

Cooper, Richard N

**Working Paper**

## An Economist's View of the Oceans

Center Discussion Paper, No. 219

**Provided in Cooperation with:**

Yale University, Economic Growth Center (EGC)

*Suggested Citation:* Cooper, Richard N (1974) : An Economist's View of the Oceans, Center Discussion Paper, No. 219, Yale University, Economic Growth Center, New Haven, CT

This Version is available at:

<https://hdl.handle.net/10419/160147>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*

ECONOMIC GROWTH CENTER

YALE UNIVERSITY

Box 1937, Yale Station  
New Haven, Connecticut

CENTER DISCUSSION PAPER NO. 219

November 1974

AN ECONOMIST'S VIEW OF THE OCEANS

Richard N. Cooper

Note: Center Discussion Papers are preliminary materials circulated to stimulate discussion and critical comment. References in publications to Discussion Papers should be cleared with the authors to protect the tentative character of these papers.

## AN ECONOMIST'S VIEW OF THE OCEANS

**RICHARD N. COOPER\***

### *Introduction*

Management of the oceans has become a highly pressing issue in the face of continuously improving technology and relentlessly growing population. The existence, size, and complexity of the United Nations Law of the Sea Conferences in 1974 and 1975 testify both to the importance of and to the difficulties involved in introducing better management into a global arena where relatively little management has existed previously.

My assignment is to indicate how one economist, not an expert on oceans or any of its particular aspects, looks at this relatively new range of issues and what guidance he would offer for future management of the resources of the oceans. It is in many ways a presumptuous undertaking, but as I scan the positions that have been taken to date on management of the oceans I believe it may also be a useful undertaking, for in a number of respects it seems to me that the participants in the process of working out a new law of the sea have lost sight of several important considerations, and in some instances have neglected their own best interests.

---

\*Frank Altschul Professor of International Economics, Yale University, New Haven, Connecticut.

**SUGGESTED PERSPECTIVE** Let me begin with some remarks on the perspective that I adopt, for in many ways it will appear to be unrealistic. First, I will try to adopt a cosmopolitan, or global, perspective. Second, I will be concerned with maximizing the benefits the world derives from its use of ocean resources as indicated by the contribution they make to world output, properly measured. This emphasis on using the world's resources as efficiently as possible is one that the large majority of economists would recognize and, I believe, would generally approve except on grounds of technical infeasibility or dissatisfaction with the distribution of income that they fear might result.

Efficiency in the use of resources is not everything we wish for, and economists recognize the existence and importance of other social goals, such as a sense of participation in decision-making, security in enjoyment of one's standard of living, reduction of unwanted risk, perceived justice in the distribution of income, and so on. But other things being equal, efficiency is desirable so long as the world's resources are limited. The very scramble now going on over ocean resources suggests that resources are very scarce, as do world inflation (which in its origins reflects a collective attempt to consume more than the world is producing) and myriad national conflicts over the distribution of income. We cannot yet afford waste. If we are to elect an inefficient solution to allocation of the ocean's resources, we should be sure that we get a great deal for it in terms of our other social objectives. Having in mind the benefits of efficient management, even if they are not fully attainable, will help in assessing the costs of attaining such other objectives and also of such political compromises as may be made to reach agreement.

All this may seem platitudinous, but I have seen too many cases where policymakers feel obliged to agree to suboptimal policies because of so-called political constraints. Their advisers in turn confine themselves to trying to understand and reconcile the various expressed interests, treating policy formation as a quasi-adversary process among those who show an interest in the subject and in the end recommending least common denominator compromises among conflicting objectives, with little or no consistency in approach, nothing to build on in the future, and neglect of considerations and relevant parties (such as consumers) which failed to make it into the arena where compromise was hammered out.

Compromises, even not very promising compromises, are of course a necessary part of the political process. Where objectives of different parties really do conflict, politicians often find ambiguity and temporizing desirable. But the role of policy advisers is different from that of politicians. Advisers should try to sharpen the issues and to minimize the extent of real conflict, which is often less than meets the eye. Rational management can often make all parties better off if enough effort is put

into framing it. Moreover, proposals for rational management of an issue can guide the efforts of policymakers, both in gathering information that would be necessary for persuading the various parties to accept rational management, and in directing such compromises as have to be made toward ones that can over time be shaped into rational management, rather than ones which will aggravate conflict in the future. In this way a basis can be laid for a consistent and efficient long run program.

Moreover, today's "political realities" often change with remarkable speed in the presence of new circumstances or new information—even as a result of persuasion. The role of leadership in policy formation, including the education of political constituencies, is not yet dead. In the areas of international monetary reform, strong "political realities" against the introduction of Special Drawing Rights and the adoption of flexible exchange rates dropped away quickly, partly as a result of new circumstances, partly as a result of persuasion.

These general introductory remarks on the perspective and on the role of policy advisers are pertinent to the oceans at the present time. Many issues are unfolding at once, and there are many conflicting positions. Economic analysis can illuminate the issues and help to separate the apparent conflict from the inevitable real conflict that is present when resources are scarce. What I propose below are some principles for making the most efficient use of the ocean's resources, with strong cognizance of the need for better distribution of income in the world. The proposals will be viewed by many as utopian, but, like much normative economic analysis, they reflect a rather down-to-earth utopianism.

**CHARACTERISTICS OF THE OCEANS AS A RESOURCE** | Thirty years ago, the oceans could be characterized as a common property resource whose surface was used for maritime transportation and which served as a medium for fish and whales, which could be caught if they could be found. Many minerals were known to reside both within the sea and underneath it, but they were virtually inaccessible. During the intervening period human pressure on the oceans increased enormously, so that what was once an apparently inexhaustible resource, relative to the technology then available and the capital we found it profitable to devote to exploiting it, is rapidly becoming a scarce resource. Already before the Second World War certain fishing areas and certain species were over fished. Now that problem has spread to dozens of species, and in addition we are concerned with the density of shipping (giving rise both to more collisions and to more pollution) and the extraction of minerals from the seabed. The oceans have long been used as a disposal medium for human wastes, but again the growing density of human settlement and the rise in human consumption are increasingly "using up" what was once a genuinely free resource. Fertilizers, pesticides,

and before long, atomic waste materials will have grown in quantity to the point of exceeding the natural absorptive capacity of the oceans. Finally, to complicate further any policy to allocate the various increasingly scarce resources of the oceans, they have become the leading medium, ahead of the atmosphere, in maintenance of strategic balance between the nuclear super-powers.

Once fish become overfished, once waste materials cease to be absorbed before they do damage, once maritime passageways become crowded with ships, what was once a free resource becomes scarce. It takes on value. In economic terms, it commands a scarcity rent.<sup>1</sup> Efficient use of the oceans then requires limiting access to those who are willing to pay this rent.

If the rent is not actually charged, but the scarcity value is present, what happens to it? It gets dissipated in one way or another, through wasted resources. In the case of fisheries, there is more investment of capital and labor than is needed to harvest the fish that are harvested. Some of the social costs of each additional vessel are imposed on other vessels through higher costs of fishing, due to the reduction of the population (stock) of fish. S. J. Holt reports that the harvest of cod in the northeast Atlantic under proper management could be taken with only half of the effort currently expended, resulting in annual savings of \$150 million or more; and Crutchfield and Pontecorvo have estimated that the rent dissipated through excessive costs amounted in the late fifties to 83 per cent of the value of the salmon catch in Bristol Bay, off southwest Alaska.<sup>2</sup> These are enormous losses. Waste disposal in excess of the absorptive capacity of the oceans becomes "pollution" and imposes costs on all those who use the polluted water, from those who like ocean beaches and sea birds to those who would like ocean fish if they were not contaminated by mercury or DDT. The costs can be very diffuse but still be costs nonetheless. Shipping congestion has not yet reached the level of congestion at the world's airports, but it has reached the point at which the risks of collision have risen substantially and therefore each additional ship imposes a cost on other shippers. the costs of collision-avoidance measures and insurance, and the actual (uninsured) losses if collision does occur.

In the case of minerals, the scarcity rent (if any) is captured by the entrepreneur who engages in extraction, or (in the case of oil) it may get dissipated through excessive drilling on a common oil pool, or (where jurisdiction is established) it is paid to a government in the form of licensing fees and royalties.

### *Contemporary Resources of the Sea*

In what follows, I propose to analyze the case of ocean fisheries

in some detail, because of the importance of fisheries and because of their relatively longer history of attempts to limit access. Similar principles apply to pollution and to maritime shipping. Seabed minerals raise somewhat different issues, which will be discussed after the other three areas of concern.

**OCEAN FISHERIES** It has become conventional to characterize a fishery stock of fish that is capable of reproducing itself at a rate that, among other things, depends upon the size of the stock, with the rate of growth fast rising and then falling as the stock becomes larger and eventually presses against the ecological limits for that particular species or group of species. Commercial fishing "creams off" part or all of the annual yield of the stock and possibly even some of the stock itself. In the last case, the stock of course declines. The cost of fishing depends among other things on the size of the stock. For any given technology and fishing effort, the cost per ton of fish harvested is lower, the larger is the stock. On these assumptions, and given a high commercial value of the fish relative to the cost of fishing, there will be a tendency under free access to the fishery for the stock to be overfished, i.e., it will be fished to the point at which the reduced stock increases fishing costs per unit catch enough to deter further entry.<sup>3</sup> Rising relative prices for the fish and/or technological improvements in fishing will lead to further depletion of the stock.

This result is economically inefficient, in the sense that the same harvest of fish could be acquired at lower economic cost if the stock in the fishery were more carefully managed. Whether it is desirable to reduce harvests for the purpose of increasing the stock of fish depends on whether the "rate of return" on reduced harvests now for the sake of lower harvesting costs later equals or exceeds the rate of return on other forms of investment, i.e., in principle the decision whether or not to rebuild depleted stocks is similar to other investment decisions. It might be the case that operating a fishery on a low stock, high cost basis is economically efficient by virtue of the social benefits flowing from the initial larger-than-sustainable harvests that reduced the stock. This result is especially likely if the social rate of discount is high, i.e., if society gives great preference to the present over the future.<sup>4</sup>

But let us assume, what is probably the case for most fisheries at real rates of interest prevailing in the world in recent years, that the depletion of fish stocks through unregulated fishing was socially a mistake and occurred because of the failure of individual fishermen in reckoning their own costs to take into account their adverse effect on total harvesting costs. Suppose therefore that it does make economic sense to rebuild the stock. How is that to be accomplished? Somehow the harvest must be reduced for a

period of time. The standard way to do this is to impose harvest quotas and to limit the length of the fishing season. Technological improvements in fishing may also be restricted. These efforts will increase the stock (or prevent its further depletion), but as they do so prices of the fish will rise and costs of fishing will fall. The tendency of costs to fall and of prices to rise, however, will attract new entrants and encourage investment in improved harvesting efficiency—especially aimed at speed of harvesting if quotas are on a first come, first served basis—both of which are socially unwarranted but privately profitable. Otherwise the profits (which are really scarcity rents, not rewards to genuine entrepreneurial effort and risk-taking) accrue to those lucky enough to have been awarded the quotas.

To encourage efficiency in the use of the fishery, it is necessary to prevent the rents on the fishery from influencing entry and investment. Indeed, some disinvestment from the initial overfished condition will generally be required (this will occur automatically through time as fishermen retire and their ships and boats age). One way of inhibiting new entry and investment is to levy a *charge* on all those who use the fishery, based on the size of the catch. The appropriate royalty per pound of fish would vary inversely with the size of the stock, i.e., it would be high for an overfished stock in order to facilitate rebuilding; it would be lower for an optimally managed stock. It may also be appropriate to impose limits on the size (as a proxy for age) of fish caught, to maximize the productive capacity of a given stock of fish, but these regulations will not generally represent an adequate substitute for a royalty charge. Levying such a charge on the world's ocean fisheries would of course generate revenue, a prospect to which I return below.

It is often suggested that we should strive for a "maximum sustainable yield" from each fishery, a biological concept of the maximum harvest attainable in a given ecological environment without depleting the stock. (Efforts may also be devoted to improving the ecological environment so the "maximum sustainable yield" is enlarged, and for some fisheries this approach seems very promising, provided entry can be limited.) In general, however, this target will result in too *small* a stock of fish for efficient use of resources. The maximum sustainable yield criterion ignores the fact that labor and capital must be devoted to harvesting the fish, and that the cost per unit catch will be lower, the larger is the stock of fish. Thus optimal management of a fishery generally calls for a *larger* stock of fish than would be required for maximum sustainable yield, to help conserve on the other resources required to harvest the fish.<sup>5</sup> Unrestricted access to the fishery will result in a smaller stock of commercially valuable fish than that required for maximum sustainable yield. From this starting point, therefore, the direction of the desired change is clear: to rebuild the the stock through reduction of harvesting *below* the sustainable yield,



provided the "return" on this investment equals or exceeds that on other investments. Moreover, since our knowledge about the characteristics of most fisheries, and in particular about the relationships between stocks, yields, and costs of harvesting, is inexact, I would propose at this stage that we strive for maximum sustainable yield, but that in our calculations of what that yield is and what charge is required to achieve it, we deliberately select from within the range of values those that lead to a higher stock. In other words, we should err on the high side.

An attempt to maximize the revenues from royalty charges, i.e., treating the fishery as a monopoly, will result in still a larger stock and lower output, except in the limiting case in which the price of the harvest from a particular fishery is beyond influence of output from that fishery. But that would introduce an inefficiency of the opposite kind: underutilization of a scarce resource. It should therefore be avoided.

To sum up for fisheries: they differ from most resources in that their efficient management calls for restriction of access to the fisheries. These restrictions in turn can be made to generate revenue, in contrast to the more usual situation in which generating tax revenue involves interference with the efficient use of resources. To find an efficient source of revenue therefore is not an opportunity to be dismissed lightly. Moreover, the total amount of revenue that might be generated from the ocean fisheries of the world is consequential: a rough calculation would put the amount of rents that might be captured at around \$2.5 billion under present circumstances. This amounts to five times the recent annual disbursements of the International Development Association, the leading source of development assistance on very easy terms, and to over twice the annual disbursements of the World Bank. Moreover, the yield might be trebled as the world's fisheries are brought increasingly under intense exploitation<sup>6</sup> and to even higher amounts if the price of animal protein rises relative to other prices.

Because of the importance of enlarging the economical sources of animal protein, there is a global interest in good management of the world's fisheries wherever they are located. Thus, there is serious question whether management should be left exclusively to individual coastal states. My impression, which would have to be confirmed by further research, is that nations have not done an outstanding job of managing those fisheries that fall exclusively within their jurisdiction. Indeed, it has been suggested that such limited success as we have had at fisheries management has come largely through international agreement rather than through exclusive national control.<sup>6</sup> In any case, it certainly cannot be taken for granted that establishment of national proprietorship over coastal fisheries out, say, to 200 miles will result in rational management.

An alternative institutional arrangement for management of ocean fisheries outside traditional territorial waters would involve the establishment

on international commissions for each ocean fishery that has been or is in danger of being overfished. Each commission would have a certain degree of autonomy, but would be tied in with a global organization such as the FAO for general policy guidance and for technical expertise in projecting prices and costs and in determining the ecological characteristics of each fishery.<sup>7</sup> Each commission, with global representation, would have responsibility for gathering detailed information on its fishery, for establishing appropriate fees for exploitation of the fishery, for establishing rules on allowable gear, and for policing proper use of the fishery.

In all cases the guidelines would be to maximize the economic yield of the fishery, thereby permitting gear restrictions to encourage growth and reproduction of the fish, for example, but not to limit improvements in fishing techniques. Technologically traditional coastal fishermen—basically those still operating in a subsistence economy—might be excluded from payment of the catch royalties; and special arrangements, discussed further below, might be necessary for aiding existing fishermen during the transition to optimally managed fishermen.

Of the three other topics requiring discussion here, pollution, navigation, and seabed minerals, the first two can be handled briefly, for, surprising as it may seem, the conceptual issues are similar to those for fisheries—at least at the high level of generalization which I am using, and with the exception of strategic considerations for navigation, discussed briefly below.

**POLLUTION OF THE OCEANS** Pollution involves the deliberate and inadvertent use of the oceans as a waste disposal medium in a way that imposes costs, real and aesthetic, on other users of the ocean. The sources of pollution are many: river runoffs of fertilizers and pesticides and industrial wastes, direct emission of urban sewage, petroleum from offshore drilling or from the cleaning of ships' tanks or from damaged ships. The oceans comprise a vast depository and can absorb much waste material—indeed, they have been absorbing nature's waste material for millenia—without damage and sometimes with great benefit, as when organisms feeding on river effluents and other waste comprise an important link in the food chain or when heat emissions alter the marine environment in a productive fashion. But the emission of waste can also have damaging local effects both to sea life and to human well-being, and in some cases, long lasting, long distance effects have been identified, especially from toxic chemicals (DDT and mercury compounds), radiocative materials, and even oil.<sup>8</sup> We need more analysis, including reasoned speculative analysis of the effects of ocean pollution. Where the external effects are negative and substantial and where compensation to the losers is difficult either because they cannot be clearly identified or because the offenders cannot be clearly identified

(as might be the case with slow mercury poisoning through consumption of fish, for example), prohibitory regulations may be required. In other cases, liability should be clearly established and stiff fines for damage should be instituted. This course seems preferable to laying down specific behavioral requirements, e.g., for the construction of tankers, for it leaves to potential offenders an incentive to find the least-cost ways of avoiding the contingent losses to them should an accident occur.

There is an obvious connection between waste disposal in the oceans and ocean fisheries; certain kinds of disposal may devastate a fishery, while others may actually be beneficial. In the former case, it would be natural to empower the fishery commissions recommended above to negotiate with damaging sources of pollution either to desist or to compensate for damage done to fishery. Procedures for adjudication of disputes between national authorities and the commissions should also be established. One possible outcome is that the polluters would be willing to pay more for the use of a given disposal area than it is worth as a fishery, and financial compromises between the two conflicting uses are of course possible, based on the marginal social benefit of each activity. This would represent another, more modest, source of revenue for the international community.<sup>9</sup>

**SHIPPING** The world's merchant fleets nearly doubled in number of ships between 1951 and 1971, and merchant tonnage nearly quadrupled. Both the average size and the average speed of merchant ships rose, so that larger ships covered more miles in any given period of time. The great growth in ship-miles travelled has increased congestion in the world's shipping lanes, and the larger size has increased both the probability of collision (because of reduced maneuverability) and the cost of collision. A number of dramatic incidents have occurred in recent years, including increased numbers of groundings as well as collisions, and for the same reasons. Shipping accidents have grown with the volume of shipping and have reached the point at which on average a 50,000 ton ship sinks every day.

As with free access to fisheries, free access to shipping lanes, once they become crowded, imposes costs on other users which ship entering the lane does not bear directly. Congestion externalities do not yet seem to be a major problem for shipping except in some ports and in a few straits, such as the English Channel and the Straits of Malacca. Moreover, such congestion as has occurred can be alleviated by laying down stricter rules of the road and providing better navigational aids, as the British government has done in the English Channel.<sup>10</sup>

Although ship captains will not like the intrusion on their traditionally wide prerogative, it will become increasingly necessary to instruct them where to move in congested areas, as is done today with aircraft.

Moreover, if some lanes become very crowded, it will be desirable to charge "congestion fees" on ships entering the lanes, not merely to pay to navigational aids, but specifically for the purpose of limiting congestion. Again major airports offer a precedent, as do fees for transiting some canals. Such fees would provide yet another source of revenue. Congestion fees are not likely to be warranted on any of the ocean sea lanes for some time, however, and tighter traffic control and better navigational aids will postpone the day even further.

As with waste disposal, it would be *possible* to charge monopoly rents for passage through certain straits, and indeed levying charges on passage has been a common source of revenue for local rulers through the ages.<sup>11</sup> But so long as the passages are not congested, such charges cause a misallocation of resources by discouraging some potential users from using the passage in question. Like tariffs, they create an artificial impediment to trade. They should therefore be avoided.

**MINERALS FROM THE SEABED** Exploiting minerals on or under the seabed poses a somewhat different analytical problem than management of fisheries, pollution, and shipping. The scarcity rents in these latter cases can be dissipated through unimpeded access, and good management requires some limitation on access, such as a royalty on fishing harvests. With deep sea minerals, on the other hand, we want to encourage as much exploitation as is economic, by as many parties as possible (to ensure competition). Making the best use of the world's resources calls for maximum economic exploitation. Therefore we do not want to impose impediments to exploitation of the seabed, except those that are required to offset the negative external effects such as ecological damage to fisheries, over-working a given oil pool, interference with shipping, and the like.

The clear implication is that restricting entry and charging stiff royalties on minerals extracted from under the oceans may not be a good idea from the viewpoint of economic efficiency. That observation must be coupled with the observation that mineral industries often do generate scarcity rents. They do so whenever the source of supply is more economical than the "marginal" or highest cost source of supply of the mineral in question, after allowance for transport costs to the leading markets. Where these rents exist, they can in principle be taxed away without loss to economic efficiency. The problem is to identify them. It is not clear that there will in fact be substantial rents on seabed mining, which at least in its early stages will be a very expensive activity. We should not count on substantial revenues from this source until we have greater knowledge about the economics of such mining. Premature imposition of license fees might discourage what is a desirable activity.<sup>12</sup>

The revenues that seem to be available from exploitation of these

resources appear to be vast—and they may in the end prove to be vast. An estimated two-thirds of offshore oil reserves lie beyond present territorial waters. At \$5 a barrel an annual production of 8 billion barrels of such oil would yield \$40 billion. But the costs of extracting such oil must not be neglected, and the “rents” may be nowhere close to \$5 a barrel. North Sea extraction costs are proving to be substantially greater than expected, and no doubt in the next several years higher cost off-loading facilities in the major consuming areas will (and should) be required to reduce the chances of pollution.

An adaptation of the approach that has already been applied in the oil industry offers a reasonable approach to the extraction of scarcity rents that may not exist. Prospectors should be allowed to undertake as much exploration and preliminary survey work on attractive areas as they like, and additional survey work should be undertaken by (international) public authorities. Then prospectors would be permitted to bid for extraction rights on specified sites, the term of the lease to be for a suitably long period of time as long as the site is worked. Under competitive bidding, the auction price should come close to the present value of any scarcity rents on a given site, on the basis of present knowledge about future costs and prices and the availability and ease of extraction of minerals from the site in question. Such auctions, based on sealed bids, have been used successfully for offshore drilling rights in the United States, and for drilling rights in Alaska, generating substantial revenues for public authorities.

Present knowledge is of course limited, and the value of a given field may prove to be substantially less or more than appeared to be the case at the time of auction, or other circumstances in the industry (e.g., the technology available) may change. To cover this contingency, the leasing agency should also impose a profits tax on the firms engaged in extraction. In this fashion, the agency will share with the firm any exceptional earnings that were not anticipated at the time of the bidding. Corporate profit taxes of around 50 per cent are normal in many countries; the profits tax in this activity might be somewhat higher, in view of the important role which purely geological factors (as opposed, for example, to sales or marketing efforts) play in the profitability of the activity. Beyond that, the world should not begrudge exceptional profits occasionally accruing to those extracting minerals from the seabed; that may be necessary to encourage firms to invest their capital in the exceptional risks involved.

I would be prepared to give some preference in the bidding to newcomers to the industry in question, in the interests of increasing the extent of global competition. The amount of preference would depend on the global structure of the industry, varying from zero for a reasonably competitive industry to, say, 15 per cent for a highly concentrated industry. In general, access to the seabed should be as wide as possible.

Some less developed countries have expressed fears that mining from the seabed will depress the prices of their important export products. On the principles outlined in the beginning of this paper, this concern is not a legitimate ground for under-exploitation of seabed minerals. If that principle were to have been widely applied throughout history, we would still be living in a static, stone-age society. (The introduction of metals undercut the use of stone!) Moreover, apart from petroleum and cobalt, the prospect of consequential effects on prices seems at present to be small.

**NATIONAL SECURITY** As far back as Adam Smith economists have recognized that "defense is more important than opulence," or, in modern terms, that prosperity is no substitute for security. They have also, it is true, been suspicious of the misuse of national defense arguments for introducing inefficiencies into the allocation of resources. But that is different from arguing that they have no validity. The bearing of national defense considerations on management of the oceans is that at present strategic deterrence rests mainly, and in the future perhaps exclusively, on missile-carrying submarines. The stakes are extremely high, and no action in the oceans should be taken that would jeopardize that use. The proposals made above are entirely consistent with freedom of movement for submarines, except that submarines must be exempt from individual transit tolls on the use of congested straits—should such tolls become desirable in the future. Instead, the Soviet Union and the United States and any other country with such submarines might reasonably be required to make annual payments for unlimited use of the straits by their submerged submarines.

#### *Distribution of Oceanic Rents*

As noted above, fisheries represent one of the relatively few areas where efficient management can be used to generate revenue, in addition to the income that accrues to fishermen. Use of the oceans for waste disposal and for shipping may offer similar opportunities, but the scale is smaller and more remote in time except for pollution of fisheries. In addition, exploitation of seabed minerals will probably give rise to some pure rents which could be taxed away without economic loss. There might be no such rents; but more likely they will be substantial, particularly after appropriate technologies have been developed and shaken down. The history of oil discovery suggests large rents, and at a minimum of normal profits tax on corporate income arising from extraction of ocean resources might be included here.

I take seriously the United Nations claim on the seabed as a "common heritage of mankind," and indeed I would go further and extend

this claim to all the world's commons, including the entire ocean area beyond territorial waters. We have an opportunity to delimit the process whereby Nature's caprice in the location of resources provides unearned windfalls, sometimes huge windfalls, to those who happen to be in proximity when the resource becomes valuable through increases in demand or improvements in technology.

Extension of this claim should not, in my view, mean detailed United Nations regulation of the use of the oceans or the seabed. In most instances detailed regulation is not warranted. What it does mean is that any revenues above cost and fair return to investors arising from use of the oceans or seabed should be used for internationally agreed purposes. That is, the international community as a whole should hold title to the property, but it should license freely the use rights, not monopolize them.

There are many possible uses for the revenue, which as we have seen above might be substantial, eventually running into tens of billions of dollars annually when fisheries, offshore petroleum, and seabed mining are taken together. The first claim on these revenues would be management costs, which should be a small portion of the total. The second claim would be scientific research germane to efficient management. This is especially important in the case of fisheries and pollution, where our ignorance of the ecological relationships is still much too great for confident management; but it also could be important in maximizing the returns from the seabed, for the manganese nodules may only be the first of many extractive opportunities.

The revenues remaining after these claims have been satisfied—and they could be substantial—could then be used for a variety of common purposes: budgetary support for the United Nations, which is frequently strapped for funds; UN peace-keeping activities; and most obviously, development assistance to the poor countries of the world.

These arrangements seem to me far better for the world community *as a community* than the current tendency of coastal states to grab for 200 miles plus. It is also far better individually for all land-locked and shelf and zone-locked countries, and for those really poor countries, such as India and a number of African nations, that have extensive coastlines but also are likely to benefit disproportionately but appropriately from the international revenues arising under these arrangements. Persuasively developed, they should appeal to many countries whose current position in the Law of the Sea Conference does not seem to conform either with their national economic interests or with the notion of a well-managed global community.

This discussion has dealt with distribution of the revenue. But what about distribution of the activity, e.g., who will actually do the mining or the fishing? In today's world of extensive government planning and influence on national economies, this is not as relevant a question as it might

at first seem to be. Economic development is better served by maximizing the revenue, that is, the net earnings, from each activity and then using the revenue to employ labor in the most effective way, which will vary from country to country. To allocate an activity such as fishing to inefficient employers is to advocate waste, and I argued earlier that we cannot afford waste in today's world. Where important market imperfections exist in the employment of labor or other resources—and there are many such imperfections in less developed countries, for that is one manifestation of their lack of development—government efforts should be directed at reducing or eliminating those imperfections, and a good source of revenue can help in accomplishing that.

### *Translation of Theory into Practice*

To manage the world's oceans efficiently we need much more information than we now have, although we made an important start; and to assure equity we need to provide for a smooth transition to proper management in those cases, such as fisheries, where extensive changes from existing practices may be required.

The need for accurate scientific and economic information is hard to over emphasize. One reason that debate over a fishery's management can continue so long, and adequate regulation be so long postponed, is that firm information on the relationship between fishing effort and the yield of the fishing population is absent. I am struck by the parallel to the gradual extension of international control over contagious diseases in the 19th century. Nations squabbled endlessly over the best methods of control, and the theories of contagion that underlay them, until complete and correct scientific information on the mode of transmission and the incubation period of each disease became available. Once that happened, international agreement on regulation occurred relatively rapidly. With international common property, distribution of the gains will always be a potential source of conflict, but how to maximize the gains should not be, once we have adequate knowledge. Thus much more effort should go into marine research. It is distressing that marine research itself seems to have become a political football at the Law of the Sea Conference, an arena in which sovereign rights are tested. Knowledge, even more than the oceans, should be common property, and its acquisition should be subject to minimal impediment.

As for transitional arrangements, some provision should be made for those who have already invested their capital and their training in fishing particular fisheries, even those that are overfished. I would suggest that harvest quotas be allocated on the basis of historical catches, with the total quota set *below* the substantial harvest so that the stocks of overfished



fisheries can grow. New entry onto such fisheries would be prohibited altogether for a specified period of time. As the fish population grows, harvesting costs will fall, giving the historical fishermen some financial room for readjustment. As the population approaches the optimum level, the fishery could be opened to new entrants, subject to a harvest royalty that would deter entry sufficiently for the population to continue to grow to the optimal level. At this point the quotas would be eliminated, and all fishermen, including the historical fishermen, would be subject to the harvest royalties, set to maintain the stock at the optimal level. As technical improvements (or the rising price of animal protein) encourage excessive fishing, the royalties would be raised.

But it is not my intention here to provide a detailed blueprint for management, so I will not dwell further on the possible institutional aspects. Rather, my purpose has been to sketch the broad principles which, as an economist concerned with the building of international community, I believe should govern the management of ocean resources.

#### Footnotes

1. Economists use the term "rent" to mean the reward above costs of production to anything that is scarce.

2. S. J. Holt, "The Food Resources of the Ocean," *Scientific American*, 1969, No. 221, page 193; and James A. Crutchfield and Giulio Pontecorvo, *The Pacific Salmon Fisheries*, Baltimore: Johns Hopkins Press, 1969, p. 117. The 81 per cent cost allows for a 50 per cent assumed increase in productivity in the salmon industry between the early thirties and the late fifties. Additional examples can be found in Francis Christy, Jr., *Alternative Arrangements for Marine Fisheries: An Overview*, Washington: Resources for the Future, 1973, page 17.

3. See Appendix for a more formal statement of these relationships and the discussion that follows.

4. It may even make economic sense, conservationists will be horrified to learn, to fish a species to extinction. For example, an isolated community near starvation will have a high rate of discount and may eat every fish it can catch. Happily this condition is not likely to obtain often.

5. As noted above, a sufficiently high discount rate may reverse this relationship, and call for depletion of the stock below that required for maximum sustainable yield.

6. These rough estimates are derived by supposing that about half the ocean fisheries of the world are now either under (generally

inefficient) regulation already, or are being overfished, and by assuming (conservatively—see the estimates cited earlier) that the average excessive resource cost on these fisheries is one-third. It has been estimated that the maximum sustainable yield of fish from the oceans under existing environmental conditions is 200 million tons, compared with the 60-70 million tons now being caught. See S. J. Holt, *op. cit.*, page 188.

6. See J. L. McHugh, "Population Dynamics and Fisheries Management," in Robert Thompson (ed.), *Marine Fishery Resources*, Oregon State University, 1972, page 83. It is interesting to speculate on why this is true, if it is true. It may be that domestic management schemes are dominated by producer groups with relatively short-term horizons, whereas elevation to the level of international dispute creates a need to impose at least a semblance of rational management, for that is the easiest way for diplomats to justify an international accord to their respective domestic constituencies.

7. A "fishery" in some instances would be a single species, in others a region where a "biomass" of different species interacts. The choice would be determined by ecological considerations in combination with economical fishing technology (e.g., whether the capacity exists to fish a single species from a diverse fishing ground).

8. See D. F. Boesch, C. H. Hershner, and J. H. Milgram, *Oil Spills and the Marine Environment*, Cambridge, Mass.: Ballinger, 1974.

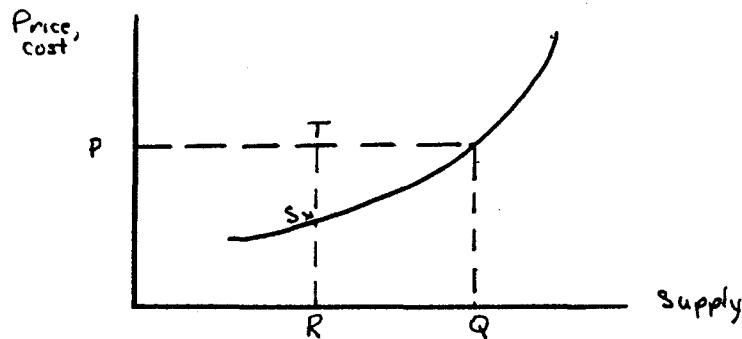
9. Charles Pearson has suggested that disposal charges might be an important source of revenue. He identifies two very different principles on which to base charges: the first arises from negative external effects on fisheries and other users, such as those discussed above; the second involves charging a "monopoly rent" to those who want to use the ocean and have no other low cost method of disposal. As Pearson recognizes, the second principle would involve a misallocation of the world's resources, since the oceans frequently do represent the channel of waste disposal that is socially least expensive. So long as that is so, and for many materials it is likely to be so for a long time, it would not be desirable to levy these monopoly rents. See Pearson, "Extracting Rent from Ocean Resources: Discussion of a Neglected Source," *Ocean Development and International Law Journal*, vol. 1, 1973, pp. 221-237.

10. Malaysia and Indonesia have so far refused to do this in the Straits of Malacca. Perhaps it will take the equivalent of a *Torrey Canyon* disaster to move them to action. See E. F. Oliver, "Malacca: Dire Straits," *U. S. Naval Institute Proceedings*, June 1973, pp. 27-33.

11. Denmark levied transit dues on ships in the Danish Sound until 1857. They were scaled down and commuted into lump sum payments, in exchange for Denmark's agreement to keep the Sound dredged and to provide navigational aids. See Charles E. Hill, *The Danish Sound Dues and the Command of the Baltic*, Durham, N. C.: Duke University Press, 1926,

pp. 282-285.

12. From the vantage point of the leading markets for a given mineral, i.e., the area with the greatest deficit in supply, we can construct a "supply schedule" that will relate the various amounts that will be offered to that market at varying prices. For minerals, the supply schedule will generally be upward sloping, and the governing price  $P$  will be that which just equates demand and supply, point  $Q$  in the figure. A producer at point  $R$  on the global supply schedule will then earn a substantial scarcity rent on his sales,  $ST$  on the assumption that the supply schedule includes the cost of capital and some reward to risk-taking. We do not know yet whether deep sea mining will be at a point like  $R$  or at a point like  $Q$ , where there is no scarcity rent—or at both points, if the costs of seabed mining vary substantially from place to place.



## APPENDIX

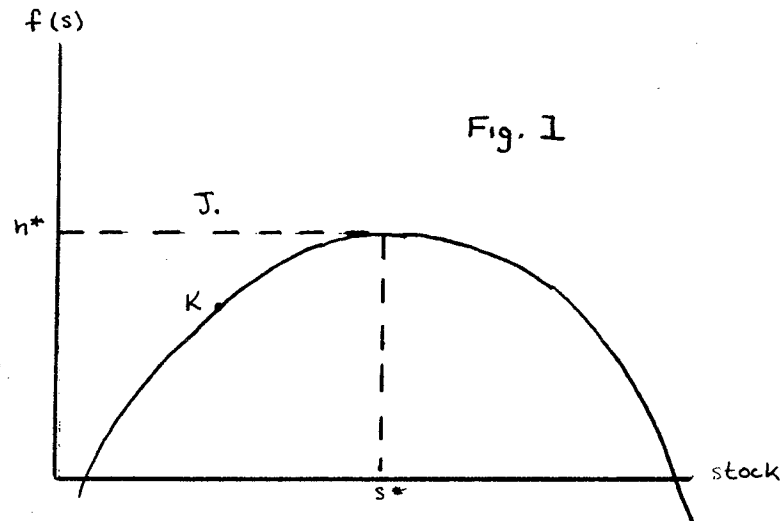
### *Simple Model of a Fishery, and a Guide to Optimum Management*

Suppose the population dynamics of a single-species fishery can be characterized by

$$(1) \quad \dot{s} = f(s) - h \quad \begin{array}{l} f'(s) > 0 \text{ for } s < s^* \\ f''(s) < 0 \\ f'(s) < 0 \text{ for } s > s^* \end{array}$$

where  $s$  is the stock of fish,  $\dot{s}$  is the change in the stock per unit time, and  $h$  is the harvest per unit time. This relationship is shown in Figure 1:  $h^*$  is the maximum sustainable yield, i.e., the largest harvest possible that will not

draw down the stock, and  $s^*$  is the stock required to generate this yield. (No distinction is made here between age-classes of the stock.) As the stock gets larger, it is assumed to reach an ecological limit to its natural size.



Suppose the costs of fishing on this fishery can be characterized by a cost function

$$(2) \quad C = C(h, s), \quad C_h > 0, \quad C_s < 0, \quad C(0, s) = 0$$

where  $C_h$  represents the incremental cost per unit of catch, stock being held constant, and  $C_s$  represents the change in costs of a given harvest resulting from an increase in the stock. In general,  $C_h$  and  $C_s$  will depend in value both on the size of the stock and on the size of the harvest. This cost function consolidates the cost functions of individual fishing units into a relationship for the industry as a whole. In competitive equilibrium, marginal harvesting cost  $C_h$  will apply to each fishing unit, and will equal average fishing costs (inclusive of normal return to capital), which are also affected by the stock of fish.

Finally, suppose for the moment that the price of this fish to the fishermen is fixed at a given value  $\bar{p}$  for all points of time  $t$  in the future.

$$(3) \quad p(t) = \bar{p}$$

This assumption will be relaxed below.

Under these circumstances, competitive access to the fishery will lead to a level of fishing such that  $C_h = \bar{p}$ , i.e., fishermen will increase their harvesting effort until marginal cost equals price. For reasons that

will become clear below, this means that *any* fishery that is fished at all will be "overfished," that is, fished somewhat beyond the economically optimal point. We do not usually notice this overfishing, however, until the price-cost incentives make it attractive to fish extensively and the fish stock drops below the maximum sustainable yield level,  $s^*$ . Harvesting may take place at a point like J in Figure 1, in which case the stock will still be declining (since harvesting there exceeds the natural growth in the stock), or at a sustainable point such as K, assured either by regulation of harvests or by a rise in  $C_h$  sufficient to keep harvesting at that level. Note that the actual harvest may be either above or below  $h^*$ , but the sustainable harvest will be below  $h^*$  (except by coincidence). Moreover, the same sustainable harvest could be achieved at lower cost if the stock were larger.

The economically optimal harvest is that harvest that maximizes the present value of the fishery. We assume here that the only value of the fishery is to produce fish. In that case, and on the other assumptions made above, we want to choose the stock  $s^{**}$  and the harvest  $h^{**}$  that maximizes

$$(4) \quad \int_0^{\infty} [\bar{p}h - C(h, s)] e^{-it} dt$$

where  $i$  is the social rate of discount (here assumed to be constant over time), which under carefully stipulated circumstances will equal the market rate of interest on "riskless" assets.

Maximizing (4) is a problem in the calculus of variations and gives rise to the Euler condition for maximization†:

$$(5) \quad \bar{p} = C_h + C_s \left( \frac{1}{f'(s) - i} \right) + \left( \frac{1}{f'(s) - i} \right) \frac{dC_h}{dt}$$

This condition must be satisfied at *all* moments of time if (4) is to be maximized.

The expression (5) requires some interpretation. The last term on the right is transitory, diminishing to zero once the sustainable optimal output has been reached. Moreover, during the transition to the optimal output this term is ambiguous in its sign; it will however generally mitigate the impact of the second term on the right, but will not offset the second term. For  $f'(s) < i$  the second term on the right-hand side will be positive. That is, the marginal cost from a *social* point of view includes a term in addition to  $C_h$ , and if fishermen have not taken this second term into account

---

†See Kelvin Lancaster, *Mathematical Economics*, New York: Mac-Millan, 1968, pp. 377-380.

they will be indulging in excessive harvesting effort at  $C_h = \bar{p}$ .

This second term,  $C_s \frac{1}{f'(s) - i}$

can be explained by considering the special case of  $s = s^*$ , where  $f'(s) = 0$ . Then this term reduces to  $-C_s/i$ , the present discounted value of the extra costs imposed for present and all future fishing by reducing the stock by one unit. Where  $f'(s) > 0$  (i.e., where  $s < s^*$ ), this discount factor is augmented by the positive productivity of an addition to the stock; where  $f'(s) < 0$  (i.e.,  $s > s^*$ ), the discount factor is diminished by the negative productivity of an addition to the stock.

Equations (1) and (5) together determine the optimum path for harvesting the fishery, and equation (2) will give the costs associated with the optimal path. So long as the optimum harvest as determined by equation (5) is below or above sustainable yield, the stock will increase or decrease according to equation (1). Only when both equations are satisfied will there be an optimum sustainable harvest, and it will in general differ from the maximum sustainable harvest. Figure 2 illustrates one plausible set of relationships:  $f(s)$  is shown as in Figure 1,  $\hat{h} = g(s)$  represents the solution of equation (5) for the optimum harvest  $\hat{h}$  as a function of the stock, neglecting the transitory term.

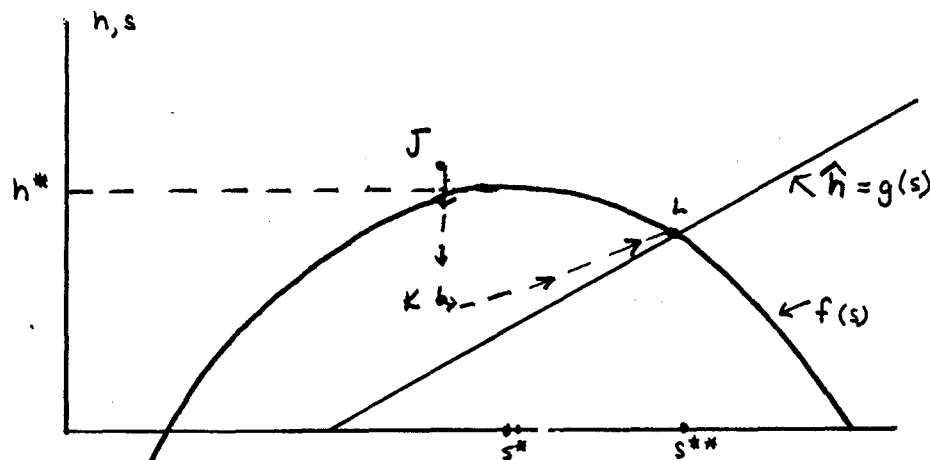


Fig. 2

It originates on the  $s$ -axis at the value of  $s$  where  $f'(s) = i$ , from equation (5), and rises to the right. If the fishery is initially fished at  $J$ , then the stock is overfished and is falling. Figure 2 indicates that the harvest should be at once to  $K$ , assuming no fixed costs of capital are associated with harvesting. At  $K$ , the stock will grow rapidly, and gradually the harvest should be increased, until it reaches  $L$ , at which point the stock will no longer be sustainable. Notice that the optimum harvest is below  $h^*$  and the optimal stock  $s^{**}$  exceeds  $s^*$  here, in order to reduce the costs of harvesting

according to equation (2).

A higher interest rate will shift  $g(s)$  to the left and may push  $s^{**}$  below  $s^*$ . Indeed, a sufficiently high interest rate will push  $g(s)$  so far to the left that it ceases to intersect  $f(s)$ , in which case the optimum path involves fishing the stock to extinction.

As unexpected increase in price will rotate  $g(s)$  counter-clockwise, calling for a higher harvest immediately after the increase in price and a decline in stock until a new equilibrium is reached.

In general, however, if prices are at or close to private marginal costs and the discount rate is moderate at an overfished point such as  $J$ , the optimal stock  $s^{**}$  will exceed  $s^*$ .

The optimum path can be achieved through the imposition of harvesting quotas. Or it can be achieved through the imposition of a harvesting tax,  $T$ . Equation (5) indicates the amount of tax that will assure optimal fishing under conditions of competition and entry unrestricted except by the tax.

$$(6) \quad T(s) = \frac{C_s}{f'(s) - i} \quad \text{at the optimum sustainable harvest.}$$

The tax should be levied on each pound of fish caught. It will decline as the stock of fish increases;  $T'(s) < 0$ . But it will not decline to zero so long as  $C_s$  differs from zero, i.e., so long as the size of the stock influences the cost of harvesting.

A tax avoids the need for direct allocation of fishing rights and it also generates revenue while encouraging efficiency. An unexpected increase in the price of fish, relative to costs, will lead optimally to an increase in harvesting and a reduction of the stock. But it will also lead to an increase in the optimal tax; the stimulus of higher prices should be damped somewhat by a higher tax.

The analysis above has made a number of strong simplifying assumptions. It is possible to indicate how their relaxation will influence the optimal path.

First, suppose the fishery as a whole faces a downward sloping demand schedule, stationary over time, instead of the fixed price assumed above. Then the optimization problem formulated in (4) should be reformulated to integrate the entire area under the demand schedule  $p(h)$  in the maximand:

$$(7) \quad \int_0^\infty \left[ \int_0^h p(x) dx - C(h, s) \right] e^{-it} dt$$

The resulting optimal path is similar in form to equation (5), except that  $p$  now varies with harvest levels instead of being constant, and will also appear in the transitory term. Allowing for the influence of harvest on demand will moderate the changes required, e.g., from J to K in Figure 2.

It is sometimes said that the problem of fisheries arises from their being "common property" and that establishment of sole proprietorship over each fishery would "internalize the externalities" and solve the problem. If each fishery faces a downward sloping demand schedule this contention is not correct if the sole proprietor is interested in maximizing revenues rather than in maximizing social welfare, for he will formulate the maximizing problem as

$$(8) \quad \max \int_0^{\infty} [h \cdot p(h) - C(h, s)] e^{-it} dt$$

This is clearly different from (7) above, and leads to an "optimal" sustainable yield harvest that calls for

$$(9) \quad p(h) + h \cdot p'(h) = C_h + \frac{C_s}{f'(s) - i}$$

The second term on the left-hand side of (9) is negative, the reduction in price that results from increasing the harvest. A monopolist looks at marginal revenue, not price, in making his output decisions. As a result, the revenue-maximizing sole proprietor will hold harvests to a *lower* level than would be socially optimal, and the fishery stock at a *higher-than-optimal* level. He would also take into account the second term on the right-hand side of (9), thus internalizing the externality. The net result could be either more or less efficient than uninhibited competition in use of the fishery.

Second, no allowance has been made for capital costs involved in fishing. If fishermen have invested in gear that do not have efficient alternative uses, then the social objective might be recast to maximize the present value of the fishery plus the capital that has been invested in fishing. With this revised objective, the optimal path from a point such as J in Figure 2 will in general call for a less abrupt drop in harvest from an initial point J. The drop in harvest (and hence the rebuilding of the stock) will be more gradual, to allow for gradual wearing out of the capital (although cases can be found for which idling some specialized capital is socially optimal). Similar modifications are required if retraining of fishermen is necessary before they can find alternative employment.

Third, no allowance has been made for changes over time in the



price of fish or in the cost of harvesting them. A secular rise in the demand for fish, other things being equal, will increase the market-clearing price. Technical improvements over time will reduce costs. Both of these effects can be allowed for in a simplified way by replacing equations (2) and (3) with

$$(2') \quad C(t) = e^{-\delta t} C_0(h, s) \quad \delta > 0$$

$$(3') \quad p(t) = p_0 e^{\mu t} \quad \mu > 0$$

Under these conditions the optimal harvesting path of equation (5) becomes

$$(5') \quad p(t) = \frac{f'(s) - i + \delta}{f'(s) - i + \mu} C_h(t) + \frac{C_s(t) + \frac{d}{dt} [C_h(t) - p(t)]}{f'(s) - i + \mu}$$

Here the prospective rise in prices at a rate  $\mu$  serves to offset the influence of the interest rate: higher interest rates call for more consumption in the present, whereas higher  $\mu$  encourages deferment of harvesting now for the sake of higher-valued harvests later.

The private marginal cost at each point in time is  $C_h(t)$ , and the fishermen will attempt to equate this with price. Thus to achieve the optimal path under competitive conditions in this case not only requires a tax per unit catch equal to the second term on the right-hand side, the extension of equation (6), but it also requires imposing a tax on the *inputs* or effort used by the fishermen at a rate

$$(10) \quad r = \frac{f'(s) - i - \delta}{f'(s) - i + \mu} - 1 = \frac{\delta + \mu}{i - \mu - f'(s)}$$

to compensate for the "lack of foresight" on the part of fishermen with respect to future costs and prices. In fact, each fisherman has no incentive to postpone his harvesting, because of the common property characteristic of the stock of fish. With the two taxes, the fisherman will have the appropriate incentive to fish at the optimal level:

$$p(t) = (1 + r) C_h + T(s)$$