The Economics of Environmental Policy†

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Economics and Ecology

THE FACT that the terms ecology and economics stem from the same root, that they deal with whole systems, and that some quantitative scientific tools — such as a maximizing calculus, input-output analysis, and simulation — can be used to advantage in both fields may suggest that there are substantial identities and analogies. Such a suggestion should be received with caution in the very interest of better understanding and cooperation between the two scientific fields. Let us put it this way: An economic system contains the interrelations constituting an ecosystem in the same sense as an ecosystem contains the interrelations representing the system of an individual organism or that of a cell. But for the scientific understanding of an ecosystem, cell biology is no more useful than ecology is for a scientific understanding of an economic system.

There would be little use in presenting here a variant of definitions of an economic system that have been advanced in the literature — except to say that economics is not concerned only with monetary valuation of costs and benefits and with maximizing net economic yields. I am partial to Jacob Viner's "definition" that "economics is what economists do." In so "doing," I shall attempt to show that economics as an analytical system can contribute to conceptual clarification and more effective public action in the important area where the concerns of ecology and economics meet. This area is environmental management or, as I shall call it here, "environmental policy."

The Meaning of Environmental Policy

The term *policy* is used with many different meanings, both in scientific and in popular language. For the present purpose, its meaning is restricted to interrelated actions (action systems) real or hypothetical, of organized publics, such as international agencies and federal, state, and local governments. This restriction of meaning is in accordance with the etymological origin of the term. Any private individuals, firms, or industries may have opinions, attitudes, and proposals pertaining to policy; they may aid or hinder the formation and implementation of policy; and they are always affected by it. The term itself, however, will be used here in the restricted sense of *public* policy.

The unifying principle that transforms a number of individual public actions into a system termed policy is supplied, first of all, by the viewpoint of the scientific observer interested in the kinds of relations that exist between individual actions in objectives, criteria, execution, and effects. In this sense, policy is both a conceptual tool of analysis — a construct — and a field of scientific inquiry.

Ideally, a second unifying principle is supplied by the objectives and criteria of the public undertaking or considering

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actions; ideally, individual actions constitute a segment of a purposefully coordinated system. In actuality, however, the objectives and criteria of actions by different publics and of the same public at different times are frequently not coordinated. Such lack of coordination and multiplicity of objectives is an important subject in the study of policy.

In environmental policy, it is helpful to differentiate between conservation and allocation. In political reality, actions in these two spheres are closely related. In economic analysis, it is useful to separate them. The term conservation policy refers to public actions affecting the distribution of physical yields (use rates) of the environment in different instants of time. The term allocation policy refers to public actions affecting the distribution of given physical yields and their benefits and costs among different users — such as countries, regions, industries, firms, and households. In technical terms, conservation policy refers to the length and the direction of use vectors with respect to time; allocation policy refers to the direction of these vectors and their benefits and costs with respect to users.[1]

Environmental Policy and Welfare Economics

In identifying the economic objectives and criteria of environmental policy, one encounters the problem of unity of science — in this case the unity of economics as an analytical system. Environmental policy cannot, in principle, be divorced from policies relating to housing, working conditions, family and racial relations, and many others. Although sometimes forgotten by present day environmental activists, such policies are interrelated, and criteria are, in principle, no different in environmental policy than in other fields of public action. In an attempt to identify such criteria, economists have developed a branch of normative economics called "welfare economics." More recently this branch has become known as the "new" welfare economics to emphasize its development in England and the United States since the 1930's. Its essential problems were recognized and its relevant theorems developed in the 1890's by Pareto.[2]

In formulating policy criteria, welfare economics takes explicit account of differences in individual preferences and incomes and of the resulting problems in aggregating individual utilities. It is an economic axiom that the marginal utility of individual income decreases with increasing income. There is no agreement among economists on whether and in what sense — ordinally or cardinally — individual utilities can be compared but welfare criteria that avoid interpersonal comparisons are generally preferred.

Classical and neoclassical economists were well aware of these problems.[3] They, however, focused on an increase of real aggregate national income as the main criterion of economic welfare.[4] Pareto's views were not in conflict with this emphasis because he believed — supported by historical experience as he

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[1] For a more detailed discussion of the economic meaning of conservation and of conservation policy see, S. V. Ciriacy-Wantrup, *Resource Conservation: Economics and Policies* 3d ed.; Berkeley, California: Division of Agricultural Sciences, University of California, 1968), pp. 1-397.

[2] Vilfredo Pareto, *Cours de Economique Politique*, F. Route, Libraire-Editeur, Lausanne, 1897. An excellent bibliography of welfare economics is apended to, E. J. Mishan, "A Survey of Welfare Economics, 1939-1959," *Economic Journal*, June 1960, pp. 197-265.

[3] The first edition of Alfred Marshall's *Principles of Economics* appeared in 1890, seven years before publication of Pareto's main work in French. Marshall mentions Pareto only in passing and in a different connection.

[4] When comparing national income at different points of time and for different countries, per capita figures are used. In appraising alternative policies, it is more useful to focus on aggregate income.

saw it — that an increase of national income and greater equality of income distribution tended to be associated. In this case an increase of national income means also an increase of economic welfare according to Pareto's criterion, at least under some generally accepted assumptions.

The Pareto criterion says that a change that makes at least one individual better off and leaves no individual worse off represents an increase of welfare. This criterion is usually interpreted to mean that welfare is increased by a change rendering it "possible" to make at least one individual better off and leave no individual worse off by compensating the losers. Most of the discussion in the new welfare economics deals with this compensation principle.

The Pareto criterion "without" compensation is so restrictive that it has little relevance for an appraisal of public policies — even if it could be practically applied. There are scarcely any policies which make nobody worse off. Furthermore, if there were such policies, the criterion would be ineffective for choosing between more than one alternative to the status quo.

The Pareto "with" criterion is conceptually not identical with the criterion "increase of national income." But the latter criterion may be regarded as a practical, first approximation to the former, provided that the policy under consideration does not appreciably increase inequality of income distribution and provided further that there are other policies in operation which work independently and continually in the direction of greater equality of income distribution. Such policies are, for example, progression in income and property taxes, high inheritance taxes, and social-welfare legislation in the narrower sense (relating to old age, invalidity, unemployment, minimum wages, public health, education, and so on). In some practically important cases, these two conditions can be regarded as fulfilled when considering resource policies in modern western societies.

The contribution of welfare economics has been a clarification of the theoretical difficulties in arriving at a social-welfare function and social indifference curves and of the operational difficulties in applying the Pareto criterion in actuality. The disservice of welfare economics has been that its terminology is used without pointing out these theoretical and operational difficulties. The false impression is created that a simple criterion is available that can be used for legislation, court decisions, administrative regulation, and other applications of policy.

Environmental Policy and Economic Optimizing

After this sketch of welfare economics, we may now raise the question of what is the conceptual meaning of economic optima. In other words, is it conceptually at all useful to make the maximization principle the basic criterion for environmental policy? The maximization principle is applied in normative economics, first as efficiency criterion for limited operations under restrictive assumptions and second as the assumed overall objective of public policy.

As efficiency criterion, the maximization principle is used, for example, in finding the optimum output under given cost and revenue functions and also in determining minimum costs for each output under given production functions and given price schedules of productive factors, that is, in determining a cost function. For these and similar purposes, the maximization principle is necessary.

There can be no disagreement on the usefulness of such operations. One may call this application of the maximization principle "efficiency economics" or, more appropriately in some cases, "efficiency engineering."

If applied as the assumed overall objective of public policy, on the other hand, the maximization principle is a construct — a scientific fiction.[5] A fiction is permissible in science if its character is clearly understood. A fiction is a deliberate, conscious deviation from reality. A fiction, however, is not a hypothesis or theory. By itself, a fiction is not intended to be validated by testing with empirical evidence. But a scientific fiction should be useful as a stimulus for or as a part of hypotheses and theories which can be tested. Hence, the test of a scientific fiction is its conceptual usefulness, its expediency in understanding, explaining, and predicting reality. A fiction becomes mere dogma and therefore unscientific if its two characteristics (consciousness of its fictional nature and conceptual usefulness) are obliterated. There are many examples in the history of science of fictions changing into dogma. One may wonder whether or not the maximization principle, as applied to policy, has become dogma in economics. There is increasing emphasis on techniques which facilitate greater numerical accuracy in the determination of optima with no conceptual gain and at the expense of "assuming away" essential economic relations.

It was suggested in the preceding section that, under certain conditions, an increase of national income may be accepted as a criterion for policy. This is the approach of benefit-cost analysis which, originating in the field of water policy, is increasingly applied to all kinds of public action affecting the environment. Limitations on the general applicability of benefit-cost analysis are imposed by a number of theoretical and practical difficulties. Some of these are the following.[6]

The quantities of goods and services making up the national income must be evaluated (weighted) in order to be aggregated. The weights used — market prices and unit values derived indirectly from prices and in other ways — are affected by the host of social institutions which influence income distribution (and thereby demand) and market form. The policies to be appraised may change income distribution and market form. Such an appraisal deals with the future. Over time, individual preferences and technology (both affecting value weights and quantities of national income) change, and these changes are highly uncertain. Again, the policies to be appraised affect these changes. Besides such "structural" changes, there are changes connected with economic fluctuations of various amplitude and duration. These, likewise, are related to the policies to be appraised.

Practical approximations to a solution of some of these difficulties are possible but only under restrictive assumptions with respect to social institutions, preferences, technology, and time periods. For policies of broader scope, these restrictive assumptions weaken validity and relevancy of results. This is true for most environmental policies. In appraising such policies, it is useful to analyze their effects upon significant conditions which influ-

[5] Next to mathematics and law, economics is the discipline in which scientific fictions are most common. But the natural sciences, especially modern physics, frequently employ fictions.

[6] For greater detail see, S. V. Ciriacy-Wantrup, "Benefit-Cost Analysis and Public Resource Development," in, Stephen C. Smith and Emery N. Castle, editors, *Economics and Public Policy in Water Resource Development* (Ames, Iowa: Iowa State University Press, 1964), pp. 9-21. *See also,* other papers in this book.

ence the *direction* and the *rate* of changes of national income and income distribution rather than to focus on quantitative changes themselves. Among these conditions, two deserve special attention in environmental policy both in the spheres of conservation and allocation. One is the institutional system which influences the use of the environment by man; this will be discussed in the following section. The other is whether or not such use leads to avoidable irreversibilities.

There is no need to go into the technical aspects of reformulating the objectives and criteria of environmental policy from the viewpoint of avoiding irreversibilities. These aspects are treated in uncertainty economics and game theory.[7] Suffice it to say that the objectives of environmental policy can often be compared to the objectives of an insurance policy against serious losses that resist quantitative measurement. There the objective is not to maximize a definite quantitative net economic yield but to choose premium payments and benefits in such a way that maximum possible losses are minimized. As a special case of this strategy, "a safe minimum standard" is frequently a valid and relevant criterion for conservation policy.

With this reformulation of objectives and criteria of environmental policy, we are mainly interested in the order of magnitude of maximum possible losses and, compared with that, of the "insurance premium" that must be paid to guard against them. As a general rule, if action is taken in time the maximum possible losses which would result from not adhering to a safe minimum standard of conservation are large in relation to the costs which must be expended in order to guarantee such a safe minimum standard.

The emphasis of this approach is on avoiding overuse rather than on achieving optimum use, on establishing base levels rather than on locating peaks, on not entering dead-end streets and on keeping direction rather than on computing the shortest distance, and on mobility and adaptability of productive factors rather than on their optimum combinations. This approach does not pretend to establish criteria for optimizing social welfare. But it offers effective direction signals turn by turn for public actions in environmental policy to increase social welfare.

Social Institutions as Decision Systems

There is scarely need to emphasize the fundamental importance of social institutions for conservation and allocation policy as differentiated in an earlier section. In particular, the impact of the various legal forms of property institutions and, derived from them, of resource tenure, taxation, and credit are well established. This impact operates through what may be called "indefiniteness," "instability," and "imbalance" of property rights.[8]

On the other hand, in economics as an academic discipline, the once great concern with social institutions has been pushed into the background during recent decades in favor of quantitative optimizing models. In these models, social institutions, if considered at all, are treated as constraints in the same way as technological conditions and resource availability. Partly, at least, institutional economics itself is to blame for this setback because it had become descriptive-historical rather than analytical in orientation, without a body of viable theory and burdened by traditions and value

[7] *Idem, Resource Conservation: Economics and Policies, op. cit.*, Chapters 17 and 18.
[8] *Ibid.*, Chapters 10-14.

judgments. It is the proposition of this section that, in the field of resource economics in general and of environmental policy in particular, an analytically oriented institutional economics is by no means obsolete as an aid in clarifying and directing policy.

When social institutions are used as constraints in optimizing models, they become conceptually indistinguishable from policy objectives. In reality, however, they are more frequently means than ends in the sense both of policy tools and of obstacles to be removed or modified. In other words, failure to realize the conceptual difference between technological and institutional constraints results in blurring and distorting the distinction between the part of the model that constitutes the objective function to be maximized or minimized; the part that constitutes the constraints describing the structure of the operation; and the part that identifies the variables and their interrelations.

When social institutions are used as constraints in optimizing models, a new optimum must be calculated for each combination of constraints; the optima calculated for different sets of constraints must then be compared. A considerable literature has grown up around this problem, known as the Theory of Second Best.[9] This term indicates that there is at least one constraint additional to the ones existing in the Pareto conditions discussed earlier. The exponents of this theory maintain that the major conclusion is a negative one: If a deviation from one of the Pareto conditions prevails, the best course of action is not to attack this deviation. On the contrary, a second-best solution is usually obtained by departing from all other Pareto conditions. To apply only a part of the Pareto conditions would change social welfare away from rather than toward a second-best position.

If this criticism of "piecemeal welfare economics" is valid — I believe it has some merit — does it not point to a basic weakness in the logic of using social institutions as constraints? If one tries to avoid the futility of piecemeal welfare economics and strives for bold changes in the combination of constraints, can one be sure that the resulting optima are comparable in a meaningful way? Is it not unavoidable that such bold changes affect some structural elements of the model, especially technology, preferences, and motivation of human agents? Are we not confronted with a problem of identification in the econometric sense on a large scale?

In view of these questions, a different analytical approach to social institutions may be considered: Social institutions may be conceptualized as decision systems on the second level of a three-level hierarchy of decision systems. On the first level, the lowest, decision-making relates to the control of inputs, outputs, and the host of similar decisions made by the operating sectors of the economy, namely, firms, industries, and public operating agencies such as water projects and irrigation districts. This level of decision systems may be called the operating level. The decision systems on the next higher level, the second, comprise the institutional framework of decision-making on the first level. One may call this level of

[9] R. G. Lipsey and Kelvin Lancaster, "The General Theory of Second Best," *Review of Economic Studies*, Vol. XXIV (1), No. 63 (1956-57).

John V. Krutilla, "Welfare Aspects of Benefit-Cost Analysis," in, Stephen C. Smith and Emery N. Castle, editors, *Economics and Public Policy in Water Resource Development* (Ames, Iowa: Iowa State University Press, 1964), pp. 22-23.

O. A. Davis and A. B. Whinston, "Welfare Economics and the Theory of Second Best," *Review of Economic Studies*, January 1965, pp. 1-14.

decision systems the institutional level. On the next higher level, the third, changes of institutions on the second level are the subject of decision-making. This level of decision systems may be called the policy level.

Decision systems on each level can be analyzed with respect to structure, functioning, and performance. Performance need not be measured in pecuniary terms even on the first level, where this yardstick is most frequently employed. So far, economists have concerned themselves largely with the structure, the functioning, and the performance of decision systems on the first level. However, some studies on the second level are available. They are concerned with water institutions, especially the systems of water rights.[10] Similar studies are needed concerning the law of the sea, the laws governing pollution, the systems of resource taxes, land tenure systems, and many other social institutions which are of interest to environmental policy. This is a promising field for the "new" institutional economics.

The purpose of decision-making on the second level is not to directly control inputs, outputs, etc., on the operating level of the economy nor to obtain a path of welfare optima at various points in time under projected conditions for these points. Rather, the purpose is to maintain and to increase welfare by continuously influencing decision-making on the lower level under constantly changing conditions that, for any point in time, can be projected only vaguely; not only is it uncertain when given anticipated conditions will occur but it is even always uncertain whether they will ever actually occur.

Decision systems on the second level therefore can be appraised only by viewing them as they function over time under various economic conditions. It is inadequate to appraise these systems by studying temporal cross-sections for particular conditions and points in time. Performance criteria need not be the same as those on the lower level. What is needed on the second level are criteria that could serve as conceptually and operationally meaningful proxies for increasing national income. They may be called intervening criteria in analogy with intervening variables. Proposals for such criteria in the appraisal of water institutions have been made elsewhere.[11]

Some Implications for the Ocean Environment

In conclusion, some implications may be drawn from the preceding analysis for the world oceans — the part of the environment which is of special interest at this juncture. There is a close similarity, if not identity, of the basic economic issues of all environmental policies, whether concerned with land, air, upland game, inland waters, or oceans.

Because of space limitations, this discussion will be confined to the living resouces of the sea and especially to fisheries. These resources are economically by far the most significant ones and, as just suggested, the basic economic issues of environmental policy are very similar for living and non-living resources and for those of the sea and those of the seabed.

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[10] S. V. Ciriacy-Wantrup, "Some Economic Issues in Water Rights," *Journal of Farm Economics*, December 1955, pp. 875-885.

Idem, "Concepts Used as Economic Criteria for a System of Water Rights," *Land Economics*, November 1956, pp. 295-312.

Idem, "Water Policy: Relations to Law and Policy," Robert Emmet Clark, editor-in-chief, *Waters and Water Rights*, Vol. 1 (Indianapolis, Indiana: The Allen Smith Company, 1967), pp. 397-430.

[11] *Op. cit.; see also, idem*, "Water Policy and Economic Optimizing: Some Conceptual Problems in Water Research," *American Economic Review*, May 1967, pp. 179-189.

Since the middle of the 1950's, fisheries policy has received considerable attention from economists.[12] All of these writers have blamed the same cause for the economic problems of the fisheries and have come to the same conclusions and policy recommendations. This cause is the alleged "common property" character of fisheries resources. The effect is said to be overexploitation of the resource, overinvestment in the fishing industry, suboptimization of net economic yield, and low per capita income of fishermen. The remedy recommended appears simple: reduce the investment in the fishing industry through limitation of entry until net yields are maximized on a sustained basis. These recommendations are repeated in the recent report of the Commission on Marine Science, Engineering and Resources appointed by the President of the United States.[13] The two recommendations regarding the "principles of fishery management" read as follows:

> "The Commission recommends that fisheries management have as a major objective production of the largest net economic return consistent with the biological capabilities of the exploited stocks.
>
> "The Commission recommends that voluntary steps be taken — and, if necessary, Government action — to reduce excess fishing effort in order to make it possible for fishermen to improve their net economic return and thereby to rehabilitate the harvesting segment of the U. S. fishing industry."

The notion that the common-property character of resources is the main cause of environmental depletion has spread recently from the fisheries to other fields of resource use and has been termed "the tragedy of the commons."[14] This catchy phrase has created much confusion. Some clarification is needed in the light of our previous discussion.

Common property of natural resources in itself is no more a tragedy in terms of environmenal depletion than private property. It all depends on what social institutions — that is, decision systems on the second level — are guiding resource use in either case. Effective social institutions to conserve common-property resources have been developed for the administration of public forests in many countries. The same is true for the conservation of game and fish whether by primitive tribes in pre-Columbian America or modern game-management departments. Agricultural land held in common by villages in medieval Europe was conserved by institutions based on custom and law before private property and the profit motive broke up these decision systems.[15] During the colonial period of the 18th and 19th centuries the spread of private property rights in resources did not prevent serious depletion of forests, range, and agricultural land in many parts of the world.

The term "common property" in itself is a misnomer when applied to fishery resources outside of territorial waters. If no institutional decision system is de-

[12] J. A. Crutchfield and A. Zellner, "Economic Aspects of the Pacific Halibut Fishery," *Fishery Industrial Research*, Vol. 1, No. 1 (Washington, D.C.: United States Government Printing Office, 1963).

F. T. Christy, Jr., and A. Scott, *The Common Wealth in Fisheries* (Baltimore, Maryland: The Johns Hopkins Press, 1965), pp. 1-281.

H. Scott Gordon, "The Economic Theory of a Common-Property Resource: The Fishery," *Journal of Political Economy*, April 1954, pp. 124-142.

Ralph Turvey, "Optimization and Suboptimization in Fishery Regulation," *American Economic Review*, March 1964, pp. 64-76.

[13] Commission on Marine Science, Engineering and Resources, *Our Nation and the Sea: A Plan for National Action* (Washington: United States Government Printing Office, 1969), pp. 92 and 93.

[14] G. Hardin, "The Tragedy of the Commons," *Science*, December 1968, pp. 1243-1248; also, Beryl L. Crowe, "The Tragedy of the Commons Revisited," *Science*, November 1969, pp. 1103-1107.

[15] S. V. Ciriacy-Wantrup, "Soil Conservation in European Farm Management," *Journal of Farm Economics*, February 1938, pp. 86-101.

vised (through effective bilateral or multilateral international treaties), these resources are *res nullius*—one class of fugitive resources—rather than *res communes*—a different class. Examples of the latter class are fishery resources in territorial public waters, upland game, and public range and forests. Another class of fugitive resources is oil, gas and, in some cases, groundwater. In this class, private property rights exist but are indefinite among a limited number of resource users. Because of the existence of three classes of fugitive resources (to only one of which the term common property can be applied), synonymous use of common-property resources and fugitive resources is misleading.[16]

Common property as an institution usually facilitates devising a regulatory system that conserves and allocates resources. If fisheries are labeled a common-property resource when no such institutional basis for regulation exists, this becomes a barrier to understanding and public action. Conceptual and terminological clarification is the first step toward adequate environmental policy.

With respect to conservation policy, "maximum sustained yield" is accepted as a general objective by fisheries biologists and, in principle, by most countries. This is a higher state of conservation than the safe minimum standard discussed above, and it is more costly to maintain. But in practice, the former state of conservation is easier to define and to administer with less biological information than is needed to diagnose with certainty at what point of exploitation irreversibility will be reached.

While maximum sustained yield constitutes a relevant, operational, and noncontroversial objective of conservation policy, this cannot be said of the objective of "maximum net economic yield" — even if its realization through limitation of entry could be agreed upon by the fishing industry.

Besides the conceptual and operational difficulties of economic optimizing discussed earlier, it can be shown that maximum net economic yield, if realized through limitation of entry, will generally lead to a decrease in social welfare.[17] Results will be similar to those under a private monopoly. Output will be lower and prices will be higher than under competition. In addition, costs of administering this scheme must be considered. There may also be other costs which are more difficult to express in monetary terms: fishermen who are "limited out" may have difficulties in finding employment elsewhere. Other fishermen may not be interested mainly in monetary returns but may enjoy fishing as part-time or seasonal work, even if they do not much more than break even. Compared with these social costs of limiting entry, the alleged overinvestment in the fishing industry — for which reliable quantitative estimates have not been given by the economists mentioned above — is probably of the second order of smalls.

Turning to allocation policy, it is here that international decision systems on the second level are needed most. Admittedly, the conservation argument is frequently used in defense of exclusive fishing zones (such as the 200-mile limit) and other devices to give the fishermen of one sovereign state preference over those of others. I have had occasion to discuss these devices informally on a

[16] For a definition of fugitive resources and for more detail on this point, see, *idem*, *Resource Conservation: Economics and Policies*, *op. cit.*, Chapter 10.

[17] For evidence on this point, see, Richard C. Bishop, "United States Policy in Ocean Fisheries: A Study in the Political Economy of Resource Management." Unpublished Ph.D. dissertation, University of California, Berkeley, 1970.

man-to-man basis with officials of several South American countries. My impression is that the conservation argument is largely a rationalization. The real concern is with allocation, that is, with greater participation by an individual country in the economic benefits from fisheries. For this concern it does not matter very much whether fishing is close to shore or further out or even whether it is done by a domestic fleet or by those of other nations. In the presently popular terminology, nations who do not belong to the "haves" in fisheries benefits want "a larger piece of the action."

There are many bilateral and multilateral institutional decision systems affecting the international allocation of benefits from ocean fisheries. Examples of these decision systems are given by Chapman and Schaefer.[18] There is a demand by a considerable number of "have not" nations (in terms of fisheries benefits) — especially in the developing world — for modification of the existing decision systems and for entirely new ones. This demand, I believe, will increase. Before such modification and replacement is attempted, it would be worthwhile to appraise the existing decision systems in their structure, functioning, and performance. There is some indication that the allocative performance of these systems has been better from the standpoint of developing nations than one might expect. But no systematic comparative appraisal is available. Such an appraisal would require a major interdisciplinary effort in which research workers from biology, international law, and economics should cooperate. While economics is best qualified to appraise performance, appraisal of structure and functioning is best undertaken by experts in international law. The biologist, in turn, is needed to appraise these systems in terms of conservation objectives.

In view of the increasing demand for an international regime of the oceans, and in order to incorporate the best and to avoid the worst of past experience in any new regime, such an appraisal may well be given a high priority by research foundations and international agencies.

[18] Wilbert McLeod Chapman, "The Theory and Practice of International Fishery Development-Management," and Milner B. Schaefer, "Investigation, Conservation and Management of the Fisheries of the High Seas with a Case Example of the Tuna Fisheries." To be published in the proceedings of the conference for which the present paper was originally prepared.