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The Pacific Salmon Fisheries

A Study of Irrational Conservation

James A. Crutchfield and
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Foreword

Fisheries in the United States are beset by senseless restrictions and marked by obsolescence, waste, and poverty. The contribution of fishermen to the national economy is negligible. Their total catch of all species is lower now than it was before the Second World War. And there is little hope for change—unless dramatically new institutions and new forms of management can be developed and adopted.

The fundamental cause of waste is open access to the stocks. Where resources are unowned or the common property of a community, there are no controls over access; no means for allocating or restricting inputs of capital and labor; and no way of preventing declining yields and the disappearance of net revenues to the industry. These consequences are particularly severe for fisheries, where demand is increasing and natural factors limit the rate of reproduction and the size of the stock. And the problems are frequently compounded by the adoption of conservation measures that impede technological innovation and make fishing more difficult and more costly.

The theory of common property resources has been explored

by a handful of economists over the past fifteen years. But little has been done to apply the theory to real fisheries or to develop and test models that co-ordinate biologic and economic functions and conditions. Indeed, aside from studies of Pacific halibut (by Crutchfield and Arnold Zellner), Georges Bank haddock, and one or two smaller fisheries, there have been virtually no empirical analyses of the economic consequences of common property in fisheries. Partly as a result of the paucity of case studies and factual demonstrations of waste, the fishery administrators have been reluctant to accept the theory and adopt the new institutions and new forms of management that are required.

This book thus provides an important contribution to the field. It demonstrates the consequences of open access and irrational conservation; develops a model that can be used in other case studies; and sets the framework for control of access and for the establishment of effective conservation rules and efficient economic measures.

This project is a significant element in the emerging marine resources program at Resources for the Future. It follows an earlier and more general study, *The Common Wealth in Ocean Fisheries,* by Francis T. Christy, Jr. and Anthony Scott, and deals directly with some of the problems identified in that study. It also bears a general relationship to a current project being undertaken within the program—a study of the law of the continental shelf by Professor L. F. E. Goldie. The relationship lies in the problems created by the fact that ownership of marine resources is frequently either non-specific or non-existent, and that because of this there are no clear-cut authorities or agencies to govern use and exploitation. This is true for the multiple uses of estuaries, the resources of the sea floor, and for international fisheries as well as domestic.

The demands on the sea are growing rapidly. Oil exploitation, taking place in deeper and deeper waters, is forcing nations to reach decisions on the extent of their jurisdiction and on the character of an international regime beyond their limits. Those nations that have rationalized their fisheries and achieved access controls (particularly Japan and the U.S.S.R.) have gained great mobility and are able to fish in all corners of the world. And as

their effectiveness increases, the problems of open access in international waters become increasingly severe. Conflicts between different uses of the sea are also growing. Shipping must thread its way through oil rigs and through concentrations of trawlers. The pressures on estuaries from pollution, land-fill, dredging, recreation, fishing, and other developments, are becoming increasingly apparent and are indicative of problems that must be resolved in both domestic and international waters.

The real challenge of the seas lies in these kinds of problems. Science and technology can open up opportunities that we have scarcely begun to anticipate. But at the same time they create great difficulties for management and for co-operation among the users; for law and efficient rules and regulations; and for the orderly and harmonious enjoyment of the resources of Davy Jones's locker.

These challenges provide the focus for our program. We hope to increase our knowledge about the developments in the marine environment, so that we can anticipate the economic and political pressures that will take place in the future. We want to examine alternative objectives, so that we can know more precisely what it is that we want to gain from the oceans. And we want to begin to explore the institutions and rules that will accommodate the growing pressures and facilitate the attainment of the goals.

These are tasks for economists, lawyers, and scholars of political science and international relations. They are difficult tasks, but extremely important. And it is hoped that this book, in addition to making its contribution to the study of fisheries economics, will stimulate social scientists to explore the problems of the marine environment and to participate in their resolution.

FRANCIS T. CHRISTY, JR.
Marine Resources Project
Resources for the Future, Inc.

December 1968

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CHAPTER 1

The Issues

While it is true that a great deal (perhaps the greater part) of what has been done in the name of "conservation policy" turns out, upon subjection to economic analysis, to be worthless, or worse, it is nevertheless also true that economic theory can offer a formulation of the conservation objective sufficiently clear and precise to permit the derivation of rational policies in the future. Such a formulation, like the application of economic theory in other fields of policy, can be no match for the passionate romanticism with which the question has been invested in political platforms and public discussion, but some of the policies of the past and present are sufficiently egregious to convince even dedicated conservationists of their error or, at least, insufficiency. Perhaps it is too much to hope that in their hour of confusion and despair, the protectors of nature might turn to economics for succor, but even idealistic hopes have the quality of springing eternal.[1]

In the broadest meaning of the term, wise use of natural resources implies evaluation of their present worth in a dynamic setting of general equilibrium. In this sense, of course, proper use of natural resources can hardly be separated from the allocation problem as a whole. Given assumptions as to rates of eco-

[1] H. Scott Gordon, "Economics and the Conservation Question," *Journal of Law and Economics*, I (October 1958), pp. 110–11.

nomic growth, patterns of demand and costs, and relative prices of substitute and complementary products, conservation of any natural resource clearly is an aspect of capital theory, involving optimal time rates of use of the assets involved and optimal factor combinations at each use rate. The essential problem from the policy standpoint is to avoid waste through faulty time distribution of use of natural resources or through inefficient combinations of their services with those of labor and capital, and hence to maximize the present value of the stream of net benefits that can be derived from them. Beyond this lies the task of applying these general principles to specific resources, specific management programs, and specific proposals for more effective utilization of the physical environment. This study of the Pacific salmon fisheries is an effort in that direction.

In the simplest case, where stocks of the resource are known and fixed in total quantity, optimal time-rate of use is the only issue, since a flow of useful services can be obtained only by using up the stock. At the opposite extreme, resources that provide a flow of services unaffected by varying rates of use present no conservation problem. These are, of course, limiting cases only, hardly to be found in the real world. Policy problems with respect to conservation are usually derived from two intermediate cases. In the first, the stock of resources is finite, but the total magnitude is unknown. In this case, the conservation problem is twofold: first, to assure the most efficient use of known stocks; and second, to undertake that amount of investment in discovery and preparation for extraction which, together with the time rate of use of existing supplies, maximizes the present value of the resource.

The second general case involves resources that are renewable, but only over an extended period of time. In these cases, the twofold nature of the conservation problem is even more clear-cut. The stock, viewed as an inventory to be used as economically as possible, is also the capital equipment, investment in which will provide for replenishment in the future. Clearly, optimal time rates of use involve both efficient conversion of part of the existing stock to current economic output, and the appropriate reservation of part of the stock for production of future supplies.

The distinction between stock and renewable resources in these terms is perhaps less clear-cut than the brief summary above suggests. It involves, among others, some implicit assumptions about future costs and prices. If we assume that the end product of a given natural resource—a fishery population, for example—will become obsolescent before the yield from new "investment" (in the sense of restricted current use) is realized, the resource becomes in effect a pure stock resource, and the conservation problem becomes one of using up the existing stock over the appropriate period of time. Similarly, if costs are expected to rise to a level at which there will be no profit from the resource no matter what the output, there is clearly no point in "conserving" in the investment sense.

These are, however, exceptions to an obviously common and important group of resource utilization problems involving renewable stocks for which maximization of present value requires simultaneous evaluation of current and potential future exploitation rates on a continuous basis. Most fishery populations fall in this category, and this study is concerned with one of the major fisheries in which conservation programming has proved essential to avoid complete destruction of the resource—biological as well as economic.

Scope of the Study

There are many reasons for choosing the Pacific salmon industry to illustrate the essential principles of an integrated fishery management program aimed at economic maximization of benefits from the resource and also to demonstrate a contrast between optimal and actual results of management. First, it is one of the most valuable of North American fisheries, and ranks high in value among individual fisheries of the world. The stakes, in terms of regional welfare, are sufficiently high to make this study more than an academic exercise, particularly in Alaska. Second, the physical functions relating investment in salmon stocks to subsequent flows of fish available for capture and the associated functions relating fishing effort to short- and long-run yield are probably more complex in the case of the Pacific salmon than in any other major exploited fishery. Despite

this complexity, management of the Pacific salmon has evolved far enough—both in its economic and in its political dimensions—to provide a usable statistical record of the physical magnitudes involved, and sufficient economic information has been generated to permit evaluation of the overall programs.

Space and time limitations preclude detailed analysis of the characteristics of the entire North American salmon fishery and the complex regulatory programs of the Pacific Coast states and of Canada (which regulates the British Columbia fishery); to do so would also involve much needless repetition. We have, therefore, focused our attention on the salmon fisheries of Alaska and Puget Sound. The Alaska fisheries present a classic case of overfishing, unalloyed with any of the other factors—pollution, deforestation, and other man-made changes in environment—which usually cloud causal analysis of declining yields. The Puget Sound sockeye and pink runs, centered on the famous Fraser River populations, illustrate the economic impact of an intensive research program and a nearly unique case of international cooperation set against a background of a full cycle of substantial depletion and subsequent partial rehabilitation. Together, the Alaska and Puget Sound fisheries account for about 90 percent of the U.S. catch of salmon and 60 to 70 percent of the total North American salmon catch by value. Between them, they illustrate virtually all of the technological and biological complexities that beset both the salmon fishing industry and the management authorities.

The stakes in salmon conservation are worthy of careful thought. Even at the depleted levels of the 1960's, the annual gross value of the Pacific salmon catch to American and Canadian fishermen has averaged over $60 million. The vicious and continuous political infighting that has plagued the conservation authorities from Alaska to the Columbia River is eloquent testimony to the participants' awareness of economic considerations in fishery management. Yet there is little evidence that the development of scientific research-oriented regulation was accompanied by any substantive awareness of the crucial importance of economic factors.

Our central theme is that rational fishery management must

evolve from the objective of maximizing the net *economic* yield of the resource. One reason for this approach is that the traditional definition of regulatory objectives in purely physical terms has left conservation authorities vulnerable to political pressures by denying them a vital basis for choice. The vulnerability comes about in the following way: a fishery shows biological evidence of "overfishing," i.e., aggregate yields may fall, the amplitude of annual oscillations in yield may increase, or—more probably—both phenomena are observed. At the same time, generally in response to an improvement in earnings as a result of a positive income elasticity of demand, fishing effort is increased. In order to protect the resource, the administrative body created to deal with the problem of "overfishing" must reduce fishing mortality. Since the fishery is an open access resource, it is impossible under current conditions to reduce effort by restricting the inputs. The regulators cannot stop more people using more equipment from going fishing. In this situation, the obvious alternative is to reduce progressively the efficiency of the individual inputs and thereby reduce the pressure exerted on the resource by a growing number of fishing units. The resulting drift into greater and greater inefficiency in the use of human and capital resources erodes both control and compliance; and the concomitant deterioration of capital equipment leaves the industry increasingly vulnerable to competition, both foreign and domestic. At the same time, the basic irrationality of legislated inefficiency tends to cause widespread discouragement and cynicism in the industry. Failure to develop regulations based on an economic calculus leads to the ad *hoc,* "hole-plugging" hodgepodge of regulations now characteristic of many fisheries. It is important to realize that the need for regulation of open access fisheries arises from economic reactions of profit-seeking units. If this fact is realized, a simple, consistent, and readily enforceable program can be developed.

The setting for any management of salmon resources is both physical and institutional. On one side is a set of complex biological problems: How is it possible to manage the population dynamics of an organism that lives in an environment over which the biologist has little control in order to approximate a chosen

level of physical yield from the resource? On the other side, the question arises: How can this be accomplished within the constraints of a given set of legal and social institutions, which lead, in the absence of intervention, to gross inefficiency and waste in the use of both human and physical capital? Clearly, any meaningful solution for the problems of a commercial fishery must account for both these facets of its structure. From the standpoint of time and money, the research required to define and quantify the essential physical relations that determine available yield is far more demanding than the economic analysis. Yet both are essential to any conservation program that could be considered a rational effort to increase the contribution of the resource to human welfare. Productive fish stocks are a necessary, but not a sufficient, condition for optimal use of those stocks.

Organization of the Study

In the following chapters we hope to demonstrate the essential validity of this statement. To do so, we develop first a general model of a commercial fishery. Production functions—and, therefore, economic supply functions—are derived from a biological model of a fish population. Given these functions, it is possible to specify the necessary and sufficient conditions for the maximization of the net economic yield from the resource. The model, in this form, is then utilized to discuss the theoretical basis of a wide range of performance characteristics associated with commercial fisheries.

The most important of these calls for an explanation of the persistent failure of a competitive structure to maximize welfare under conditions of free entry to an open access resource. From this basic premise, Chapter 2 examines the problems of valuation of an industry in which long-run equilibrium is reached only at zero net economic yield. In addition, we consider the implications of heavy overcapitalization for the cyclical performance of the industry.

Following the exposition of the relevant theoretical issues, we present two case studies of Pacific salmon fisheries. The primary objective of these studies is to test the hypotheses advanced in Chapter 2. This process requires elaboration of the historical

development of these fisheries in terms quite different from those that have been advanced elsewhere.

Chapter 3 provides a summary of all major types of gear employed in catching Pacific salmon and a description of each of the regulatory measures that have been used to control fishing mortality. The next three chapters are devoted to the development and structure of the Alaska salmon fishery and to the management programs that have been devised to deal with its problems. In Chapter 7, a technique is developed and applied to measure the potential economic rent from one of the most important segments of the Alaska fishery, the Bristol Bay red (sockeye) salmon operation.

Chapters 8 and 9 carry forward the same analysis with respect to the Puget Sound salmon fishery. The history and structure of the fishery and of the regulatory program are analyzed in Chapter 8, while Chapter 9 presents a calculation of potential net economic yield using a different technique than that employed in the Bristol Bay case.

Chapter 10 brings together the threads of the earlier discussion, and extends the estimates of net economic rent to other salmon-producing areas in North America. On the basis of the conclusion that the economic waste implicit in present methods of regulation is large enough to warrant serious concern, the elements of a salmon-management program, geared to maximum net economic yield as the prime objective, are then developed. The impact of Japanese high-seas fisheries for salmon on any management program that may be devised is also considered. In Chapter 11, our conclusions are compared to those reached in other case studies of marine fisheries, and the implications of these findings for subsequent world development of marine resources are noted.

Only passing attention has been given the sport fishery, despite its increasing economic significance, because the introduction of another type of human predation upon the salmon does not alter the fundamental conclusions reached. Where appropriate, however, reference has been made to the overlapping of sport and commercial activities, and to the implications for optimal regulatory programs.

For the same reason, relatively little attention has been paid the troll fishery. Although commercial trollers take a large and increasing proportion of the total catch of chinook and silver salmon (the great bulk of it for sale in the fresh and frozen market), they are, for all practical purposes, virtually free of regulation at the present. Moreover, the total troll catch is still very small in relation to the total North American salmon catch.

We feel that an analysis in economic terms of the history and practice of management in the salmon fisheries is a project well worth doing in its own right. There is much to be learned from a more precise explanation of the interaction of economic structure, resource characteristics, and regulatory technique. It is also highly significant, however, that the results of our study conform closely to those of a number of other investigations of fisheries and management programs of entirely different types. As indicated in the concluding chapter, the disappointing results of the conservation effort in the Pacific salmon fishery stem from structural defects in institutional arrangements and regulatory concepts, which are of far greater potential significance when viewed in a worldwide context. The pace of technological change in the high-seas fisheries is rapidly sweeping aside national and regional boundaries. Poor economic performance of the fisheries is not simply a result of the complex biological characteristics of particular fish stocks or peculiarities of the geographic area in which the fishery is prosecuted. What has happened in the salmon fishery now threatens all fisheries where the prices of end products relative to harvesting costs provide sufficient incentive to convert fish stocks to economic goods. The prospective growth in the demand for animal proteins, coupled with the tremendous impact of new capital investment in modern fishing vessels and gear in European and Asian countries, promises to provide just such incentives.

CHAPTER 2

Bio-Economic Models of Exploited Fisheries

Throughout the world, both within national economies and on the high seas, there are important resources that are not owned by anyone. In almost all cases the exploitation of these unowned resources is on a basis of competitive withdrawal: a basis which differentiates the usage of common property (or, more properly, open access) resources from that of private property in general.[1] Both classical and neoclassical economists have noted, and in some cases discussed at length, this distinction. In the debate over "empty economic boxes" in the early 1920's, Frank H. Knight clearly specified the issues involved.[2]

[1] The term "common property," as it has been used by economists, is incorrect in a strict legal sense. If a resource is not owned, it is not property. We will, therefore, employ the term "open access resources."

Professor Donald F. Gordon has informed us that in the annals of the Mecklenburg Agricultural Society in the 1820's, J. H. von Thünen gave an extended analysis of the open access resource problem. The basic article in the current economic literature is the original contribution of H. Scott Gordon, "The Economic Theory of a Common Property Resource: The Fishery," *Journal of Political Economy*, 62 (April 1954), pp. 124–42.

[2] Frank H. Knight, "Some Fallacies in the Interpretation of Social Cost," *Quarterly Journal of Economics*, XXXVIII (1924), pp. 582–606. Reprinted in *Readings in Price Theory*, G. J. Stigler and K. E. Boulding (eds.) (Richard D. Irwin, Inc., 1952), pp. 160–79.