Multi-Disciplinary Study of Water Quality Relationships:

A CASE STUDY OF YAQUINA BAY, OREGON

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MULTI-DISCIPLINARY STUDY OF WATER QUALITY RELATIONSHIPS: A CASE STUDY OF YAQUINA BAY, OREGON

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PREFACE

This publication presents the results of an ambitious multi-disciplinary study of a complex water quality problem. While the case study area has largely reached an equilibrium in its struggles with this social problem, it is hoped that this study of an actual situation will be helpful to those who are concerned with the more general case.

There is currently much concern about environmental quality, generally, and about water quality in particular. There is also much current interest in multi-disciplinary efforts in research and education. This publication is about both subjects. The problem of water quality was attacked by representatives of the disciplines of economics, fisheries biology, and engineering. Numerous problems of a complex nature were encountered in the process of the investigation. In some instances we believe new ground has been broken with respect to methodology and empirical results. We have been disappointed by our inability to make significant progress on other problems.

The problem basically is one of how a community or a geographic area manages the economic activity which affects its environmental quality. In the process of investigating this general problem, the following specific issues were confronted:

1. The economic value of outdoor recreational activity to a community.

2. The direct and indirect economic effects on a community of alternative levels of water quality resulting from industrialization.

3. The relationship of angler success to angler effort, and the consequent effect of this on economic activity in a community.

4. The hydrology of an estuary, and especially the impact of discharging a pollutant in one part of the estuary, on water quality in all other parts of the estuary.

5. The effect of varying levels of water quality on the yield of aquatic resources in various parts of the estuary.

6. The generalization of laboratory work in fisheries biology to field conditions in the estuary.

7. Consideration of the institutional means by which a community may manage the natural resources at its disposal.

8. Consideration of the management alternatives open to a community resulting from unique local conditions.

Dr. Herbert H. Stoevener carried the heaviest load in executing the entire research project. In addition, the study gave Dr. Stoevener the opportunity to pioneer in the application of input-output analysis to small areas. The literature on the economics of outdoor recreation is now much better developed than it was when this work was undertaken. As a result, Dr. Joe B. Stevens faced numerous conceptual and empirical problems in estimating the economic effects of different levels of water quality. His efforts in relating fishing effort to fishing success, and in measuring differences in income elasticities for different types of fishing, were original and are largely unique examples in the literature.

In addition to the individuals who appear as authors and those who are cited in the manuscript, there are others who contributed to the original idea of the project and at various stages of the research. Dr. Charles Warren, Department of Fisheries and Wildlife, Oregon State University, deserves special mention. I acknowledge a real intellectual debt to him for this project, as well as for many other insights. Dr. Warren has stimulated many, both inside and outside his own discipline. Dean Fred Burgess, School of Engineering, also recognized the need for, and supported, work on the economics of water quality at Oregon State at an early date. The study was initiated in 1963; at that time neither the concern for such issues nor the methodology for treating them were as far advanced as they are today.

We also acknowledge especially the contributions of Professors Lyle D. Calvin, Wilbur P. Breese, and R. E. Dimick at Oregon State University, and of

Chapin Clark at the University of Oregon Law School. Harry Wagner and Rollie Rousseau of the Oregon Game Commission, Kenneth Spies of the Oregon State Sanitary Authority, athe Lincoln County Extension Service, the Chambers of Commerce of Newport and Toledo, and the Oregon State Tax Commission provided much valuable information. We are grateful to Professors John Waelti of the University of Minnesota and Bruce Rettig of Oregon State University for their critical reviews. Mrs. Alice Schoenhard assisted in editing the manuscript. Last, but not least, we are indebted to Mrs. Audree Berrey who typed numerous drafts as well as the final copy of this publication, sometimes doing this work under difficult circumstances.

Dr. Stoevener had responsibility for assembling and coordinating the material in the entire manuscript, and had the main responsibility for Chapters I, III, and IV. Dr. Stevens prepared Chapters II and VI. Dr. Horton and Mr. Parrish assumed responsibility for Chapter V. Dr. Sokoloski prepared Chapter VII and assisted with numerous other parts of the study. Chapter VIII was written by me.

Emery N. Castle
Corvallis, Oregon
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Chapter I

INTRODUCTION

The nation's water resources are used very extensively for the disposal of wastes. This use is so significant that any change in national waste disposal policy is potentially very demanding in terms of private and public financial resources. For example, it has been estimated that capital requirements from the Federal budget amount to $20-$23 billion for the 1969-73 fiscal years to implement national policy in water quality management [U.S. Congress. Senate. 1968].

Public policy in water pollution control, as it has been promulgated during recent years, is further complicated by the fact that its application requires a large amount of technical information. Knowledge must be available on the physical and biological, as well as on the socio-economic effects of controlling water pollution. This includes the availability of data on the technical and economic feasibility of alternative approaches to achieving a certain water quality objective. Generation of the information necessary for national water quality management is, itself, demanding in terms of financial and research resources.[1/]

In this study we analyzed an actual water quality management problem. We focused our efforts on outlining the framework within which certain economic questions of water pollution can be answered. Furthermore, we emphasized the methods of measurements by which the physical and economic consequences of similar water pollution problems can be evaluated. Instead of being primarily concerned with the quantitative magnitudes which were applicable to the problem under investigation, our efforts were directed mainly toward making explicit

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1/ Outlays for training in water pollution by one Federal agency amounted to nearly $4 million during fiscal 1969 [Division of Manpower and Training, 1969].

the kinds of data necessary for an analysis of this problem, and how these data could best be treated to develop information which is meaningful for public policy purposes. As a result, two major products were obtained from this work. First, we were able to show how available data can be utilized in the decision-making framework and, more importantly, what types of data are currently lacking. Research resources allocated toward the development of this missing information would have a relatively high pay-off. Second, we were able to make some advances in methods which need to be employed to analyze a problem such as this. And again, it was possible to provide some guidance for future research.

The empirical setting of this study was provided by the Yaquina Bay area in Lincoln County, Oregon. This area, of about 220 square miles, has an estimated population of 10,000 and is centered on the estuary of the Yaquina River. The city of Newport (population 5,300) is located at the mouth of the estuary, and is the county seat as well as a harbor for commercial fishing boats and for ocean-going vessels. The latter are used mainly to transport wood and wood products from Newport and the surrounding area. Some of the commercial catch of fish is processed in Newport. This harbor is also the base for numerous sport fishing boats to be used on the ocean as well as in the bay itself. Sportsmen fish principally for salmon in the ocean; they catch mainly salmon, trout, bottomfish, herring, and crabs, and dig for clams in the estuary. As a result of Newport's proximity to these water-related recreational resources and to U.S. Highway 101, the tourist industry has developed as a prominent part of the economy.

The other major town in the area, Toledo (population 3,050), is quite different in its characteristics. It is located on the bay about 10 miles inland from the ocean. The lumber industry dominates this town. A kraft process pulp mill was established in Toledo in 1958, and more than 50 percent of all employment in Toledo in 1960 was in manufacturing. All but a small fraction of the manufacturing employment was in some way related to the lumber industry.

Several other much smaller communities were included in the study area. Most of them line Highway 101, and are typical of their location on a major tourist route. Others are small communities supporting the lumber industry of Toledo. The study area was defined as comprising the labor market area for the major employers in Toledo and Newport.

The dual orientation of the area's economy toward industrial production and tourism is at the heart of the water pollution problem. Specifically, waste disposal from the pulp mill at Toledo into the estuary at Toledo or at other downstream locations was thought to have significant negative effects upon the recreational use of the estuary when plans for the operation of this plant were made in the late 1950's. Actually, this controversial issue was resolved when it was agreed that the mill would dispose of its wastes directly into the Pacific Ocean via a pipeline, thus minimizing its water quality effects upon the estuary.

The public policy debate which resulted from the decision to locate the industrial plant at Toledo was thought to provide a realistic setting within which the objectives of the study could be pursued. Also, Oregon State University has maintained a laboratory at Yaquina Bay for many years, so that the biological information about the estuary was relatively more abundant than it would have been for most other bodies of water.

In this report we shall discuss, first, how the demand for and value of the recreational fishery in Yaquina Bay, given the current regime of water quality, were estimated (Chapter II). Chapter III will treat the economic impact of the current level of recreational activity upon the study area. Chapter IV will analyze relevant alternative waste disposal methods in Yaquina Bay. Chapter V assesses the biological consequences of these alternative waste disposal schemes, while they are evaluated from an economic viewpoint in Chapter VI. The final two chapters concern themselves with water quality management institutions, and some broader interpretations of the results of this study to public policy in water quality management.

Chapter II

THE DEMAND FOR SPORT FISHING AT YAQUINA BAY

Measurement of Recreation Values

The problem of evaluating the costs and benefits of water pollution control would not be so difficult were it not for the nature of some of the values which are often sacrificed because of water pollution. These are values, including recreation, which are not determined by market activity. Much outdoor recreation in the U.S. has traditionally been characterized by public resource ownership and free or low-cost access by the public. The Yaquina Bay sport fisheries are a case in point. Fishing licenses are required for some species, but nothing resembling a true market mechanism exists wherein the value of the sport fishing opportunity might be reflected in a market price.

The extra-market nature of the sport fishery thus makes it necessary to simulate, or impute, market prices in order to evaluate the benefits of water pollution control. The procedure generally used for simulating such a market is that of estimating a demand function for the recreational activity. The demand schedule, as far as goods and services ordinarily handled through the market are concerned, reveals the quantities of the recreational experience which would be taken at alternative prices.

In order to make use of recreational opportunities, the recreationist often needs to make certain expenditures. An angler, for instance, needs to buy fishing equipment and transport himself to and from the fishery. A distinction should be made, however, between these demands and that for the recreational opportunity itself. The latter is the subject of analysis in this chapter. Economists will readily recognize that the former may give rise to indirect benefits. These will be treated in the following chapter.

Most empirical estimates of demand schedules for outdoor recreation have used as a proxy "price" variable the differential travel costs associated with the locational dispersion of users. The original impetus for this idea seems to have come from Hotelling [1949], who suggested defining concentric zones around the recreational site, so that travel costs to the site would be approximately constant within each zone. The travel cost and the number of visitors from each zone could then be plotted in order to define the demand curve. Users from the closer zones would enjoy a "consumer's surplus" by not having to pay the full travel costs of users in the more distant zones. Integration of the area under the demand curve would indicate the extent of consumer's surplus and thus afford an estimate of the recreational value of the site.

Clawson [1959] can be credited with further developing the basic Hotelling model for the measurement of recreational values. Clawson suggested that a demand schedule should first be estimated for the _entire recreational experience_, including the related but separable phases of anticipation, travel to the site, experience at the site, travel from the site, and recollection. From this schedule, it would be possible to derive a demand schedule for the site _itself_ in terms of quantities taken at alternative fee increases. This schedule would be accomplished by the simplifying (but admittedly naive) assumption that differences in usage are caused solely by the differences in money costs of visiting the site.

Brown _et al_. [1964] have extended the Hotelling-Clawson model to include family income and distance from the recreational site as additional determinants of the quantity taken. In their study, the authors estimated a "net economic value" of $3 million for the Oregon salmon-steelhead sport fishery in 1962. Net economic value was defined as the annual value of the sport fishery resource to a single owner if a market were to exist for the opportunity of fishing for salmon and steelhead. A 50 percent increase in net economic value was projected for 1972, assuming that income and population trends of the past 10 years continue.

Specification of the Demand Model

The literature review above suggests that the costs of travel to and from the fishery provide a variable by which one might simulate a market price for sport fishing. These costs can be referred to as "transfer" costs, since they are those expenditures needed to transport, feed, and perhaps lodge the angler. It is also recognized that family income would likely influence the quantity of recreation taken. A third variable, distance from the fishery, was used by Brown et al. [1964] to reflect the cost of the visit in terms of time. For the purposes of this study, a demand model was specified as:

$$Q = f(P, I, D), \tag{2.1}$$

where

Q = quantity of angling effort,

P = transfer costs per angler day,

I = family income of angler,

D = distance from the angler's home to the fishery.

In order to provide data for estimation of the demand model, a field survey of anglers at Yaquina Bay and a related mail survey were conducted in 1963 and 1964.[1/] Data were collected from 369 bottomfish angling parties, 120 salmon angling parties, and 69 clam digging groups. The anglers were stratified by distance and income characteristics, and values for the quantity, price, income, and distance variables were developed for each angling party. Mean values of each of the variables were then computed for each cross-sectional stratification. The variables were defined more precisely as follows, where ij's indicate elements of stratification as defined by distance and income:

$\overline{Q}_{ij}$ = number of angler days per 10,000 population during a 12-month period in 1963-1964, as estimated by an index method of estimation (see Appendix I for further explanation),

$\overline{P}_{ij}$ = variable transfer costs per participant day, including actual costs of meals, lodging, and expenditures at marinas, and an imputed round-trip travel cost of 6 cents per mile,

$\overline{I}_{ij}$ = yearly family income of angler,

$\overline{I}^2_{ij}$ = squared value of family income,

1/ Additional details on the surveys and measurement procedures can be found in Stevens [1965].

$\bar{D}_{ij}$ = round-trip distance from residence of the angler to Yaquina Bay.

It was originally intended to have six distance zones, ranging from 0 to 200 miles from the fishery, and eight income sub-zones, for a total of 48 cross-sectional observations on each fishery. Sufficient data were not available with which to compute meaningful averages for all 48 observations; thus, some aggregation was necessary. Twelve observations (per fishery) were finally available for demand estimation in the bottomfish and salmon fisheries, but only six observations could be obtained for clam digging.

Estimation of Demand Functions and Net Economic Values

An exponential demand function was estimated for each fishery through multiple regression analysis of the data. Natural logarithms of the dependent variables were used. A preliminary analysis indicated a high degree of interrelationship between price and distance variables; thus, the distance variable was deleted. (This suggests the difficulty involved in empirically separating time and monetary costs of travel.) Without considering the distance variable, the demand equation for the bottomfish fishery was

$$\widehat{\ln Q} = 8.32341 - 0.68069\ P^{**} + 0.13274\ I - 0.01285\ I^2 \qquad (2.2)$$
$$(R^2 = 0.92) \qquad (0.07366) \qquad (0.12744) \qquad (0.00743)$$

For the salmon fishery, the demand equation was

$$\widehat{\ln Q} = 5.59954 - 0.69690\ P^{**} + 0.53153\ I^{**} - 0.02214\ I^{2}{}^{**} \qquad (2.3)$$
$$(R^2 = 0.95) \qquad (0.05770) \qquad (0.10448) \qquad (0.00490)$$

The demand equation for clamming was estimated as

$$\widehat{\ln Q} = 8.28347 - 1.17091\ P - 0.15330\ I \qquad (2.4)$$
$$(R^2 = 0.73) \qquad (0.45902) \qquad (0.17442)$$

Standard errors of the regression coefficients are shown in parentheses. Coefficients of the proxy price variable carried negative signs in all three equations and were highly significant in two. This lends support to the argument that the demand for sport fishing can be viewed in the same conceptual manner as the demand for other goods and services.

These equations represent what Clawson would term demand functions for the recreational experience as a whole. They also make possible the derivation of a demand curve for the fishery itself. By holding the income variable constant and incrementally increasing the value of the price variable, the equations will yield estimates of the quantity of angling effort that would be taken at a series of assumed increases in the price paid by anglers for access to the fishery.

Table 2.1. Estimated Number of Angler Days Taken at Alternative Increases in the Price Paid to Fish at Three Yaquina Bay Sports Fisheries

Price increase per angler day (dollars)	Bottomfish	Salmon	Clams
0	28,372	10,236	6,446
0.50	20,207	7,204	3,592
1.00	14,332	5,075	1,998
1.50	10,244	3,589	1,113
2.00	7,238	2,558	620
3.00	3,682	1,275	54
4.00	1,854	564	0

Interpretation of the relationship in Table 2.1 can be viewed in two manners, which are simply different ways of looking at the same phenomenon. One could conceive of a hypothetical monopolistic owner of the sport fishery who would charge that price which would maximize revenues. Another interpretation is that the schedule represents net "rent" which anglers would be willing to pay for various levels of use of the fishery. In either case, the maximized amount represents an estimate of the annual "net economic value" of the sport fishery, or that value which would result if a market were to exist for participation in the fishery. The data in Table 2.2 indicate that revenues, or "rent", from the Yaquina Bay fisheries could be maximized by charging $1.50 per angler day for salmon and bottomfish angling and $1.00 per day for access to the clam beds. At these levels of price increase, total revenue, or "rent", would equal $22,747 per year.[2/]

Table 2.2. Schedule of Gross Revenues Accruing to a Nondiscriminating Monopolistic Owner of Three Yaquina Bay Fisheries

Price increase per angler day (dollars)	Gross Revenues		
	Bottomfish	Salmon	Clams
0.50	$10,103	$3,602	$1,796
1.00	14,332	5,075	1,998
1.50	15,366	5,383	1,670
2.00	14,476	5,116	1,240
3.00	11,046	3,825	162

One interesting implication of the demand equations is that the income elasticity of demand is negative for two of the three fisheries.[3/] These elasticities, computed at the means of the income variable ($\bar{I}$) and the quantity variable ($\hat{Q}$), were derived from the demand equations as

$$\frac{\partial Q}{\partial I} \cdot \bar{I}/\bar{Q} \tag{2.5}$$

The income elasticity for salmon angling was positive (+1.38), but negative income elasticities were estimated for bottomfishing (-0.24) and clam digging

2/ Net economic values of the fisheries were also computed by the consumer's surplus method of integrating the areas under the demand curves of Table 2.1 (see Appendix II). According to this method, the net economic value of the three fisheries was $62,819 per year.

3/ An interesting policy implication is provided by the relationship between income elasticities and possible pricing systems for outdoor recreation. If equity considerations are to be incorporated into the pricing system, the level of price might be based in part on the income elasticity. In the Yaquina Bay case, zero prices might be set for clam digging and bottomfish angling, while some higher price could be established for salmon fishing.

(-0.8).[4/] The effects of these elasticities were quite evident when current trends of growth in population and per capita income were taken into account. The total number of angler days in the salmon, bottomfish, and clam fisheries was projected to increase by 59.6, 13.2, and 0.6 percent, respectively. Population growth and the secular increase in per capita income would both tend to shift the demand curve for the salmon fishery to the right. In the clam and bottomfish fisheries, however, the negative income effects would partially offset the increased demand brought about by population growth.

Assessment of Methodology and Results of Demand Estimation for the Three Yaquina Bay Fisheries

From the time of its origin, the quantitative measurement of recreational values has had its opponents. Some claimed that it was impossible to place monetary values on a basically esthetic resource. Others admit that it is perhaps possible to do so, but not really necessary, and perhaps even undesirable. To the former, we admit that it is not possible to make inter-personal comparisons of the utility or satisfaction resulting from certain experiences. It is often possible, however, to measure what a person is willing to sacrifice, in terms of goods and services, to obtain the experience in question. The travel costs and other expenditures which serve as the proxy price variable in the demand equations are a measure of the angler's willingness to sacrifice purchasing power with which he could obtain other goods and services.

To those claims that recreation measurement is unnecessary or undesirable, three comments are relevant. First, increases in income and leisure of an expanding population have resulted in an increased demand for outdoor recreation, including sport angling. This trend is clearly projected to continue into the future. Second, many outdoor recreational resources are publicly owned; consequently, the market mechanism on which the economist usually

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4/ These elasticity estimates are greater in absolute value than those previously published [Stevens, 1966] due to a computational error in the earlier estimates. This error occurred as a result of not taking the estimating equations out of natural logarithm form before computation of income elasticities. We are indebted to Gardner M. Brown and Steve Matthews of the University of Washington for pointing out the error.

relies for valuation has largely been inoperative. Third, society is interested in economic comparisons of the value of land and water resources in alternative uses. While resource policy decisions are not made solely on economic criteria, these criteria are an essential part of the decision-making process.

With regard to demand estimation for the Yaquina Bay fisheries, some comments are in order on the extent to which the "true" value of the fisheries has been measured. The first comment must be a reminder that secondary benefits were not considered in the above analysis. Chapter III is devoted to this task. A second comment is that the estimates above probably are biased downward from the "true" value. There may be several reasons for this. Several minor recreation uses of Yaquina Bay were excluded from analysis because of insufficient data on cutthroat and steelhead fishing, sport crabbing, skin diving, and water skiing. Another recreational use which was not considered was the attraction for non-anglers who enjoy driving along the estuary and watching anglers, waterfowl, and the activity at the moorages. This attraction is complemented by the existence of Yaquina State Park, which overlooks part of the estuary and is used extensively by picnickers and sight-seers. Although this value was not estimated in this study, the fact that sight-seers come from varying distances indicates that demand measurement could also be made for this type of user.

Another type of "use" which has been excluded provides a more esoteric argument. The argument is analogous to the one forwarded in behalf of the preservation of wilderness areas. If given a choice, most non-users of Yaquina Bay would prefer that the estuary remain unpolluted. These people might hope to visit Yaquina Bay sometime in the future, or they might simply argue for preservation for the sake of preservation. Some might never visit Yaquina Bay, but would argue that it is "worth something" to know that a unique natural resource is being preserved for future generations. Whether this vicarious "demand" can, or should, fall within the realm of economic measurement is debatable. Economic efficiency is not sufficiently broad to serve as a general criterion for all resource policy decisions; other criteria should and will be considered. If the effects on economic efficiency of a particular decision with respect to resource use can be specified, however, the basis for public debate can more nearly be agreed upon.

Chapter III

THE IMPACT OF SPORT ANGLING ON THE YAQUINA BAY ECONOMY

The Nature of the Economic Impact

The preceding chapter discussed one measure of the economic value generated by the Yaquina Bay sport fishery. There are, however, additional considerations which may be relevant from the local economy's viewpoint. It is generally recognized that beneficial effects result from the expenditures which recreationists make in the local area. Fishermen may purchase food, gasoline, fishing tackle, etc., in Newport in conjunction with their fishing trips to Yaquina Bay. Businessmen directly supplying recreationists with these products benefit from the latter's expenditures. Moreover, a portion of the increase in the incomes of these businesses is spent again locally, for example, to hire laborers or to purchase supplies. This permits another series of beneficial effects to be recorded.

If an economy were completely self-sufficient, and if individuals and businesses would not retain any of the income increases for savings, the chain of beneficial effects would continue forever; the "multiplier" would be infinitely large. While it is known that the marginal propensity to consume, or the proportion of an increase in income which is re-spent, is less than one, the other constraint upon the size of the multiplier may be more important in the case of a small and relatively simple economy. In such an economy, a large proportion of expenditures by businesses and individuals is made for imports. Imports represent a "leakage" from the viewpoint of the local area, as the secondary beneficial effects described above occur outside of the area of relevance to the local interest.

Local secondary effects may be an important variable in resource management decisions at the local level. We shall indicate later how this variable may operate in a decision-making framework. First, it will be necessary to be concerned with the measurement of these effects. The above discussion indicated that the structure of the local economy, the economic ties through which the various sectors of an economy are related, is a key element in this analysis. Input-output analysis was chosen as a method to characterize the structure of the economy. We shall turn next to a discussion of this step in the analysis.

The Input-Output Model as a Tool for Measuring the Impact

Interindustry analysis as an empirical technique has its origin with the writings of Wassily W. Leontief in the 1930's.[1/] Since then it has found many applications and has been extensively discussed.[2/] The technique has also been applied to problems of natural resource management. Professor Ciriacy-Wantrup [1954] suggested the possibilities of its use in benefit-cost analysis. A list of only a few applications in the natural resources area includes the work by Lofting and McGauhey [1963] in California, by Jansma [1964] in Oklahoma, and the water quality study in the Colorado River Basin.[3/] A recently completed study in Oregon [Bromley, Blanch, and Stoevener, 1968] applied the technique to the analysis of the economic consequences of changes in some Federal land use policies.

Interindustry analysis starts with a transactions table, or an accounting system of the economy. The accounts refer to individual industrial groupings or sectors. They describe the flows of goods and services in the economy under study. The system of interindustry accounts can be presented in the form of an equation, as:

$$\sum_{j=1}^{n} x_{ij} + Y_i = X_i \qquad \text{where } i = 1 \cdots n, \qquad (3.1)$$

1/ See, for example, Leontief [1936].

2/ A bibliography on the subject has been prepared by Riley and Allen [1955].

3/ For one report on this study, see Wollman [1963].

where

X_i = value of output of Sector i,

x_{ij} = value of the flow of goods and services from Sector i to Sector j, and

Y_i = value of final demand for output of Sector i.

Thus we view the output (X_i) of each sector of the economy to be equal to the sum of this sector's sales to all of the other sectors of the economy, ($\sum_{j=1}^{n} x_{ij}$) and its sales to "final demand", (Y_i).

The elements of x_{ij} comprise the endogenous part of the input-output system. Through them are expressed the interindustry effects of changes in the level of production in one sector upon the others.

The elements Y_i represent the sum of the exogenous or autonomous demands. The level of these is not determined as part of the system. Investment, consumption, government purchases, and exports are generally the components of final demand [Chenery and Clark, 1959]. It is with respect to these that we refer to a model as being "open". To close the model, these activities would have to be included among the endogenous sectors. It is customary, however, to refer to a model as being "closed" when only one or more of the elements of final demand are incorporated into the intersectoral flow matrix [Brems, 1959]. In the case of our study, we closed the model with respect to household demand. This will be treated in greater detail at a later point.

The next step in input-output analysis, the computation of the technical coefficient matrix, involves the most important assumption of the method, linearity of the production function. The matrix has the elements

$$a_{ij} = \frac{x_{ij}}{X_j} \qquad \text{where } i, j = 1 \cdots n. \tag{3.2}$$

These elements have the following interpretation: They denote the quantity of output of Industry i required to produce one unit of output of Industry j.

We can now rewrite our basic equation as

$$X_i = \sum_{j=1}^{n} a_{ij}X_j + Y_i \qquad i = 1 \cdots n, \quad \text{or} \tag{3.3}$$

$$X_i - \sum_{j=1}^{n} a_{ij}X_j = Y_i \qquad i = 1 \cdots n. \tag{3.4}$$

In matrix notation, this can be expressed as $X - AX = Y$, where

X = column vector of outputs

Y = column vector of final demands

$A = n \times n$ matrix of technical coefficients.

Given A and Y, we can solve for X:

$$X = (I-A)^{-1}\, Y, \text{ where I is an identity matrix.} \tag{3.5}$$

The elements of the inverse matrix are the interdependence coefficients. These coefficients indicate the amount of product required of Sector i per unit of final demand of Sector j, taking into account all the intersector flows in the endogenous part of the transactions matrix.

Because the principal reason for using the input-output technique[4/] stems from the idea that such a model would realistically describe changes in the area's income by sector of economic activity, it is essential to focus attention upon the issue of treating consumer income and household demand as autonomous or induced.

We described earlier the nature of the economic interdependence of the

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4/ A distinction has been drawn in the literature between "input-output" and "from-to" models. Input-output models primarily use data on the technical production relationships, while an economy's trade relationships are featured in from-to models. According to this classification, our technique is more appropriately referred to as a from-to model. However, we choose the more familiar term for the purpose of this report. For more discussion of this point, see the article by C. L. Leven [1961].

various business sectors of the economy. We also noted that, in this study, the model was closed with respect to household demand. This means that the Household sector's place in the economy is viewed exactly like that of any other business sector. As a result, sales in the area to local households are not "leakages", as they would be if consumption purchases were part of final demand, but are portrayed as part of the local economy's interdependent structure. Given some increase in one of the sector's final demand, the model will indicate the resulting multiplier effects considering that the associated increases in household incomes (as businesses hire more labor, for example) will also be partly re-spent in the local area, and thus will stimulate local business activity, leading to further increases in household incomes.

The Structure of the Area's Economy

The area's economy is most readily described by reference to Table 3.1. The numbers in the table are a counterpart to the relationship portrayed by Equation 3.1. The numbers in Columns 1-16 represent interindustry purchases. They are the sales made by the sector listed on the left to the sector whose number appears at the top of the column. For example, the entry in the 6th row and 12th column indicates that an estimated $300,000 worth of goods were sold by the Fisheries sector to the local Wholesale and Retail (product-oriented) sector.

Row and Column 16 refer to the Household sector. The entries in the column indicate the estimated quantities purchased by local households from the various industrial and commercial sectors of the economy. In the Household row are found the estimated sales of the Household sector (largely in the form of labor services) to the other sectors in the economy.

The Final Demand column contains the items previously described. For the economy as a whole, more than half of total production is for final demand. In particular, the Lumber, Pulp, and Paper sector exports most of its output. As one might expect, those sectors which largely produce services serve mainly the local market, and their sales to final demand are proportionately lower.

Table 3.1. Transactions Matrix, Yaquina Bay Area, Oregon, 1963 (Thousands of Dollars)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Final Demand	Total Sales
1. Lumber, Pulp & Paper..	1,042										400					281	46,887	48,609
2. All Other Manufacturing..................	3		1	15	2	2		2	1	1	54	32			5	15	160	294
3. Hotels, Motels, Trailer Parks.........						1					75				3	244	643	966
4. Cafes & Taverns.......	11			2		1	*									1,112	859	1,985
5. Marinas & Marine Supplies.............	6					64		4			4				*	57	573	708
6. Fisheries.............						358						300					3,991	4,649
7. Service Stations, Automotive Sales & Repair................	2,002		*	2	48	78	1,043	708	68	1	214	52	40	90	76	5,353	1,776	11,552
8. Communications, Transportation............	1,721		19	38	68		24	21	19	38	40	38	5		35	725	192	2,981
9. Professional Services.	22	1	1	1	20	8	1		31	7	3	20	4	4	24	787	216	1,196
10. Banks & Loan Agencies.	60	6	24	24		60	12				6	30	18		3	1,250	116	1,658
11. Construction..........	1,001		41	3	9	6	4	1	4	2	1,354	51	45	5	39	1,487	2,356	6,406
12. Other Product-Oriented Wholesale & Retail....	256	1	170	358	17	356	18	4	27	9	94	135	35	21	62	7,066	1,363	9,990
13. Other Service-Oriented Wholesale & Retail....	43		273	70	14	24	107	22	34	33	120	118	70	7	138	1,941	692	3,706
14. Agriculture...........	70	39										220		3		34	141	507
15. Government............	675	2	21	3	2	10	25	13	5	29	22	47	31	16		596	2,556	4,052
16. Households............	6,983	117	319	571	169	949	1,066	793	595	430	1,349	1,234	2,041	33	2,167	126	5,868	24,808
Import & Value Added..	34,717	128	97	899	359	2,732	9,252	1,413	412	1,108	2,672	7,714	1,417	329	1,500	3,734		
Total Purchases.......	48,609	294	966	1,985	708	4,649	11,552	2,981	1,196	1,658	6,406	9,990	3,706	507	4,052	24,808		124,069

* Less than five hundred.

The last column of Table 3.1 indicates the composition of the economy's output. It is estimated that more than a third of total sales originate in the Lumber, Pulp, and Paper sector. This sector also purchases nearly one-third of the area's household services.

The estimated magnitudes in Table 3.1 are largely the result of three data-gathering tasks specifically undertaken for the purposes of this study. First, a list of business firms was established for the Newport-Toledo area. The firms on this list were classified by sector,[5/] and again by major classifications within each sector. As nearly as possible, 25 percent of the number of firms in each subsector were chosen at random for interviewing.

During the interview, a questionnaire (Appendix III) was completed with the respondent, which emphasized collection of information on total sales and their distribution, payrolls, and investments. Nearly 200 usable questionnaires were obtained.

After expanding these sample data to the population of all firms in the area and making some adjustments in the totals on the basis of available secondary data, they became the basis for most of the numbers presented in Table 3.1.

The above survey gave only very limited information about another set of relationships. This pertained to total household incomes in the area, and the distribution of expenditures made by local consumer households in the various business sectors.

To obtain more information on this household income-consumption relationship, a second survey was conducted. Questionnaires were completed during

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5/ While the sector names as shown on the left side of Table 3.1 are fairly descriptive, the sector referred to as "Government" may need some explanation. Generally, government purchases are considered as a part of final demand, and therefore this sector is not included in the endogenous part of the matrix. However, for this study area the level of operation of local governmental units was thought not to be independent of the economic activity in the study area. Hence the transactions of schools and county and city governments were listed in Row and Column 15.

personal interviews with 199 households. "Area sampling" was employed during this survey. The area was stratified, geographically. A starting place was chosen at random for each of the city precincts, as well as for the rural areas. The interviewer started at this point and interviewed every $n^{\underline{th}}$ household, until the pre-determined number of interviews was obtained. The sample data were again expanded to yield the population estimates.[6/] These data and those provided by the business survey provided the basis for the entries in Column 16 of Table 3.1.

Finally, data on the interrelationships of the Government sector with the business community were obtained from published budgets and interviews with governmental officials. These data are presented primarily in Column and Row 15 of Table 3.1.

Table 3.2 was derived from the data in Table 3.1 by use of Equation 3.2. The entries in this table are referred to as "direct coefficients", because they indicate the direct output response required in the sector of the row when the output of the sector of the column changes by one unit. For example, the entry in Row 12 and Column 4 indicates that, as sales in the Cafes & Taverns sector increase by one dollar, an additional 18 cents will be purchased from the Other Product-Oriented Wholesale & Retail sector.

Of special interest are the entries in Row 16. These indicate the primary factor purchases resulting directly from a one-dollar increase in output by the sector listed at the top of the column. While the magnitudes of these coefficients differ considerably from one another, it is most important to notice that almost without exception, the commercial sectors of the economy purchased more inputs per dollar of output from the Household sector than they did from any other sector of the local economy. The Agriculture sector is the most significant exception. However, in the study area, agriculture is a declining sector and is even currently not very important in terms of total output. Furthermore, the hired labor input on the study area farms was small,

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6/ For more detail on this part of the study, see Gibbs and Stoevener [1967]. The sampling scheme is discussed in Gibbs [1966].

Table 3.2. Direct Coefficients, Input-Output Data, Yaquina Bay Area, Oregon, 1963

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Lumber, Pulp & Paper..............	.02144										.06244					.01132
2. All Other Manufacturing..........	.00005		.00123	.00749	.00337	.00051		.00080	.00100	.00072	.00837	.00322			.00123	.00062
3. Hotels, Motels, Trailer Parks.......						.00029					.01171				.00084	.00983
4. Cafes & Taverns.....	.00023			.00102		.00028	.00004									.04481
5. Marinas & Marine Supplies...........	.00011					.01382		.00124			.00058				.00008	.00231
6. Fisheries..........						.07701						.03003				
7. Service Stations, Automotive Sales & Repairs...........	.04120		.00029	.00086	.06812	.01683	.09026	.23758	.05665	.00041	.03343	.00517	.01092	.17786	.01874	.21578
8. Communications, Transportation......	.03540		.01934	.01892	.09570		.00207	.00719	.01567	.02289	.00627	.00380	.00126		.00864	.02922
9. Professional Services...........	.00044	.00357	.00140	.00068	.02887	.00176	.00012		.02577	.00407	.00042	.00202	.00097	.00830	.00588	.03174
10. Banks & Loan Agencies...........	.00123	.02028	.02469	.01202		.01283	.00103				.00093	.00299	.00483		.00074	.05037
11. Construction........	.02059		.04266	.00139	.01219	.00118	.00033	.00027	.00350	.00135	.21134	.00506	.01212	.00911	.00963	.05993
12. Other Product-Oriented Wholesale & Retail...........	.00526	.00230	.17571	.18033	.02341	.07657	.00158	.00123	.02223	.00557	.01464	.01349	.00949	.04042	.01533	.28483
13. Other Service-Oriented Wholesale & Retail...........	.00088		.02823	.03544	.01989	.00512	.00927	.00742	.02865	.01963	.01874	.01179	.01901	.01450	.03394	.07825
14. Agriculture.........	.00144	.13258										.02202		.00493		.00139
15. Government..........	.01388	.00778	.02184	.00139	.00320	.00205	.00217	.00432	.00398	.01757	.00349	.00468	.00824	.03117		.02401
16. Households..........	.14366	.39809	.32974	.28760	.23810	.20414	.09226	.26586	.49704	.25938	.21060	.12350	.55081	.06503	.53478	.00508

while the value of operator and farm family-owned labor services were difficult to determine. Hence the estimate of the coefficient may be in error.

The inverse matrix presented in Table 3.3 is computed by use of Equation 3.5. The entries in this table are also referred to as "direct and indirect coefficients". Unlike the coefficients in Table 3.2, they portray not only the direct impact upon a sector's output when production in another sector increases by one unit, but they include the effects of all of the economy's interrelationships as described by the model. For example, the coefficient in Row 12 and Column 4 indicates that sales in the Other Product-Oriented Wholesale & Retail sector will increase by an estimated 32 cents for each dollar increase in output of the Cafes & Taverns sector. This effect is due not only to the direct relationship between these two sectors, as described by Table 3.2, but it also reflects the fact that, as a result of its output change, Sector 4 made purchases from sectors other than 12. The resulting increases in output by these sectors, as well as by Sector 12, led to additional purchases from Sector 4. The coefficient 0.31995 is an estimate of the effect of all of these direct and indirect interdependencies in the economy.

The sums of the columns of interdependence coefficients presented in Table 3.3 are of special interest. These are generally referred to as "multipliers". They indicate the total effect, in terms of the economy's output, resulting from a one-dollar change in the final demand faced by the industry of the column. For example, an increase (decrease) of one dollar in the final demand of the Cafes & Taverns sector (Column 4) will generate an estimated additional increase (decrease) of $1.18 of output in the economy.

Again, it must be remembered that "output", as it is defined here, includes sales by the Households sector. In the above example, the Cafes & Taverns sector purchased an estimated $0.45 from Households per dollar of its sales.

The coefficients in the Households row have special significance of their own. Ultimately, we wish to ascertain the effects of some external incident (a change in final demand) upon the incomes of the private individuals

Table 3.3. Inverse Matrix, Input-Output Data, Yaquina Bay Area, Oregon, 1963

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Lumber, Pulp & Paper...............	1.02747	.00925	.01580	.00771	.00771	.00530	.00240	.00650	.00120	.00637	.00880	.00370	.01330	.00348	.01298	.02136
2. All Other Manufacturing...........	.00099	1.00160	.00439	.00940	.00481	.00182	.00041	.00190	.00310	.00184	.01190	.00391	.00223	.00074	.00343	.00355
3. Hotels, Motels, Trailer Parks.......	.00280	.00592	1.00844	.00487	.00450	.00381	.00153	.00417	.00758	.00406	.01932	.00219	.00812	.00190	.00883	.01378
4. Cafes & Taverns.....	.01049	.02443	.03198	1.02102	.01787	.01466	.00634	.01727	.03121	.01666	.01838	.00870	.03289	.00715	.03253	.05718
5. Marinas & Marine Supplies............	.00076	.00139	.00196	.00124	1.00115	.01583	.00036	.00223	.00180	.00098	.00181	.00096	.00188	.00044	.00195	.00324
6. Fisheries...........	.00247	.00566	.01302	.01041	.00477	1.08937	.00145	.00387	.00766	.00388	.00479	.03503	.00759	.00297	.00771	.01261
7. Service Stations, Automotive Sales & Repairs...........	.11677	.16749	.19856	.12418	.20627	.10562	1.13628	.36289	.24863	.10344	.16013	.06271	.20280	.24024	.21155	.32872
8. Communications, Transportation......	.04518	.02020	.04745	.03615	.11162	.01368	.00738	1.02173	.04140	.03663	.02625	.01113	.02788	.00683	.03501	.04548
9. Professional Services............	.00840	.02350	.02670	.01644	.04332	.01357	.00494	.01320	1.05023	.01696	.01473	.00904	.02605	.01432	.03079	.04333
10. Banks & Loan Agencies............	.01355	.04928	.06475	.03672	.02156	.03128	.00865	.02079	.03728	1.01989	.02388	.01391	.04395	.00894	.03957	.06769
11. Construction.........	.04569	.04618	.11837	.03999	.04870	.02869	.01209	.03202	.06190	.03256	1.30495	.02294	.07588	.02569	.07199	.10370
12. Other Product-Oriented Wholesale & Retail............	.07604	.17399	.40013	.31995	.14651	.18250	.04464	.11897	.23540	.11932	.14713	1.07657	.23336	.09118	.23707	.38768
13. Other Service-Oriented Wholesale & Retail............	.02491	.05549	.36149	.08190	.06183	.03851	.02400	.04720	.09792	.05670	.06904	.03196	1.09062	.03420	.10526	.12198
14. Agriculture.........	.00362	.13808	.01046	.00897	.00445	.00474	.00124	.00343	.00661	.00341	.00554	.02462	.00650	1.00730	.00674	.01086
15. Government..........	.02140	.02833	.04694	.01616	.01603	.01247	.00661	.01626	.02501	.02876	.01853	.01148	.03003	.03689	1.02174	.03714
16. Households..........	.22868	.54448	.71272	.44583	.39811	.31977	.14032	.38474	.69544	.37137	.40908	.19366	.73308	.15915	.72488	1.27428
TOTALS.........	1.62922	2.29527	3.06316	2.18157	2.09921	1.88162	1.39864	2.05717	2.55237	1.82283	2.32346	1.51251	2.53586	1.64142	2.55203	2.53258

in the area who provide labor, capital, and management inputs for the operation of the local economy. The coefficients of Row 16 provide an estimate of these effects.

Inspection of the entries in Row 16 of Table 3.3 indicates that changes in final demand have the greatest impact upon household incomes in the area when they occur in the Other Service-Oriented Wholesale & Retail sector. The Government, Professional Services, and Lodging sectors are also very important in this respect. It is interesting to note that these four sectors are (although in reverse order) also the top four when all sectors are ranked by the size of their business multipliers.

Table 3.4 presents a ranking of the economy's sectors, by size of business multipliers and household coefficients. The correspondence between the rankings of the commercial and Government sectors is striking. It is another reflection of the importance of the "wage bill" as a stimulant of economic activity in a regional economy. An area which depends heavily on material imports is likely to minimize "leakages" by emphasizing development of labor-intensive industries. This consideration would be less important in a more complex economy in which the dependencies among the various industrial sectors are more important.

Table 3.4. Sector Rankings in Order of Decreasing Magnitude of Business Multipliers and Household Coefficients, Input-Output Model

	Sector Numbers in Order, by Declining Size of Business Multiplier and Household Coefficient															
Business Multiplier	3	9	15	13	16	11	2	4	5	8	6	10	14	1	12	7
Household Coefficient	13	15	3	9	2	4	11	5	8	10	6	16	1	12	14	7

An Estimate of the Local Economic Impact of Sport Angling

The structural relationships described in the preceding section are used to estimate the economic impact upon the local economy which results from the use of Yaquina Bay by sport fishermen.

The impact is initiated by recreationists' expenditures made in the area for goods and services used in association with their recreational use of the estuary. The levels of these expenditures were obtained through the interview and post-card surveys conducted with recreationists, as described in Chapter II. These expenditures are summarized in Table 3.5.

Table 3.5. Recreationists' Expenditures by Fishery

Fishery	Expenditures
Bottomfish..........................	$ 95,926
Clams................................	11,891
Salmon...............................	44,120
Trout................................	2,613
TOTAL........	$154,550

The same survey data also made possible the allocation of the total expenditures made by recreationists to the various business sectors as they were defined in the input-output model. This distribution of expenditures is shown in Table 3.6.

Table 3.6 indicates that only 5 of the 16 sectors of the economy are affected significantly by the recreational expenditures under consideration here. The Marinas and Marine Supplies sector has the highest ratio of expenditures by sport fishermen to total sector final demand, or about 8.3 percent. This measure is an indication of the fact that the sport fishery, in itself, makes only a limited contribution to a sector's final demand.

What about the overall economic effects stimulated by the initial expenditures made by recreationists? We need to turn to the input-output model.

Table 3.6. Recreationists' Expenditures, by Economic Sector

Sector	Expenditures
Hotels, Motels, Trailer Parks..................	$ 23,995
Cafes & Taverns.................................	25,346
Marinas & Marine Supplies.......................	47,601
Service Stations, Automotive Sales & Repairs...	19,319
Communication, Transportation..................	618
Other Product-Oriented Wholesale & Retail......	34,465
Other Service-Oriented Wholesale & Retail......	3,246
TOTAL.............	$154,550

It is assumed that changes in the level of expenditures made by recreationists are not the result of those forces whose operation is described by the sectoral interrelationships. Instead, changes in the levels of these expenditures are a reflection of economic forces beyond those portrayed by the input-output model. A change in consumers' preferences for this kind of recreational services, or a change in the quality of the recreational experience, would be examples of such exogenous factors. Thus it is appropriate to view changes in the level of these expenditures as changes in the "final demand" faced by the economy. Use of Equation 3.5 and of the data in Tables 3.3 and 3.6 yields an estimate of the overall effects upon economic activity in the area if the recreational expenditures considered here would cease to be made. The results are presented in Table 3.7.

Table 3.7 indicates that the overall output effect upon the economy is approximately $317,000. This is slightly more than twice the $154,550 expenditure made by recreationists in the area. Thus, in terms of the earlier discussion, the "multiplier" for these types of expenditures is estimated to be about 2.0.

It is also interesting to note the distribution by sector of the overall change in sales. Comparison of Table 3.6 with Table 3.7 indicates that,

Table 3.7. Effect of $154,500 Sport Fishing Expenditures upon Total Sales, by Sector, Input-Output Data

	Sector	Change in Sales
1.	Lumber, Pulp, & Paper	$ 1,163
2.	All Other Manufacturing	724
3.	Hotels, Motels, Trailer Parks	24,669
4.	Cafes & Taverns	28,037
5.	Marinas & Marine Supplies	47,782
6.	Fisheries	2,066
7.	Service Stations, Automotive Sales & Repairs	42,742
8.	Communications, Transportation	8,616
9.	Professional Services	3,619
10.	Banks & Loan Agencies	4,313
11.	Construction	7,461
12.	Other Product-Oriented Wholesale & Retail	63,482
13.	Other Service-Oriented Wholesale & Retail	18,827
14.	Agriculture	1,586
15.	Government	2,930
16.	Households	59,380
	TOTAL	$317,397

in general, those sectors which were affected most severely by the initial recreational expenditures still bore most of the impact when the economy's structural relationships are taken into account.

The correspondence between these two measures of the effects of recreational expenditures is less than perfect, however. Some sectors, namely Other Product-Oriented Wholesale & Retail (Sector 12) and Service Stations, Automotive Sales & Repairs (Sector 7) make relatively more sales to other sectors of the local economy than do Marinas & Marine Supplies (Sector 5) and Cafes and Taverns (Sector 4). For this reason, the former sectors are more severely affected by changes in the economy's final demand than are the latter sectors which, by the nature of their sales, are less closely linked to the remainder of the local economy.

Again, we must call attention to the entry in the Households row of Table 3.7. It is estimated that $59,380 of household sales result from the recreational expenditures. This sum represents the flow of income to households associated with the local business activity generated by the local expenditures made by sport fishermen in Yaquina Bay.

Chapter IV

ALTERNATIVE WASTE DISPOSAL METHODS

Up to this point we have been concerned with a description of the Yaquina Bay sport fishery, given the existing water quality regime. We focused upon the demand for this fishery and estimated its economic value. Furthermore, we derived an estimate of the economic impact which is exerted upon the local area by the expenditures of participants in this recreational fishery. This chapter, and the two following it, will be devoted to an evaluation of various methods of waste disposal from the kraft mill at Toledo, in terms of the criteria discussed in Chapters II and III. Such an evaluation will, first of all, require a description of the relevant alternative waste disposal methods. This assignment will be completed in the present chapter.

A report prepared by Harris [1964] evaluates alternative methods of disposing of wastes at the pulp and paper mill located at Toledo, Oregon. While models do not exist which will predict such measures as waste concentration, dissolved oxygen, and temperature with a high degree of statistical accuracy, results that exert a representative effect can be identified. Additional measures of "pollution", such as odor, sludge deposits, slime growths, scum, and color, were beyond the means of the Harris study.

Using the limited data available for August 1955 (low flow) and February 1956 (high flow), pollution concentrations were obtained as averages over a tidal cycle, using diffusion coefficients in a computerized solution for the model of a well-mixed estuary. Dissolved oxygen measures were obtained by a similar process. The alternative methods of effluent disposal originally considered were:

1. Disposal by pipeline at various points in the estuary.
2. Treatment by various methods, followed by dilution in the estuary.
3. Storage during low river flows, with disposal at high river flows.

4. Low flow augmentation.
5. Disposal by pipeline of all wastes into the ocean.
6. Disposal by barge of strong wastes into the ocean, and disposal of weak wastes into the estuary.

The above methods may be classified as either dilution, treatment, transportation, or storage. The dilution alternatives may be adequately represented by considering either dilution at the head of the navigable portion of the estuary (Toledo) or dilution at a mid-estuary point (McLean Point) indicated in Figure 4.1.[1/] The treatment process singled out was the process of activated sludge, the only possible technique which would meet the required standards of pollution treatment for this type of effluent. The alternative of storage of effluent at low flows had to be dismissed, due to the problem of a high water table within a feasible geographic area. In addition, this storage of effluent would generate an odor which could be a serious problem. Low flow augmentation involves the myriad of evaluation problems associated with the construction of a storage facility, a facility which might very well be designed primarily for some other function, such as municipal water supply, recreation, and irrigation. In that suitable storage sites did not appear to exist, this waste management alternative was not considered further. The final alternatives, piping and barging, are similar methods in terms of water quality. Barging is more expensive; therefore, this alternative was also excluded. The alternative of treatment by activated sludge was also ruled out because of the remaining high level of toxic compounds in the kraft mill effluent.

In light of the above considerations, the alternatives to be considered in succeeding chapters are:

[1/] At Grassy Point, cost is comparable to that of McLean Point, but waste concentration is greater at all affected sections [Harris, p. 11].

As indicated in Chapter V, the biological analysis will be concerned with the higher values of waste concentrations observed for Grassy Point. These higher concentrations were thought to provide a benchmark for the biological effects. Estimates for the biological consequences of a McLean Point disposal could be derived from them.

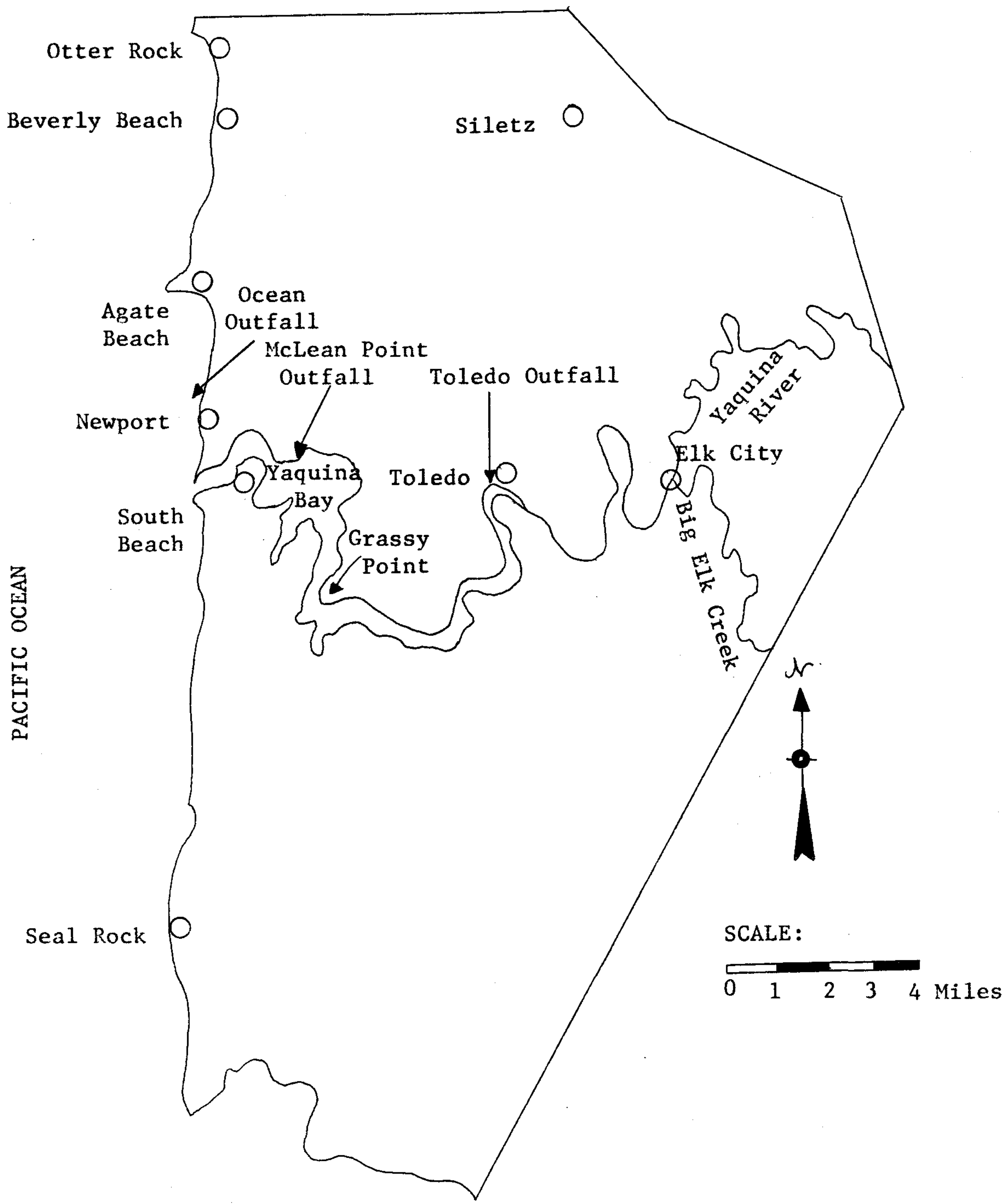

Figure 4.1. Yaquina Bay Area, Lincoln County, Oregon.

1. Disposal by dilution at Toledo.
2. Disposal by dilution at McLean Point.
3. Disposal by pipeline to an ocean outfall.
4. A combination of the above alternatives, such as disposing of a part of the effluent in the estuary at Toledo, and transporting the remainder by pipeline to the ocean.

Chapter V

THE PREDICTED INFLUENCE OF KRAFT MILL EFFLUENT ON THE FISHERY RESOURCES

Introduction

We now turn to the identification of the biological losses to the recreational fishery that would occur from the presence of kraft mill effluent (KME) in the estuary in the concentrations predicted by Harris [1964]. (KME and other terms used in this chapter are defined in Table 5.1.) We approached our investigation in three steps: (1) The angler survey which was discussed earlier provided data to determine the principal sport fishes and invertebrates in the catch, and to determine their distribution within the bay. (2) Bioassays were conducted from April through September 1964 to determine the 48- and 96-hour TL_m values of KME to the species studied [Parrish, 1966]. (3) An application factor of 1/10 of the 48-hour TL_m value was used to determine the maximum tolerable concentration of KME. The analyses from these three steps were then combined with the Harris [1964] predictions of KME concentrations in order to determine the impact of the waste disposal alternatives on the fishery resources in the estuary.

Literature Review

The literature contained little information on the effects of KME on estuarine fishes. Most bioassay studies with KME have been performed on various species of salmon (*Oncorhynchus*). Underyearling sockeye salmon (*O. nerka*) tolerated a maximum concentration of 4.8 percent full bleach KME in salt water. Under diminishing oxygen supply, the maximum allowable effluent concentration was lowered to 2.5 percent [Alderdice and Brett, 1957]. Chinook salmon (*O. tshawytscha*) and coho salmon (*O. kisutch*) were used in salt-water bioassays of both whole KME and a combined waste composed of various constituents from kraft mill processes. Chinook salmon 250 to 280 days old were most sensitive to the combined waste and tolerated up to a 1.6 percent concentration. The

Table 5.1. Definition of Terms Used in Chapter V

Term	Definition	Source
KME	KRAFT MILL EFFLUENT: An alkaline waste from the manufacture of paper produced by the digestion of certain types of wood with a strong caustic solution containing sodium hydroxide, sodium sulfate, and sodium sulfide.	Shreve, 1956
TL_m	MEDIAN TOLERANCE LIMIT, or the concentration at which just 50 percent of the test animals are able to survive for a specified period of exposure.	Doudoroff *et al.*, 1951
BIOASSAY	A test using the response of living organisms to artificial environmental situations, usually under controlled laboratory conditions.	
APPLICATION FACTOR	A factor that can be used (multiplied) with 96- or 48-hour TL_m values to indicate concentrations of the waste or material in question that are safe in the receiving water.	National Technical Advisory Comm., 1968
BOD	BIOCHEMICAL OXYGEN DEMAND: The amount of oxygen required by bacteria while stabilizing decomposable organic matter under aerobic conditions.	Sawyer, 1960
WHITE WATER	Waste water containing fines, wire-life extenders, and starch from the screening process in the manufacture of paper.	
STRONG WASTE	Waste water composed of spilled waste from the washers, continuous digester systems, and evaporators used in the manufacture of paper. Also included are tail water or contaminated condensates, lime mud, and dregs.	
WEAK WASTE	Composed of pump cooling water and white water from the manufacture of paper.	

growth rate of chinook salmon was reduced when the fish were confined to 0.6 percent whole KME [Holland *et al.*, 1960].

Some salmonids demonstrated marked avoidance to KME in laboratory experiments, while others did not. In one study in fresh water, chinook salmon exhibited a marked avoidance reaction to concentrations of 1.3 to 10.0 percent KME. Under the same conditions, coho salmon exhibited less avoidance and steelhead trout (*Salmo gairdneri*) showed no marked avoidance reactions [Jones et al., 1956]. In a study in salt water, coho salmon did not avoid whole KME in concentrations of 42 percent, even though 32 percent KME was fatal after 14 days' exposure [Holland et al., 1960]. These data indicate that some young salmonids may not avoid lethal concentrations of KME in salt water. The toxicity of various components of KME to selected salmonids, centrarchids, minnows, and aquatic insects also has been investigated [Van Horn, Anderson, and Katz, 1949; Haydu, Amberg, and Dimick, 1952; Webb, 1958; Courtright and Bond, 1969].

DeWitt [1963] used a synthetic waste to study the effects of KME on freshwater organisms in artificial streams. Cole [1935] noted that the toxicity of black liquor from the kraft process was generally decreased by aeration. The National Technical Advisory Committee [1968] in its discussion of marine and estuarine organisms concluded that a substantial portion of pulpmill wastes, including the toxic components, are very amenable to microbial degradation. Other authors have studied the effects of KME on oysters (*Crassostrea virginica*), Atlantic salmon (*Salmo salar*), and lobsters (*Homarus americanus*) [Galtsoff et al., 1947; Sprague and McLeese, 1969a,b].

No quantitative information was available on the sport catch of estuarine fishes in Yaquina Bay. The Oregon State Game Commission has surveyed the ocean catch of salmon from the mouth of the Yaquina River [Campbell and Locke, n.d.]. The Fish Commission of Oregon conducted a survey of the clam harvest in selected areas of the bay from June 22 through September 20, 1960 [Snow and Demory, 1961].

Materials and Methods

Much of the primary information required for this part of the study also had to be collected from anglers. Specifically, the interest was in estimating the total daily catch and its distribution by geographic area of the estuary. The same survey which was employed for other aspects of the study also yielded the data required here. The details of the survey design are discussed in

Appendix I, and need not be restated at this point. Instead, we turn directly to the laboratory methods used.

Laboratory Procedures

With few exceptions, laboratory bioassay procedures were patterned after those suggested by Doudoroff et al. [1951]. Bioassays were conducted in 18 liters of standing salt water mixed with KME to some predetermined percentage. Aquaria were wide-mouth, five-gallon glass jars. Experiments were conducted in a dark, constant temperature room at 19 $\pm$ 2°C. Contrary to the recommendations of Doudoroff et al., all test solutions were aerated. Aeration was necessary because of a higher ratio of fish mass to water volume than that suggested by Doudoroff et al.

Biological Procedures

Results of the angler survey were used to determine the five most frequently caught fin-fish species in Yaquina Bay. These five species were the white seaperch (*Phanerodon furcatus*), striped seaperch (*Embiotoca lateralis*), pile perch (*Rhacochilus vacca*), starry flounder (*Platichthys stellatus*), and kelp greenling (*Hexagrammos decagrammus*). These fishes and the dungeness crab (*Cancer magister*) were used in bioassay tests because they were the most economically important species captured by sport fishermen. In addition, the young of walleye surfperch (*Hyperprosopon argenteum*) and English sole (*Parophrys vetulus*) were used as test animals because of their small size and availability. Pacific herring (*Clupea pallasii*), jack smelt (*Atherinopsis californiensis*), and black rockfish (*Sebastodes melanops*) were of economic importance, but because the young were difficult to capture they were not used in the bioassays.

Test Specimens

Both vertebrate and invertebrate test specimens were obtained from Yaquina Bay. Captured fish were retained in a 250-gallon holding tank supplied with water pumped from the bay. Crabs were held near the laboratory in submerged wire cages attached to a floating dock. All specimens were fed while in holding tanks or cages.

conditions by placing them in aquaria with water of the same temperature as that in the holding tank and allowing the water to warm to room temperature (19 ± 2°C.) over two or three days. Doudoroff et al. [1951] suggested that test organisms be acclimated for at least 10 days. Lack of suitable aquaria and laboratory space limited the time for acclimation. Specimens were not fed during acclimation or test periods.

Kraft Mill Effluent

Kraft mill effluent was collected by Georgia-Pacific laboratory personnel at their paper mill at Toledo, Oregon. At the time of this study the strong waste water was pumped to the ocean for discharge, while the weak waste was pumped into the bay at Toledo. Automatic sampling devices on each waste line collected a small quantity of effluent at periodic intervals. The small samples from each line were combined in separate 55-gallon holding tanks. Each Thursday the composite samples, representing seven days' effluent, were brought to the laboratory. The samples of strong waste were stored in stoppered glass containers out of direct sunlight. The weak waste was stored out of direct light in open, wide-mouth, five-gallon jars.

Flow volumes for each seven-day period were supplied by the Georgia-Pacific mill. Using these figures, the strong waste, weak waste, and water fractions were combined to form a total waste representative of the probable effluent that the mill would discharge if all wastes were placed directly into the bay at one point.

Salt water from Yaquina Bay was added to the test solutions in place of the fresh-water fraction to keep the salinity as high as possible in high percentage KME tests. This was done to prevent placing an extra stress on the test organisms because of lowered salinities that would result if freshwater was used as a diluent and to approximate the high salinity conditions of the bay during periods of low river flows in summer.

Control solutions were composed of salt water mixed with freshwater equal in amount to the combined strong and weak waste components in the highest test concentration. Thus, test organisms in the control solution would be subjected to the same decrease in salinity as those in the strongest waste concentration, and should reflect any direct effects of reduced salinity.

Bioassay Procedures

All bioassays were conducted for 96 hours, or until more than 50 percent of the test organisms died. Dissolved oxygen levels were maintained at five ppm or higher in most test solutions. No attempt was made to test the effects of dissolved oxygen concentrations on fish survival; however, KME usuall exerts a chemical toxicity before the biochemical oxygen demand can greatly affect the oxygen supply [McKee and Wolf, 1963; Waldichuk, 1962].

Preliminary tests were conducted for each species to determine the approximate upper and lower limits of toxicity of KME. The lower limit was defined as the highest concentration at which more than 50 percent of the organisms lived for 96 hours. The upper limit was defined as that concentration at which more than 50 percent of the organisms died within 24 hours. After these values were determined, they were marked on a log scale. The distance between the points was divided into equal sections, based on the number of concentrations to be tested. This method was not used with the starry flounder, English sole, and dungeness crab. For these species, concentrations were increased by 5 or 10 percent from the predetermined lower value to the upper value, according to the range to be tested.

Organisms chosen for final tests were the smallest available. Average lengths and weights are given in Table 5.2. No abnormal or injured fish were used in the tests, and no individual fish was used more than once for experimental purposes. When available, 20 specimens were used per test concentration. When over 10 fish were used per concentration, the fish were equally divided into two jars per concentration. If sufficient fish (20) were not available, the greatest number on hand was used. Doudoroff et al. [1951] recommended using no more than two grams of fish per liter of test solution, but, because of the large size of the test specimens in relation to the available test aquaria, it was not possible to follow this recommendation.

Table 5.2. Weights and Sizes of Test Organisms Used in Bioassays of KME Toxicity

Species	Weight (grams)			Length (millimeters)			Remarks
	Max.	Min.	Ave.	Max.	Min.	Ave.	
Starry Flounder..	50.0	2.2	22.1	190.0	58.0	102.8	Total length
White Seaperch...	--	--	3.8	76.0	57.0	67.6	Fork length
Dungeness Crabs:							
Small size....	44.8	3.2	10.3	65.0	26.0	37.2	"Length" is carapace width
Large size....	136.0	76.0	112.1	100.5	78.0	90.5	
Striped Seaperch.	14.9	6.6	9.5	97.0	78.0	87.3	Fork length
Kelp Greenling...	22.1	3.5	12.2	130.0	75.0	105.0	Total length
English Sole.....	--	--	4.5	80.0	62.0	72.2	Total length

All test and control solutions were renewed every 24 hours to prevent possible detoxification of the waste by the test organisms. All dead animals were removed from the test containers and their number recorded as soon as observed.

A TL_m was derived for each species by straight line graphical interpolation after the method recommended by Doudoroff *et al*. [1951] and American Public Health Association [1960].

Chemical Procedures

Temperatures and samples for chemical analyses were obtained every 24 hours, just before solutions in the aquaria were changed, and at the end of the test period. Salinity samples were taken from control aquaria only.

Determinations of dissolved oxygen concentration were made according to the Alsterberg (Azide) modification of the Winkler method [American Public Health Association, 1960]. There are substances in KME that interfere with oxygen determinations by the Winkler method and produce lower oxygen values than actually exist in the solutions [Breese, 1965; DeWitt, 1963]. The exact amount of interference has not been established; however, the modified Winkler method was the best method available.

Hydrogen ion concentrations were determined with a battery-operated Model N-2 Beckman pH meter.

Salinity determinations were made with hydrometers and corrected for temperature.

Results

Magnitude and Distribution of Catch

Analysis of the angler survey revealed that the 3,260 sportsmen who were interviewed spent approximately 2,790 hours in quest of food fishes and invertebrates. These anglers harvested 375 pounds of chinook salmon, 155 pounds of coho salmon, 68 pounds of cutthroat trout, 9 pounds of steelhead, 271 pounds of dungeness crabs, 1,880 pounds of clams, and 3,249 pounds of miscellaneous fishes. Of the sportsmen interviewed, 24 fished for dungeness crabs, 384 clammed, 198 angled for trout and steelhead, 387 angled for salmon, and 2,267 angled for miscellaneous fishes [Parrish, 1966]. Because our study was concerned mainly with the influence of KME on the distribution of certain fishes in Yaquina Bay, the data presented will be limited to the catch and distribution of miscellaneous species, and particularly those used in the bioassays. The distribution is discussed by geographic "zones" of the estuary. These are delineated as shown in Figure 5.1.

The hours spent angling for miscellaneous fishes, the combined weight of the fishes caught, the pounds of fishes captured per angler hour, and the percent by weight of each of the test species in the catch of the anglers interviewed is reported by month in Table 5.3. The total weight of each of the test species for each zone and for a sampling year is recorded in Table 5.4. For the month of August, 1963, the sample weight, estimated weight, and percent of these weights for each test species by zone is recorded in Table 5.5.

In August the most important species in the catch (pounds) was starry flounder, followed in order by pile perch and kelp greenling (Table 5.5). The populations of white and pile seaperches appeared to be uniformly distributed throughout the bay. The peak of the distribution curve for each species occurred in Zone II. According to the sample catch information, striped seaperch, walleye surfperch, starry flounder, and kelp greenling were restricted in their distribution. Walleye surfperch were not recorded in the catch for Zone I, and striped seaperch, kelp greenling, and starry flounder were not recorded in the catch for Zone III (Table 5.5).

The period May through September contained the months in which the largest numbers of estimated angler hours were recorded (Table 5.6). The largest number of angler hours was recorded in August, and the largest estimated catch occurred in May. White seaperch were the most important species in the total yearly catch (pounds), followed in order by starry flounder and pile seaperch.

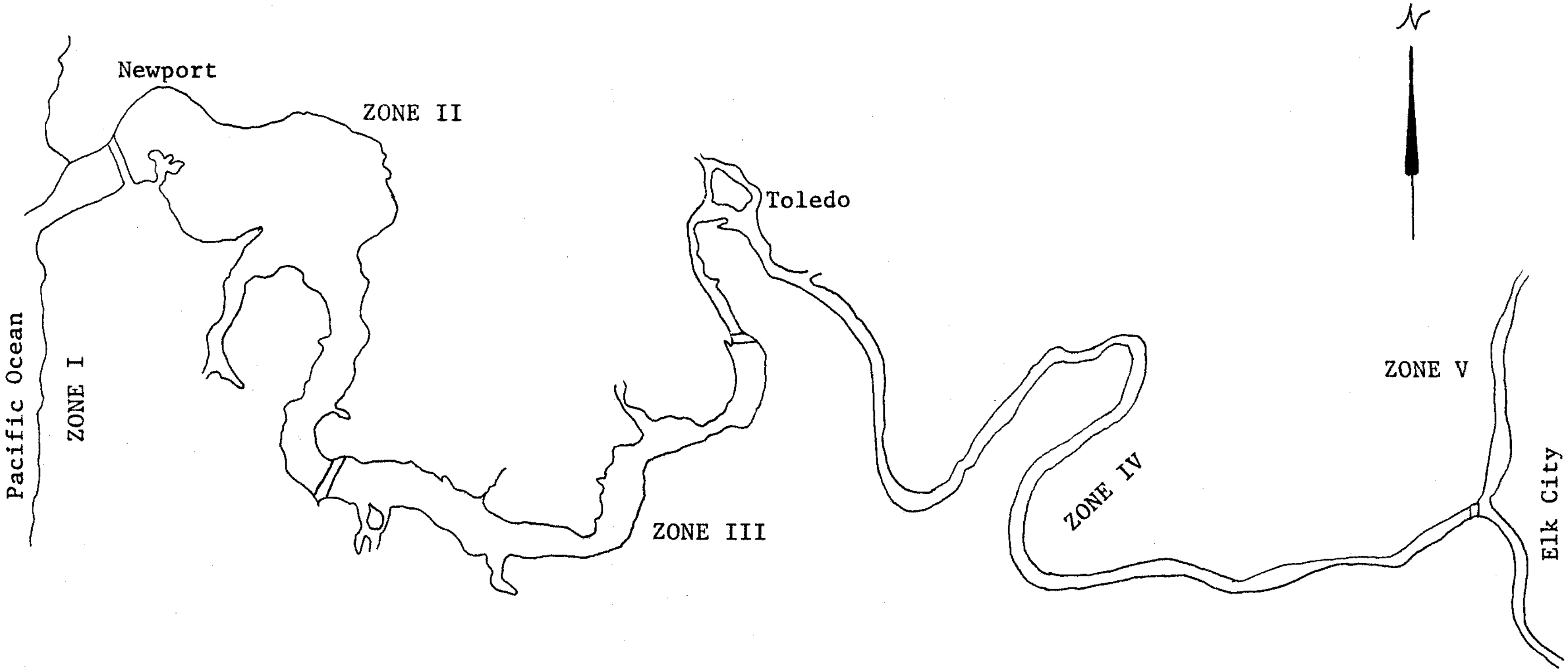

Figure 5.1. The Zones of Recreational Activities in The Yaquina Bay Area.

Table 5.3. Number of Angler Hours, Weight and Catch per Angler Hour for Miscellaneous Fishes, and Percent by Weight of the Test Species in the Catch of the Anglers Interviewed Each Month for One Year in Yaquina Bay

				Percent by Weight of Each Species in the Monthly Catch					
Date	Angler Hours	Weight of misc. fish (lb.)	Catch per angler hr. (lb.)	White Seaperch	Pile Perch	Striped Seaperch	Walleye Surfperch	Kelp Greenling	Starry Flounder
8-63	877.5	282.0	0.3	9	15	4	3	15	29
9-63	914.5	329.5	0.4	5	10	5	1	4	9
10-63	31.3	14.3	0.6	7	0	0	1	18	74
11-63	1.5	0.3	0.2	0	0	0	0	100	0
12-63	65.4	263.8	4.0	15	0	12	0	2	3
1-64	72.2	82.8	1.5	45	12	34	0	3	2
2-64	118.3	149.5	1.3	4	15	6	8	7	2
3-64	316.2	113.0	0.4	17	7	18	7	16	22
4-64	393.1	438.3	1.0	9	38	14	0	8	21
5-64	443.5	692.3	1.6	33	21	15	0	1	19
6-64	569.5	336.5	0.6	21	0	9	0	5	11
7-64	1,085.3	546.5	0.5	13	6	7	2	5	16

Table 5.4. Weight of Test Species Captured by Anglers Interviewed for One Sampling Year in Yaquina Bay

	Weight in Pounds for Each Test Species in Each Zone						
Zone	White Seaperch	Pile Perch	Striped Seaperch	Walleye Surfperch	Kelp Greenling	Starry Flounder	Total
I	39.0	7.5	64.0	1.3	80.0	152.5	344.3
II	387.8	288.3	274.8	40.5	89.0	265.0	1345.4
III	120.0	167.3	14.8	3.3	0.8	85.5	391.7
IV	5.5	0.0	0.0	0.0	0.0	3.5	9.0
V	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	552.3	463.1	353.6	45.1	169.8	506.5	2090.4

Table 5.5. Sample Weight, Estimated Total Weight, and the Percent of these Weights for Each Test Species in Each Zone for the Month of August, 1963, in Yaquina Bay

	Percent of the Sample Weight in Each Zone				Estimated Weight for Each Zone			
Species	Sample Weight (lbs.)	Zone I	Zone II	Zone III	Estimated Weight (lbs.)	Zone I	Zone II	Zone III
White Seaperch.......	24.5	6.1	80.8	13.1	557.7	34.0	450.6	73.1
Pile Perch...........	42.5	1.2	94.1	4.7	929.5	11.1	874.7	43.7
Striped Seaperch.....	10.5	57.1	42.9	0.0	247.9	141.6	106.3	0.0
Walleye Surfperch....	9.5	0.0	94.7	5.3	185.9	0.0	176.0	9.9
Starry Flounder......	82.5	51.8	48.2	0.0	1,797.1	930.9	866.2	0.0
Kelp Greenling.......	41.5	35.5	64.5	0.0	929.5	330.0	599.5	0.0

Table 5.6. Estimated Angler Hours and Catch of Miscellaneous Fishes, and Estimated Weight of Each Test Species in the Catch for Each Month in Yaquina Bay

Date	Estimated Angler Hrs.[a/]	Estimated Catch (lbs)	Estimated Weight (lbs.) of Each Test Species in the Catch						
			White Seaperch	Pile Perch	Striped Seaperch	Walleye Surfperch	Kelp Greenling	Starry Flounder	Total
8-63	20,656	6,196.8	557.7	929.5	247.9	185.9	929.5	1,797.1	4,647.6
9-63	11,469	4,887.6	244.4	488.8	244.4	24.4	195.5	439.9	1,637.4
10-63	1,561	936.6	65.6	0.0	0.0	84.3	168.0	689.3	1,007.8
11-63	1,900	380.0	0.0	0.0	0.0	0.0	380.0	0.0	380.0
12-63	2,392	9,568.0	1,435.2	0.0	1,148.2	38.3	191.4	287.0	3,100.1
1-64	1,116	1,674.0	753.3	200.9	569.2	0.0	50.2	33.5	1,607.1
2-64	3,773	4,904.9	171.7	735.7	294.3	392.4	343.3	98.1	2,035.5
3-64	4,745	1,898.0	322.7	132.9	414.6	132.9	303.7	423.3	1,630.1
4-64	4,495	4,495.0	404.6	1,708.1	629.3	13.5	359.6	944.0	4,059.1
5-64	10,804	17,286.4	5,704.5	3,630.1	2,593.0	0.0	155.6	3,284.4	15,367.6
6-64	9,465	5,679.0	1,192.6	0.0	511.1	11.4	284.0	624.7	2,623.8
7-64	17,206	8,603.0	1,118.4	516.2	602.2	172.1	430.2	1,376.5	4,215.6
TOTALS	89,582	66,509.3	11,970.7	8,342.2	7,154.2	1,055.2	3,791.6	9,997.8	42,331.7

[a/] From Stevens [1965].

Bioassays

Based on the final bioassays [Parrish, 1966], survival and daily median tolerance limits (TL_m's) for each species are presented in Table 5.7. The TL_m for white seaperch was 17.0 percent KME in 48 hours and 10.6 percent KME in 96 hours. All white seaperch died within 12 hours in the 32.0 percent concentration.

Results for striped seaperch were similar to those for white seaperch. The 48-hour TL_m was 17.3 percent and the 96-hour TL_m was 9.6 percent. Two out of 10 (20 percent) of the control specimens died. Since there were no mortalities in the 4.0 percent concentration, the test was considered valid.

Starry flounder had a 48-hour TL_m of 25.0 percent KME and a 96-hour TL_m of 12.2 percent. Most flounder lived for 96 hours in the 5.0 percent concentration.

All English sole lived in a 5.0 percent concentration of KME, but none survived in the 30.0, 40.0, and 50.0 percent concentrations. No sole lived over 72 hours in the 20.0 percent concentration. The 48-hour TL_m for English sole was 18.7 percent and the 96-hour TL_m was 8.5 percent KME.

Kelp greenling had a 48-hour TL_m of 31.0 percent KME and a 96-hour TL_m of 15.2 percent. In the 35.0 percent concentration, fish survived over 48 hours but all were dead by the end of 72 hours.

Dungeness crabs were the least affected by the KME tested. KME concentrations up to 50.0 percent produced no mortality of adult crabs and only a 6.0 percent mortality of small crabs. A mortality of 18.0 percent occurred in the control group of small crabs. Some of the small crabs molted while in the test aquaria and were unable to defend themselves while their exoskeletons hardened. Therefore, mortalities of small crabs were thought to be primarily due to cannibalism rather than KME toxicity, since crabs with soft exoskeletons were able to survive if not attacked.

Table 5.7. Percent Survival of Species in Various Concentrations of KME, and Median Tolerance Limits of KME for Each Species

Species	Time (hrs)	Percent Concentration of KME						TL_m (% KME)	Control
		6.0	9.4	14.0	21.0	32.0			
White Seaperch	48	94	100	61	39	0		17.0	100
(N = 18)	96	83	72	0	0	0		10.6	100
		4.0	6.0	9.0	13.0	20.0			
Striped Seaperch	48	100	90	90	100	20		17.3	100
(N = 10)	96	100	80	60	0	0		9.6	80
		5.0	10.0	20.0	30.0	40.0	50.0		
Starry Flounder	48	100	94	72	30	0	0	25.0	94
(N = 18)	96	94	67	6	0	0	0	12.2	94
		5.0	10.0	20.0	30.0	40.0	50.0		
English Sole	48	100	95	45	0	0	0	18.7	100
(N = 20)	96	100	35	0	0	0	0	8.5	100
		8.0	12.0	17.0	24.0	35.0			
Kelp Greenling	48	80	90	80	70	40		31.0	100
(N = 10)	96	80	70	40	0	0		15.2	100
					30.0	40.0	50.0		
Dungeness Crabs	48				100	100	100	--	88
(N = 17 small)	96				100	100	94	--	82

Preliminary bioassay data only were determined for walleye surfperch and pile perch. A lack of sufficient numbers of test specimens prevented refined bioassays for these two species. Tests of five walleye surfperch per aquaria were conducted in concentrations of 4.0, 8.0, 16.0 and 32.0 percent KME. No fish survived for 24 hours in the 32.0 percent concentration. In the 16.0 percent concentration all fish were dead within 48 hours, and no fish lived for 72 hours in the 8.0 percent solution. Therefore, the 48-hour TL_m was approximately 11.0 percent and the 96-hour TL_m was approximately 5.0 percent.

Groups of six or seven pile perch were subjected to preliminary tests in two different weekly samples of KME. In one sample of waste in concentrations of 4.0, 8.0, 16.0 and 32.0 percent, all fish in the 32.0 percent concentration died in less than 48 hours, but all fish survived for 48 hours in the 16.0 percent concentration. A second series of KME concentrations of 16.0, 20.0, and 30.0 percent was tested with groups of eight pile perch. In this series no fish lived over 48 hours in any of the KME solutions. These results emphasize variations in KME toxicity that can occur.

Because there was no apparent correlation of the information on chemicals with the final survival figures, a detailed analysis of the chemical data is omitted. The range of chemical data for all final tests was as follows: salinity 20.0-31.8 ppt; pH 7.6-8.1; and dissolved oxygen 4.4-8.2 mg/l with most values ranging between 6.0 and 8.0 mg/l.

Maximum Allowable Concentrations

The maximum allowable concentrations of KME for the species tested were determined by use of an application factor of 1/10 of a 48- and 96-hour TL_m. These are listed in Table 5.8. The computed safe concentration (maximum allowable concentration) using 1/10 of a 48-hour TL_m is approximately twice as strong as the concentrations resulting from the use of 1/10 of a 96-hour TL_m in all tests except those for the white seaperch. Maximum allowable concentrations, calculated from the 48- and 96-hour TL_m's, were used to predict changes in the distributions of fishes in the bay if KME were present. Final conclusions were based on the concentrations determined by 1/10 of a 48-hour

Table 5.8. Maximum Allowable Concentration of KME for Each Species Tested, Computed With an Application Factor of 1/10 of a 48-Hour TL_m and 1/10 of a 96-Hour TL_m

Species	1/10 x 48-hr. TL_m	1/10 x 96-hr. TL_m
White Seaperch................	1.7	1.06
Striped Seaperch..............	1.73	0.96
Starry Flounder...............	2.5	1.22
English Sole..................	1.87	0.85
Kelp Greenling................	3.1	1.52
Dungeness Crab................	---	---

TL_m, since that application factor was the one most frequently used in the literature [Aquatic Life Advisory Committee, 1955; Henderson, 1958].1/

Some Limitations

Several problems arose in the conduct of the angler survey. Occasionally an uncooperative angler would be encountered by the interviewer. If the angler refused to answer questions, the interviewer was instructed not to persist. In this manner we hoped to prevent the recording of erroneous information that might be given by an angry sportsman.

Accurate angler counts were difficult to make during periods of bad weather. Many of the larger boats were almost completely enclosed and the only way to determine the number of anglers was to count the fishing rods extending from the boat. This was particularly difficult when the angler counts were conducted from an automobile.

1/ Subsequent to this analysis, the National Technical Advisory Committee [1968] has recommended that an application factor of 1/20 of a 96-hour TL_m be used for unstable or biodegradable materials (such as KME).

Poor visibility sometimes made accurate angler counts almost impossible. Occasionally, early morning counts were cancelled due to the combination of scant light and thick fog. Heavy rain also reduced visibility and made accurate observation difficult.

The distribution of the various fishes was determined by zone only. As the anglers were interviewed, the specific area within the zone in which they were fishing was not recorded. Because of this, the precise location and relative abundance of the various species could not be determined.

According to data from the catch sampled, some of the populations of fish appeared to be restricted in their distribution during the month of August. Even though kelp greenling and starry flounder were not recorded in Zone III in August, 1963, small fishes of these two species were captured in Zone III in August, 1964, as far up the bay as Mile 11 (Figure 5.2) [Jacobson, 1965]. Striped seaperch were caught around Mile 7 (Zone III) during earlier [Gnose, 1965] and later periods of the year, even though they did not occur in the catch records for Zone III in August. Walleye surfperch were not reported from Zone I in August, 1963, but were captured there in other months of the year. Some ecological factor may have prevented these fishes from inhabiting these areas in August, but the possibility seems remote. A more logical assumption was that the fish were present in the zones mentioned, but were not captured by the anglers interviewed.

Several problems were encountered during conduct of the bioassays. The final test on starry flounder required a large quantity of KME. Therefore, to insure enough effluent from one weekly sample for the complete 96-hour test, the fish in the 20 percent and 30 percent concentrations in the two test series conducted (both series conducted simultaneously) were placed into one aquarium for each concentration when the total number of surviving fish in the same waste concentration numbered 10 or fewer.

When testing dungeness crabs in 50 percent KME, it was difficult to maintain a high level of dissolved oxygen (D.O.). Attempts to increase the level of D.O. in the aquaria by increasing the rate of aeration were not successful.

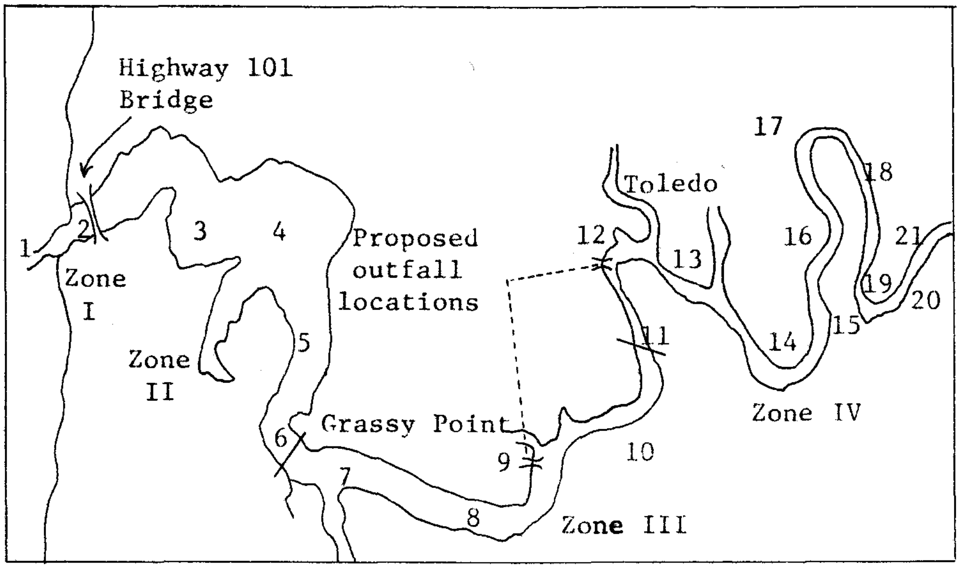

Figure 5.2. Map of Yaquina Bay, Oregon, Marked in Nautical Miles. Proposed Outfall Locations are Indicated by the Dotted Lines. [Harris, 1964.]

Increased aeration produced a violent foaming action. The foam increased until it flowed out of the aquaria. Waldichuk [1962] noted that salt-water tended to enhance the frothing action of some of the black liquor constituents of KME. If foaming was allowed to continue, the KME solution in the aquaria turned a lighter color and a soapy black scum would form on the outside of the aquaria.

Breese [1965] used bay mussel larvae (*Mytilus edulis*) to test the toxicity of dried foam and liquid residue of KME. He concluded that the dried foam was more toxic than the liquid residue produced by violent aeration. Additional testing showed a substantial loss of toxicity of the original KME concentration when the wet foam was not returned to the waste. In order to prevent excess foaming in our aquaria, the aeration rate was reduced. This resulted in lowered levels of D.O. Because all adult crabs and 94 percent of the young survived 96 hours in 50 percent KME, the lowered D.O. did not appear harmful to the test organisms.

While conducting bioassays on the selected estuarine species, simultaneous tests with the same effluent on a standard test fish were not conducted. Consequently, the bioassay results for each species of fish cannot be compared, since there was no way to measure small changes in the toxicity of weekly samples of KME. The test results reported, however, should be in the approximate toxicity range for each species tested because: (1) The final test results were near the toxicity levels indicated by the preliminary tests. (2) According to the pulp mill laboratory personnel, there were no changes in mill operation that would greatly affect the toxicity of the waste. (3) Of all the samples of KME used in bioassays on fin-fish, only one sample had a toxicity level that seemed to be appreciably higher than the others. That sample was used in the preliminary test on pile perch and was easily detected.

Another factor affecting the TL_m's was aeration of the waste in the aquaria. Aeration may have removed some of the toxic, volatile components present in the waste which would increase the TL_m's for the species tested. However, the test results using aerated KME should be indicative of the effects of KME on fish populations in Yaquina Bay because: (1) the strong effluent from the Georgia-Pacific mill is aerated as it is pumped into storage lagoons. From the open lagoons the waste is pumped to the bay. (2) After entering the estuary, the waste must travel through several tidal cycles for a distance of 9 to 12 nautical miles before reaching the ocean. Yaquina Bay is classified as a well-mixed estuary from August through November [Burt and McAlister, 1959], and KME wastes should be well exposed to sunlight and air. By the time such wastes reached areas where substantial populations of fish exist, the toxicity of the more stable components should be more important as a factor affecting the populations of fish than the unstable components present in the discharge.

Toxicity values of aerated KME may be more indicative of conditions that would occur up or down bay from the discharge point of the Toledo pulp mill than the toxicity values established from a waste that contained all of its volatile components. The toxicity values expressed here, however, should not be used for any purpose other than that for which they were established -- to give an indication of the possible effects of KME on the more important estuarine fishes of Yaquina Bay.

Application of Experimental Results to Yaquina Bay Study Area

Harris [1964] utilized salinity and river flow data obtained by Burt and Marriage [1957] to determine average KME concentrations in Yaquina Bay (Figure 5.3). The concentrations of KME reported by Harris were based upon selected waste discharge points and on salinity and river flow data taken in August, 1955, and February, 1956. August is the time normally most critical to fishes exposed to KME in the bay, because this is the period of lowest river flow (when waste concentrations in the estuary will be highest) and the period of highest water temperatures (when available concentrations of D.O. will be lowest and metabolic activities will be rapid). Consequently, our predictions of the effects of KME on the populations of the tested species in Yaquina Bay were based on the data available for August, 1963. These predictions were made for alternative location of the waste outfall at Grassy Point and Toledo.

We recognize that the maximum allowable concentrations computed may not represent a true life or death point. Fish populations may exist for varying

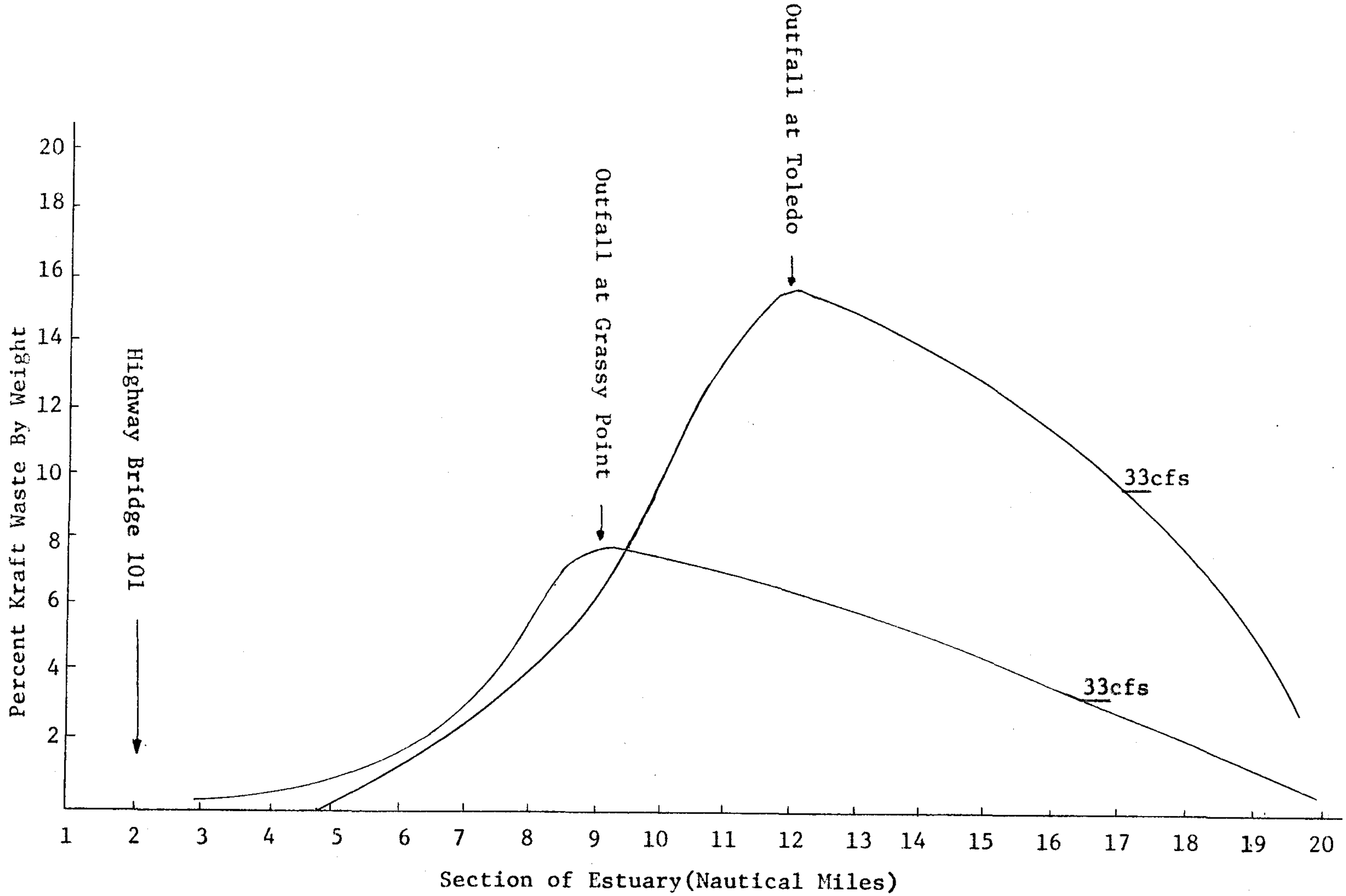

Figure 5.3. Curves of the concentrations (Percent) of Kraft Waste Resulting in the Yaquina Estuary if the Effluent From a 600-ton Per Day Kraft Process Mill were Discharged at Either Grassy Point or Toledo. (River flow assumed to be 33 cubic feet per second.) (From Harris, 1964)

periods of time in concentrations greater than the maximum allowable concentration. There is no information available on the effects of KME on the growth or reproductive success of the species tested, even though a significant reduction in either or both of these factors could prove to be limiting but not necessarily fatal to the species.

Another unknown is the effect of KME on the food organisms. The preferred food organisms of a species could conceivably be reduced greatly by concentrations of KME that could be tolerated by the predator. Breese [1964] conducted tests on *Phaeodactylum* sp. and found a reduction in growth of the algae in the presence of 5-20 percent KME. However, whether the reduction was caused by some toxic action of the KME or by the reduced light penetration due to the color of KME was not determined.

The avoidance reactions of the species tested to concentrations of KME are not known. If the tested species tended to avoid very low concentrations of KME, their distributions could be less than the maximum allowable concentration of KME computed for each species.

The following assumptions were made concerning the application of the bioassay results to the populations of the species tested:

1. The fishes used in the bioassays were representative of the species and should accurately reflect the effects of KME pollution on populations of these fishes in Yaquina Bay.

2. The conditions under which the laboratory bioassays were conducted were assumed to be analogous to natural conditions which occur in the bay, thus allowing the direct application of the results to the existing fish populations.

3. The populations of fish in the bay were assumed to be at an equilibrium of abundance. Thus, if portions of the bay were polluted, fish in the polluted areas would be displaced and lost to the fishery.

4. The total waste discharge from the pulp mill was 15,000 gallons of effluent per ton of pulp produced, and the low river flow for August, 1963, was 33 cubic feet per second [Harris, 1964]. Due to the scarcity of river flow and salinity data and to the necessary approximations in the computer solution used, Harris indicated that the average predicted pollution concentrations can only be considered as approximate.

5. The distribution of the tested species are assumed to be random throughout each zone.

6. The maximum allowable concentration of KME predicted for each species tested is assumed to represent the point beyond which the population of each species can not exist.

Based on these assumptions, the percent reduction in the linear distribution of each tested species was calculated for the month of August (Tables 5.9 and 5.10). If the waste were discharged at Grassy Point, and if the maximum allowable concentration were calculated from the 48-hour $TL_{\underline{m}}$, the percent reduction in linear distribution for the tested species would vary from 16 to 55 percent (Table 5.9). If the discharge point were located at Toledo and the same application factor were used, the percent reduction in linear distribution would be 3 to 8 percent less than the reduction that would occur if the location were at Grassy Point. The discharge of KME at the Grassy Point outlet would reduce the distribution for the tested species from 0.3 to 0.8 nautical miles more than if Toledo were used as the waste discharge point.

The use of the 96-hour $TL_{\underline{m}}$ for computing the maximum allowable concentration produced a larger reduction in linear distribution for either outfall location than was produced on the basis of a 48-hour $TL_{\underline{m}}$. Based on the 96-hour $TL_{\underline{m}}$, the difference between the amount of distribution lost to the fish populations resulting from the use of either outfall location would be from 0.4 to 1.5 nautical miles, with the use of the Toledo outlet producing a smaller reduction in the fish distributions. Waste discharge at Toledo would result in a reduction of almost 50 percent in the area of distribution for all species tested, except the striped seaperch, while waste discharge at Grassy Point would prevent the

Table 5.9. The Percent Reduction in Linear Distribution of Certain Fishes in Yaquina Bay In August, Calculated with 1/10 of a 48- and a 96-Hour TL_m, and Based upon the Discharge of Hypothetical Quantities of KME at Grassy Point

			0.1 x 48-hr. TL_m		0.1 x 96-hr. TL_m	
Species	Discharge Point	Original Distribution (nautical mi.)	Predicted Distribution (nautical mi.)	Percent Reduction in Distribution	Predicted Distribution (nautical mi.)	Percent Reduction in Distribution
Kelp Greenling	Grassy Point	11	6.8	38	5.8	47
Starry Flounder	"	11	6.7	39	5.0	55
White Seaperch	"	11	5.9	46	5.0	55
Striped Seaperch	"	7	5.9	16	5.0	29
Walleye Surfperch	"	11	5.0	55	3.8	66

Table 5.10. The Percent Reduction in Distribution of Linear Area of Certain Fishes in Yaquina Bay in August, Calculated with 1/10 of a 48- or a 96-Hour $TL_{\underline{m}}$, and Based Upon the Discharge of Hypothetical Quantities of KME at Toledo

			0.1 x 48-hr. $TL_{\underline{m}}$		0.1 x 96-hr. $TL_{\underline{m}}$	
Species	Discharge Point	Original Distribution (nautical mi.)	Predicted Distribution (nautical mi.)	Percent Reduction in Distribution	Predicted Distribution (nautical mi.)	Percent Reduction in Distribution
Kelp Greenling	Toledo	11	7.3	34	6.2	44
Starry Flounder	"	11	7.0	36	5.8	47
White Seaperch	"	11	6.4	42	5.8	47
Striped Seaperch	"	7	6.4	9	5.8	17
Walleye Surfperch	"	11	5.8	47	5.3	52

use of over 50 percent of the distributional area of all species tested, except the striped seaperch and the kelp greenling.

Since catch was recorded by zone, a comparison was made of the reduction of area in each zone, based on the discharge of waste at Grassy Point or Toledo, and calculated with 1/10 of a 48-hour TL_m and 1/10 of a 96-hour TL_m (Table 5.11). If the waste outlet were placed at Grassy Point, and if the 48-hour TL_m were used in computing the maximum allowable concentration, almost all of Zone III would be unusable to the tested species. Zone II would be reduced slightly for the white and striped seaperch populations. The walleye surfperch would lose 25 percent of their area of distribution in Zone II. If the waste outfall were placed at Toledo, the effect of the waste on all species would be reduced. Only walleye surfperch would be reduced in area in Zone II, and all species except the walleye surfperch could utilize a portion of Zone III. The percent loss of distributional area would be less if the waste outfall were placed at Toledo.

If the 96-hour TL_m, instead of the 48-hour TL_m, were used in calculating the maximum allowable concentrations, the percent reduction in area of distribution would be increased (Table 5.11). If the waste were discharged at Grassy Point, 100 percent of the distributional areas of each species in Zone III would be unusable. From 10 to 55 percent of Zone II could not be utilized by the tested species. A waste discharge location at Toledo would still remove 100 percent of Zone III for all species except kelp greenling. The loss of Zone II would only be 5 to 18 percent with most species, and there would be no reduction of distributional area for kelp greenling. Regardless of whether a 48- or 96-hour TL_m was used, the reduction of area of distribution would be less if the kraft mill waste were discharged at Toledo rather than at Grassy Point.

Summary

Based on results of the angler survey and the bioassays, the following conclusions were reached:

1. A total of 3,260 sportsmen, who spent approximately 2,790 hours in quest of food fishes and invertebrates in Yaquina Bay, were

Table 5.11. The Percent Reduction in Areal Distribution for Each Species in Each Zone for August, Calculated with 1/10 of a 48- or 96-Hour TL_m and Based on a Discharge Point of Grassy Point or Toledo

	GRASSY POINT						TOLEDO					
	Percent Reduction of Area in Each Zone						Percent Reduction of Area in Each Zone					
	0.1 x 48-hr. TL_m			0.1 x 96-hr. TL_m			0.1 x 48-hr. TL_m			0.1 x 96-hr. TL_m		
Species	Zone I	Zone II	Zone III	Zone I	Zone II	Zone III	Zone I	Zone II	Zone III	Zone I	Zone II	Zone III
Kelp Greenling......	0	0	84	0	10	100	0	0	74	0	0	96
Starry Flounder.....	0	0	86	0	25	100	0	0	80	0	5	100
White Seaperch......	0	2.5	100	0	25	100	0	0	92	0	5	100
Striped Seaperch....	0	2.5	100	0	25	100	0	0	92	0	5	100
Walleye Surfperch...	0	25.0	100	0	55	100	0	5	100	0	18	100

interviewed during the sampling year. The estimated total number of angling hours spent by the entire population that year was 89,582. Thus, the sampling rate was about 3.1 percent.

2. The largest estimated number of angler hours (20,656) was recorded in August, and the largest estimated catch (17,286 lbs.) occurred in May.

3. White seaperch was the most important species in the total yearly catch (pounds), followed by starry flounder and pile perch.

4. The following 48-hour $TL_{\underline{m}}$'s as percent KME were determined for each species: white seaperch, 17.0; striped seaperch, 17.3; starry flounder, 25.0; English sole, 18.7; kelp greenling, 31.0. Dungeness crabs were not affected by the concentrations of KME to 50 percent.

5. The maximum allowable concentration of KME for each species tested, computed with an application factor of 1/10 of a 48-hour $TL_{\underline{m}}$, was: white seaperch, 1.7 percent; striped seaperch, 1.7 percent; starry flounder, 2.5 percent; English sole, 1.9 percent; and kelp greenling, 3.1 percent.

6. The greatest reduction in distributional area for the species tested would occur if the kraft pulp mill waste outfall was located at Grassy Point instead of Toledo.

7. The following percent reductions in distributional area for each of the tested species would occur if the 48-hour $TL_{\underline{m}}$ was used to calculate the maximum allowable concentrations of KME discharged at the Toledo location: white seaperch, 42 percent; striped seaperch, 9 percent; starry flounder, 36 percent; kelp greenling, 34 percent; and walleye surfperch, 47 percent.

8. One of the purposes for conducting this research was to identify relevant biological data needed to apply the results of bioassays to various water quality situations. The application of the results of bioassays to the specific pollution problem attempted in this chapter has revealed the following areas of needed research:

   (a) The avoidance reactions of estuarine fish to various dilutions of KME should be further investigated. Avoidance tests have been conducted on some species of salmon [Jones *et al*., 1956]. These tests were conducted under laboratory conditions, and may not indicate the actual reactions of fish in a natural environment. If estuarine fish tend to avoid sub-lethal concentrations of KME, avoidance tests could be more important to the prediction of changes in fish distribution than toxicity tests.

   (b) Additional research on application factors is needed. After conducting the bioassays for this chapter, concurrence was reached with the statement of Warren and Doudoroff [1958] that simple application factors should be developed, each intended for use in connection with the control of one particular kind of waste only. If the application factors of 1/10 of 48- and 96-hour TL_m's are going to be accepted, a responsible agency should recommend conditions under which each application factor is used.

   (c) Information is lacking on the life histories of estuarine fishes. Knowledge of the temperature and oxygen requirements and salinity tolerances of the individual species is needed, so that the effects of variations of these factors on fish under the stress of KME pollution can be ascertained. The distributions of larval, juvenile, and adult fish should be accurately determined, so that the effects of KME on their distributions can be predicted. Life history studies should also provide information on the food habits of estuarine fish in order that bioassays can be conducted on the preferred foods.

(d) Tests should be made to determine the effects on the bottom fauna of fiber beds resulting from the discharge of KME in an estuary. According to Waldichuk [1962], the blanketing effect of fiber beds can have very detrimental effects on the bottom fauna of an estuary.

(e) The seriousness of tainting fish flesh by KME should be determined. Tamura, Itazawa, and Morita [1954] reported that KME gives an unpleasant odor to fish flesh. Taste may take precedence over toxicity in determining the effects of KME on the economic value of a fishery.

Chapter VI

AN ECONOMIC EVALUATION OF ALTERNATIVE LEVELS OF WATER QUALITY

The Role of Water Quality in Relation to Economic Benefits

Identification of a Recreation Quality Variable

As discussed in the previous chapter, the biological characteristics of water which appear to be of most significance for sport fisheries are the dissolved oxygen and toxicity levels. Changes in these parameters may bring about changes in the extent, vigor, and composition of the fishery resources. These characteristics, however, clearly refer to water quality rather than to the quality of the recreational opportunity as experienced by the sport angler. As such, then, physical parameters of water tell us nothing about the value of the fishery resource supported by this water.

Obviously there is a need to relate the physical parameters of water quality in sport fisheries to the decision framework of the angler. Water quality is not difficult to define; it is less obvious how to treat recreational quality. Little disagreement would be anticipated with the statement that "quality" somehow affects an individual's demand for outdoor recreation. Specifically, though, how can the quality of the recreational experience in sport angling be measured? The differences and likenesses of "quality" and "quantity" have been debated for centuries. The controversy can be traced back as far as Aristotle, who believed that quality was the basis for saying that things are like or unlike, similar or dissimilar, whereas quantity was the basis for saying that they are equal or unequal [Hutchins, 1952]. A counterargument immediately presents itself: if one admits that qualities are subject to variations in intensity or degree, does this variation also amount to a quantitative change? An affirmative answer to this question was assumed in this study. The position was also taken that some degree of quantitative measurement of the quality characteristics involved in the sport angling experience is appropriate and justifiable. The work of Zvi Griliches can be cited as being in substantial accord with this position. Griliches [1963] has proposed that the quality of a commodity be regarded as a composite of a number of different characteristics, each of which may be objectively measured or ranked.

Turning specifically to sport angling, various characteristics could be indicative of the quality of the recreational experience. The innate attractiveness of a fishery, the degree of access, and the degree of crowding are all quality considerations, as are more indirect factors such as roads, lodging, camping, and dining facilities en route to the fishery. Each of these factors is limited in usefulness by a substantial degree of subjectivity in terms of individual valuations. There is one other attribute of sport fishing, however, that is quite amenable to objective measurement. This attribute is the level of fishing success per unit of effort, as experienced by the angler. Empirically, angler success can be represented by a number of variables; "number of salmon per trip", "pounds of bottomfish per hour", and "number of clams per day" were the variables used in this study.

In addition to being amenable to objective measurement, it is argued that angling success has a high degree of relevance to the decision framework of the angler. This is not to say that anglers are highly responsive to success changes in all fisheries, but it is a hypothesis which can be subjected to empirical testing. It must be admitted, of course, that characteristics other than angling success may also be part of the bundle of quality attributes of a sport angling experience. These characteristics present much greater measurement problems; thus, it seems desirable to utilize a variable characterized by both relevance <u>and</u> ease of quantification.

With this selection of a variable to represent the quality of the recreational experience, the demand model for sport fishing at Yaquina Bay can now be more fully specified as

$$Q = f(P,I,D,K), \tag{6.1}$$

where

Q = quantity of angling effort,

P = transfer costs per angler day,

I = family income of angler,

D = distance from the fishery, and

K = angling success per unit of angling effort.

An aggregate demand function is obtained in conventional economic theory by summing up the demand functions of all individuals. The price and quantity variables are most directly relevant in this regard. Another type of aggregate relationship, however, would also be conceptually useful. This is the relationship between the level of angling success and the quantity of angling taken, or the behavioral "success-effort" relationship. A positive relationship would be anticipated, although the slope and degree of linearity of the function are matters for empirical determination.

A Biological Production Function

The problem of relating deterioration in water quality to changes in sport fishery recreational values involves biology as well as human behavior. Let us first examine some relevant biological aspects.

The first consideration is that of biomass, or the total biological production within the fishery. The production of biomass is determined by physiological, ecological, and physical factors; it may also be influenced by the intensity of fishing in previous time periods. Water temperature, dissolved oxygen (DO) levels, and toxic constituents are all water quality parameters and important determinants of total biomass. The existence of critical levels of the above factors implies a relationship between water quality and biomass that is at least curvilinear and perhaps discontinuous at some point.

Given unique levels of water quality and biomass, a biological production function can be envisioned between inputs of angler effort and the yield of fish taken in a sport fishery. Total yield corresponds to total physical product of production economic theory, whereas angling success per unit of angling effort is the marginal physical product. Although the form of the production function is an empirical question, congestion of anglers and possible depletion of fish stocks through overfishing could cause diminishing marginal productivity at high levels of angler effort. The general form of a biological production function for a sport fishery might be as shown in Figure 6.1.

Should water quality be reduced through lower dissolved oxygen levels or higher toxicity and temperature, the biological production function would shift downward. This would imply downward shifts in both the yield (total physical product) and success (marginal physical product) functions. Reduced water quality may be evidenced through lethal effects when dissolved oxygen levels become too low to support aquatic life, or when water temperature or concentration of toxic substances exceed the tolerance levels of the species. Sub-lethal effects may also be important. Avoidance reactions to low oxygen levels, or to toxic constituents such as KME, may exist. Oxygen "blocks" frequently prevent salmon runs from entering streams. Reduced oxygen levels may also cause reductions in rates of growth, reproduction, mobility, and vigor of a fish stock. Other sub-lethal effects are known or suspected by biologists, but with varying degrees of certainty.

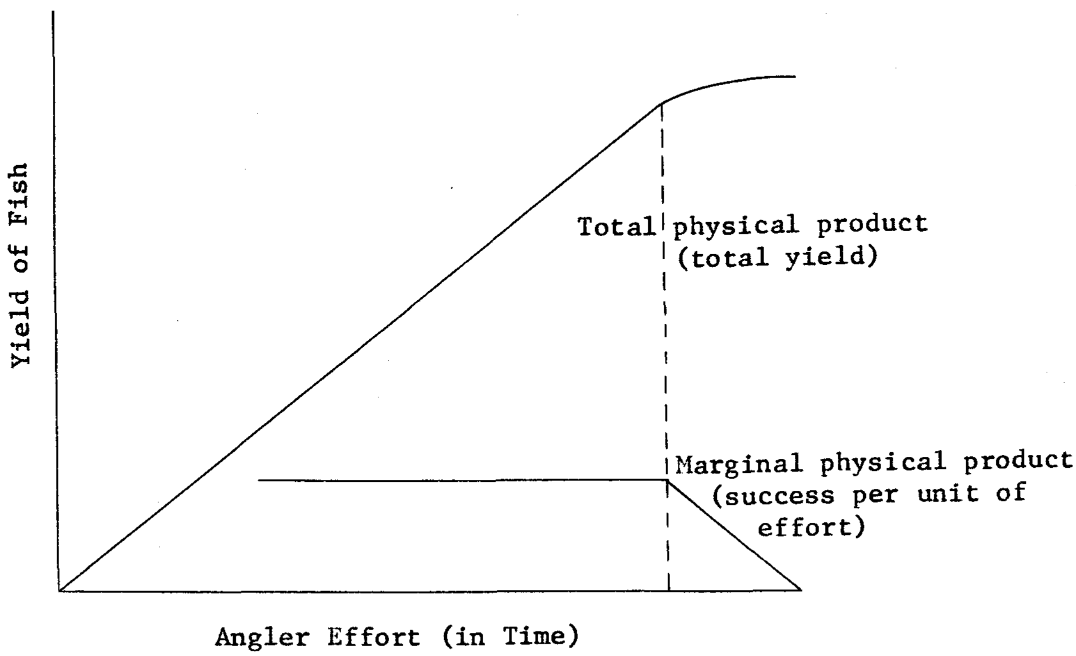

Figure 6.1. Biological Production Function for a Sport Fishery.

Equilibrium Between Biological and Behavioral Relationships

The quality variable which was identified for sport angling can now be linked to the biological production function. This will allow us to relate a particular level of water quality to the aggregate quantity of angling taken in a sport fishery. The possibility of determining the primary and secondary benefits of water pollution control may now become more apparent. What is needed is to be able to relate changes in angler effort, due to water pollution, to changes in value of the fishery itself (primary benefits) and to changes in incomes generated in the local economy (secondary benefits). This task was attempted empirically for the Yaquina Bay fisheries; the results are described later in this chapter. For now, let us return to the theoretical model.

The behavioral success-effort relationship and the marginal product of the biological production function establish the equilibrium levels of angling success and angling effort (Figure 6.2). This relationship must be viewed as analogous to the interaction of supply and demand in the determination of equilibrium price and quantity. In this analogy, biological "success" would be the supply function, and the behavioral "success-effort" relationship would be the demand function. Although the solution above is static, both functions are influenced by dynamic shifters. The biological success function is subject to day-to-day shifts, seasonal shifts, and secular shifts that depend on ecological factors and the level of management of the fishery. The behavioral success-effort function may be shifted by changes in population, income, tastes and preferences, leisure, and angling success at alternative fisheries.

The bioeconomic model thus makes possible, in a static sense, the determination of the impact of water pollution on the aggregate level of angler effort. A reduction in water quality through reduced dissolved oxygen, higher toxicity levels, or high water temperatures, would inhibit the production of biomass and cause the yield and angling success functions to be shifted downward. The lowering of the biological "success" function from S_0 to S_1 in Figure 6.2 would indicate a reduction in total angler effort from E_0 to E_1.

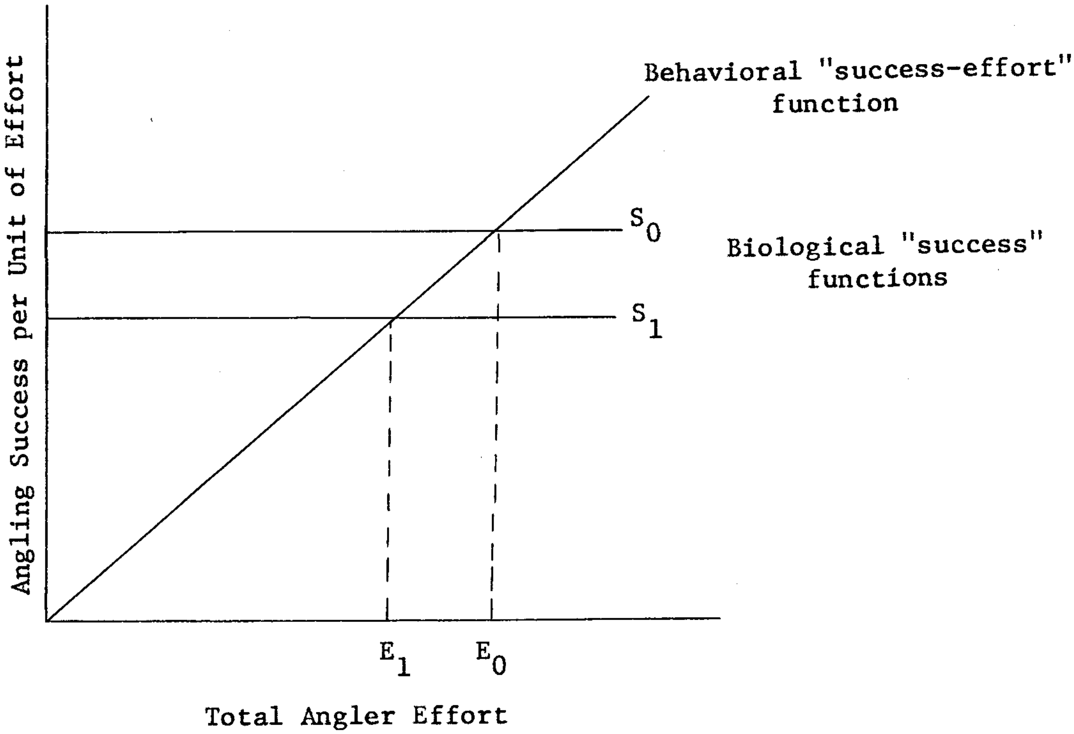

Figure 6.2. Determination of the Impact of Changes in Water Quality on Total Angler Effort in a Sport Fishery.

Implementation of the Bio-Economic Model

The operational strategy of research can now be developed more fully, given the theoretical model described above. Viewed sequentially, the empirical work can be broken down into two tasks. These are (a) estimation of the biological success function for each waste disposal alternative discussed in Chapter IV, and (b) estimation of the behavioral "success-effort" relationships for each fishery. The first task was undertaken by the biologists; the second by economists. We turn now to a description of these two empirical tasks.

Empirical Relationships Between Water Quality and Angling Effort

The Effects of Water Pollution on Angling Success

The sport fishery was divided into three categories (bottomfish, salmon, and clams), and the biological effects on the fish population were estimated for each waste disposal alternative. These estimates were based on the analysis of Chapter V, as supplemented by fisheries biology literature on those species for which bioassays were not conducted. The effects on angling success were assumed to be the same as the effects on fish population.

For the first alternative, dilution at Toledo, it was estimated that there would be a 15 percent reduction in the bottomfish population (and angling success), and a 75 percent reduction in the salmon population (and angling success). Clams were assumed to be unaffected by this disposal alternative.[1/]

The derivation of these estimates can be explained in the following manner. In the study of bottomfish, a crucial step is the use of a 1/10 application factor to adjust TL_m's for loss of biomass through processes other than death within the time limit associated with the particular TL_m. At the present state of knowledge, this adjustment is commonly used by scientists, although without any apparent scientific basis. By the use of this factor in combination with more scientific techniques, it has been determined that sample concentrations of KME would have definite effects upon certain bottomfish species. A study designed to simulate the concentration of KME in Yaquina Bay indicated that at a 6 percent concentration, up to 83 percent white seaperch (a representative bottomfish) survived a 96-hour TL_m. The application factor, a measure of reproductive ability, size, quality deterioration, etc., would reduce the concentration having an equivalent result to 6/10 of 1 percent. The tested concentration which first resulted in total elimination of this species was the 14 percent 96-hour TL_m (Table 5.6). Harris [1964] has shown by means of concentration curves that there would be KME concentrations up to 4 percent in

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1/ As apparent from Chapter V, no experiments were conducted with clams. This estimate and subsequent ones about the effect of kraft mill waste upon clam populations were based upon judgment by fisheries biologists engaged in research with clams at Yaquina Bay.

in Zones I and II. These are the predominant habitats for bottomfish. The percent reduction in linear distribution was estimated at between 5 and 15 percent; thus, a 15 percent reduction in bottomfish population was assumed as an upper limit for disposal by dilution at Toledo.

No bioassay analyses were conducted on the effect of kraft mill effluent on the salmon fishery in Yaquina Bay. Information from other fisheries, however, may serve as a guide to the likely reaction to certain concentrations. In one instance, sockeye salmon could tolerate up to a 4.8 percent full bleach KME solution in salt water, though decreasing DO levels lowered this figure to 2.5 percent [Alderdice and Brett, 1957]. In another instance, mature chinook became critically sensitive at concentrations of 1.6 percent, but younger coho and chinook resisted a 3.6 percent concentration for 14 days [Holland *et al.*, 1960]. In addition, a 0.6 percent solution was sufficient to produce a reduction in the growth rate of chinook salmon. Chinook also exhibited a marked avoidance of concentrations between 1.3 and 10.0 percent KME, while coho exhibited less avoidance, and steelhead little avoidance [Holland *et al.*, 1960]. Even more crucial was the fact that some young coho would *not* avoid lethal concentrations.

As salmon pass through the Yaquina estuary, certain zones of higher KME concentrations appear as barriers. Although the exact effects of these concentrations are not known, there is reason to believe that exposure for periods similar to those described above would be lethal. The speed of migration then becomes an important issue. Mature salmon will move in a pattern reflecting the conflict between the spawning urge and any tendency toward avoidance, both modified by the existence of freshets. Young salmon moving to the ocean experience similar reactions.

These salmon may move at speeds anywhere between 5 and 30 miles per day; thus, there is some probability that concentrations lethal in three to five days and spread over a 15 to 25 mile range could result in significant reduction in either the fall immigration or the spring emigration.

If, in fact, the disposal of a 600 ton-equivalent load of KME will result in KME concentrations ranging from 2 to 16 percent between Mile 6 and Mile 20 of the estuary, and UBOD concentrations ranging from 4 to 14 ppm between Mile 9 and Mile 16, then it appears reasonable to assume a reduction in the salmon population of 75 percent. This estimate may be an upper limit in the short-run, but the cumulative effect over a period of years may be even greater.

By using the same background information and reasoning, it was estimated that disposal by dilution at McLean Point would result in a 30 percent reduction in bottomfish angling success, a 25 percent reduction in salmon angling success, and a 75 percent reduction in clam-digging success. The latter result would be due primarily to a reduction in edible specimens. For disposal by dilution of a 300 ton-equivalent load at Toledo and piping a 300 ton-equivalent load to the ocean outfall, the values are reduced by one-half of 600 ton-equivalent load disposal at Toledo. This would result in a 7.5 percent decrease in bottomfish angling success and a 37.5 percent decrease in salmon angling success.

Measurement of "Success-Effort" Relationships

With the demand model for sports angling now more fully specified in a conceptual sense by inclusion of the success variable, attention can be given to problems of measuring the relationships between angling success and angling efforts. One problem is the choice between time series and cross section data. Time series models are commonly used in demand analysis because of price variability over time. With a sport angling demand model, however, cross-sectional estimation seems preferable because of the geographical dispersion of anglers and consequent variability in transfer costs. This, however, raises the problem of being able to obtain cross-sectional estimates of the behavioral success-effort relationships. One would expect that cross-sectional differences in angling success might be due largely to experience and knowledge of the fishery. It was thus deemed advisable to estimate the success-effort relationships from time series data and independent of the demand models of Chapter II [Stevens, 1965].

Although time series models are capable of estimating the aggregate response of anglers to success changes over various lengths of time periods, they can give no indication of cross-sectional variability among anglers in patterns of response. For this reason, a cross-sectional analysis of angler response to a series of hypothetical situations was also conducted. In the next three sections, time series and cross-section estimation procedures and results are presented and compared.

A. Time-Series Models: The intent to estimate a relationship between angling success and effort does not permit one to ignore other variables that might be closely related to one or the other. On the contrary, a fairly complete model must be specified to isolate the desired relationship. Consequently, several categories of factors which would "shift" the success-effort relationship were identified. These categories were (1) angling success at alternative fisheries, (2) total amount and distribution of leisure, (3) weather, (4) population growth, and (5) income characteristics of anglers. The *a priori* importance of each category depended upon the length of the time period under consideration. Population growth, for instance, could be disregarded in the short-run models.

Several multiple regression equations were estimated for salmon fishing to isolate the success-effort relationship. Although sufficient data were not available for the in-bay fishery, available data from the offshore salmon fishery at Yaquina Bay were taken to be equally appropriate. One equation estimated from 29 weekly observations was as follows (standard errors of the regression coefficients are shown in parentheses):

$$\begin{array}{lllll} Y = -1118.30 & + \; 3016.35\, X_1^{*} & + \; 66.9242\, X_2^{**} & - \; 2987.300\, X_3^{**} & \quad (6.2) \\ (R^2 = 0.55) & \quad (1104.10) & \quad (16.2013) & \quad (993.776) & \end{array}$$

where

Y = total angler trips across the "bar" in sport and charter boats at Newport,

X_1 = average number of salmon per angler trip in the Newport offshore fishery during the previous week,

X_2 = vehicle count at three Oregon coastal state parks within 100 miles of the fishery (taken to represent the distribution of angler leisure),

X_3 = an index of bar crossing conditions into the offshore fishery, including wind, fog, and ocean swells.

This equation revealed a positive, significant relationship between angling effort (Y) and angling success (X_1). It also made possible the estimation of a "success elasticity" which indicates the expected change in angler effort associated with a unit change in angling success, holding all other variables constant. An elasticity of +0.58 was computed from this equation, indicating that a 10 percent increase in angling success would induce an increase in angler effort of 5.8 percent. In another equation, estimated from 193 daily observations, the success elasticity for salmon fishing at the same fishery was estimated as +0.375. The smaller elasticity for the shorter time period of observation seems to imply that some time lag is involved in the transmission and receipt of information on success changes.

Time periods of analysis are generally separated, by convention, into the "short-run" and the "long-run". Price elasticities of demand estimated from long-run data will usually be larger, or more elastic, than those with data from shorter time periods. This is not unexpected in that consumers require time to adjust to new price parameters and change their spending patterns. It was hypothesized that anglers, as consumers, also require time to adjust to changes in angling success. As the length of time increases, the level of knowledge of past and present success at alternative sites increases and anglers have additional opportunity to purchase fishing equipment and become better acquainted with other fisheries. One would thus expect success elasticities estimated with long-run data to be larger than those estimated with short-run data.

This tendency toward larger adjustments with longer time periods was evident in a multiple regression equation for another Oregon coastal salmon fishery. A success-effort relationship estimated with yearly data for the offshore Winchester Bay salmon fishery over the 1952-1964 period was:

$$\underset{(R^2 = 0.67)}{Y} = -418.755 + \underset{(65.766)}{209.537\, X_1^{**}} + \underset{(0.08186)}{0.19870\, X_2^{*}} \qquad (6.3)$$

where

Y = total angler trips per year into the offshore fishery, per 10,000 population in Oregon,

X_1 = average number of salmon taken per angler trip,

X_2 = real per capita income in Oregon.

A success elasticity of 0.999 was estimated from this equation. It thus appears that salmon anglers, if given sufficient time to adjust their angling patterns, may react to changes in angling success with a response very close to unit elasticity, although the short-run response may be considerably less.

Although there appeared to be a significant relationship between angling success and effort in the Yaquina Bay salmon fishery, other types of fishermen may be less responsive to success changes. Changes in bottomfishing angling effort at Yaquina Bay, for instance, were explained largely by the distribution of angler leisure, local weather conditions, and adverse bar conditions which forced offshore salmon anglers to remain in the estuary. The influence of bottomfishing success appeared to be negligible except during certain times of the year, and then perhaps for only a few experienced and devoted local anglers. The regression coefficient of the success variable in one equation implied a success elasticity of 0.09, suggesting a very inelastic success-effort relationship. Furthermore, the regression coefficient was only slightly larger than its standard error, thus indicating a low degree of confidence in the reliability of the estimate.

Two explanations can be offered for the difference in success elasticities between salmon anglers and bottomfish anglers. First, the level of knowledge of success changes seems to be much greater for salmon anglers because of news media coverage of Oregon Game Commission reports. Second, the underlying motivations of the two types of anglers may be quite different. Bottomfish anglers may be more responsive to change in some other representative criterion of recreational quality, such as degree of crowding or adequacy of launching facilities. The argument that success is a valid representation of quality in bottomfish angling seems to be less tenable than in salmon angling, although a superior measure is not immediately apparent.

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$$\begin{array}{llll} Y = -418.755 & + \; 209.537\, X_1^{**} & + \; 0.19870\, X_2^{*} & \\ (R^2 = 0.67) & \quad (65.766) & \quad (0.08186) & \end{array} \tag{6.3}$$

where

Y = total angler trips per year into the offshore fishery, per 10,000 population in Oregon,

X_1 = average number of salmon taken per angler trip,

X_2 = real per capita income in Oregon.

A success elasticity of 0.999 was estimated from this equation. It thus appears that salmon anglers, if given sufficient time to adjust their angling patterns, may react to changes in angling success with a response very close to unit elasticity, although the short-run response may be considerably less.

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B. Cross-Section Models: Analysis of the time series data has indicated that the longer the time period, the greater is the response that can be expected to success changes. There is also reason to expect that increased distance from the angler's residence to the fishery will cause the success-effort relationship to be more elastic. This might be expected because of the greater number of angling locations available to the more distant anglers. In addition, a positive correlation might be expected between angler incomes and success elasticities, due to the larger number of leisure-time alternatives of anglers with higher incomes.

In order to test these hypotheses, mail questionnaires were used to elicit responses on a series of hypothetical angling situations. Each angler was first asked how many days he had spent fishing at Yaquina Bay during the past year. He was then asked to indicate the number of days he would have spent fishing at Yaquina Bay last year if each of a series of six hypothetical levels of success had prevailed. Success at all alternative fisheries was assumed to remain constant at actual levels. Multiple regression analysis was used to isolate the success-effort relationship and to derive estimates of success elasticities. The models were specified as:

$$\hat{Y} = \hat{b}_o + \hat{b}_1 X_1 + \hat{b}_2 X_1^2 + \hat{b}_3 X_2 \qquad (6.4)$$

where

Y = number of days which the angler indicated he would have fished,

X_1 = hypothetical level of success,

X_2 = number of days actually fished.

As many as six observations were available for each angler, since there were six hypothetical success levels. The data were stratified by distance and income of anglers, and a regression equation was estimated for each stratum. When evaluated at the means, the success elasticities ranged from zero to 0.76 for salmon anglers, from 0.66 to 1.18 for bottomfish anglers, and from 0.54 to 1.07 for clam diggers (Table 6.1). Larger elasticities were generally associated with increased incomes and distances from the fishery, thus supporting the reasoning stated earlier.

Table 6.1. Summary of Success Elasticity Estimates

Fishery	Time Series Data: Short-run	Time Series Data: Long-run	Cross-Section Data from Hypothetical Situations, Angler Stratum a/
Salmon	0.375 b/	0.999 c/	0.00 (0-25 miles, < $8,000)(0.16)
	0.584 d/		0.00 (0-25 miles, ≥ $8,000)(0.27)
			0.52 (26-200 miles, < $8,000)(0.80)
			0.76 (26-200 miles, ≥ $8,000)(0.42)
Bottomfish	0.09 b/	d/	0.66 (0-25 miles, < $8,000)(0.88)
			0.95 (0-25 miles, ≥ $8,000)(0.42)
			0.66 (26-90 miles, < $8,000)(0.28)
			0.93 (26-90 miles, ≥ $8,000)(0.44)
			0.88 (91-200 miles, < $8,000)(0.52)
			1.18 (91-200 miles, ≥ $8,000)(0.44)
Clam	e/	e/	0.80 (0-25 miles, < $6,000)(0.63)
			1.07 (0-25 miles, ≥ $6,000)(0.57)
			0.97 (26-200 miles, < $6,000)(0.61)
			0.54 (26-200 miles, ≥ $6,000)(0.80)

a/ Data in first parenthesis indicate distance from angler's residence to Yaquina Bay, and yearly family income. Figure in second parenthesis indicates the coefficient of multiple determination obtained in the regression equation for that stratum.

b/ Estimated for time periods of one day.

c/ Estimated for time periods of one year.

d/ Estimated for time periods of one week.

e/ Estimates were not made.

C. Comparisons and Critical Analysis: A variety of data and types of analysis were utilized in the derivation of success elasticities; thus, some synthesis of results is desirable. Table 6.1 summarizes the various elasticity estimates. Prior to selection of the "best" estimates, the criteria for such a selection should be defined. Among these criteria might be (1) accuracy in terms of freedom from bias, and (2) relevance to a particular decision-making framework. If one wished to predict the immediate impact on angler effort of some change in success, the short-run time series estimates might be most relevant. The response to a change in angling success due to water quality deteriorations, on the other hand, would be more appropriately regarded in terms of a long-term response. Admittedly, a definite short-run response might be forthcoming, but the long-run adjustment would be most indicative of the total response to success changes. For our purposes of estimating water pollution control benefits, then, the long-run estimates would be most relevant. The wording of the hypothetical situations in the cross-section models implied a time period of one year; thus, these estimates were taken to represent long-run responses. Considering these factors, the most appropriate estimates of success elasticities would seem to be the cross-section estimates for clam and bottomfish fisheries and the long-run time series estimate for the salmon fishery. Despite suspected bias, the lack of alternative estimates forced the use of cross-section results for the first two fisheries.

At this point, the overall reliability of this manner of obtaining data via hypothetical situations should be critically discussed. Economists generally prefer to make inferences regarding economic behavior on the basis of what people actually do, rather than what they say they will do. Even if the units of measurement may have been somewhat confusing, and the hypothetical situations fairly abstract, the various distance-income stratifications should have been equally affected. While the absolute levels of the estimated relationships may be questioned, comparisons between groups should be largely unaffected.

A claim is often made to the effect that responses to direct questioning are usually overstated. Consumers might indicate, for instance, that they would purchase more of a commodity at some very low price than they would actually purchase. This is perhaps true. In the success-effort questioning, however, many anglers indicated that they would fish the same number of days at Yaquina Bay regardless of the level of success. This occurred among salmon anglers who, as a group, were demonstrated to be responsive to success changes by the time-series analysis, as well as among the more casual clam diggers and bottomfish anglers. These responses indicate that either (a) some overriding quality considerations would more than compensate for any reduction in success, or (b) an understatement bias exists in the responses. While the first explanation cannot be disregarded, it is argued that the latter possibility is more relevant. It may have involved less mental effort for mail respondents to give the same answer to all hypothetical levels of success than it would have to introspect sufficiently to give more realistic answers. While the degree of introspection required may have been asking too much of the mail respondents, there seems to be a fairly strong argument that the responses were subject to an understatement bias.

Empirical Relationships Between Angling Effort and Economic Values

The methodology for measuring the demand for the three sport fisheries at Yaquina Bay (Chapter II) and the impact of these fisheries on the local economy (Chapter III) can now be utilized to estimate the economic benefits of each of the pollution control alternatives (Chapter IV). The two sections which follow deal with the determination of direct and indirect benefits respectively.

Direct Benefits

Estimates of "net economic value" for each of the three sport fisheries were presented in Chapter II. These estimates provide a bench-mark in that they reflect the economic values of the fisheries in the absence of water pollution. It may be recalled that the maximum revenues to a non-discriminating monopolist owner of the three fisheries were estimated to be $22,747 per year, based on 1963 data. Viewed in another manner, this would have been the maximum "rent" that users of the fisheries would have been willing to pay.

The question now arises, "What would be the value of the fisheries if the wastes from the pulp mill were to be disposed of in the alternative manners described in Chapter IV?" The conceptual framework for answering this question has been established earlier in this chapter; the reader is referred especially to Figure 6.2. To recap briefly, deteriorations in water quality would reduce angling success and thus bring biological "success" and behavioral "success-effort" relationships into a new equilibrium at a lower level of angler effort. Estimates of the empirical relationships between water quality and angling success (i.e., the effect on biological "success") and those between angling success and angling effort (i.e., behavioral "success-effort") have been made earlier in this chapter.

What remains to be done now is to draw the various empirical estimates together in order to determine the direct benefit of each waste disposal alternative. These benefits are defined as the difference in net economic value of a fishery, with and without water pollution. In other words, the potential loss in recreational values which is averted by preventing water pollution is the direct benefit. The various waste disposal alternatives will have different effects on the fisheries; thus, it would be expected that the direct benefit would be greater for some alternatives than for others.

The net economic value of the fisheries in the absence of pollution was determined by estimating demand functions for the fisheries, and then finding that level of fee increase which would maximize the rent to a hypothetical monopolist owner. The same procedure is followed for determining the net economic value of the fisheries in the presence of water pollution. The "success-effort" relationships, together with the data on quantity, price, and angler incomes in the demand equations of Chapter II, allow for the estimation of revised demand equations which correspond to the lower levels of angling success.

The procedure followed in generating the data for the revised demand equation is described in the following steps:

(1) The percentage reduction in angling success brought about by each waste disposal alternative was determined.

(2) The success elasticity associated with each revised level of angling success was calculated. This step was necessary because the value of an elasticity coefficient depends upon the point on the function at which it is calculated. The revised estimates of success elasticities were quite similar to the original estimates, although most were slightly more elastic because of the lower level of success.

(3) The percentage reduction in total angler days was calculated for each cross-sectional stratification of the demand model. This reduction was simply the product of Steps (1) and (2) above. For example, if angling success were reduced by 50 percent and the relevant success elasticity were 1.0, the number of angler days taken by anglers in a particular stratum would be reduced by 50 percent.

(4) The percentage reduction in angler days was applied to the original values of the quantity variable. In essence, this introduced a "shift" in the original demand schedule. However, this was a non-parallel shift for clam and bottomfish fisheries, since the percentage reductions in total angler days vary among different distance and income strata.

(5) Data on transfer costs and family income remain unchanged from the original demand model.

Having revised the data in view of the lower level of angling success, it was then possible to estimate revised demand equations for each of the three fisheries. The equations for the clam, bottomfish, and salmon fisheries were, respectively:

$$\text{(a)} \quad \widehat{\ln Y} = \underset{(R^2 = .72)}{6.81624} - \underset{(.41273)}{1.05283}\, P - \underset{(.15683)}{0.10701}\, I \qquad (6.5)$$

$$\text{(b)} \quad \widehat{\ln Y} = \underset{(R^2 = .93)}{7.86893} - \underset{(.07142)}{0.68738^{**}}\, P + \underset{(.12356)}{0.12287}\, I - \underset{(.00721)}{0.01341}\, I^2 \qquad (6.6)$$

$$\text{(c)} \quad \widehat{\ln Y} = 4.94486 - 0.69152\ P^{**} + 0.52347\ I^{**} - 0.02185\ I^{2**} \quad (6.7)$$
$$(R^2 = .96) \quad (.05657) \qquad (.10242) \qquad (.00481)$$

The variables are defined in Chapter II.

By finding that level of fee increase which would maximize revenues to a hypothetical non-discriminating monopolist owner (or maximize "rent" paid by anglers), it was then possible to determine the value of each fishery, given each of the waste disposal alternatives. These estimates are shown in Table 6.2.

Having derived net economic values for each of the three fisheries in the <u>absence</u> and in the <u>presence</u> of varying degrees of water pollution, the potential direct benefits associated with a waste disposal alternative are synonymous with the difference between the two estimates of net economic value.[2/] It can be seen from Table 6.3 that the largest benefit, $7,050 per year, would be associated with avoiding disposal of the pulp mill effluent at McLean Point, midway between the pulp mill and the ocean, and disposing of it in the ocean, instead. Two factors account for this. If the mill wastes were disposed of at McLean Point, the damage to the down-bay bottomfish fishery would be greater than for the other two alternatives. Also, the McLean Point outfall is in the immediate vicinity of the clam beds. As a consequence, waste disposal at this point would completely destroy the economic value of the clam resource.

<u>Indirect Benefits</u>

Before any judgment can be made on the efficiency of investment in the various waste disposal alternatives, the magnitude of indirect benefits should be considered. Indirect benefits are identified here as benefits from the recreational use of Yaquina Bay which are in addition to those described as direct

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2/ Some degree of controversy exists among economists as to the most appropriate interpretation of a recreation demand schedule in determining net economic value. Two alternative measurements, the change in consumer's surplus and the change in willingness to pay, are discussed in Appendix II. It is of interest to note here that when the consumer's surplus method is used, the benefits from disposal at McLean Point are substantially greater ($20,239) than are estimated by the non-discriminating monopolist method.

Table 6.2. Net Economic Value of the Three Fisheries (per year), Assuming Various Waste Disposal Alternatives a/

	Bottomfish	Salmon	Clams	Total
Existing Situation (negligible pollution):				
1) Disposal at ocean outfall...............	$15,366	$5,383	$1,998	$22,747
Waste Disposal Alternatives:				
2) Disposal by dilution at Toledo (near pulp mill).................	$13,376	$1,453	$1,998	$16,827
3) Disposal by dilution at McLean Point (between pulp mill and ocean)................	$11,647	$4,050	$ 0	$15,697
4) Disposal by dilution of 1/2 of effluent at Toledo and 1/2 at ocean outfall..........	$14,285	$3,852	$1,998	$20,135

a/ Based on maximum revenues to hypothetical non-discriminating monopolist.

Table 6.3. Direct Benefits Per Year Associated With Changing to Ocean Disposal from the Three Waste Disposal Alternatives, by Fishery a/

	Fishery			
	Bottomfish	Salmon	Clam	Total
Disposal by dilution at Toledo..	$1,990	$3,930	$ 0	$5,920
Disposal by dilution at McLean Point......................	$3,719	$1,333	$1,998	$7,050
Disposal by dilution of 1/2 of effluent at Toledo and 1/2 at ocean outfall.........	$1,081	$1,531	$ 0	$2,612

a/ Based on method of maximizing revenues to hypothetical non-discriminating monopolist.

benefits in the preceding section. It will be recalled from Chapter III that indirect benefits were defined as the income payments to local households associated with the expenditures made by recreationists in the Yaquina Bay area. The total of these benefits was estimated to be $57,418 per year.

It is now necessary to evaluate these indirect benefits for each of the water quality management alternatives discussed in Chapter IV. To do this will require, first, the derivation of the use of some of the relationships discussed earlier in this chapter, as well as those from the input-output model presented in Chapter III. Specifically, the following steps were taken:

(1) Demand equations were re-estimated for each waste disposal alternative, as in the previous section, but attention was focused on the estimated quantity of angler days taken <u>without</u> the imposition of any hypothetical fee increase.

(2) The estimated number of angler days was multiplied by the estimated expenditure per participant day (obtained from the sample survey of fishermen). The results of these computations are presented in Table 6.4.

(3) Total recreational expenditures associated with each waste disposal alternative were dis-aggregated by sector of the input-output model. For effluent disposal into the ocean, this was accomplished earlier (Table 3.6). The expenditures for the other disposal alternatives were allocated in the same proportions to the various commercial sectors of the economy, as had been done for disposing of the waste by pipeline to the ocean. The results of these calculations are presented in Table 6.5.

(4) The data in Table 6.5 can also be viewed as the levels of final demand associated with the alternative waste disposal methods. The use of these data and Table 3.3, as described by Equation (3.5), permits us to derive an estimate of the effect upon total sales in the economy resulting from the

Table 6.4. Estimated Recreational Expenditures, by Fishery and Disposal Alternatives

Fishery	Disposal Alternative[b]			
	Ocean[a]	Toledo	McLean Point	Toledo & Ocean
Bottomfish..........	$ 95,926	$ 82,995	$ 70,511	$ 87,512
Clams...............	11,891	11,891	1,713	11,891
Salmon..............	44,120	11,215	33,808	27,182
Trout...............	2,613	2,613	2,613	2,613
TOTAL.......	$154,550	$108,716	$108,645	$128,198

a/ Taken from Table 3.5.

b/ Total expenditures for the Toledo and McLean Point disposals were almost identical; therefore, these two alternatives will be considered as one for further computation of indirect benefits.

Table 6.5. Estimated Recreational Expenditures by Commercial Sector, and Waste Disposal Alternatives

Sector	Disposal Alternative		
	Ocean[a]	Toledo or McLean Point	Toledo & Ocean
Hotels, Motels, Trailer Parks.....	$ 23,995	$ 16,879	$ 20,059
Cafes & Taverns.....	25,346	17,829	21,188
Marinas & Marine Supplies..........	47,601	33,484	39,729
Service Stations, Automotive Sales & Repairs.........	19,319	13,590	16,150
Communications, Transportation....	618	435	517
Other Product-Oriented Wholesale & Retail..........	34,465	24,244	28,813
Other Service-Oriented Wholesale & Retail..........	3,246	2,283	2,714
TOTAL.........	$154,550	$108,716	$129,198

a/ From Table 3.6.

implementation of each of the waste disposal alternatives. These estimates are presented in Table 6.6. The data in the first column of this table describe again the existing water quality level, and are taken from Table 3.7.

The numbers in Table 6.6 have precisely the same meaning as was attached to the estimates of the economic impact of the sport fishery (Chapter III). The figures in the first column reflect the local economic impact of waste disposal by pipe line into the ocean, which is assumed to leave the recreational fishery in the bay unaffected. As with the computation of direct benefits, the ocean disposal may be viewed as a bench-mark to which the alternative waste disposal methods may be compared. Total area sales would be lowest ($223,000) for disposing of the effluent at Toledo or McLean Point, while the effect upon sales would be intermediate ($265,000) for disposing of one-half of the waste into the estuary at Toledo, with the remainder being piped to the ocean.

The various disposal alternatives bear a similar relationship to each other when expressed in terms of their effects upon area household incomes (Table 6.6), as they do in terms of total sales. It is estimated that nearly $50,000 of household incomes would be generated from recreational expenditures associated with the Toledo and Ocean disposal, while less than $42,000 would result from disposing of all of the effluent at Toledo or McLean Point. In comparison, $59,380 of household incomes would be associated with waste disposal to the ocean.

It may also be instructive to view these effects from the standpoint of changing the existing water quality regime to the alternative waste handling methods. Table 6.7 makes this comparison. It indicates that annual losses in household incomes would amount to nearly $10,000 and $18,000 for changing the present water quality management system to "Toledo and Ocean" and "Toledo or McLean Point" disposal, respectively.

At this point it is appropriate to focus again upon the limitations within which the above numerical estimates must be viewed. Estimates of the secondary benefits are, first of all, subject to the limitations underlying

Table 6.6. Effect of Sport Fishing Expenditures upon Total Sales, by Disposal Alternative and Sector, Using Input-Output Analysis

Sector	Disposal Alternative		
	Ocean[a]	Toledo or McLean Point	Toledo & Ocean
Lumber, Pulp & Paper..............	$ 1,163	$ 818	$ 972
All Other Manufacturing.............	724	509	605
Hotels, Motels, Trailer Parks.......	24,669	17,371	20,623
Cafes & Taverns.......	28,037	19,722	23,437
Marinas & Marine Supplies............	47,782	33,611	39,943
Fisheries............	2,066	1,453	1,727
Service Stations, Automotive Sales & Repairs...........	42,742	30,059	35,718
Communications, Transportation......	8,616	6,062	7,203
Professional Services...........	3,619	2,546	3,025
Banks & Loan Agencies.	4,313	3,035	3,605
Construction..........	7,461	5,251	6,237
Other Product-Oriented Wholesale & Retail..	63,482	44,663	53,070
Other Service-Oriented Wholesale & Retail..	18,827	13,250	15,740
Agriculture..........	1,586	1,116	1,326
Government............	2,930	2,062	2,449
Households............	59,380	41,765	49,619
TOTAL..........	$317,397	$223,293	$265,299

[a] From Table 3.7.

Table 6.7. Estimated Effects upon Total Area Sales and Household Incomes, of Changing from Ocean Disposal to Alternative Waste Handling Systems

Disposal Alternative	Effect Upon	
	Total Sales	Household Incomes
Toledo and Ocean.................	$52,098	$ 9,761
Toledo or McLean Point...........	94,104	17,615

the estimates of recreational participation at Yaquina Bay, given the existing water quality regime. Furthermore, they are subject to errors in the estimates of the various success-effort relationships which, in turn, depend upon the reliability of the estimates of the underlying biologic and hydrologic relationships. These shortcomings have been discussed in earlier sections.

There are, however, additional limitations which are intrinsic to the method of secondary benefit estimation employed in this study. One may criticize the results of the analysis because an inappropriate method was used to derive them. Students of input-output techniques have generally agreed that models of the type employed here are most appropriately used to describe the existing structure of a regional economy. They are less well suited for the analysis of the effects of significant changes imposed upon the economy from the outside. Such models can only portray the impact of these exogenous variables within the existing economic structure, which is determined by the trade relationships existing before the economic change occurred. In other words, such influences as changes in factor or product prices which are likely to affect the existing trade relationships cannot be reflected in the model. The application in this study required, of course, the prediction of the consequences of exogenous changes, namely, variations in the levels of recreational expenditures. Perhaps there is one ameliorating circumstance: as indicated earlier, the effects analyzed here involve proportionately small variations in the levels of final demand. Hence, required changes in trade relationships are also likely to be small. Later on, we will analyze one case which violates this condition.

Another source of error which is also difficult to assess is contained in the data used for the construction of the input-output model. As was indicated, part of the data was collected through sample surveys. The effects of sampling errors in data collection for input-output models are difficult to quantify. No attempt at formal quantification was made in this study. Furthermore, on the basis of a subjective evaluation, the various primary and secondary data sources did not seem to be of uniform reliability. Data from various sources had to be combined and reconciled with one another. It is likely that these processes involved errors of judgment. The only possible checks on the extent of these kinds of errors is the comparison of the results from this study with those obtained from other studies. One such comparison was made. Generally, the multipliers estimated by this model were consistent with those obtained in the other application [Bromley and Stoevener, 1969].

Chapter VII

INSTITUTIONAL CONSIDERATIONS

Introduction

Institutional considerations represent one of the final steps in this analysis of the economic consequence of different levels of water quality in Yaquina Bay [Sokoloski, 1967]. Ideally, these considerations will provide sufficient information to complement the various quantitative results in the process of generating policy considerations.

The step-by-step process of quantitative analysis has revealed the interdisciplinary nature of this endeavor. The combination of investigations in engineering, biology, and economics has produced distinct quantitative results for each of the hypothesized effluent disposal procedures and their resultant water quality levels. It is possible, however, that one or more of the alternatives examined will be entirely precluded by some prevailing institutional element, or conversely, that the institutional environment will need to be modified to some degree to permit enactment of the alternative(s) considered.

Each of the disposal alternatives have implications with respect to the economic sectors affected by these alternatives. Each different resource use pattern involves water rights, pollution laws, and/or administrative guidelines or mechanisms associated with the previous resource use pattern. Existing institutions may either be conducive or inhibitory to resource use adjustments. Given these considerations, the results of prior analysis are now re-examined from the point of view of the institutional implications involved.

The Institutions

Water Rights

Those who use the water of the estuary, and those who are subject to the environmental effects of the waste, have certain rights which exist as a lower limit to their use of the water. Beyond this, individual rights are merged into a common right to use the water.

The minimum rights existing in the absence of ownership take the form of legal rights. These rights substitute for ownership in the economic decision-making process. Being subject to the interpretation of the courts, these legal property rights are, at best, completely secure only in the short-run.

The following are condensations of pertinent Oregon Revised Statutes regarding water laws now in force in Oregon.

<u>537.110</u> All water within the State belongs to the public.

<u>537.120</u> All waters in the State may be appropriated, subject to existing rights.

<u>537.130</u> A permit from the State Engineer is necessary to appropriate water for beneficial use(s).

<u>537.140</u> Each application shall designate source, use, and associated construction.

<u>537.160</u> Subject to the degree of beneficial use and conflict with existing rights, the State Engineer shall grant a permit.

<u>537.170</u> A conflicting application for the right to appropriate water must be submitted to the State Water Resources Board, which rejects or revises said application, using such guides as:

(a) conserving the "highest (priority) use"

(b) "maximizing economic development"

(c) retaining State control

(d) the quantity available

(e) existing rights

<u>537.250</u> An individual water right shall continue so long as the water is applied to a beneficial use.

<u>540.030</u> If scarce, water shall be allocated in the order of municipal, agricultural, and finally industrial, uses.

<u>540.140</u> The State Engineer shall make regulations governing the distribution of water, subject to individual rights and State laws.

540.720 No person shall use or waste water entitled to another.

Briefly, these laws apply only in varying degrees to the regulation of water rights on the Yaquina Bay Estuary. This is because exclusive rights cannot be granted for the use of estuarine waters, and because there has been little adjudication of fresh water rights in the humid regions of Oregon.

Pollution Law

As pollution increased with the growth in water use, administration of pollution problems followed the typical riparian-appropriative sequence. Certain guidelines for the compensation of damages incurred by pollution were developed. In pre-statutory form, compensation to damaged lower riparian owners was measured by losses in market value of the property [American Law Review, Vol. 38]. Loss of rights and liability were not to be included in these damages [American Law Review, Vol. 47]. If the damage is repairable at a lower cost, this cost becomes the measure of compensation. Non-permanent, abateable injury may be equated with depreciated values during damaged periods. Punitive claims, loss of the use and enjoyment of private property, noxious odors, loss of fishing privileges or the right to unpolluted water, will lead to allowance of damage claims in some cases [American Law Review, Vols. 46 and 49]. Although the State may restrain the uses of water in the interest of general welfare, it may not eliminate private property rights [Roberts, 1936].

Early statutes supplementing rights decisions were concerned solely with domestic and farm purposes and fish life [Oregon State Planning Board, 1956]. It was not until 1938 that anything other than these few statutes on specific subjects existed. At this time an initiative measure was passed which created the State Sanitary Authority within the State Board of Health. Oregon Revised Statutes pertinent to the operation of this authority and to this study are given below in digest form.

449.077 In the interest of public welfare, safety, peace and morale of the people, it is declared to be the public policy of the State of Oregon to: (a) maintain reasonable standards of purity, and (b) foster and encourage cooperation. (Note: this chapter shall be liberally construed for these purposes.)

<u>449.080</u> Designates powers to encourage cooperation, formulate, revise, study, and enforce pollution load requirements.

<u>449.086</u> Considers the extent to which floating or suspended solids, organisms, and biochemical oxygen demands may be allowed in water.

<u>449.095</u> The use of water as an effluent carrier is not acceptable, and is classified as a public nuisance.

<u>449.100</u> Power is relegated to the State Sanitary Authority to use legal measures to prevent pollution when an emergency requires immediate action to protect public health.

<u>509.460</u> Proclaims that it is unlawful for any individual or public agency to deposit injurious matter into State waters.

In addition to these State statutes, the Federal Water Pollution Control Act and its successors inevitably influence the formation of water policy. The following are summarizations of the general character of this Act.

1. Reaffirms congressional policy to protect states' rights.
2. Empowers the Secretary of Health, Education, and Welfare to initiate enforcement proceedings when pollution of interstate waters was occurring.
3. Authorized increased technical assistance and research effort by using non-Federal public and private institutions.
4. Authorized collection and distribution of appropriate data.
5. Directed the Surgeon General to continue to encourage interstate compacts and uniform laws.
6. Authorized grants to state and interstate agencies for water pollution control activities.
7. Authorized Federal grants for the construction of municipal treatment works.

Subsequent amendments stressed the value of interstate compacts, and the necessity of action being initiated only upon the request of the states in matters concerning interstate or navigable waters. The Clean Water Restoration Act of 1966 dictates a study of all estuarine zones of the United States to determine the effects of all forms of pollution on the many uses of water in these areas.

Government Operation and Organization

Government organizations can be described with respect to their legal limits and performance efficiency.

Legal Limits - County. There are provisions for two types of county government in Oregon - the county court or commission form, and the county manager form. As of 1966, the latter alternative had never been adopted. Under the former, a maximum of seven officers may be elected and additional officers, as specified by the constitution, may be appointed.

Within this framework, counties are units of limited governing powers, designated as public corporations; they do not have the power to enact legislation for the general public health, safety, and welfare. All authority is derived from the original constitution of the State and additional amendments or statutes dealing with some specific functions. This includes recent provision for planning and zoning commissions.

In 1958 a county home rule amendment was passed which allows county voters to "adopt, amend, revise or repeal a county charter" (Oregon Constitution, Article VI, Section 10). Counties are allowed to exercise powers which are a matter of county concern, if not disallowed by state law. Thus, county government may be free (theoretically) to establish a more modern framework for the administration of its tasks, unencumbered by the framework of the past. Adoption in Oregon has been hindered by the fact that this amendment has been laid out in excessive detail, somewhat defeating the conceptual purpose of home rule.

Legal Limits - Special Districts. Although each type of special district in Oregon has some unique characteristic, "all are organized in a manner similar to cities, following the basic steps of petition, hearing, and election" [Oregon Legislative Interim Committee on Local Government, 1956]. The proceedings to begin a district may be initiated by a city or county governing body or by the county court acting upon a popular petition. Most have three-to-five members serving without compensation, with only a few requiring skilled, well-paid members. There is little authority for these districts to perform more than one duty, and each new activity therefore requires a new district if this form of management is desired. The fiscal authority of these districts must be within the limits prescribed by statutes.

Legal Limits - State. At the state level, one unit which would be appropriate as a water management unit is the State Water Resources Board. In that this group is specifically concerned with water resources, its legal guidelines are more extensive than those of the counties and special districts. A summary statement of these guidelines is as follows:

1. To be concerned with general welfare - for maximizing economic growth associated with water - through integrated development plans - to secure maximum beneficial use and control while always considering multiple use.

2. To consider supply, conservation, and augmentation of state water resources and subsequently to formulate a plan to achieve the needs revealed by these studies.

3. The Board shall consider existing rights (if toward a beneficial use), maximum economic development for the state as a whole, discouraging exploitative single purpose use, maintaining stream flow and discouraging pollution, while considering human needs first.

4. Subject to existing rights and priorities, the Board may classify and reclassify waters as an aid in formulating a balanced development program.

Relevant Empirical Results

Earlier portions of this publication present quantitative estimates of the effects of certain water quality management alternatives. Those results that are relevant to this analysis provide information about:

1. The implied changes in the distribution of the physical uses of water - both with respect to quantity and quality.

2. The specification of those sectors within the economy involved with each alternative water use pattern.

3. The magnitude of each sector's involvement for each alternative (indirect effects).

4. The magnitude of the direct results for each alternative.

With this information one can proceed to:

1. Examine legal conflicts associated with certain physical changes, and identify which, if any, of the existing management entities can initiate and supervise these changes.

2. Determine the ability of these entities to involve those affected by each alternative in the public processes of choosing between these alternatives.

3. Determine the degree to which each sector might participate, depending to some degree on the ascertainable extent of its unavoidable economic involvement.

4. Determine the degree to which sectors other than those directly concerned might be affected by and, therefore, involved in the decision-making process.

Pertinent data, as summarized in Table 7.1, indicate that the impact of changing the disposal alternative from the one actually implemented would be largely confined to those sectors affected directly by a decrease in final demand. Nearly 90 percent of the total change in household incomes would occur in those sectors which directly supply goods and services to recreationists.

Further, the magnitude of the largest possible change in total sales ($94,104) amounts to less than 1/10 of 1 percent of the gross sales of the Yaquina Bay economy ($124.07 million). Although some incentive for adjustment is still provided, the mechanism to facilitate this adjustment need not be designed for massive reorientation. Instead, the data suggest that institutional modification should focus on providing for incremental change.

Evaluation: The Role of Institutions

Four elements of this analysis remain to be discussed. These are: (1) criteria for the evaluation of government entities; (2) a measure of net flows; (3) the relation of these flows to the role of compensation in welfare theory; and (4) the positive elements of certain existing institutions with regard to the compensation issue and adjustments in resource use patterns.

(1) Though the government entities considered here have been evaluated to

Table 7.1. Distribution of Losses Associated with Changing from Ocean Disposal to Other Disposal Alternatives, by Sector

Sector	Toledo or McLean Point		Toledo and Ocean	
	Reduction in Total Sales a/	Reduction in Household Incomes b/	Reduction in Total Sales a/	Reduction in Household Incomes b/
Hotels, Motels, Trailer Parks........................	$ 7,298	$ 2,406	$ 4,046	$ 1,334
Cafes & Taverns..................	8,315	2,391	4,600	1,323
Marinas & Marine Supplies........	14,171	3,374	7,839	1,866
Service Stations, Automotive Sales & Repair................	12,683	1,170	7,024	648
Communications, Transportation................	2,554	679	1,413	376
Other Product-Oriented Wholesale & Retail............	18,819	2,324	10,412	1,286
Other Service-Oriented Wholesale & Retail............	5,577	3,072	3,087	1,700
Sub-Total..............	(69,417)	(15,416)	(38,421)	(8,533)
Households......................	17,615	89	9,761	50
Remaining Sectors................	7,072	2,085	3,916	1,155
TOTAL ALL SECTORS.........	$94,104	$17,590	$52,098	$9,738

a/ Computed from Table 6.6.

b/ Computed by multiplying the reduction in a sector's sales by that sector's household row coefficient (a_{16_j}) from Table 3.2.

a degree, it is possible that future solutions to the problems of resource management may include either alterations of existing forms or the addition of new units. For this purpose, and to further specify strong and weak points in existing forms, the following criteria are suggested. They may also be used to design the "ideal" unit or set of units. The unit of government should:

(a) Be large enough to enable benefits from its service to be felt primarily within its jurisdiction and to permit realization of economies of scale;

(b) have the legal and administrative ability to perform services assigned to it;

(c) have a sufficient number of functions so that its governing processes involve a resolution of conflicting interests, with significant responsibility for balancing government needs and resources;

(d) have its functions controllable by and accessible to its residents (the resource users);

(e) have a continuous management process (for water) characterized by flexibility, both with respect to administrative policy and the actual form of the administrative organization; and

(f) have the authority and ability to represent its resource users in all activities involving other local, state, and federal entities having similar responsibilities.

(2) Previous references to the magnitude of the monetary flows resulting from the initiation of a disposal alternative were only gross measures. These results do not fully account for all of the marginal social effects of the alternatives considered. To do this, it is also necessary to consider changes in the costs associated with each disposal alternative as well as the benefits associated with each. This total effect would more completely represent the net effect of contemplated changes in disposal techniques, as compared to the existing ocean disposal. The following formula may be used to ascertain the net residual:

$$(EC - NC) - [(EBF - NBF)] = Net \qquad (7.1)$$

where

EC = Cost of the existing waste disposal method.

NC = Cost of the new disposal method being considered.

EBF = Direct and indirect benefits resulting from fishing activity associated with the water quality level of the existing disposal alternative.

NBF = Direct and indirect benefits resulting from fishing activity associated with the water quality of a new disposal alternative.

Net = The incremental gain or loss to the area economy resulting from a comparison of changes in costs of disposal and resultant income flows for a given alternative as compared to the original disposal technique.

The residuals for the alternatives to ocean disposal are shown in Table 7.2.

These figures are solely for the sport fishery within the bay; they do not account for expenditures complementary to but not measured by fishing activity. The data included here, however, do provide some indication of rank as to social benefit to be generated by the various disposal alternatives.

(3) In the context of welfare economics, a familiar example is recited which involves three firms. Firm A follows a production pattern which affects Firm B, and is beyond B's control. Next, results are altered through prices in B's inputs and/or outputs; the chain of events will subsequently involve Firm C, which deals with these inputs or outputs. The interaction between A and B is designated a technological externality, and that between B and C a pecuniary externality.

These external relationships and the resultant flows may be equated with the sectoral interrelationships keyed to water quality levels as studied here. The results in Table 7.2 give a measure of the cumulative effect of these flows.

Table 7.2. The Residual of Costs and Benefits for Disposal Alternatives Within Yaquina Bay, as Contrasted to Ocean Disposal

Method of Disposal	Annual Costs[a]		Cost Savings	Annual Benefits[b]				Benefit Reductions (EBF - NBF)		Annual Net Gain
				EBF		NBF				
	EC	NC	(EC - NC)	Direct	Indirect	Direct	Indirect	Direct	Indirect	
Existing:										
Ocean.....	$139,000	$ --	$ --	$22,747	$59,380	$ --	$ --	$ --	$ --	$ --
Alternatives:										
Toledo....	--	6,000	133,000	--	--	16,827	41,765	5,920	17,615	109,465
McLean Point...	--	44,000	73,000	--	--	15,697	41,765	7,050	17,615	48,335
Toledo - Ocean...	--	100,500	38,500	--	--	20,135	49,619	2,612	9,761	26,127

a/ Annual costs include amortization, power, and operation and maintenance [Harris, 1964].

b/ From Tables 6.2 and 6.6.

An additional element of welfare theory which may now be focused upon as being relevant is the matter of compensation. With respect to the relationship between Firms A, B, and C, above, it is possible that there may be sufficient opportunity and incentive for B to be willing to "bribe" A into restraining that particular activity which generates a technological diseconomy. C might contribute a portion of this bribe. Both would calculate the quantity of their bribe and their willingness to participate on a marginal basis, as would Firm A in its decision to accept the bribe.

Without repeating all of the complex arguments concerning various imperfections in the optimization qualities of this scheme, let it suffice to say that in a second-best maximization scheme, i.e., maximizing subject to certain constraints, the bribe techniques could be used to improve resource allocation. Further, in a public framework one might substitute an approximately equivalent technique of charging effluent dischargers and use these funds to install treatment facilities. Additional funds could be obtained by taxing gains from those benefiting from the treated water.

The quantitative elements of this study provide many of the measures necessary for such a plan, and the legal elements indicate the feasible range. It would seem appropriate, therefore, to include this compensation mechanism in a final evaluation of the capabilities of certain government management forms. This issue is discussed in greater detail in the next chapter.

(4) Using the criteria stated in (1), the values in (2), and acknowledging the potential of (3), the following administrative organization is suggested. It represents a combination of state and local units, with each level doing the function to which it was best suited.

<u>Functions of the Local Unit</u>

(a) Register conflict and desire for change.

(b) Request information on economic, biological, legal, and engineering parameters.

(c) Petition for the designation of an area as a resource area.

(d) Schedule elections or other local decision-making processes, conforming to alternatives allowed by the state agency.

(e) Administer local operative details.

Functions of the State Unit

(a) Oversee the establishment of the local resource area.

(b) Delineate alternatives and provide data.

(c) Indicate solutions consistent with state resource planning.

(d) Aid in the supervision of elective or other decision-making processes.

(e) Register conflict and desire for change, external to the local unit.

Conclusions

Throughout this chapter the central theme has been concerned with the degree to which existing institutions might alter the degree to which any of the disposal alternatives might be considered or enacted. Further, an examination of the magnitude and pattern of monetary flows suggests a structure for a management entity.

At this juncture one must conclude that the most formidable barriers to adjustment are pollution laws which prohibit any degree of effluent dilution, and the absence of a local management unit to facilitate whatever adjustments might be possible. When one considers the complexity of resource management problems, the need for flexibility in management becomes apparent.

Though institutions do not presently exist with the capabilities for the resource management activities considered here, there are many positive elements in these institutions which may act as foundation blocks for a state-local management structure. Considering existing characteristics of the problem and selected other criteria, a state-local form is suggested. Within this form the State Water Resources Board, or similar agency, would provide supervisory, coordinating, and data collecting and analysis services. The local unit, a special district or county, could be vested with certain initiating and operating functions.

In summation, not all the disposal alternatives physically and biologically possible can be considered within the present institutional environment. Should it be acceptable to those sectors affected, and also to those with appropriate authority, certain legal and administrative adjustments can be identified which would facilitate the initiation of new alternatives. The following chapter attempts to focus these ideas within such a decision framework.

Chapter VIII

RESOURCE MANAGEMENT DECISIONS

Externalities and Public Policy

The previous chapters have considered in depth the various facets of the resource quality problem of the case study area. The purpose of this chapter is to integrate these many considerations into a meaningful whole, with an eye to the public management of these natural resources. Resource quality management cannot be entrusted entirely to private decision-making; it is a problem for public policy. The case study situation provides a classic illustration of public policy issues inherent in the pollution problem.

To this time the literature on water quality has concentrated almost exclusively on a viewpoint which might be described as that of "society as a whole". The economist has, in his discipline, a normative construct which permits him to judge policy on the basis of impact on "net national benefits" [Kneese, 1962]. It is this construct that leads to the development of the "basin-wide firm" and permits the choice of policies that will maximize the economic return from the resources of the area.1/ Such a tool is an exceedingly valuable one, because it provides for the judgment of private and public decisions and for the use of such institutional devices as taxes and subsidies. The technique is a relatively simple one. If an enterprise economy does not behave in such a way that the laissez-faire decisions of individuals result in the greatest total good, the incentive system is changed so that they will. This powerful notion forms much of the basis for resource management policy.

As noted earlier, the reason that individual decisions will not necessarily result in maximum net benefits for society is the existence of what the

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1/ The assumption here, of course, is that the distribution of income is not materially affected, and that prevailing prices provide an accurate yardstick to the system of preferences existing in society.

economist calls "externalities". Earlier in this publication, estimates of these "externalities" were presented for the case study area. Stated crudely, "externalities" are defined as those benefits and costs resulting somewhere in society that are not reflected in the stimuli of the private decision-maker. The damage caused by a polluter is the classic example of an externality. An external cost is called a "diseconomy". An external benefit is called an "economy". An obvious method of modifying stimuli is to tax those economic activities creating diseconomies and to bless with bounties (or subsidies) those economic activities that result in external economies.

As powerful as the above notion is, however, it is not a complete framework for resource quality management. It does not pretend to describe a situation in detail. It does not consider motivation in detail. As a consequence, it tends to emphasize normative considerations rather than explain motivation in a positive sense.

In the typical situation there is virtually no one who is considering the "national" or "regional" situation as such. We normally have "polluters" and those who suffer from pollution. However, there is evidence that people are considering community and area impacts to a much greater extent than has previously been the case. Even so, there is benefit in viewing the situation from the standpoint of those who are the principal participants. In this connection, it will make a difference whether the polluter has already located in an area and is in business, or whether he is making a location decision.

Limitations of the Study

There are innumerable limitations in a study of this kind. One of the more obvious problems is that of correctly estimating the magnitudes involved. The authors are well aware that substantial error may be associated with the estimates presented. There are, however, more serious but more subtle limitations that need to be discussed in depth. These are discussed under two main headings: (1) present-day conditions and uncertainty, and (2) items not measured.

Present-Day Conditions and Uncertainty

Care has been exercised in the manuscript to qualify all empirical estimates. Again, it is emphasized they are, in all cases, estimates. Furthermore, it was impossible in many cases to place confidence limits on the estimates. For this reason, an element of uncertainty is introduced into the analysis. This source of uncertainty is not judged to be serious for the following reasons:

1. Considerable effort and care was expended in developing the estimates. Accepted methodology was used at all stages in their development.

2. The order of magnitude among the crucial variables is such that tremendous error would have to exist before substantive conclusions would change. This can be substantiated by a study of inequalities presented below.

3. The case study area was selected as an example of a class of problems existing in society. Although the accuracy of estimates is highly desirable for actual decisions in the case study area, they are not crucial to the conclusions reached from this research. It is important to know, of course, that such estimates can be made, and to realize the problems encountered in making such estimates.

Another source of uncertainty is of much greater concern in a decision context. This relates to the changes that will inevitably occur with the passage of time. Some decisions are irreversible or can be reversed only at very high cost. In such cases the penalty of a wrong decision can be quite high. Quality changes in the environment are often considered to be in this category. However, as man better understands his environment, his ability to reverse a given process will improve. Nevertheless, until such knowledge is at hand or on the horizon, prudence would suggest a healthy conservatism. In the following discussion, conditions existing at the time of the study are assumed. Suggestions regarding institutional design, however, are made in light of the need for new information to be reflected in group decisions as such information becomes available.

Items Not Measured

Not all of the undesirable effluents from the paper mill have the potential of being discharged into the estuary. Some escape into the atmosphere and contribute to air pollution.[2/] If a total enumeration of costs and benefits of the location of the plant were desired, these would have to be taken into account. However, the exclusion of air pollution effects does not affect the conclusions pertaining to institutional design.

In the estimates of economic activity affected by the paper mill, measurement was made of those activities where a direct causal relationship was evident. We know that some activities were not considered. Commercial crabbing, oyster production, and bait fishing are cases in point. Furthermore, there are those who enjoy the estuary for scenic purposes only, but whose enjoyment is reduced by the knowledge that pollution is occurring. Whether these types of effects are significant or not is an open question.

Value Judgments

In the paragraphs that follow, an attempt is made to bring the preceding materials together in a way that will be most helpful in group decision-making. In doing this, certain value judgments are necessary. These value judgments are made explicit as follows:

1. Those affected by economic decisions should have an opportunity to participate in the making of those decisions. This is consistent with democratic traditions, although there is no scientific proof at this time that this necessarily maximizes human welfare.

2. The economic institutions and economic variables for the

2/ An analysis of the effects of air pollution on residential property values in Toledo has been reported in an earlier publication [Jaksch and Stoevener, 1970].

total economy are taken as given. It is recognized that these may not be optimum. Nevertheless, the presumption is that they are not highly undesirable or a democratic society would change them. In any case, to treat them as variables would change the focus of this study from that of the economics of water quality management.

3. A resource management institution is inadmissible which prevents the maximization of net national product. It is recognized that all decisions made will not necessarily result in this end, and no judgment is made that they necessarily should. However, it is believed a resource management institution which would preclude this would not be a viable institution.

4. The relative superiority of different distributions of a given amount of community or area income cannot be determined on scientific grounds. Institutional design must provide for choices in this respect.

The Case Study Situation

The following variables are defined as having relevance to the case study situation.

R_d = Direct benefits of recreation. This has been estimated to be the amount fishermen are willing to sacrifice rather than do without the fishing experience. This benefit will accrue automatically to a community if recreationists reside in the community. Of course, benefit would accrue to the community in any case if a charge were made for recreation.

R_i = Indirect benefits of recreation. These benefits are "induced by" and "stem from" the recreational activity in the area. They consist mainly of the increase in net income of the businesses supplying those who engage in recreational activity (marinas, restaurants, motels, etc.).

P_d = Direct benefits of the paper mill. This is a rough measure of the economic advantage of locating in this particular place over another location in or outside the area.

P_i = Indirect benefits resulting from industrial activity which causes the pollution. The increase in area income resulting from the industrial payroll provides an example.

C_p = Cost of pollution control. This is the least costly method of maintaining water quality while the mill is in operation.

For the case study area the following empirical estimates are made (annual):

R_d - \$ 5,920	P_d - Unknown	C_p - \$133,000
R_i - \$17,615	P_i - \$6,860,000	

The following relationships became important in considering the water quality management problem. The inequalities correspond to the empirical estimates made for the case study situation:

$$R_d < R_i \qquad (8.1)$$

$$R_d + R_i < C_p \qquad (8.2)$$

$$C_p < P_d \qquad (8.3)$$

$$C_p - (R_d + R_i) < P_i \qquad (8.4)$$

$$P_i > R_d + R_i \qquad (8.5)$$

We will consider each inequality in turn.

Inequality (8.1) suggests that the indirect benefits from recreational use in the community are greater than the direct benefits. In the case study area, the relationship is about 3 to 1.[3/] This firmly establishes the appropriate

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[3/] This inequality is reduced when the consumer's surplus measure of direct recreation benefits is used (Appendix II). Using this method, recreation benefits amount to \$16,924 per year, instead of \$5,920.

interest of the community at large in the resource management problem. The input-output model in Chapter III indicates those sectors of the local economy that are the most directly affected. This has considerable implication with respect to institutional design, and will be developed more fully later in this chapter.

Inequality (8.2) indicates that the damage to the direct and indirect beneficiaries from pollution is less than the annual cost of waste disposal. In the case study area, the relationship is in the neighborhood of 1 to 5.[4/] This suggests, of course, that it is uneconomic, in terms of present-day relationships, to dispose of the waste in the manner in which it is disposed of at present. We return to this relationship in detail later.

Inequality (8.3) suggests that the cost of treatment is less than the value of the site to the polluter. The magnitude of P_d is not known for the case study area. It is presumed to be greater than C_p because if it were not, it would be uneconomic for the paper mill to remain in business. As will be seen later, the size of P_d is of crucial importance in group decision-making.

Inequality (8.4) is also of importance in group decision-making. This inequality states that the cost of waste disposal, less the cost of the damage, is less than the indirect value of the polluting industry to the community. This will be elaborated upon later in the context of actual decision-making.

Inequality (8.5) states that the indirect contribution of the industry to the community is greater than the damage caused by the pollution. Again, it is emphasized that this is in terms of present-day conditions, and will not necessarily hold for future conditions. However, given the magnitudes which exist in the case study area, it is obvious that conditions would have to change greatly for the sign of the inequality to be reversed.

Two additional relationships become relevant for the case study area at this point:

4/ This ratio is reduced to 1 to 4 when the consumer's surplus measure is used.

$$P_d + P_i > R_d + R_i \qquad (8.6)$$

$$P_d + P_i > C_p. \qquad (8.7)$$

Inequality (8.6) states that it is in the national as well as the community interest for the industry to locate in the area. Inequality (8.6) is obviously true if inequality (8.5) holds; however, the inequality sign for the latter could go the other way and (8.6) could still hold as written above. Inequality (8.7) has significance in that it suggests some type of control would be feasible if both direct and indirect benefits are taken into account.

Group Decision-Making and Institutional Design

The input-output tables in Chapter III, and the five variables defined above, identify the sectors of the economy affected by water quality decisions in the estuary. As indicated in the previous chapter, some type of public district which would provide for the involvement of individuals from these sectors would be appropriate. Such a body should have the power to tax and to spend money to implement group decisions and achieve group objectives. If such an organization existed, consistent with value judgments developed earlier, it could then make use of the relationships represented by the inequalities presented above. An input-output model of the type presented in Chapter III could be used to identify those who could have a voice in the decisions of the district. Obviously in an economy such as the one in the case study area, almost every citizen should be a participant according to the criteria outlined earlier.

To the time of this study, the economic literature would suggest that an economic optimum (maximization of net national benefits) could be achieved only by permitting the industry to operate with the imposition of an effluent charge equivalent to the external diseconomy ($R_d + R_i$). The result would be the sacrifice of the economic output of the fishery. The incidence of the effluent charge upon the polluting firm would mean a reduction in P_d. Presumably the community would be compensated in the amount of $R_d + R_i$, and could use the compensation for whatever community project it might desire. If there were no locational advantage to this particular site of the polluting firm, P_d would be zero. The long-run effect of implementing the effluent charge would lead to a reduction in the output of the polluting firm or a discontinuation of production.[5/] However, if P_d does not disappear as a result of the effluent charge, a competitive advantage for this site continues to exist. In this case the level of output may or may not be affected by an effluent charge, depending upon the cost structure of the firm.

Because it is economic to locate the plant in the area, and because P_d is apparently greater than either C_p or $(R_d + R_i)$, the crucial question becomes one of who will pay for the cost of pollution or treatment. A community may decide that it does not wish to sacrifice the quality of its natural resources. It may be even more reluctant to sacrifice an industry that has indirect benefits in the neighborhood of six to seven million dollars annually.[6/] Because of the apparent size of P_d in this particular case, it is possible for a community to achieve both objectives. The size of P_d is a measure of the natural advantage of the area for pulp and paper production. The larger this is, the greater the alternatives in public policy decision-making. These alternatives will relate to how this income can be distributed among the participants in the decision process. In the case study area, the following are examples of alternatives. (Obviously there are other alternatives that could be identified.)

1. The public district (the community or area representative group) could, in the form of effluent charges, charge the pulp and paper plant the amount of damage caused ($R_d + R_i =$ \$23,535). P_d would be reduced by this amount to the industry.

2. The industry could be forced to adopt a waste disposal technique that would preserve the recreational industry. This was the course actually followed. The annual cost or the

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5/ The price of the output may also be affected. In the case study situation, however, the output of the polluting industry is believed to be such a small part of industry output that a change in its output will not have any noticeable effect on price.

6/ For the reasons discussed on pages 88-89, the estimate of these indirect benefits is not very reliable. However, the magnitude of these benefits in relationship to the other relevant variables appears to be such that even a substantial error in this estimate would leave the conclusions of this section unaffected.

reduction in P_d suffered by the industry, if it bore the entire cost, would amount to an estimated \$133,000. Of course, the industry would not necessarily have to bear the entire cost. A community might decide to bear costs in the amount that the waste disposal cost (C_p) exceeded the diseconomy ($R_d + R_i$). In the case study area this would amount to an approximate \$115,465 annually.

The final solution will be a function of bargaining power and the magnitude of the economic variables involved. The public district organization should (1) permit this bargaining to occur in a decision-making context, and (2) bring to bear trained economists, statisticians, biologists, and engineers in determining the empirical data needed for rational decision-making. The limits of the final decisions will be determined by the economic variables. Resolution within these limits will necessarily be a function of the political process which has been assumed here to be consistent with democratic traditions. Table 8.1 is presented to illustrate the kinds of choices which would face a public district. This table suggests that different communities could quite logically resolve their problems in very different ways. This total analysis suggests further that very important questions have not previously been faced in the economic literature on environmental quality. The question of the size of P_d is of legitimate public concern. Furthermore, the distribution of P_d between the industry and the community needs careful examination and, given the value judgments earlier made explicit, is a proper subject for public decision.

Table 8.1. Possible Outcomes in the Relationship of Economic Variables and Bargaining Implications

Relationship	Bargaining Implication
Situation 1	
$P_d > C_p$ $P_d > (R_d + R_i)$ $C_p > (R_d + R_i)$	As P_d is greater than both C_p and $R_d + R_i$, a public district has a choice of maintaining environmental quality or suffering the diseconomy $(R_d + R_i)$. Which one of these alternatives will be selected is likely to depend upon the relative magnitudes of P_i and R_i.
Situation 2	
$P_d > C_p$ $P_d > (R_d + R_i)$ $C_p < (R_d + R_i)$	In contrast to Situation 1, the costs of controlling pollution (C_p) are less in this case than the costs of suffering the diseconomy $(R_d + R_i)$. Hence an additional incentive is provided to maintain environmental quality.
Situation 3	
$P_d < C_p$ $P_d < (R_d + R_i)$ $(P_d + P_i) > C_p$ $(P_d + P_i) > (R_d + R_i)$	The indirect benefits of the locational advantage (P_i) must be considered. The community would be better off with the industry if P_i were greater than $(R_d + R_i)$. Whether environmental quality is preserved or the diseconomy suffered would be similar to decisions outlined in Situations 1 and 2. If quality is preserved, cost-sharing with the industry will be necessary, as P_d is smaller than C_p.
Situation 4	
$P_d < C_p$ $(P_d + P_i) > C_p$ $(P_d + P_i) < (R_d + R_i)$	The community will be better off with the industry, but cost-sharing of waste disposal or treatment is indicated.

Table 8.1. (Continued)

Relationship	Bargaining Implications
Situation 5	
$P_d < C_p$ $P_d < (R_d + R_i)$ $(P_d + P_i) < C_p$ $(P_d + P_i) > (R_d + R_i)$	The community will be better off with the industry, but sufferance of the diseconomy is suggested.
Situation 6	
$P_d < C_p$ $(P_d + P_i) < C_p$ $(P_d + P_i) < (R_d + R_i)$	The community is better off without the industry.

Appendix I

INDEX ESTIMATION OF ANGLER EFFORT

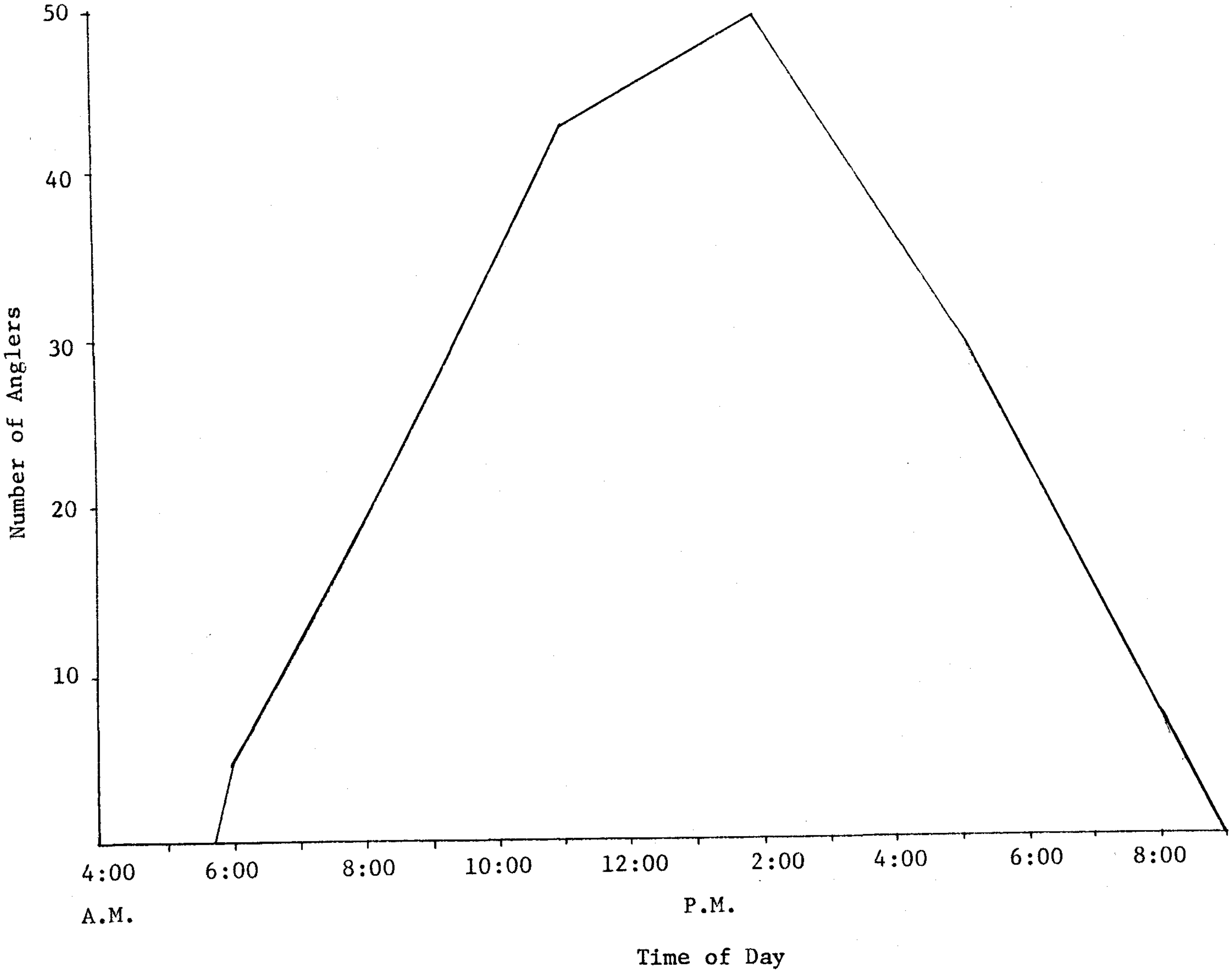
In investigations of angling effort, recourse is often made to sampling from a finite population of licensed anglers. Expansion of sample statistics on effort to population estimates is thus made possible. The Yaquina Bay situation was quite different in that licenses are not necessary for bottomfish angling or clam digging.

In view of the "open" nature of the angling population, an "index" method was used to estimate angler effort.[1/] This method was based on the assumption that there existed a stable time pattern of fishing intensity throughout the day. Periodic counts of anglers on randomly selected days made it possible to establish these patterns. On such days, from three to five counts were made of all anglers in each fishery. Complete counts were made during the summer months at 6:00 A.M., 8:00 A.M., 11:00 A.M., 2:00 P.M., and 5:00 P.M., and during the winter months at 9:00 A.M., 12:00 noon, and 3:00 P.M. Complete counts of this type were made on 68 days during the year. These counts were averaged over monthly time periods in order to derive an "average" time pattern of angling intensity for each month. The area under the graph on this pattern represented the number of angler hours. As an illustration, Appendix Figure I.1 shows the time pattern for bottomfish anglers during the month of August, 1963. Separate patterns were established for each fishery except the clamming activity, which was excluded from this method of estimation because of the influence of low tides on clam digging intensity.

Once the "average" time patterns were derived, it was possible to estimate total angler hours in each fishery on a particular day. The index for estimation of total angler hours (H_i) on the i^{th} day, was

$$H_i = A_i \, (\overline{H}/\overline{A}) \qquad (I.1)$$

1/ Dr. Lyle Calvin of the Department of Statistics at Oregon State University suggested this method to the project personnel.



Appendix Figure I.1. Average Time Distribution of Angling Effort in the Bottomfish Fishery, August, 1963.

where

A_i = number of anglers counted at time t on the $i^{\underline{th}}$ day,

$\overline{H}$ = number of angler hours in the "average" day,

$\overline{A}$ = number of anglers counted at time t on the "average" day.

The survey procedures called for daily collection of data on A_i; that is, to record the number of anglers in each fishery at a particular time. Angler counts were generally made at 11:00 A.M. and 2:00 P.M. each day during the summer, and at 11:00 A.M. and 12:15 P.M. during the winter.

By making daily counts, monthly and yearly estimates of total angler hours in each fishery were accumulated (Appendix Table I.1). The estimates of total angler hours were then converted to estimates of "total angler days" by computing the mean time spent fishing by parties which had completed their angling days. Confidence limits on the means were also estimated for each fishery (Appendix Table I.2).

After the yearly total of angler days in each fishery had been estimated, it was necessary to allocate this total among the stratifications based on distance and income. To accomplish this, six distance zones were identified. The allocation of total angler days among the six distance zones was made on the percentage of anglers from each zone interviewed in the field survey. A separate category was established for those anglers living farther than 200 miles from Newport, and those who indicated that their principal reason for being at Yaquina Bay at the time they were interviewed was for business or to visit friends. This category was arbitrarily excluded from the demand models, on the grounds that fishing or digging clams at Yaquina Bay was not the primary purpose of the visit.

After stratifying the quantity variable by distance zones, it was necessary to allocate each of the zone totals by income subzones. Anglers were asked in a mail survey to record the number of days they had spent angling in that particular Yaquina Bay fishery during the past year. These anglers were also listed

Appendix Table I.1. Estimated Angler Hours in the Bottomfish, Salmon, and Cutthroat-Steelhead Sport Fisheries, by Month

	Bottomfish	Salmon	Cutthroat-Steelhead
August, 1963	20,656	3,227	a/
September, 1963	11,469	7,301	4,197
October, 1963	1,561	7,575	2,751
November, 1963	1,900	414	1,768
December, 1963	2,392	0	973
January, 1964	1,116	0	526
February, 1964	3,773	0	220
March, 1964	4,745	0	6
April, 1964	4,495	0	b/
May, 1964	10,804	134	b/
June, 1964	9,465	3,330	284
July, 1964	17,206	8,051	738
August, 1964	a/	14,434	1,001
September, 1964	a/	a/	523
Yearly total	89,582	35,635 c/	12,464

a/ Totals were not estimated.

b/ Angler counts were not made because angling season was closed.

c/ An average of the two August totals was used in computing yearly total.

Appendix Table I.2. Yearly Total of Angler Days, by Fishery, with Average Time Fished Per Completed Interview

Fishery and Season	Total angler hours	Average time fished in hours a/	Total angler days	Number of observations
Bottomfish:				
Summer (August and September 1963, and July, 1964)	49,155	3.08 ± .37	15,944	115
Rest of year	40,427	2.54 ± .42	15,911	69
(Total)	(89,582)		(31,855)	
Salmon:				
Summer (August, 1963, and May, June, July, and August, 1964)	20,345	2.75 ± .35	7,403	137
Fall (September, October, and November, 1963)	15,290	4.36 ± .52	3,511	69
(Total)	(35,635)		(10,914)	
Cutthroat-Steelhead:				
(Entire year)	(12,464)	4.01 ± 1.96	(3,110)	10

a/ Based on completed interviews only, with confidence limits on means established at the 95 percent level of probability.

on the questionnaire. The distribution of days fished, by income categories, furnished the basis for allocating total angler days from each distance zone among the income subzones.

As mentioned previously, clam digging times were closely related to the daily low tides. This obviously violated the assumption of a stable time pattern; therefore, the index method of estimation was not used. Clam diggers were counted daily at the time of low tide, and these counts were taken to represent "angler days". The allocation of total angler days among distance zones and income subzones was made in the same manner as for the salmon and bottomfish fisheries.

Appendix II

CONSUMER'S SURPLUS AS A MEASURE OF DIRECT BENEFITS

The method used in this study for measuring recreation values and benefits has been that of determining the maximum revenues that could be obtained by a hypothetical non-discriminating monopolist (NDM). The latter, by definition, is one who would charge a single price to all consumers, and thereby not discriminate among them. This price, for any fishery, would be the one which would maximize gross revenues to the monopolist as owner of the resource. Conversely, the price could be viewed as yielding the maximum "rent" that the anglers, taken as a whole, would be willing to pay for use of the resource. At the time these estimates were made, this methodology was generally accepted as a reasonable one.

Since that time, however, the arguments for an alternative measure of recreation values have received general acceptance. The measure referred to is the consumer's surplus (CS) method. Proponents have argued that this method (a) has a more basic foundation than NDM in terms of economic theory, and (b) requires no additional empirical information beyond that required by the NDM method (i.e., that contained in Appendix Table II.1).

Briefly stated, the consumer's surplus technique is based on the premise that all consumers, with one exception, receive a "surplus" from not *having* to pay that price which they would be *willing* to pay for a commodity. The exception is the marginal user, who actually pays all that he would be willing to pay, and thus derives no surplus. The downward slope of the demand curve for any commodity, including those sport fisheries studied here, gives rise to the above phenomenon. If the price of the commodity were to increase, some portion of total consumer's surplus would be removed because (a) those users close to the margin would no longer purchase the commodity, and (b) the gap between actual price and the demand price by non-marginal users would narrow. Carrying this example one step further, if price were increased from

Appendix Table II.1. Annual Net Economic Values of the Three Fisheries

	Consumer Surplus				NDM[a]
	Bottomfish	Salmon	Clam	Total	Total
Existing:					
Ocean disposal..	$42,273	$14,872	$5,674	$62,819	$22,747
Alternatives:					
Toledo.........	36,266	3,955	5,674	45,895	16,827
McLean Point....	31,590	10,990	0	42,580	15,697
Toledo-Ocean....	38,751	10,488	5,674	54,913	20,135

a/ Non-discriminating monopolist.

an existing level (zero, in the fishery case) to that price where all users are priced out of the market, the total consumer's surplus would have been captured. The analytical counterpart is integration of the demand curve (in Appendix Table II.1); the measured outcome reveals total consumer's surplus, or the willingness of consumers to pay.

Four demand curves were derived for each fishery in this study. One pertained to the existing ocean outfall method of disposal; the other three were for various in-bay disposal sites. Net economic values, as derived from the consumer's surplus method, are shown in Appendix Table II.1. The direct benefits associated with each of the three in-bay alternatives are shown in Appendix Table II.2. Each value is simply the increment in total willingness to pay for access to the sport fishery, with and without some level of water quality deterioration.

In that the consumer's surplus method measures the entire area under the demand curve, the direct benefits associated with the disposal alternatives are considerably higher than with the NDM method. On the other hand, the choice of a measurement technique causes no substantive changes in the conclusions reached in Chapters VII and VIII. Direct and indirect benefits would still be

Appendix Table II.2. Direct Benefits Per Year Associated With the Three Disposal Alternatives

Disposal Alternatives	Consumer Surplus				NDM[a/]
	Bottomfish	Salmon	Clam	Total	Total
Toledo................	$ 6,007	$10,917	$ 0	$16,924	$5,920
McLean Point..........	10,683	3,882	5,674	20,239	7,050
Toledo-Ocean..........	3,522	4,384	0	7,906	2,612

a/ Non-discriminating monopolist.

considerably less than the costs of any of the in-bay alternatives, as indicated by the excess of potential cost-savings over benefit reductions shown in Appendix Table II.3.

Appendix Table II.3. The Residual of Costs and Benefits for Disposal Within Yaquina Bay, as Contrasted to Ocean Disposal, Using Consumer's Surplus as Measure of Direct Benefits

Disposal at	Annual Cost Savings[a/]	Annual Benefit Reduction[a/]		Annual Net Gain
		Direct	Indirect[a/]	
Toledo..............	$133,000	$16,924	$17,615	$98,461
McLean Point.........	73,000	20,239	17,615	35,146
Toledo-Ocean.........	38,500	7,906	9,761	20,833

a/ From Table 7.2.

(Field Survey Questionnaire on Yield and Expenditures)

OREGON STATE UNIVERSITY

Number of people in party to be interviewed: ________________ Area of Bay ________________

Time interview started: ____________________________ Date ____________________________

Hello! I am working on a survey for Oregon State University and if you don't mind, I would like to ask you a few questions.

(1) a. We are interested in finding out how many fish you caught (adjust terminology to respondent's activity) on this trip today. If you caught any, would you mind if I weighed them? (Record species, number, and weights in Table 1. Repeat Question 2 for each species caught. If necessary let respondent refer to map.)

b. (If no catch, ask:) What kind or kinds are you fishing for? ____________________________

____

(2) In what area of the Bay did you catch these? (Record answer in Table 1.)

(3) Were you in any other area of the Bay during this trip today? Yes ________ No ________ (If yes, ask Question 4: if no, skip to question 5.)

(4) In what other area? (Record answer in Table 1)

(5) At approximately what time did you (all of you) start fishing on this trip today?

________________ ________________ ________________

(6) If applicable:
How much time did you spend in area (s) (from Table 1)? (Record answer in Table 1.)

(7) a. Were you fishing or clamming for any other kind or kinds on this trip today? Yes ________ No ________ (If no, skip to Question 8.)

b. What other kind or kinds?

________________ ________________ ________________

c. For how long did you do that? ____________________________

(8) Would you please tell me where you are from?

____________________________________ (Name of home town)

(If from Newport-Toledo, skip to Question 20; if from outside of the area ask Question 9.)

(9) How many days have you been in the Yaquina Bay area on this trip? ________ days

(10) How many days are you planning to stay here after today? ________ days

(11) What is the principal reason for your stay in the Yaquina Bay area?

Business ______________________ Fishing, clamming, etc. ______________________
Visiting friends or relatives ____
Other (specify): ____

Table 1.

Species	Number	Weight (lbs.)	Area	Time (hrs.)

Ask questions 12-18 only to non-residents of Newport-Toledo who have been in this area on this trip for one or more nights and whose principal reason for being in this area is "Fishing, clamming, etc."

Ask question 19 to those non-residents who have been in this area for less than one night and whose principal reason for being in this area is "Fishing, clamming, etc."

Ask question 20 when the principal reason for being in this area was <u>other than</u> "Fishing, clamming, etc."

(12) We are also interested in expenditures you've made while in the Yaquina Bay area. You said that you have been here for ______ nights (from Question 9). Would you tell me where you (all of you) stayed overnight? ______________________________________

(13) What has been the cost of your lodging for this time? $ ____________

(14) Since you have been in the Yaquina Bay area, how many breakfasts, lunches, and dinners have you eaten in a restaurant?

Breakfasts ____________ Lunches ____________ Dinners ____________

(15) What were your total expenditures for meals eaten in a restaurant while you have been in the Yaquina Bay area? $ ____________

(16) Did you buy any food or drinks in this area which you prepared yourself? Yes _____ No _____
(If no, skip to Question 18.)

(17) What were your expenditures for this? $ ____________

(18) a. What other expenditures did you make while on this trip and in this area? To help you remember, let me ask separately for each of these items:

Boat rental	$ ____________
Fishing tackle rental or purchase	____________
Bait	____________
Boat launching and storage	____________
Gasoline and oil for boat	____________
Boat equipment (life preservers, fire extinguishers, etc.)	____________
Motor or boat maintenance and repairs	____________
Cruises	____________
Gasoline and oil for car	____________
Car repairs and maintenance	____________
Clothing	____________
Souvenirs	____________
Photography equipment and supplies	____________
Camping equipment	____________
Telephone and telegraph	____________
Entertainment	____________
Others ____________	____________

b. In addition to you (all of you here), how many other people were included for these expenditures? ____________

(19) a. We are also interested in expenditures you've made while in the Yaquina Bay area. I have a list of items, would you please tell me how much, if anything, you (all of you) spent for each item on this list since your arrival in the Yaquina Bay area?

	Expenditures
Meals in restaurants	$ ____________
Groceries	____________
Boat rental	____________
Fishing tackle rental or purchase	____________
Bait	____________
Boat launching and storage	____________
Gasoline and oil for boat	____________
Boat equipment	____________

Motor or boat maintenance and repairs	$ ________
Cruises	________
Gasoline and oil for car	________
Car repairs and maintenance	________
Clothing	________
Souvenirs	________
Photography equipment and supplies	________
Camping equipment	________
Telephone and telegraph	________
Entertainment	________
Others ________	________

b. In addition to you (all of you here) how many other people were included for these expenditures? ________

(20) We are interested in expenditures you've made in connection with your activity in Yaquina Bay. Therefore, would you please tell me what expenditures you've made in connection with this trip today in this area for the following items:

	Expenditures
Boat rental or purchase	$ ________
Bait and tackle	________
Gasoline and oil for boat	________
Boat launching	________
Other ________	________

Respondent's name, address and telephone:

Name ________

Street ________

City ________ State ________

Telephone ________

THANK YOU.

Point of contact with respondent:

Boat ________ Shore ________ Dock ________ Moorage or public launching site ________

Other ________

Stage of completion of fishing trip during interview:

Completed ________ Not completed ________

Time interview ended: ________

Interviewer's signature: ________

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