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THE DOMAIN OF POPULATION DYNAMICS AND PRODUCTION ECONOMICS IN FISHERIES MANAGEMENT RESEARCH

by

A. A. SOKOLOSKI

J. A. CRUTCHFIELD

File Manuscript No. 85
December 1971

U.S.

NATIONAL MARINE FISHERIES SERVICE

ECONOMIC RESEARCH LABORATORY

ABSTRACT

THE DOMAIN OF POPULATION DYNAMICS AND PRODUCTION

ECONOMICS IN FISHERIES MANAGEMENT RESEARCH

by

A. A. Sokoloski[1] and J. A. Crutchfield[2]
United States

With growing conceptual acceptability of fishery management techniques which advocate the reduction in the number of units of effort applied to overexploited and/or overcapitalized fisheries it is increasingly necessary that some readily usable measures be developed which may serve all those involved in fishery management and supporting research. Toward this end this paper examines the foundations of measures of fishing effort and fishing power as conceived within the domains of population dynamics and production economics. The degree to which each discipline generates different and mutually exclusive measures is examined, along with an attempt to delineate a separate and distinct role for each discipline within the overall process of generating supporting information needed in all generalized fishery management plans.

[1] Formerly, Chief, Branch of Supply and Resource Use Research, Economic Research Division, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce. Now with Division of Water Quality Standards, Environmental Protection Agency.

[2] Professor of Economics, University of Washington

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A. A. Sokoloski
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This paper is to be presented at the OECD Symposium on Fisheries Economics, Paris, France November 29 - December 3, 1971

INTRODUCTION

On February 9 and 10, 1971, the Division of Economic Research of the National Marine Fisheries Service convened a meeting of a small group of economists and biologists (appendix A) for the purpose of considering aspects of fisheries management of mutual interest to both disciplines. These include (1) measurement of fishing effort; (2) population dynamics; (3) production economics, and (4) bio-economic models. The meeting was informal and unstructured and not in any way related to an official policy setting activity. The primary thrusts of the two day discussion were to (a) ascertain the degree to which real differences existed in the measures of fishing effort calculated by each discipline, (b) ascertain the specific use for each measure, (c) determine the interrelationship between the two measures, and (d) to improve communications between biologists and economists.

At the conclusion of this meeting it was generally felt that no precise answers had been obtained to these questions. Nevertheless, some progress had been made and the authors were informally requested to draft a statement for review by the participants, with the hope that this statement might serve to crystallize some of the issues and thereby provide some guidance to administrators responsible for the use of both disciplines in fishery management.

The following statement was drafted by the authors and subsequently revised as a result of comments received by the participants of the original two day meeting. Although a modicum of agreement has been reached by all concerned that this is a fairly representative statement, many differences still remain on several points. For this reason, as well as the usual absolution of reviewers, this statement is the sole responsibility of the authors, and the other participants in this meeting as well as the National Marine Fisheries Service are not responsible for errors that may subsequently be revealed. Indeed, we fully expect the discussion generated in this Symposium to result in substantial further improvements in this statement.

The Reasons For Measuring Fishing Effort

Toward this end the first observation to be made is that there are in fact two separate purposes for measuring fishing effort, though there currently are neither two distinct measures, nor two distinct methodologies. The first of these relates to the dynamics of population evolution. Toward this end the population dynamics expert (P.D.E.) is relied upon to provide a measure of the impact of vessels upon the fish population, designated fishing mortality, not merely to tabulate the number of fish removed during a given time period, but to combine this with other determinants o. mortality and some estimate of recruitment, and to predict not only the stock of fish which may be available to harvest in the following year, but also that stock which will be continually available for a given level of harvesting effort.

To provide this input the P.D.E. divides his efforts into two categories. Within the first he concentrates on measuring yield and fishing mortality. In some circumstances this data is subsequently converted to other measures for use by others, such as numbers of boats, hours fishing, etc. Within the other category of activity the P.D.E. concentrates on the measurement of fish abundance. Here he uses controlled samples of vessels, indexing their fishing power, to obtain an estimate of the rise and fall of abundance.[1] Some confusion has arisen because both of these sub-activities have resulted in policy proclamations, although most concern has been with the proper use of the standardized sample of vessels active within a particular fishery. The primary reason for this concern is the need to have measures of fishing power which will indicate the varying fishing power of vessles with differenct packages of technology, so that as the distribution of these vessels changes over time the ramifications upon the stock can be assessed.[2]

To this point we have sketched the inputs to the final product of the P.D.E. function, an estimate of the maximum percentage of the gross biomass which can be sustained, this estimate based upon past fishing mortalities which have resulted from measured fishing pressure as a percentage of total mortality.

At his juncture we would like to introduce the activities of the production economist (P.E.). The P.E. is interested in the determinants of productivity (Profitability). He focuses upon the components of the harvesting machine: labor, vessel type, age, etc.; ascertaining the degree to which each, in combination with certain location strategies, will maximize net economic return: The relevant variables are not only physical catch and the cost of each input but also the prices that can be obtained for the products (often in different mixes). Since the operator is attempting to maximize some monetary value rather than a

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[1]Beyond this measure of fishing power the P.D.E. must discriminate between the dynamic consequence of harvesting immatures rather than matures.

[2]Out current description of this technology package may be considerably handicapped by the available data.

physical quantity, these monetary values have been and will continue to be the principal result of and motivation for changing technological packages.

Having made these calculations the P.E. can readily "contruct" an ideal vessel package for any given set of input and output prices. Therefore, if management dictates the harvesting of some fixed quota he can provide guidance as to the "optimum" number of boats which may be used to harvest that quota; or, given an existing fleet, he can rank vessels according to the best use of labor and capital components and suggest a cutoff point if the fleet needs to be reduced. Other economists with broader interests and responsibilities can adjust these quidelines based on additional calculation of social costs if that appears to be necessary.

The Interdisciplinary Ties

Some of the interrelations between the P.D.E. and the P.E. can now be readily identified (see also Appendix B). Two critical common elements are the production guideline, the quantity to be harvested each year for a managed common property resource and the degree to which we can assure this harvest level. Both disciplines have a vital interest in this benchmark. In a sense it is the terminal product of the P.D.E. and the starting point for the P.E. As we move back from this point into the realm of the P.D.E. we become increasingly enmeshed in purely biological interrelationships. As we move in the other direction we become enmeshed in the more purely commercial elements of investment risk, harvesting cost-effectiveness, distribution, and product demand.

The source of conflict (confusion between the two disciplines) can now be specified. Two measures of fishing power exist. One is used by the P.D.E. as a tool in measuring the dynamic consequences of fishing mortality upon species biomass and age/size distribution. Technological change over time is an expression reflecting the general change in the character of the fleet upon the dynamic processes of population change. As used by the economist fishing power is a measure of the catching capability of vessels, this measure varying as different vessels use different labor, vessel, gear combinations. It is usually calculated for a given point in time, with several time periods either compared or combined to give some measure of change over time. The measure is used to decide how best to combine inputs to maximize profits from the harvest of a fixed quota, and how many units will be needed to harvest a quota.

This later activity is the source of conflict. For approximately forty years the P.E. has been concerned with allocating inputs to produce supply levels demanded by the consumer. If the supply is fixed by a quota this is only a special case, one which has been encountered many times elsewhere. In addition, the P.E. has also been involved in determining the optimum aggregate level of production. Therefore, it is difficult for him to accept as socially meaningful production goals which are specified in purely physical terms. As an example, he is interested in the guidelines used to determine why a yellowfin tuna quota may be set at 120,000 tons. This is in addition to his knowledge of the most economically efficient fleet to harvest that goal. But whatever production goal is to be met, the P.E. ascribes critical importance to a management framework which encourages fishing enterprises to take it at lowest possible cost and which rewards rather than penalizes further improvements in the efficiency of vessels and gear.[1]

The P.D.E. uses a measure of fishing power as a dynamic tool for defining sustained yield options. Economists use a measure of fishing power to allocate these physical catch targets during each time period. Beyond this, the need to assure that the catch levels selected are both biologically and economically optimum suggests the following questions:

(1) Can and/or should the two measures of fishing power be combined into one "universal" measure?

(2) Can the two functions of the two disciplines be specifically designed so that a determination can be made as to where P.D.E. ends and P.E. begins?

(3) If not, does this dictate the need to form multidisciplinary teams to formulate the crucial guidelines to management decisions?[2]

If the NMFS is to face its management responsibilities in full faith (especially if legislation to implement the Geneva Convention is to be passed and if a new state/federal management program is to be initiated), answers to these questions should be top priority and program changes based on these answers, if necessary, should be initiated immediately.

As a start in answering the first of these question we are including below a brief reading list on the economiist's concept of a production function. We are humbly suggesting that it would be of considerable

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[1]The lowest cost P.E. solution does not include the costs (social "or" economic) of adjusting to that solution. These would be ascertained once the goal has been clearly established.

[2]Those attending this two day workshop provided answers to each of these three questions, responding with an emphatic no to the first question, a moderate yes to the second and a stronger yes to the third. Indeed, some m specific suggestions for initiating number three, and hopefully we can call on Federick Bell to elaborate on this subsequent activity. Also, it was suggested by many that this initial activity should concentrate upon the mutual data needed to support this interdisciplinary research endeavor.

value if certain P.D.E.'s would read this material and indicate ways in which this method of identifying productivity differentials would differ from those of the P.E. The P.D. readings were supplied by Richard Hennemuth and John Gulland. If economists could comment specifically on these readings this small group of reading could be referred to in future discussions. These readings, confined to just a few hours for each discipline, are provided below.

Economics:

1. Samuelson, Paul H. Economics, 8th Edition, McGraw-Hill, 1971. 9-26 and 513-535.

2. Leftwich, Richard H. The Price System and Resource Allocation, Holt, Rinehard & Winston, 3rd Edition, 1965. pp. 98-125.

3. Heady, Earl O. Economics of Agricultural Production and Resource Use, Prentice-Hall, 1952, pp. 21-51.

4. Ruttan, Vernon W. The Economic Demand for Irrigated Acreage. Published for Resources for the Future, Inc. by the Johns Hopkins Press, 1965, pp. 16-33.

5. Bell, Frederick W., The Relation of the Production Function To the Yield on Capital for the Fishing Industry In: Recent Developments and Research in Fisheries Economics, F.W. Bell, & J.E. Hazelton, eds. Ocean Publications, 1967, pp. 87-116.

Population Dynamics:

1. Schaefer, M.B. 1965. The scientific basis for a conservation program. In papers presented at the International Conference on the conservation of the living resources of the sea. Rome, May 1955. United Nations, A/CONF. 10/7, New York. (U.N. publication Sales No. 1956. II.B.1).

2. ____________ Some considerations of population dynamics and economics in relation to the management of commercial marine fisheries, Jour. Fish. Res. Bd. of Canada, Vol. 14 No. 5 pp 669-689.

3. Gulland, J.S. Ed. 1964. Contributions to Symposium 1963 on the measurement of abundance of fish stocks. Rappet Proc. Verg., vol. 155 (papers No. 1, 14, 15, 17, 22, 28).

4. _________ & J.E. Carroz. 1968. Management of Fishery Resources. Advances in Marine Biology Vol. 6. Acad. Press, Longon, N.Y. pp. 1-71

5. Chapman, D.G. 1960. Statistical problems in Dynamics of Exploited Fisheries Populations. Proc. Fourth Berkeley Symp. on Math. Stat. and Prob., Vol. IV, pp. 153-168, Univ. of Calif. Press.

6. Cushing, D.H. 1968. Fisheries Biology. Ch. 4 & 5, pp. 61-90 Univ. of Wisc. Press.

7. Crutchfield, J.A. 1969. Ed. Biological and economic aspects of fishery management. Proceedings of conference under auspices of the College of Fisheries and Department of Economics, University of Washington, Seattle, Feb. 17-19.

APPENDIX A: Attendants, Biologist/Economists Meeting, National Marine Fisheries Service, February 9-10, 1971, Washington, D.C.

Biology

Dr. Alan Longhurst, National Marine Fisheries Service

Dr. Brian Rothschild, University of Washington

Dr. Richard Hennemuth, National Marine Fisheries Service

Dr. William Lenarz, National Marine Fisheries Service

Dr. Jerome Pella, National Marine Fisheries Service

Dr. James Joseph, Inter-American Tropical Tuna Commission

Dr. John Gulland, FAO

Dr. William Schaaf, National Marine Fisheries Service

Mr. George Hirshhorn, Biological Laboratory

Economics

Dr. James Crutchfield, University of Washington

Dr. Lawrence Van Meir, National Canners Association

Dr. Harvey Hutchings, National Marine Fisheries Service

Dr. Frederick Bell, National Marine Fisheries Service

Dr. Adam Sokoloski, University of Rhode Island

Dr. Edward Kane, Boston College

Dr. Virgil Norton, National Marine Fisheries Service

Dr. Giulio Pontecorvo, Columbia University

Mr. Paul Adam, OECD

Mr. Ernest Carlson, National Marine Fisheries Service

APPENDIX B

What we are trying to measure:

Biologist

(1) Physical interdependies between fish & its environment, with fishery mortality being part of the environment.

Therefore:

a. Fishing input assumed to be at certain levels

b. This input needs to be precisely specified in terms of

-time actually fishing
-specific locations
-standardized gear.

Uses

1. Allocating standardized fishing effort

2. measuring ecological interdependencies

Economist

(2) Physical determinants of vessel productivity (sic. profitability)

Therefore:

a. Concentrate upon vessel, its characteristics and the harvesting pattern

b. The owners reaction to change is crucial

c. Technological change is measured continuously.

Uses

1. To suggest the optimum investment and operations strategy for each vessel.

2. to suggest an optimum strategy for the use and character of the entire fleet.

Basic Issue: For all uses, at what point is the cost of an additional increment of information greater than the additional increment of value derived from that information?