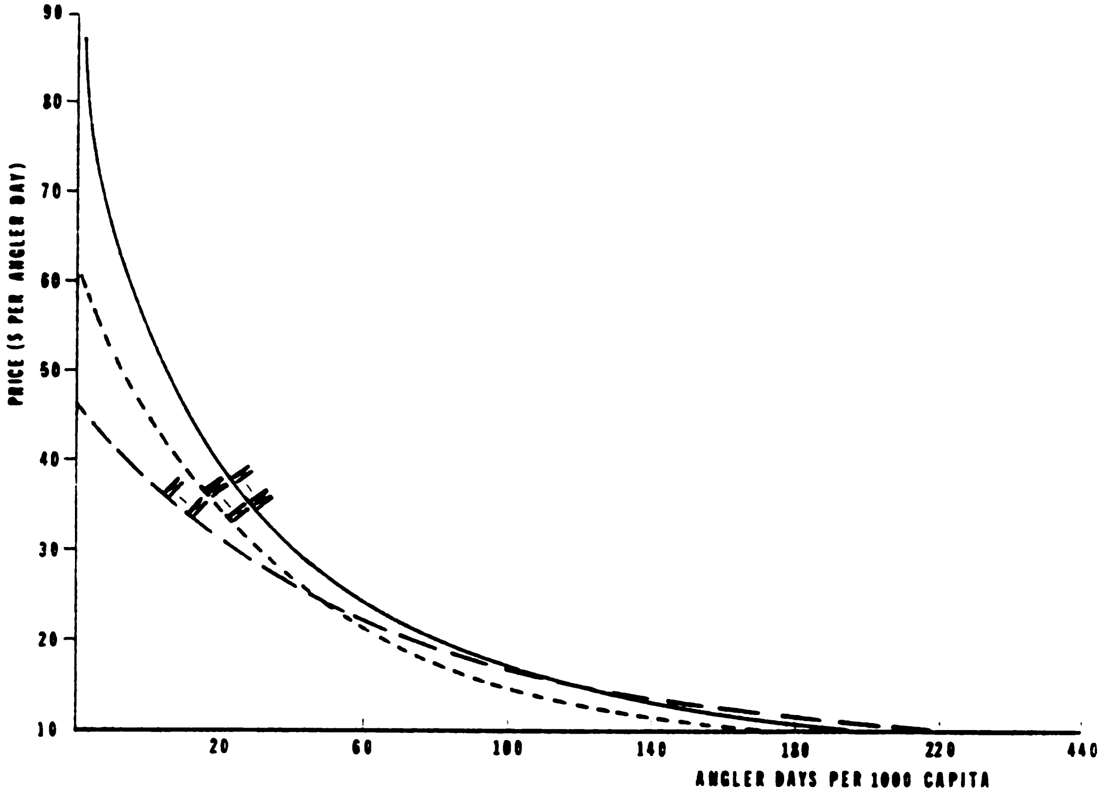
General Description

Anglers' demands for the different varieties of angling are determined by estimating demand functions for each specific angling product. Demand curves are then plotted and compared to assess anglers' relative preferences for angling in Michigan's Great Lakes. The following figures illustrate the demand curves for all of the angling products identified in the classification of each seasonal type of fishing. A letter code for each permutation of attributes is used to delineate the various qualities of angling. In the case of multiple attributes, levels of catch rate and those attributes which denote availability or high levels for a product are labeled to facilitate easy comparison. For example, in Figure 21, H-M is the demand curve for products having high any trout and moderate any salmon catch rates (product number 1 in Figure 13) during the winter-spring season; there are no other attributes describing period I salmonid fishing. In Figure 24, H-PB-LK indicates the demand for angling products with high steelhead catch rates, high publicity, presence of lake throughways, and no fly-fishing regulations (product number 1 in Figure 16); H represents the demand for angling products having high steelhead catch rates, low publicity, lake throughways unavailable, and no fly-fishing regulations (product number 4 in Figure 16). The demand equations estimated for each angling product are given in Tables 5-12 of Appendix B.

Angling for Great Lakes Salmonids

Figures 21, 22, and 23 illustrate the demand curves for the three seasonal periods, respectively, In general, products in greatest demand are those with (1) higher trout catch rates during period I, and (2) higher trout catch rates at relatively low prices and higher salmon catch rates at somewhat high prices in periods II and III. The demand equations also indicated that higher trout and salmon catch rates are generally substitutes for lower catch rate products, particularly in period II. In period II low catch rate products are also substitutes for especially high trout and salmon catch rate products. In addition, anglers substitute inland trout, inland gamefish, and inland panfish angling for low catch rate trout and salmon angling products in period III.

These findings reflect two different classes of salmonid anglers. First, there are those who probably "key" on or exhibit a strong preference for trout throughout the year. This is especially true during winter-spring and fall, when trout abundance and distribution is greatest. At these times, anglers have ample opportunity to fish for trout around the state, and need not travel far to do so. Second, there are a group of anglers who may be considered more dedicated salmon anglers, as displayed by their willingness to pay higher prices for products



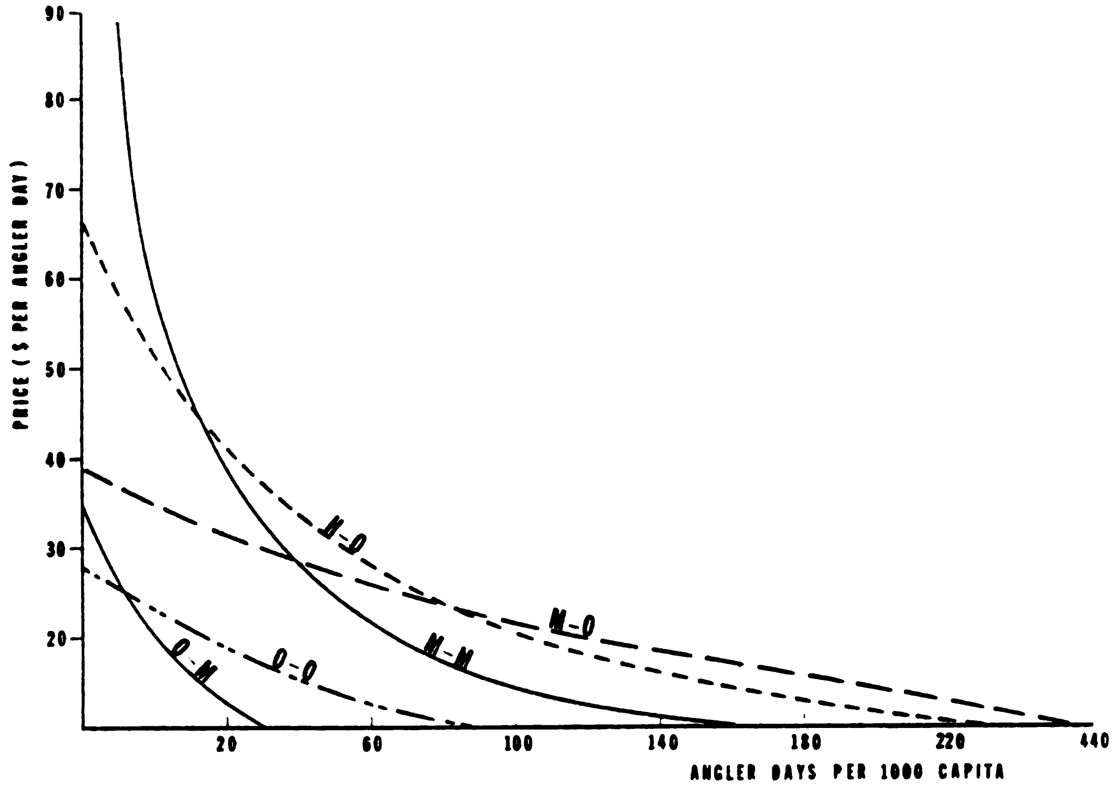


Figure 21. Demand curves for the eight salmonid angling products identified by any trout-any salmon catch rates in period I: H = high, M = moderate, and O = other.

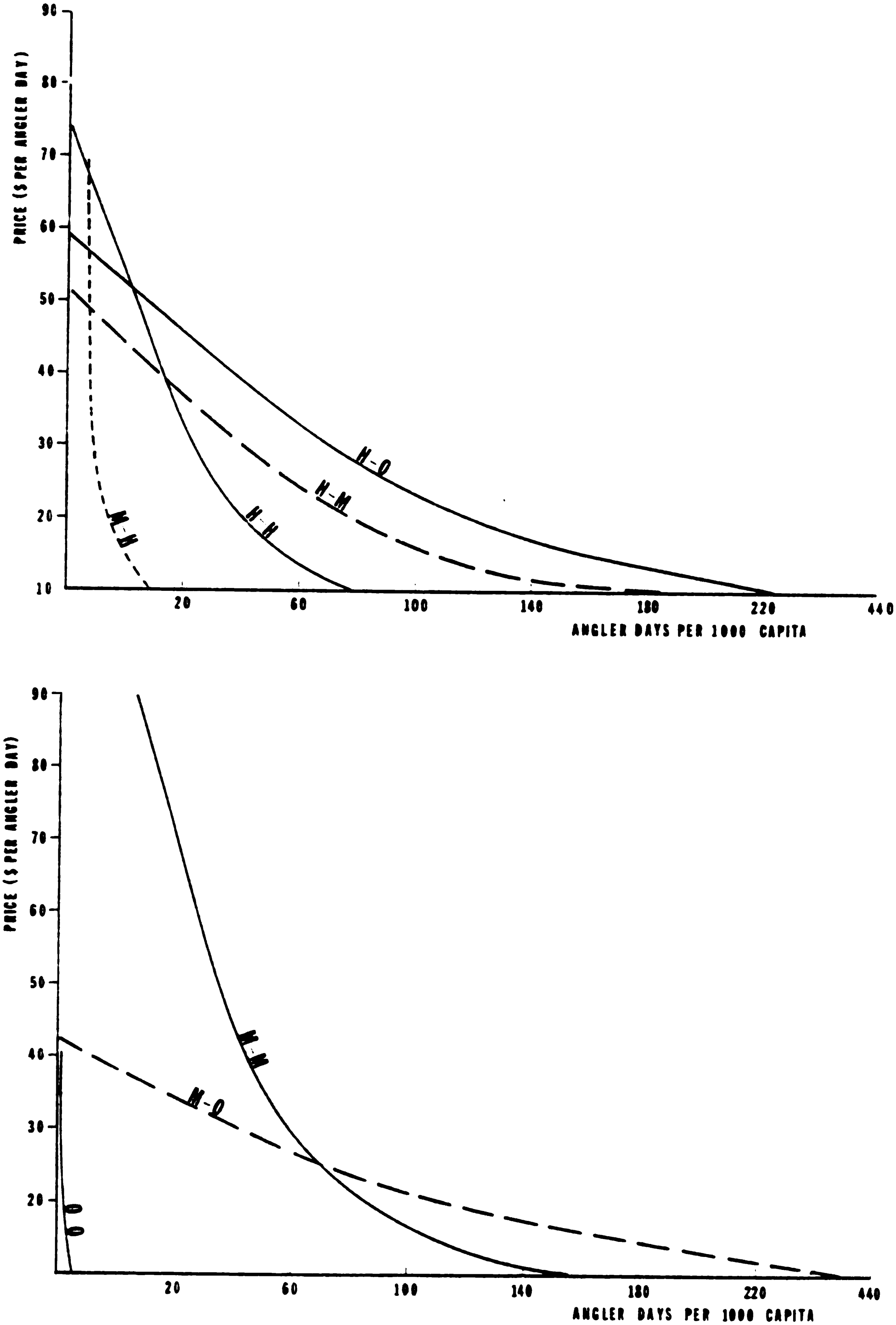


Figure 22. Demand curves for the seven salmonid angling products identified by any trout-aggregate salmon catch rates in period II: H = high, M = moderate, and O = other.

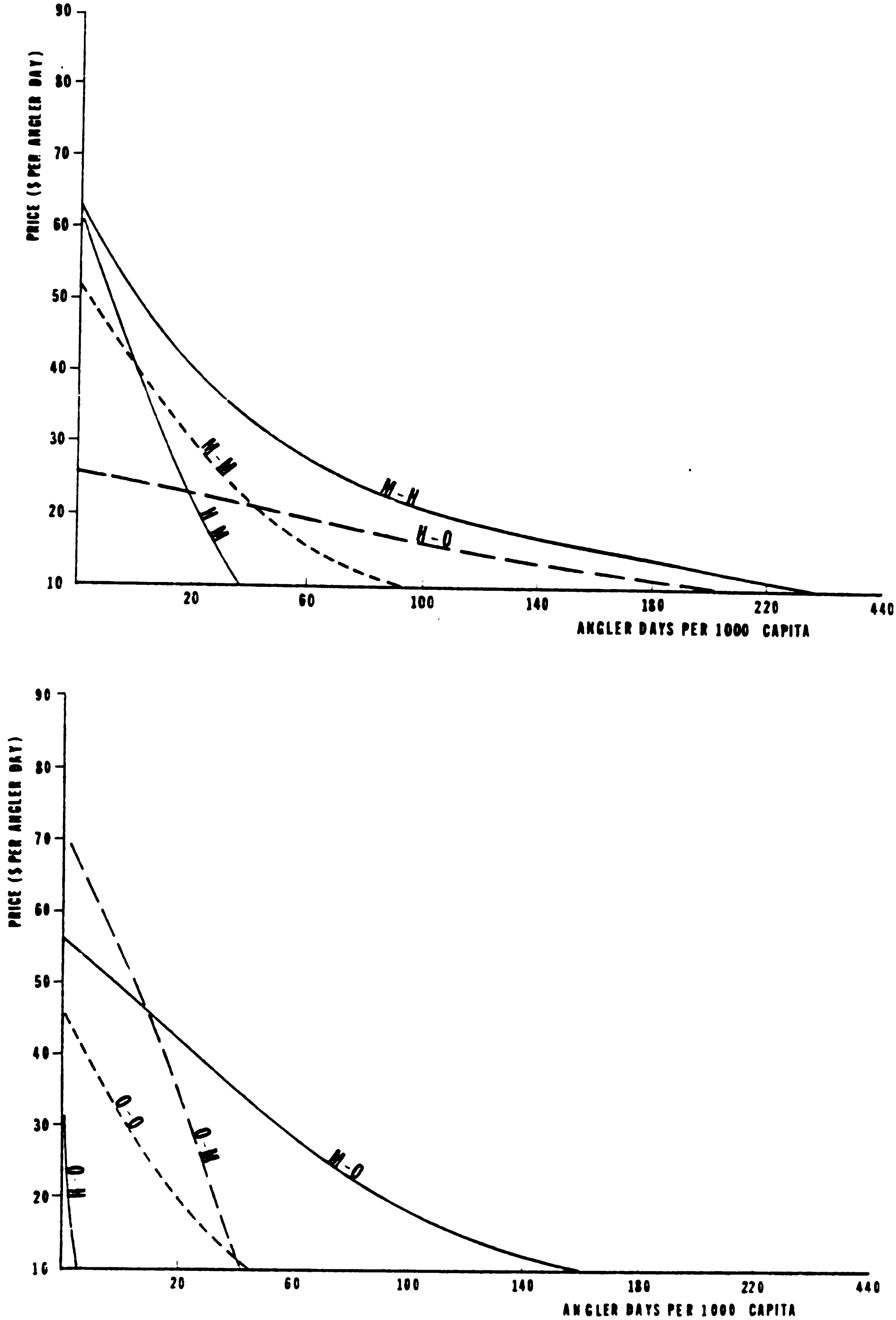


Figure 23. Demand curves for the eight salmonid angling products identified by any trout-aggregate salmon catch rates in period III: H = high, M = moderate, and O = other.

with high salmon catch rates. Apparently, these anglers are traveling greater distances to reach the rather specific locations providing higher "quality" salmon fishing, particularly along the western shore of the lower peninsula.

Angling for Anadromous Fish

Demand curves for the various anadromous angling products are illustrated in Figures 24 and 25. In period I anglers show strong preferences for (1) high steelhead catch rate areas receiving little publicity and having no lake throughways, (2) higher steelhead catch rate areas receiving high publicity and containing lake throughways, especially at high prices, and (3) somewhat more moderate steelhead catch rate products with either high publicity or lake throughways present, particularly at lower prices. In addition, anglers were found to substitute (1) higher steelhead catch rates for lower ones, (2) areas with lake throughways for those which have higher catch rates but no lake throughways, and (3) Great Lakes salmonid and non-salmonid angling for low steelhead catch rates when lake throughways are present.

During period III, products generally with (1) higher aggregate salmon/steelhead catch rates having either or both lake throughways and snagging, and (2) moderate catch rates and no lake throughways or fly-fishing regulations are in greatest demand. Moreover, anglers substitute

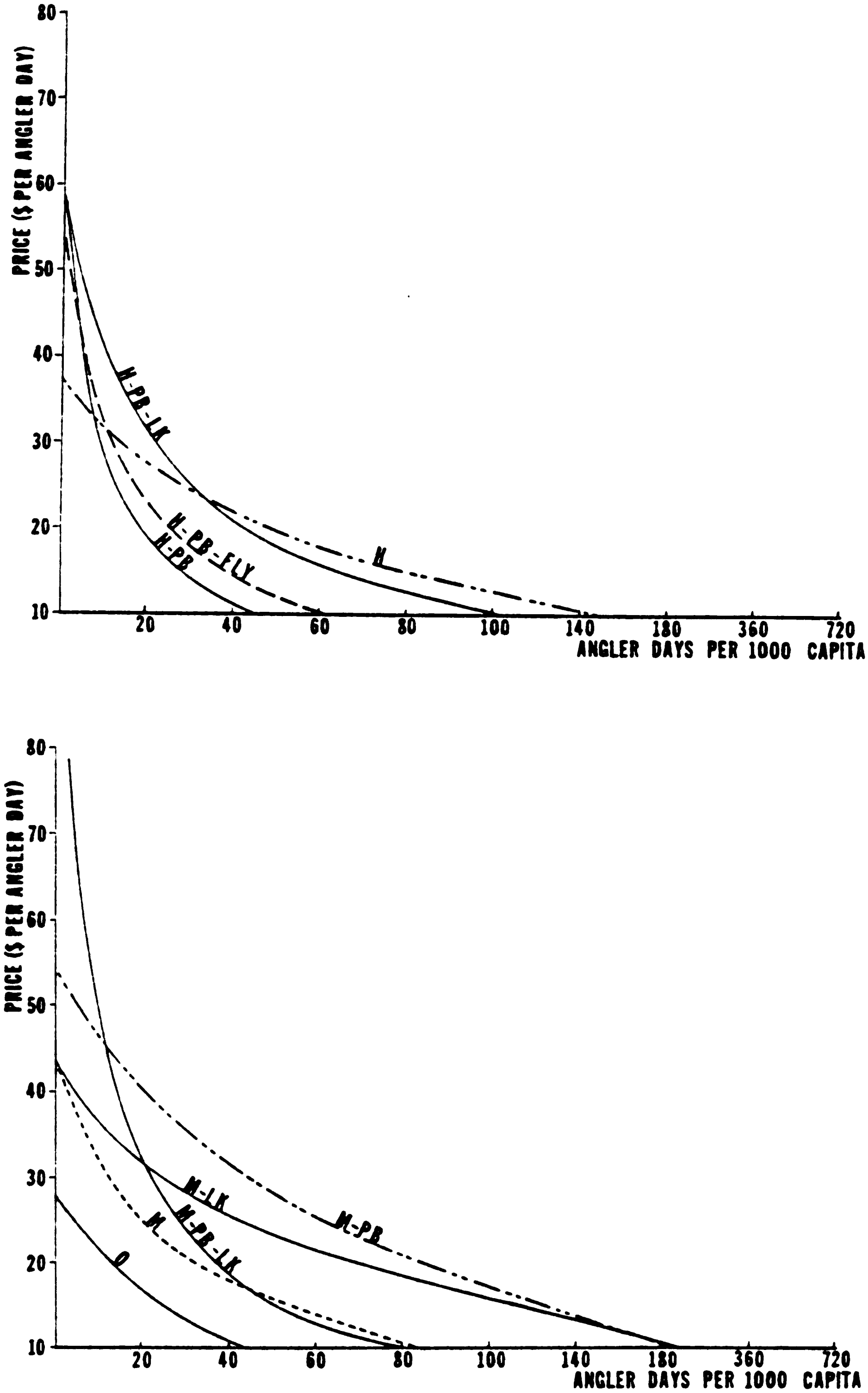


Figure 24. Demand curves for the nine anadromous angling products identified by steelhead catch rate-publicity- lake throughways-fly fishing regulations in period I.

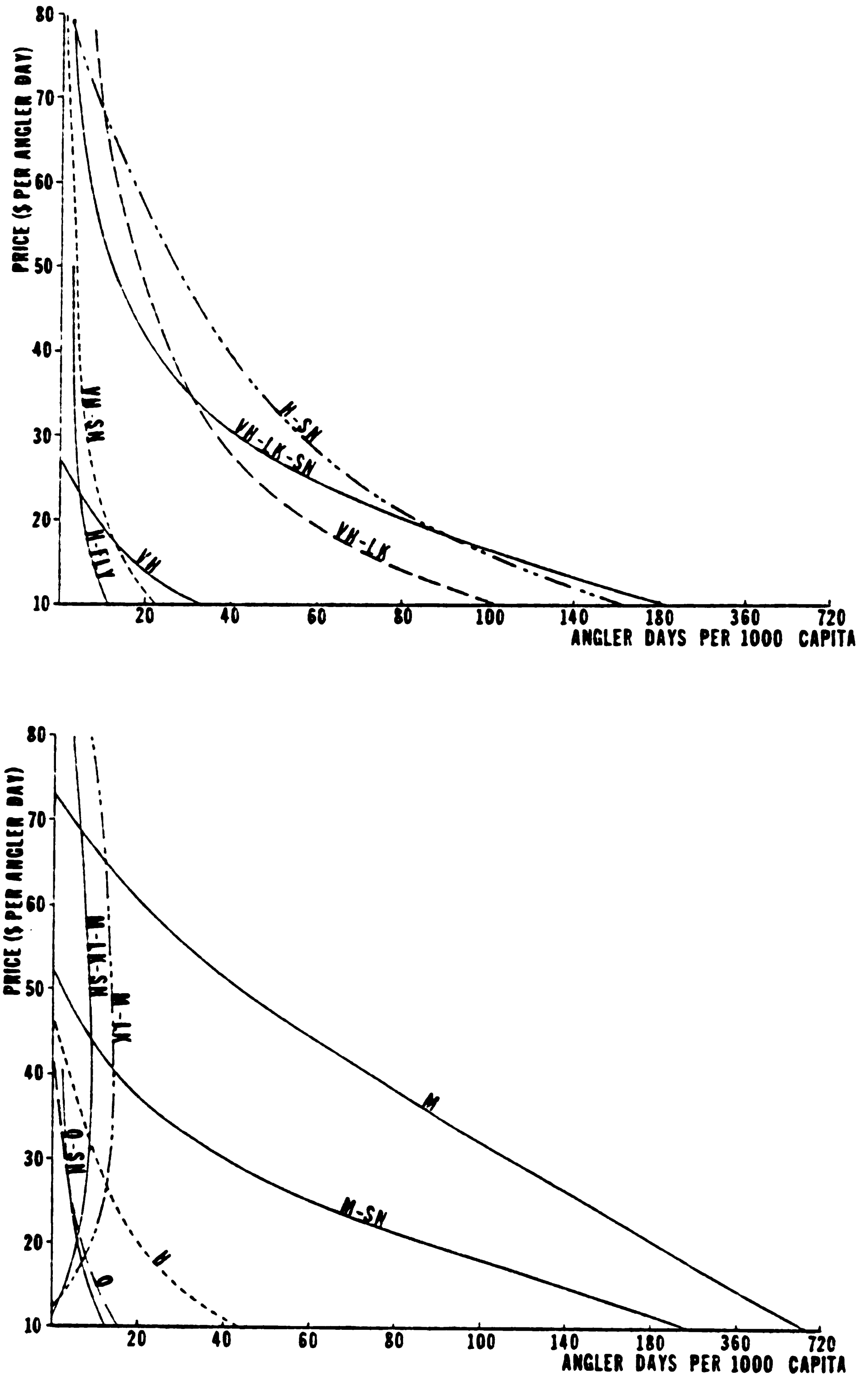


Figure 25. Demand curves for the thirteen anadromous angling products identified by aggregate salmon/steelhead catch rate (VH = very high)-lake throughways-snagging regulations-fly fishing regulations in period III.

very high catch rates for low ones and in cases where snagging is permitted in moderate catch rate areas, moderate catch rates for higher ones.

These relationships suggest that (1) in period I steelhead anglers reveal strong preferences for higher catch rate areas which are well publicized and/or because lakes at river mouths provide additional angling opportunities, (2) in period I the presence of lake throughways enhances the desirability for angling at lower catch rate areas, (3) in period I anglers find open-water Great Lakes angling roughly equivalent to lower steelhead catch rate areas when lake throughways are present; the opportunities for salmonid and non-salmonid angling are greater because of the convenient access to open-waters and because both can be fished from boats, (4) in period III anglers prefer higher salmon/steelhead catch rates when either or both lake throughways are present and snagging is permitted, (5) in period III anglers prefer moderate salmon/steelhead catch rates, no lake throughways and no special regulations in counties situated in the northern lower peninsula and upper peninsula; perhaps anglers expect higher quality angling in the northern part of the state, and (6) in period III anglers are willing to switch to lower catch rate areas when snagging is also permitted.

Angling for Great Lakes Non-Salmonids

The non-salmonid product demand curves are illustrated in Figures 26, 27, and 28. Generally, they show demand is greater for (1) higher panfish and gamefish catch rate products in period I, (2) higher panfish catch rate products at lower prices and high gamefish and panfish catch rate products at high prices in period II, (3) high gamefish catch rate products in resort areas in period II, and (4) high yellow perch catch rate products in period III. In addition, the demand equations indicated that in period I higher panfish catch rate angling in the Great Lakes and inland panfish angling are substitutes for lower panfish catch rates in Great Lakes open-water. In period II inland gamefish angling generally is a substitute for more moderate panfish and gamefish angling products in the Great Lakes. In period III both inland panfish and gamefish angling are substitutes for low yellow perch catch rate angling in Great Lakes open-water.

These relationships suggest that in general non-salmonid anglers prefer a yellow perch/panfish fishery which provides higher catch rate possibilities. The greatest demands for higher panfish catch rate products are observed at low and high prices during winter-spring and summer. No doubt many anglers feel panfish and perch are easily caught and are an excellent source of food, so they are willing to travel varying distances to obtain high catch rate products. Those anglers interested in gamefish

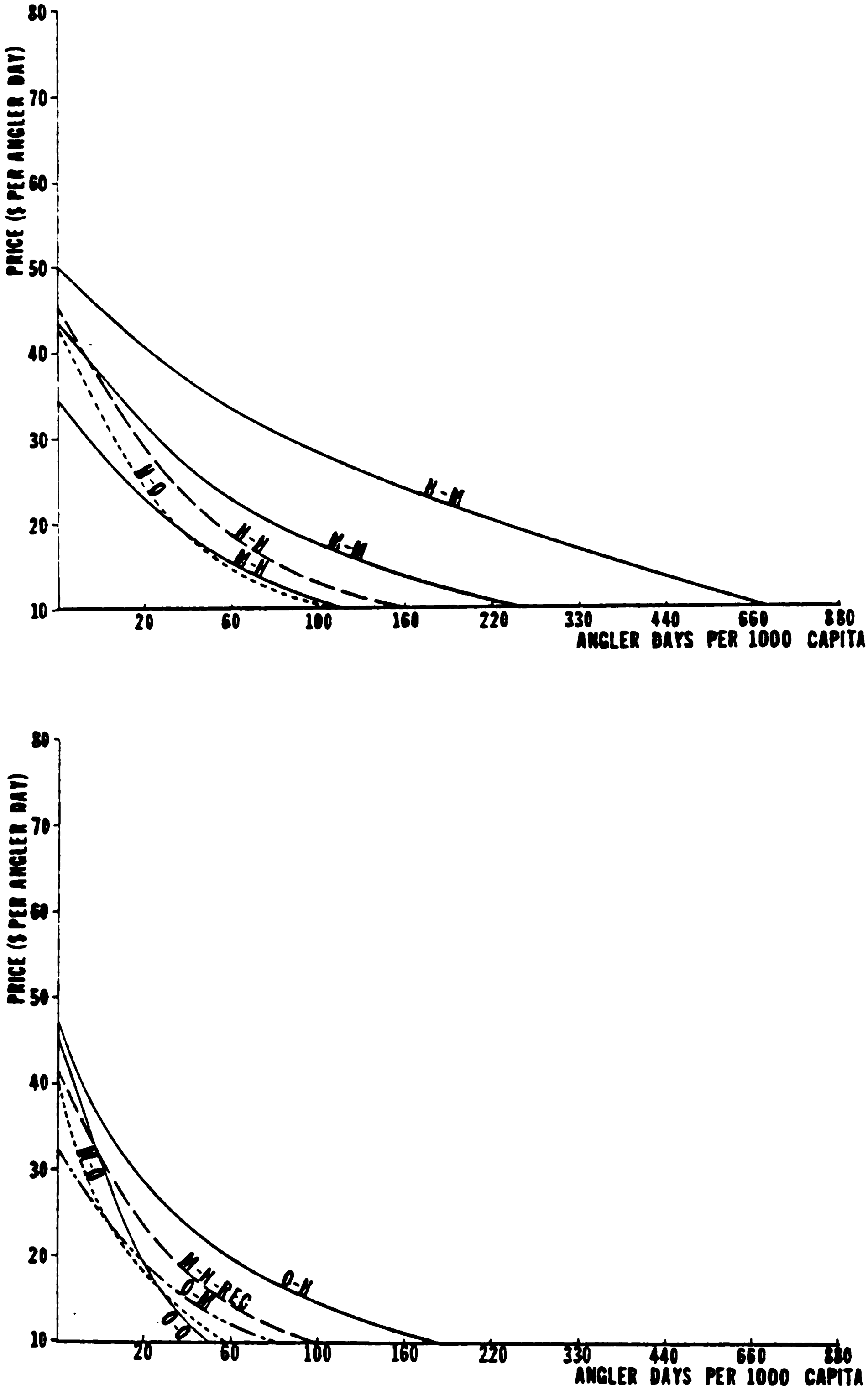
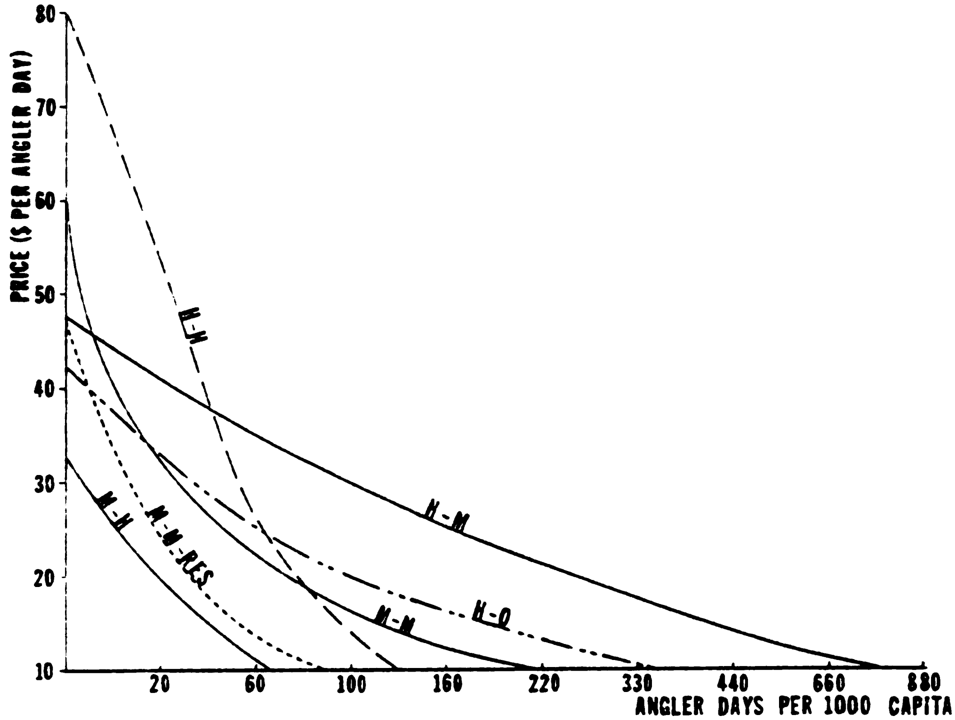


Figure 26. Demand curves for the ten non-salmonid angling products identified by aggregate panfish-aggregate gamefish catch rates-special bass regulations in period I.



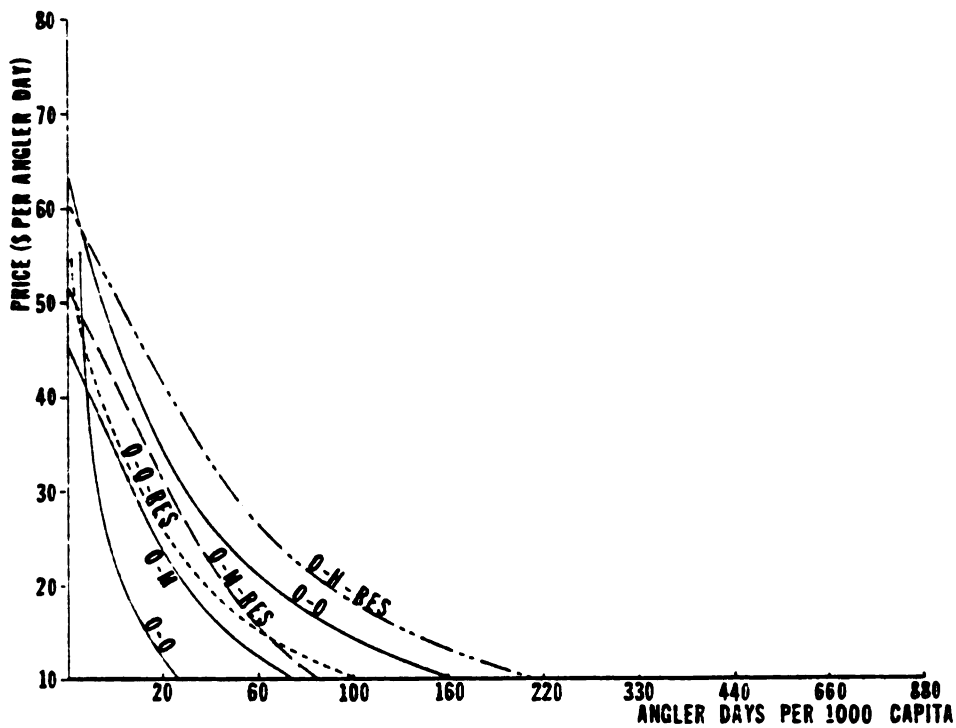


Figure 27. Demand curves for the twelve non-salmonid angling products identified by any panfish-aggregate gamefish catch rates-resort areas in period II.

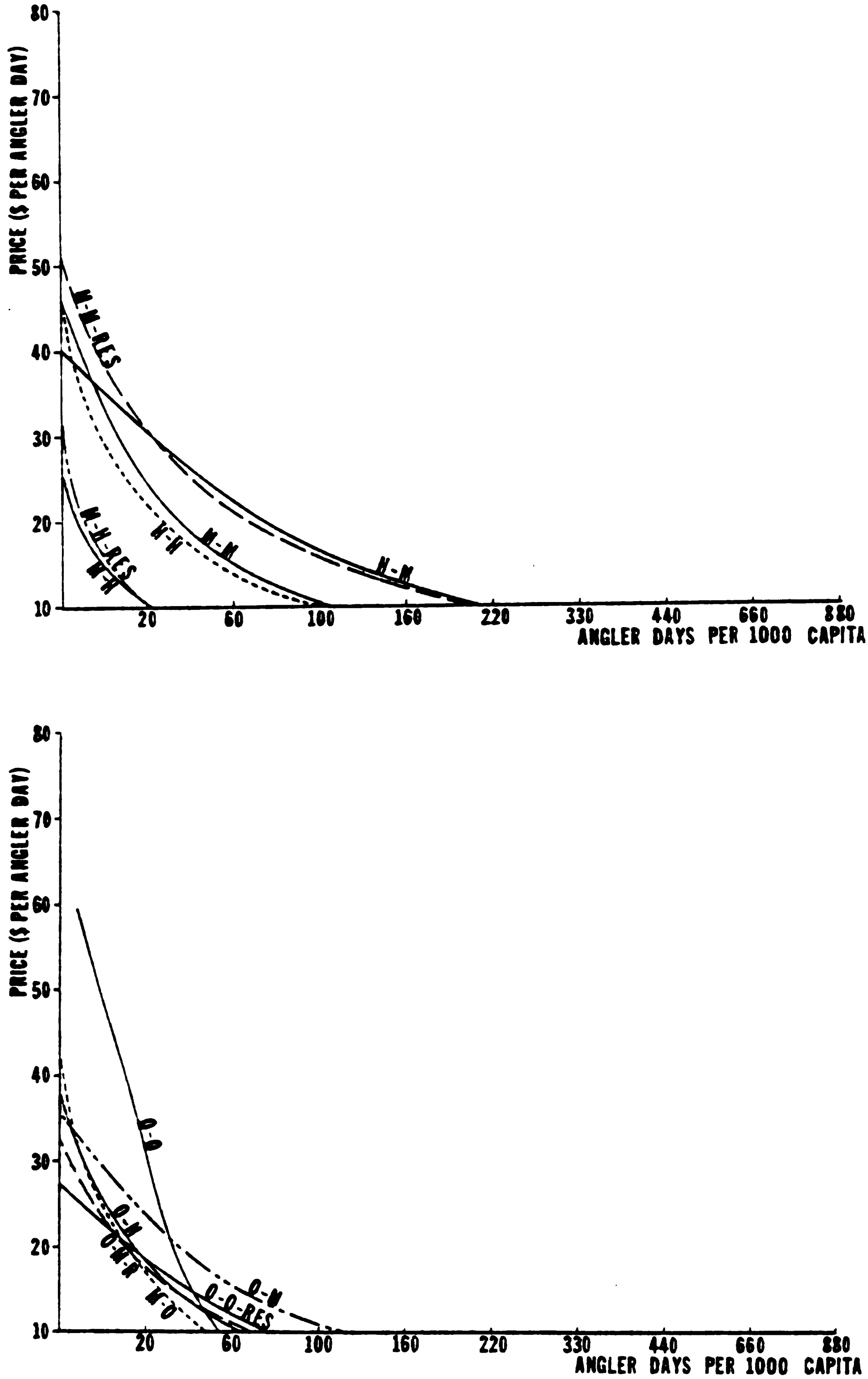


Figure 28. Demand curves for the twelve non-salmonid angling products identified by yellow perch-any other species catch rates-resort areas in period III.

angling products with higher catch rates may believe that this species group is particularly vulnerable during the winter-spring and early summer seasons; bass, walleye, pike and muskie each spawn at this time and are more susceptible to hook and line fishermen because of their normally more aggressive behavior during spawning season.

Not surprisingly, the demand analyses have generally supported the intuitive feeling that demand is greater for higher catch rate products. Other demand studies utilizing this classification procedure have shown somewhat similar results. Talhelm (1972) found that angling products in greater demand were with higher catch rates and larger stream sizes. A study of salmon-steelhead fishing in Michigan (Talhelm, 1973b) also showed that (1) demand is greatest for high catch rate products, (2) anglers are willing to switch from lower catch rate angling locations to high catch rate locations and (3) a stronger positive relationship exists between personal income per capita in the anglers' origin county and the demand for higher catch rate angling. In addition, Talhelm concluded that salmon-steelhead anglers (1) consider inland trout angling as equivalent to salmon-steelhead angling, (2) they strongly prefer high catch rate salmon-steelhead angling to other gamefish angling, and (3) they strongly prefer high catch rate salmon-steelhead angling to perch-panfish angling, particularly during summer.

VI. CONCLUDING OBSERVATIONS

This research has utilized a discriminant analytical technique to define angling quality for Michigan's 1976 Great Lakes salmonid and non-salmonid sport fisheries. Furthermore, this definition of quality is integrated into a demand and supply model for angling recreation in Michigan. These separate but related analyses provide several kinds of useful information to fisheries managers and planners: (1) a description of Great Lakes fisheries in terms of the attributes or characteristics of angling apparently most important to anglers; (2) descriptions of the specific varieties (qualities) or products of angling comprising the general forms of Great Lakes angling; (3) indications of anglers' preferences for each of the specific angling products within a general product group; (4) an indication of the willingness of anglers to substitute one kind of angling for another; and (5) the prices or costs of each specific angling product to anglers originating from any location.

These kinds of information should prove extremely useful in formulating management programs for Michigan's Great Lakes sport fishery resources. It is recognized that recreation quality is an important demand determinant.

An explicit consideration of this concept provides greater insight into the preferences of anglers for the different characteristics associated with Great Lakes angling activities. Managers and planners can concentrate on those aspects of the angling experience in greatest demand and thereby increase the efficiency of management programs by making socially optimal choices. Such important management questions as what "kinds" of recreation should be developed and where, which characteristics should be provided and expanded, which characteristics should be altered or contracted, are more easily answered by understanding the exact nature of peoples demands for outdoor recreation. To ensure that resources are properly utilized and investment decisions are properly allocated for the greatest public good, the personal perceptions of recreation users must be evaluated in the decision-making process.

An additional guide for determining the optimal level of management efforts is to estimate the benefits of various management programs for Michigan's sport fisheries. By comparing the trade-offs of several hypothetical choices, managers may select a strategy which maximizes social welfare. This kind of information will be provided in future studies using the results of my research in a computerized simulation model. The demand equations will be used to predict the gain or loss in direct benefits to users that would result from planned or unplanned changes in angling attributes over time. This would be equivalent to changing the product ("quality") of fishing at a certain location. A number of such hypothetical changes in specific attributes will be made to test various alternative management strategies for each type of Great Lakes fishing. The model will estimate (1) the changes in user benefits and participation levels that would be produced by changes now or in the future at specific counties, (2) the changes in user benefits and participation that would be produced now or in the future by creating new fishing sites with certain attributes, (3) the effects of both types of changes on the participation levels at other counties in the system, and (4) the amounts of participation at present and expected in the future for all counties relevant for a particular type of fishing.

APPENDICES

APPENDIX A

DEPARTMENT OF NATURAL RESOURCES

SURVEY QUESTIONNAIRE

APPENDIX A

DEPARTMENT OF NATURAL RESOURCES SURVEY QUESTIONNARIE

STATE OF MICHIGAN

NATURAL RESOURCES COMMISSION
CARL T. JOHNSON
E. M. LAITALA
DEAN PRIDGEON
HILARY F. SNELL
HARRY H. WHITELEY
JOAN L. WOLFE
CHARLES G. YOUNGLOVE

WILLIAM G. MILLIKEN, Governor

DEPARTMENT OF NATURAL RESOURCES

STEVENS T. MASON BUILDING, BOX 30028, LANSING, MICHIGAN 48909
HOWARD A. TANNER, Director

Dear License Holder:

You have been selected to participate in our annual survey of sport fishing in Michigan. Only four fishermen out of each one hundred license buyers will be surveyed this year. Therefore, your response is very important for an accurate account of where people fished what they fished for, and how many fish they kept in 1976.

Please return your completed questionnaire even if you did not go fishing this year. Since we value the response of everyone in the survey, you can expect a reminder in about three weeks if we do not hear from you.

Thank you for your time in helping us improve fishing in Michigan.

Sincerely,

Henry J. Vondett
Acting Chief, Fisheries Division

1976 MICHIGAN SPORT FISHING SURVEY: JANUARY 1 - DECEMBER 31

1 WHERE IS YOUR PERMANENT RESIDENCE?

County ______________________ State ______________________

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2. DID YOU FISH IN MICHIGAN DURING 1976?

YES ☐ Please continue with question # 3

NO ☐ Please return this questionnaire by mailing it in the enclosed post paid envelope

---

CONTINUE ON THE OTHER SIDE OF THIS SHEET

[illegible]

1	2	3	4	76	77	78	79	80

3. DID YOU FISH ON THE GREAT LAKES OR THEIR CONNECTING WATERS (Lake St. Clair, Detroit, St. Mary's and St Clair Rivers) FOR FISH OTHER THAN SALMON OR TROUT IN 1976?

YES ☐ Please complete TABLE A and then continue with question # 4

NO ☐ Please continue with question # 4

TABLE A – GREAT LAKES FISHING

WHERE DID YOU FISH ON THE GREAT LAKES AND CONNECTING WATERS?			DAYS AT EACH LOCATION?	HOW MANY FISH (EXCLUDING SALMON AND TROUT) DID YOU CATCH AND KEEP AT EACH LOCATION?									
				NUMBER IN CATCH									
LOC No	NAME OF HARBOR BAY GREAT LAKE, OR CONNECTING WATER	COUNTY OR NEAREST TOWN OR CITY	NUMBER OF DAYS FISHED	WALLEYE OR SAUGER	LG OR SM MOUTH BASS	NORTHERN PIKE OR MUSKY	YELLOW PERCH	SUNFISH, BLUEGILL, ROCK BASS	CRAPPIE OR WHITE BASS	BULLHEAD OR CATFISH	SUCKER	MENOMINEE WHITEFISH OR CISCO	OTHER
5–7	(8–10)	(11–12)	(13–14)	(41)	(44)	(47)	(50)	(53)	(56)	(59)	(65)	(68)	(70)
Ex	Saginaw Bay	Pinconning	3	9			20						
441													
442													
443													
444													

4. DID YOU FISH ON INLAND LAKES OR STREAMS FOR FISH OTHER THAN TROUT AND SALMON IN 1976?

YES ☐ Please complete TABLE B and then continue with question # 5.

NO ☐ Please continue with question # 5.

TABLE B – INLAND LAKE AND STREAM FISHING

WHERE DID YOU FISH?			DAYS AT EACH LOCATION?	HOW MANY FISH (EXCLUDING TROUT) DID YOU CATCH AND KEEP AT EACH LOCATION?									
				NUMBER IN CATCH									
LOC No	NAME OF STREAM OR LAKE	COUNTY OR NEAREST TOWN OR CITY	NUMBER OF DAYS FISHED	WALLEYE	LG OR SM MOUTH BASS	NORTHERN PIKE OR MUSKY	YELLOW PERCH	SUNFISH BLUEGILL	CRAPPIE (SPECKS) OR WHITE BASS	BULLHEAD OR CATFISH	ROCK BASS	SUCKER	OTHER
(5–7)	(8–10)	(11–12)	(13–14)	(41)	(44)	(47)	(50)	(53)	(56)	(59)	(62)	(65)	(70)
Ex	Teal Lake	Negaunee	2				5						
551													
552													
553													
554													

5. HAVE YOU FISHED FOR TROUT OR SALMON DURING 1976?

YES ☐ Please continue with question # 6

NO ☐ Please skip questions # 6, # 7, and # 8 and return only this sheet in enclosed post paid envelope.

6. DID YOU FISH IN 1976 ON THE GREAT LAKES OR THEIR CONNECTING WATERS (Lake St. Clair, Detroit, St. Mary's and St. Clair Rivers) FOR COHO SALMON, CHINOOK SALMON, LAKE TROUT, RAINBOW TROUT, OR BROWN TROUT?

YES ☐ Please complete TABLE C on the other side of this sheet →
NO ☐ Please continue with question #7

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7. DID YOU FISH IN 1976 FOR STEELHEAD (Rainbow Trout over 15 inches) CHINOOK, COHO, OR ATLANTIC SALMON IN GREAT LAKES TRIBUTARIES DOWNSTREAM FROM THE FIRST BARRIER TO MIGRATING FISH OR IN ANY OF THE FOLLOWING LAKES: (Lake Macatawa, Pentwater Lake, Muskegon Lake, Manistee Lake, Lake Charlevoix, White Lake in Muskegon County, Portage Lake in Manistee County, Platte Lake and Loon Lake in Benzie County, Pere Marquette Lake, Duck Lake in Muskegon County, and Pigeon Lake in Ottawa County?

YES ☐ Please complete TABLE D on the other side of this sheet →
NO ☐ Please continue with question # 8.

PRIMARY SALMON AND STEELHEAD STREAMS *

LAKE SUPERIOR STREAMS

RIVER	COUNTY
Anna	Alger
Black	Gogebic
Carp	Marquette
Chocolay	Marquette
Dead	Marquette
Falls	Baraga
Huron	Baraga, Marquette
Laughing Whitefish	Alger
Little Garlic	Marquette
Ontonagon	Ontonagon, Houghton
Presque Isle	Gogebic
Silver	Baraga
Sturgeon	Baraga, Houghton
Sucker	Alger
Two Hearted	Luce

LAKE MICHIGAN STREAMS

RIVER	COUNTY
Bear	Emmet
Bear Creek	Manistee
Betsie	Benzie
Black	Van Buren, Allegan
Black	Mackinac
Boardman	Grand Traverse
Boyne	Charlevoix
Big Cedar	Menominee
Crockery Creek	Ottawa, Muskegon
Crystal	Leelanau
Elk	Antrim
Fish Creek	Ionia, Montcalm
Flat	Kent, Ionia
Galien	Berrien
Grand	Ottawa, Kent, Ionia
Jordan	Antrim
Kalamazoo	Allegan
Leland	Leelanau
Little Manistee	Manistee, Lake
Big Manistee	Manistee
Manistique	Schoolcraft
Maple	Clinton, Ionia
Menominee	Menominee
Muskegon	Muskegon, Newaygo
Paw Paw	Berrien
Pentwater	Oceana
Pere Marquette	Mason, Lake, Oceana, Newaygo
Platte	Benzie
Prairie Creek	Ionia
Rabbit	Allegan
Rogue	Kent
Sable	Mason
St. Joseph	Berrien
Stoney Creek	Ionia, Clinton
Stony Creek	Oceana
Sturgeon River	Delta
Swan Creek	Allegan
Thornapple	Kent
White	Muskegon, Oceana
Whitefish	Delta

LAKE HURON STREAMS

RIVER	COUNTY
Au Gres	Arenac, Iosco
Au Sable	Iosco
Black	Alcona
Carp	Mackinac, Chippewa
Cass	Saginaw, Tuscola
Cheboygan	Cheboygan
Chippewa	Isabella, Midland
Diamond Creek	Huron
Elk Creek	Sanilac
Flint	Saginaw, Genessee
Kawkawlin	Bay
Nagel's Creek	Presque Isle
Ocqueoc	Presque Isle
Pigeon	Huron
Pine	Alcona, Iosco
Pine	Mackinac, Chippewa
Pinnebog	Huron
Rifle	Arenac, Ogemaw
Saginaw	Bay, Saginaw
Shiawassee	Saginaw, Shiawassee
Tawas	Iosco
Thunder Bay	Alpena
Tittabawassee	Saginaw, Midland
Trout	Presque Isle
Whitney Drain	Arenac

LAKE ST. CLAIR STREAMS

RIVER	COUNTY
Clinton	Macomb, Oakland

LAKE ERIE STREAMS

RIVER	COUNTY
Huron	Monroe, Wayne
Raisin	Monroe

* PLEASE ALSO REPORT YOUR FISHING FOR SALMON AND STEELHEAD ON STREAMS NOT LISTED.

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8. DID YOU FISH IN 1976 FOR BROOK, BROWN, RAINBOW, LAKE TROUT, OR SPLAKE ON INLAND LAKES OR STREAMS?

YES ☐ Please complete TABLE E on the other side of this sheet →
NO ☐

1 2 3 4   76 77 78 79 80

TABLE C – GREAT LAKES SALMON AND TROUT FISHING

WHERE DID YOU FISH FOR SALMON AND TROUT ON THE GREAT LAKES?			DAYS AT EACH LOCATION?	HOW MANY FISH DID YOU CATCH AND KEEP AT EACH LOCATION? NUMBER IN CATCH				
LOC. No.	NAME OF HARBOR BAY GREAT LAKE OR CONNECTING WATER	COUNTY OR NEAREST TOWN OR CITY	NUMBER OF DAYS FISHED	LAKE TROUT OR SPLAKE	RAINBOW TROUT	BROWN TROUT	COHO SALMON	CHINOOK SALMON
(5–7)	(8–10)	(11–12)	(13–14)	(23–25)	(26–28)	(29–31)	(35–37)	(38–40)
Ex.	Lake Michigan	Manistee	5		4			
111								
112								
113								
114								

TABLE D – STREAM FISHING FOR SALMON AND STEELHEAD

ON WHICH LISTED STREAMS DID YOU FISH FOR SALMON AND STEELHEAD?			DAYS AT EACH LOCATION?	HOW MANY FISH DID YOU CATCH AND KEEP AT EACH LOCATION? NUMBER IN CATCH			
LOC. No.	NAME OF RIVER OR STREAM (or named lake)	COUNTY OR NEAREST TOWN OR CITY	NUMBER OF DAYS FISHED	STEELHEAD	COHO SALMON	CHINOOK SALMON	ATLANTIC SALMON
5–7	8–10	11–12	(13–14)	(26–28)	(35–37)	(38–40)	(70–72)
Ex.	White River	Muskegon	5	4			
221							
222							
223							
224							

TABLE E – INLAND LAKE AND STREAM FISHING FOR TROUT

WHERE DID YOU FISH FOR TROUT?			DAYS AT EACH LOCATION?	HOW MANY FISH DID YOU CATCH AND KEEP AT EACH LOCATION? NUMBER IN CATCH			
LOC. No.	NAME OF INLAND RIVER OR LAKE	COUNTY OR NEAREST TOWN OR CITY	NUMBER OF DAYS FISHED	LAKE TROUT OR SPLAKE	RAINBOW TROUT	BROWN TROUT	BROOK TROUT
5–7	(8–10)	(11–12)	(13–14)	(23–25)	26–28	(29–31)	32–34
Ex.	Fox River	Seney	5		4	2	
331							
332							
333							
334							

APPENDIX B

MISCELLANEOUS INFORMATION

APPENDIX B

MISCELLANEOUS INFORMATION

Table B1. Various Species Combinations Tested as Alternative Catch Rate Attributes in the Classification of Great Lakes Salmonid Angling

Species Combination		Period Tested	Catch Rate Levels[1]	Permutations
1. Any salmonid		1,2,3	3	3
2. Any salmonid		1,2,3	4	4
3. Any trout	Coho or Chinook	1,2,3	3	9
4. Any trout	Aggregate salmon	1,2,3	3	9
5. Aggregate trout	Coho or Chinook	1,2,3	3	9
6. Aggregate trout	Aggregate salmon	1,2,3	3	9
7. Steelhead or Brown trout	Lake trout, coho or chinook	1,2,3	3	9
8. Steelhead or Brown trout	Aggregate others	1,2,3	3	9
9. Aggregate Steelhead and brown trout	Lake trout, coho or chinook	1,2,3	3	9

[1]3 is equivalent to high, moderate, low catch rates. 4 is equivalent to very high, high, moderate, low catch rates.

Table B1. (Continued)

Species Combination		Period Tested	Catch Rate Levels[1]	Permutations
10. Aggregate steelhead and brown trout	Aggregate others	1,2,3	3	9
11. Steelhead, lake trout or coho	Chinook or brown trout	1,2,3	3	9
12. Any trout	Any salmon	1,2,3	4	16
13. Steelhead	Any other salmonid	1,3	3	9
14. Steelhead, brown trout or coho	Lake trout or chinook	1,2,3	3	9
15. Brown or lake trout	Steelhead, coho or chinook	1,2,3	3	9
16. Aggregate brown or lake trout	Any one other	1,2,3	3	9
17. Aggregate steelhead, coho and chinook	Lake trout or chinook	1,2,3	3	9
18. Chinook	Any other salmonid	2	3	9
19. Chinook	Aggregate others	2	3	9
20. Chinook	Aggregate others	2	4	12
21. Lake trout	Steelhead or brown tr. Agg. salmon	2,3	3	18

Table B1. (Continued)

	Species Combination		Period Tested	Catch Rate Levels[1]	Permutations
22. Lake trout	Steelhead or Brown trout	Agg. salmon	2,3	3	10
23. Steelhd.	Lake or Brown trout	Agg. salmon	3	3	18
24. Steelhd.	Lake trout or Brown trout	Agg. salmon	3	3	18
25. Steelhd.	Brown trout	Agg. others	3	3	10
26. Steelhd.	Lake or Brown trout	Coho or chinook	1	3	12
27. Aggregate all salmonids			1,2,3	High Mod. high Moderate Mod. low Low	5

Table B2. Various Species Combinations Tested as Alternative Catch Rate Attributes in the Classification of Great Lakes Anadromous Angling

Species Combination		Period Tested	Catch Rate Levels[1]	Permutations
1. Steelhead		1	3	3
2. Steelhead		1	4	4
3. Steelhead		1	High Moderate Low Very low	4
4. Steelhead	Coho or chinook	3	3	9
5. Steelhead or coho	chinook	3	3	9
6. Steelhead	Aggregate coho and chinook	3	3	9
7. Steelhead or chinook	Coho	3	3	9
8. Steelhead or chinook	Coho	3	4	16
9. Steelhead, coho, or chinook		3	3	3
10. Steelhead, coho, or chinook		3	4	4
11. Aggregate steelhead, coho and chinook		3	3	3
12. Aggregate steelhead, coho and chinook		3	4	4

[1]3 is equivalent to high, moderate, low catch rates.
4 is equivalent to very high, high, moderate, low catch rates.

Table B3. Various Species Combinations Tested as Alternative Catch Rate Attributes in the Classification of Great Lakes Non-Salmonid Angling

Species Combination[1]			Period Tested	Catch Rate Levels[2]	Permutations
1. Any One panfish	Any One gamefish		1,2,3	3	9
2. Any One panfish	Any One gamefish		1,2,3	3	9
3. Any One panfish	Aggregate gamefish		1,2,3	3	9
4. Aggregate panfish	Any One gamefish		1,2,3	4	12
5. Aggregate panfish	Aggregate gamefish		1,2,3	3	9
6. Yellow perch	Any One other		1,2,3	3	9
7. Yellow perch	Crappie or bluegill	Any One gamefish	1,2,3	3	18
8. Walleye or yellow perch	Any One other		1,2,3	3	9
9. Yellow perch	Walleye	Any One other	1,2,3	3	12&18
10. Yellow perch	Bass	Any One other	1,2,3	3	12&28
11. Bass	Any One panfish	Pike or walleye	1,2,3	3	12,15&18
12. Bass	Northern pike	Any One other	1,2,3	3	18
13. Any One panfish	Any One gamefish		1,2	4	12

[1]Panfish includes yellow perch, bluegill, crappie, white bass. Gamefish includes smallmouth and largemouth bass, pike, walleye, muskie.

[2]3 is equivalent to high, moderate, low catch rates. 4 is equivalent to very high, high, moderate, low catch rates.

Table B4. Non-Catch Rate Factors Utilized in the Inventory for Great Lakes Salmonid, Non-Salmonid, and Anadromous Sport Fishing

1. Publicity:

   Any public or private means of disseminating information concerning the opportunity, availability, or potential success for obtaining Great Lakes sport fishing recreation in a particular county.

   (1) High - county frequently in paper and news reports

   (2) Low - county receiving little publicity.

2. Piers:

   Any man-made structure constructed perpendicular to a lake shoreline which affords anglers a broader range of fishable waters than if solely restricted to the shore itself.

   (1) Yes - one or more present in a county.

   (2) No - unavailable in a county.

3. Bays:

   A distinctive natural inlet of water occurring along the shoreline of Great Lakes waters. Offers protection from the vagaries of severe coastal weather and provides a more accessible and convenient location for Great Lakes angling activities.

   (1) Yes - found in a county.

   (2) No - none found in a county.

4. Lake Throughways:

   A natural inland lake occurring at or near the mouth of an anadromous river and which provides an additional source of salmonid angling activity.

   (1) Yes - one or more found in a county.

   (2) No - none found in a county.

Table B4. (Continued)

5. Stream Size:

   The drainage order of anadromous river systems which receive a significant amount of angling pressure.

   (1) Small - fourth order or smaller river in a county.

   (2) Large - fifth order or larger river in a county.

   (3) Great Lakes interconnecting waterways - St. Clair, Wayne, and Chippewa counties.

6. Landlocked Anadromous Fishery:

   A river system sustaining a significant anadromous fishery due to high level stocking programs in adjoining landlocked water bodies other than the Great Lakes.

   (1) Yes - found in a county.

   (2) No - none found in a county.

7. Dams or River Obstructions:

   A man-made or natural structure present in the important anadromous river systems which effectively act as barriers to the upstream migrations of anadromous fish.

   (1) Low - no river blockage(s) found in a county

   (2) High - river blockage(s) found in a county

8. Stream Availability:

   The down valley length (in miles) of river water available for Great Lakes anadromous fishing in a county. This includes only those rivers supporting a significant salmonid run so as to generate considerable angler interest.

   (1) Low - less than 10 miles

   (2) High - greater than 50 miles

   (3) Other

Table B4. (Continued)

9. Snagging:

   Any liberalized salmon fishing area permitting the retention of foul-hooked coho and chinook salmon.

   (1) Yes - permitted in a county

   (2) No - unavailable in a county

10. Fly-Fishing:

   A regulation reserved for quality fishing areas limiting the method of harvesting sport fish in an anadromous river.

   (1) Yes - permitted in a county

   (2) No - unavailable in a county

11. Special Regulations:

   Limits the number of anglers who may fish on a stretch of anadromous river.

   (1) Yes - applicable in a county

   (2) No - not applicable in a county

12. Regional Attraction:

   The respective aesthetic attractiveness and uniqueness of various portions of Michigan which may influence an anglers desirability for angling there.

   (1) Upper peninsula counties

   (2) Northern lower peninsula counties

   (3) Other counties

13. Coastal and Non-coastal Anadromous Angling:

   Anadromous sport fishing opportunities found either in coastal or non-coastal counties.

   (1) Coastal counties

   (2) Inland counties

Table B4. (Continued)

14. Complementary Recreation:

Any alternative recreational opportunities found in close association with angling activities and which ultimately makes the angling experience more pleasureable. These may include overnight lodging or camping facilities, historic sites, scenic viewing areas, other forms of water-based recreation, etc.

(1) High - numerous complements available in a county

(2) Low - few, if any complements available in a county

(3) Other

15. Non-Urban Angling Environment:

An angling experience relatively removed from the many disturbances and environmental externalities of heavily urbanized areas.

(1) County with considerable urban pressure

(2) County with moderate urban pressure

(3) County with little urban pressure

16. Special Bass Sport Fishing Regulations:

A regulation prohibiting the retention of Great Lakes smallmouth and largemouth bass for a period beyond the regular open season of May 29.

(1) Closed season until June 19 for certain counties

(2) Other

17. Special Walleye Sport Fishing Regulations:

A regulation permitting the retention of Great Lakes walleye for the entire year. Normally, the season is closed for their spawning period from March 1 to May 15.

(1) Year round open season for certain counties

(2) Other

The following tables give the demand equation coefficients estimated for the specific angling products defined by each classification scheme. The equations for each product (Q_i) are read down the columns.

The first price variables in each equation are always linear and inverse functions of the minimum available price of product i (P_i). The remaining price variables are the possible specific and general substitute products which may be included in any one equation. The general angling substitutes are defined as follows: (1) GLS: Great Lakes salmonid; (2) GLNS: Great Lakes non-salmonid; (3) GLAS: Great Lakes anadromous salmonid; (4) INTR: Inland trout; (5) INGAM: Inland gamefish; (6) INPAN: Inland panfish.

Table B5. Demand Equations for the Products Defined for Winter-Spring Great Lakes Salmonid Angling

Q_i	1	2	3	4	5	6	7	8
Constant	-110.6	-77.8	-67.7	-55.2	-96.0	-7.2	-118.2	-25.5
bP_i	.58	.26	.19	.20	1.10	.07	.38	.26
b/P_i	3119.0	2529.7	2157.3	189.4	5734.0	488.3	3444.4	1291.9
Substitutes								
1	*	-	.07	-	-	-	-	-
2	-	*	-	-	-	-	-	-
3	-	-	*	.05	-	-	-	-
4	-	-	-	*	-	-	-	-
5	-	-	-	-	*	-	.06	.12
6	-	-	-	.11	-	*	-	.22
7	-	-	-	-	-	-	*	-
8	-	-	-	-	-	-	-	*
GLNS	-	-	.16	-	-	-	-	.69
GLAS	-	-	-	-	-	-	-	-
INTR	-	-	-	-	-	-	-	-
INGAM	-	-	-	-	-	-	-	-
INPAN	-	-	-	-	-	-	-	-
INCOME	.002	.004	.002	.001	.01	.001	.005	.008
R^2	.418	.551	.494	.584	.247	.303	.377	.404

Table B6. Demand Equations for the Products Defined for Summer Great Lakes Salmonid Angling

Q_i	1	2	3	4	5	6	7
Constant	-28.3	-26.0	-58.7	-6.8	-55.5	-101.6	-1.9
bP_i	-.19	-.55	-1.18	-.03	-.27	.73	-.01
b/P_i	733.2	2012.3	2294.9	102.4	1366.1	5439.7	10.7
<u>Substitutes</u>							
1	*	.40	1.17	-	-	.06	-
2	-	*	.26	-	-	-	-
3	-	.41	*	-	-	-	-
4	-	-	-	*	-	-	-
5	-	-	-	-	*	-	-
6	.52	-	-	-	-	*	-
7	-	.009	-	-	-	-	*
GLNS	-	-	-	-	-	-	-
GLAS	-	-	-	-	-	-	-
INTR	-	-	-	-	-	-	-
INGAM	-	-	.17	-	-	-	-
INPAN	-	-	-	-	-	-	-
INCOME	.002	.004	.0003	.001	.011	.009	.0004
R^2	.053	.204	.278	.026	.071	.352	.065

Table B7. Demand Equations for the Products Defined for Fall Great Lakes Salmonid Angling

Q_i	1	2	3	4	5	6	7	8
Constant	18.3	109.4	-.36.5	-2.3	79.3	-.06	77.1	-2.3
bP_i	-.40	-5.68	.68	-.46	-1.59	-.02	-.55	-.44
b/P_i	188.8	1916.1	4059.1	917.1	1054.9	19.1	83.5	352.2
Substitutes								
1	*	3.91	-	-	1.89	.0006	-	-
2	-	*	-	-	-	-	-	-
3	.35	-	*	-	-	-	-	-
4	-	-	-	*	-	-	-	-
5	-	-	-	-	*	-	-	-
6	-	-	-	-	-	*	-	-
7	-	-	-	.25	-	-	*	.56
8	-	-	-	-	-	-	-	*
GLNS	-	-	-	-	-	-	-	-
GLAS	-	-	-	-	-	-	-	-
INTR	-	-	-	-	-	.02	-	-
INGAM	-	-	-	-	-	.02	-	-
INPAN	-	3.70	-	.63	-	.01	-	-
INCOME	.002	.02	.004	.002	-.01	-.00002	-.006	-.001
R^2	.046	.189	.388	.077	.091	.142	.026	.105

Table B8. Demand Equations for the Products Defined for Winter-Spring Great Lakes Anadromous Angling

Q_i	1	2	3	4	5	6	7	8	9
Constant	-14.1	-26.5	-11.3	-52.1	-11.8	-46.8	-79.7	-46.2	5.8
bP_i	.006	.11	.03	.07	-.02	-.42	.54	.24	-.45
$b/\bar{P}_i$	1251.6	839.8	539.6	2034.0	866.9	2206.5	3044.4	974.2	557.4
Substitutes									
1	*	-	-	-	-	.75	-	-	-
2	-	*	-	-	-	-	-	-	-
3	-	-	*	-	-	-	-	-	-
4	-	-	.02	*	-	.05	-	-	.39
5	-	-	-	-	*	-	-	-	-
6	-	-	-	-	-	*	-	.37	-
7	.15	-	-	.37	.03	-	*	-	-
8	-	-	-	-	-	-	-	*	-
9	-	-	-	-	-	-	-	-	*
GLS	-	-	-	-	.01	-	-	-	-
GLNS	-	-	-	-	.09	-	-	.16	.73
INTR	-	-	-	-	-	-	-	-	-
INGAM	-	-	-	-	.02	-	-	-	-
INPAN	-	-	-	.42	-	-	-	-	-
INCOME	-.002	.0009	.0001	-.005	-.0001	-.004	-.002	.0008	-.008
R^2	.564	.413	.371	.320	.368	.325	.507	.384	.239

Table B9. Demand Equations for the Products Defined for Fall Great Lakes Anadromous Angling

Q_i	1	2	3	4	5	6	7
Constant	-80.9	-25.9	-3.9	-4.0	-9.3	0.5	34.4
bP_i	.31	-.24	-.03	.10	-.47	.0006	-.21
b/P_i	2573.8	915.9	216.1	587.4	1482.8	120.9	447.1
Substitutes							
1	*	-	-	-	-	-	-
2	-	*	-	-	-	-	-
3	-	-	*	-	-	-	-
4	-	-	-	*	-	-	-
5	-	-	-	-	*	-	-
6	-	-	-	-	-	*	-
7	-	-	-	-	.76	-	*
8	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-
10	-	.36	-	-	-	-	-
11	-	-	-	.05	-	-	.11
12	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-
GLS	-	-	-	-	-	-	-
GLNS	-	-	-	-	-	-	-
INTR	-	-	-	-	-	-	.15
INGAM	-	-	-	-	-	-	-
INPAN	-	-	-	-	-	-	-
INCOME	.004	.003	.0007	-.003	-.002	-.0001	-.006
R^2	.238	.107	.093	.077	.118	.065	.040

Table B9. (Continued)

Q_i	8	9	10	11	12	13
Constant	18.7	37.3	-58.9	-213.3	-2.3	9.7
bP_i	-.12	-.25	.33	.15	-.01	-.20
b/P_i	-183.7	-403.4	3354.7	7398.5	126.9	110.5
Substitutes						
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	-	-	-	-	-	-
4	-	-	-	.56	-	.13
5	-	-	-	.06	-	-
6	-	-	-	-	-	-
7	-	-	-	-	-	-
8	*	-	-	-	-	-
9	-	*	-	-	-	-
10	-	-	*	-	.02	.08
11	-	-	-	*	.01	-
12	-	-	-	-	*	-
13	-	-	.13	-	-	*
GLS	-	-	-	-	-	-
GLNS	-	-	-	-	-	-
INTR	-	-	-	-	-	-
INGAM	-	-	-	-	-	-
INPAN	-	-	-	-	-	-
INCOME	-.0001	-.0004	-.004	.01	-.00005	-.002
R^2	.005	.014	.336	.281	.058	.090

Table B10. Demand Equations for the Products Defined for Winter-Spring Great Lakes Non-Salmonid Angling

Q_i	1	2	3	4	5	6	7	8	9	10
Constant	-61.1	-321.2	-51.1	-9.1	-38.9	-130.2	-29.5	-88.3	-53.4	-13.9
bP_i	.51	2.48	.38	.18	-2.4	1.10	.24	.69	.45	-.53
b/P_i	2199.4	9938.4	1513.9	1354.1	1514.1	3717.6	850.9	2616.1	1283.7	404.5
Substitutes										
1	*	-	-	-	-	-	-	-	-	-
2	-	*	-	-	-	-	-	-	-	-
3	-	-	*	.0005	-	-	-	-	-	-
4	-	-	-	*	-	-	-	-	-	-
5	-	-	-	-	*	-	-	-	-	-
6	-	-	-	-	-	*	-	-	-	-
7	-	-	-	-	-	-	*	-	-	.33
8	-	-	-	-	-	-	-	*	-	-
9	-	.10	-	-	-	-	-	-	*	-
10	-	-	-	-	.06	-	-	-	-	*
GLS	-	-	-	-	-	-	-	-	-	-
GLAS	-	-	-	-	-	-	-	-	-	-
INTR	-	-	-	-	-	.55	-	-	-	-
INGAM	-	-	-	-	-	-	-	-	-	-
INPAN	-	-	-	.13	-	-	.001	-	-	.29
INCOME	-.001	-.001	.0002	-.005	.0001	-.002	-.0001	.0001	.0008	.0009
R^2	.874	.927	.935	.568	.681	.568	.701	.861	.609	.268

Table B11. Demand Equations for the Products Defined for Summer Great Lakes Non-Salmonid Angling

Q_i	1	2	3	4	5	6
Constant	7.5	-292.6	-171.9	-8.7	-18.7	-111.8
bP_i	-.70	1.51	1.37	.19	.04	.74
b/P_i	866.7	10463.3	5068.0	974.1	1120.4	2958.7
<u>Substitutes</u>						
1	*	-	-	-	-	-
2	-	*	-	-	-	-
3	-	-	*	-	-	-
4	-	-	-	*	-	-
5	-	-	-	-	*	-
6	-	-	-	-	-	*
7	-	-	-	-	-	-
8	-	-	-	-	-	-
9	-	-	-	-	-	-
10	-	-	.12	-	-	-
11	-	-	-	-	-	-
12	-	-	-	-	-	-
GLS	-	-	-	-	.03	-
GLAS	-	-	-	-	-	-
INTR	-	-	-	-	-	-
INGAM	.64	2.06	-	.09	-	-
INPAN	-	.37	-	-	-	-
INCOME	.003	-.008	-.001	-.004	-.001	.003
R^2	.359	.414	.748	.212	.272	.403

Table B11. (Continued)

Q_i	7	8	9	10	11	12
Constant	-9.8	-42.6	49.5	.22	-46.6	-107.3
bP_i	.02	-.20	-.75	-.39	.24	.21
b/P_i	304.1	2404.5	663.2	766.1	1372.8	2056.6
Substitutes						
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	.03	-	-	-	-	-
4	-	-	-	-	-	.38
5	-	-	-	-	-	-
6	-	-	-	-	-	-
7	*	-	-	-	-	-
8	-	*	-	-	-	-
9	-	-	*	-	-	.08
10	-	-	.73	*	-	-
11	-	-	-	-	*	-
12	-	-	-	-	-	*
GLS	-	-	-	-	-	-
GLAS	-	-	-	-	-	-
INTR	.08	-	.22	-	-	.24
INGAM	-	-	-	-	-	-
INPAN	-	.87	-	-	.20	-
INCOME	-.0002	-.0007	-.008	-	.0007	.005
R^2	.483	.245	.068	.070	.310	.447

Table B12. Demand Equations for the Products Defined for Fall Great Lakes Non-Salmonid Angling

Q_i	1	2	3	4	5	6
Constant	-75.9	-33.3	-8.9	-11.1	-103.0	-100.5
bP_i	.57	-.39	.13	.12	.69	.41
b/P_i	1542.6	2614.7	347.9	395.5	2878.4	1534.7
Substitutes						
1	*	-	-	-	-	-
2	-	*	-	-	-	-
3	-	-	*	-	.19	-
4	-	-	-	*	-	-
5	-	-	-	-	*	-
6	-	-	-	-	-	*
7	-	-	-	-	-	-
8	.16	.66	-	-	-	.38
9	-	-	-	-	-	-
10	-	-	-	-	-	.17
11	-	-	-	-	.14	-
12	-	-	-	-	.08	-
GLS	-	-	-	-	-	-
GLAS	.06	-	-	-	-	-
INTR	-	-	-	-	-	-
INGAM	-	.39	-	-	-	-
INPAN	-	.94	-	-	-	-
INCOME	.001	-.01	-.001	-.001	-.001	.004
R^2	.385	.349	.266	.339	.637	.255

Table B12. (Continued)

Q_i	7	8	9	10	11	12
Constant	-27.2	-47.8	-66.3	-125.9	-29.7	-3.3
bP_i	.07	.39	.62	.07	.53	-.64
b/P_i	646.8	1000.6	1168.3	1634.5	1423.3	248.3
<u>Substitutes</u>						
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	-	-	-	-	-	-
4	-	-	-	-	-	-
5	-	-	-	-	-	-
6	-	-	-	-	-	-
7	*	-	-	-	-	-
8	.26	*	-	1.88	-	.24
9	-	-	*	-	-	-
10	.19	-	-	*	-	-
11	-	-	-	-	*	-
12	-	-	-	-	-	*
GLS	-	-	-	-	-	-
GLAS	-	-	-	-	-	-
INTR	-	-	-	-	-	-
INGAM	-	-	.25	-	-	.19
INPAN	-	.15	-	-	-	.27
INCOME	-.001	.0007	.001	-	-.005	.003
R^2	.245	.306	.314	.227	.239	.133

Table B13. Final Product Identification Numbers for the 41 Coastal Counties Offering Great Lakes Salmonid Angling

	County	Period I	Period II	Period III
1.	Alcona	3	3	3
2.	Alger	5	2	1
3.	Allegan	1	1	4
4.	Alpena	1	2	3
5.	Antrim	5	5	5
6.	Arenac	4	6	7
7.	Baraga	5	3	2
8.	Bay	8	7	8
9.	Benzie	3	5	3
10.	Berrien	3	4	4
11.	Charlevoix	5	3	2
12.	Cheboygan	8	6	4
13.	Chippewa	8	6	8
14.	Delta	7	6	2
15.	Emmet	7	3	4
16.	Gogebic	4	6	8
17.	Grand Traverse	2	5	5
18.	Houghton	7	6	5
19.	Huron	5	6	5
20.	Iosco	6	6	7
21.	Keweenaw	7	6	5
22.	Leelanau	7	1	1
23.	Luce	5	6	5
24.	Mackinac	7	6	5
25.	MaComb	6	7	6
26.	Manistee	3	5	3
27.	Marquette	4	6	5
28.	Mason	1	5	4
29.	Menominee	8	7	2
30.	Monroe	8	7	8
31.	Muskegon	4	6	4
32.	Oceana	8	1	5
33.	Ontonagon	8	3	5
34.	Ottawa	4	6	8
35.	Presque Isle	1	6	2

Table B13. (Continued)

	County	Period I	Period II	Period III
36.	St. Clair	4	7	5
27.	Sanilac	8	7	8
38.	Schoolcraft	7	7	7
39.	Tuscola	8	7	8
40.	Van Buren	4	2	4
41.	Wayne	8	7	8

Table B14. Final Product Identification Numbers for the 52 Counties Offering Great Lakes Anadromous Salmon-Steelhead Angling

	County	Period I	Period III
1.	Alcona	8	4
2.	Alger	4	4
3.	Allegan	7	9
4.	Alpena	8	11
5.	Antrim	8	11
6.	Arenac	8	11
7.	Baraga	8	11
8.	Bay	9	13
9.	Benzie	5	2
10.	Berrien	3	10
11.	Charlevoix	7	9
12.	Cheboygan	8	11
13.	Chippewa	4	13
14.	Clinton	9	13
15.	Delta	9	11
16.	Emmet	4	13
17.	Gogebic	9	11
18.	Grand Traverse	8	11
19.	Gratiot	9	13
20.	Houghton	8	13
21.	Huron	8	13
22.	Ionia	4	10
23.	Iosco	6	5
24.	Iron	9	13
25.	Kalkaska	9	13
26.	Kent	6	3
27.	Keweena	8	13
28.	Lake	2	6
29.	Leelanau	4	11
30.	Luce	3	13
31.	Mackinac	4	11
32.	MaComb	9	13
33.	Manistee	1	1
34.	Marquette	8	7
35.	Mason	1	1

Table B14. (Continued)

	County	Period I	Period III
36.	Menominee	4	11
37.	Midland	9	13
38.	Monroe	9	13
39.	Muskegon	1	8
40.	Newaygo	4	5
41.	Oceana	7	2
42.	Ogemaw	9	11
43.	Ontonagon	9	13
44.	Ottawa	6	3
45.	Presque Isle	4	7
46.	Saginaw	8	10
47.	St. Clair	9	13
48.	Sanilac	9	13
49.	Schoolcraft	9	10
50.	Tuscola	9	12
51.	Van Buren	8	7
52.	Wayne	9	12

Table B15. Final Product Identification Numbers for the 41 Coastal Counties Offering Great Lakes Non-Salmonid Angling

	County	Period I	Period II	Period III
1.	Alcona	10	12	1
2.	Alger	10	11	11
3.	Allegan	10	7	8
4.	Alpena	7	4	8
5.	Antrim			
6.	Arenac	6	1	10
7.	Baraga	10	9	9
8.	Bay	3	3	6
9.	Benzie	10	12	12
10.	Berrien	10	3	2
11.	Charlevoix	8	6	8
12.	Cheboygan	9	10	12
13.	Chippewa	5	9	5
14.	Delta	1	8	9
15.	Emmet	8	10	8
16.	Gogebic	10	9	11
17.	Grand Traverse	10	10	12
18.	Houghton	10	11	11
19.	Huron	6	2	2
20.	Iosco	9	6	10
21.	Keweenaw	10	11	11
22.	Leelanau	10	12	12
23.	Luce	10	11	11
24.	Mackinac	2	5	3
25.	MaComb	4	10	10
26.	Manistee	10	6	9
27.	Marquette	10	9	8
28.	Mason	10	6	8
29.	Menominee	9	8	11
30.	Monroe	9	2	1
31.	Muskegon	6	6	4
32.	Oceana	10	10	10
33.	Ontonagon	10	11	11
34.	Ottawa	7	6	6
35.	Presque Isle	9	12	10

Table B15. (Continued)

	County	Period I	Period II	Period III
36.	St. Clair	4	10	10
37.	Sanilac	10	7	10
38.	Schoolcraft	9	9	9
39.	Tuscola	7	7	7
40.	Van Buren	10	7	7
41.	Wayne	4	10	10

Table B16. Catch Rate Factors Utilized in the Final Product Classifications for Great Lakes Salmonid Angling. Catch Rates are in Fish Per Angler Day (AD).

Period	Species	Definition
Winter-spring	Lake Trout:	High: over 1.5 fish/AD Moderate: 0.5-1.5 fish/AD Low: less than 0.5 fish/AD
	Steelhead:	High: over 1.0 fish/AD Moderate: 0.4-1.0 fish/AD Low: less than 0.4 fish/AD
	Brown Trout:	High: over 1.0 fish/AD Moderate: 0.4-1.0 fish/AD Low: less than 0.4 fish/AD
	Coho Salmon:	High: over 1.0 fish/AD Moderate: 0.6-1.0 fish/AD Low: less than 0.6 fish/AD
	Chinook Salmon:	High: over 1.0 fish/AD Moderate: 0.4-1.0 fish/AD Low: less than 0.4 fish/AD
Summer	Lake Trout:	High: over 1.2 fish/AD Moderate: 0.5-1.2 fish/AD Low: less than 0.5 fish/AD
	Steelhead:	High: over 0.8 fish/AD Moderate: 0.3-0.8 fish/AD Low: less than 0.3 fish/AD
	Brown Trout:	High: over 0.8 fish/AD Moderate: 0.3-1.0 fish/AD Low: less than 0.3 fish/AD
	Aggregate Coho and: Chinook	High: over 0.8 fish/AD Moderate: 0.4-0.8 fish/AD Low: less than 0.4 fish/AD

Table B16. (Continued)

Period	Species	Definition
Fall	Lake Trout:	High: over 1.4 fish/AD Moderate: 0.4-1.4 fish/AD Low: less than 0.4 fish/AD
	Steelhead:	High: over 1.2 fish/AD Moderate: 0.6-1.2 fish/AD Low: less than 0.6 fish/AD
	Brown Trout:	High: over 1.0 fish/AD Moderate: 0.5-1.0 fish/AD Low: less than 0.5 fish/AD
	Aggregate Coho and: Chinook	High: over 0.9 fish/AD Moderate: 0.4-0.9 fish/AD Low: less than 0.4 fish/AD

Table B17. Catch Rate Factors Utilized in the Final Product Classifications for Great Lakes Anadromous Angling. Catch Rates are in Fish per Angler Day (AD).

Period	Species	Definition
Winter-spring	Steelhead:	High: over 1.2 fish/AD Moderate: 0.4-1.2 fish/AD Low: less than 0.4 fish/AD
Fall	Aggregate Steelhead, Coho and Chinook:	Very High: over 1.0 fish/AD High: 0.6-1.0 fish/AD Moderate: 0.3-0.6 fish/AD Low: less than 0.3 fish/AD

Table B18. Catch Rate Facotrs Utilized in the Final Product Classifications for Great Lakes Non-Salmonid Angling. Catch Rates are in Fish Per Angler Day (AD).

Period	Species	Definition
Winter-spring	Aggregate yellow perch bluegill: crappie and white bass	High: over 6.0 fish/AD Moderate: 3.0-6.0 fish/AD Low: less than 3.0 fish/AD
	Aggregate bass, pike: and walleye	High: over 0.6 fish/AD Moderate: 0.2-0.6 fish/AD Low: less than 0.2 fish/AD
Summer	Yellow perch:	High: over 9.0 fish/AD Moderate: 3.0-9.0 fish/AD Low: less than 3.0 fish/AD
	Bluegill:	Moderate: over 3.0 fish/AD Low: less than 3.0 fish/AD
	Crappie:	Moderate: over 2.0 fish/AD Low: less than 2.0 fish/AD
	Aggregate bass, pike: and walleye	High: over 0.6 fish/AD Moderate: 0.2-0.6 fish/AD Low: less than 0.2 fish/AD
Fall	Yellow perch:	High: over 12.0 fish/AD Moderate: 6.0-12.0 fish/AD Low: less than 6.0 fish/AD
	Bluegill:	Moderate: 3.0 fish/AD Low: less than 3.0 fish/AD
	Crappie:	High: over 5.0 fish/AD Moderate: 2.0-5.0 fish/AD Low: less than 2.0 fish/AD
	Bass:	High: over 1.0 fish/AD Moderate: 0.4-1.0 fish/AD Low: less than 0.4 fish/AD
	Walleye:	High: over 1.0 fish/AD Moderate: 0.4-1.0 fish/AD Low: less than 0.4 fish/AD

Table B18. (Continued)

Period	Species	Definition
	Northern Pike:	High: over 0.8 fish/AD Moderate: 0.2-0.8 fish/AD Low: less than 0.2 fish/AD

Table B19. Common and Scientific Names of Fish Species

Common	Scientific
Lake trout	*Salvelinus namaycush*
Brown trout	*Salmo trutta*
Steelhead (rainbow) trout	*Salmo gairdneri*
Coho salmon	*Oncorhynchus kisutch*
Chinook salmon	*Oncorhynchus tshawytscha*
Brook trout	*Salvelinus fontinalis*
White bass	*Morone chrysops*
Crappie	*Pomoxis* spp.
Yellow perch	*Perca flavescens*
Smallmouth bass	*Micropterus dolomieui*
Largemouth bass	*Micropterus salmoides*
Walleye	*Stizostedion vitreum*
Sauger	*Stizostedion canadense*
Northern pike	*Esox lucius*
Muskellunge	*Esox masquinongy*
Bluegill	*Lepomis macrochirus*
Sunfish	*Lepomis* spp.
Rock bass	*Ambloplites rupestris*
Smelt	*Osmerus mordax*
Carp	*Cyprinus carpio*
Suckers	*Catostomus* and *Moxostoma* spp.
Alewife	*Alosa pseudoharengus*
Sea lamprey	*Petromyzon marinus*
Herring, chubs	*Coregonus* spp.
Catfish	*Ictalurus* spp.

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