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FISHERMAN & FISH CONSUMER INCOME UNDER THE 200-MILE LIMIT

by

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Cambridge, Massachusetts 02139

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Sea Grant Program

Administrative Statement

If the pending legislation to establish a 200-mile limit for offshore waters is passed, the United States could gain unilateral control over the domestic continental shelf fisheries off its coasts. Regulations will be needed for efficient management of the fisheries to prevent overfishing, and this report describes research that has analyzed alternative management schemes to guide regulatory agencies in setting up control mechanisms.

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Acting Director

January 1976

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AUTHOR'S NOTE

This paper represents a departure for this author and the M.I.T. Sea Grant program. Both in the past have attempted to confine their publications to reports of original, in-depth analyses. This report is neither. It is a brief summary of some obvious resource allocation principles. Our only excuse for this departure is that:

1) These principles have been almost completely ignored in the past in fisheries management;
2) With the imposition of a 200-mile limit, the United States may have a one-shot opportunity to remedy this fact.

By the time that in-depth analysis was completed, this opportunity may be lost forever. Therefore, we have chosen to add our voice to those pleading that enforcement of efficient controls on entry be combined with any movement toward a 200-mile limit, even though our work in the area hardly qualifies us for a leading role in pleading this position.

1. INTRODUCTION

There are a number of indications that U.S. unilateral control of the fisheries on its continental shelves is a real possibility. In many quarters, there appears to be the feeling that such control coupled with the exclusion of foreign fishermen will automatically solve the problems of the domestic fishing industry. This paper argues that this is not the case; that even if we outlawed all foreign fishing off our shores, domestic fishermen are quite capable of completely overfishing domestic stocks. Moreover, I shall attempt to show that not only are they capable of so doing, but in the absence of effective control on entry, they will inevitably implement this capability. The 200-mile limit in itself will not solve the basic resource management problem. Rather by putting the management of the resource under the control of a single entity, the United States, it allows that entity the opportunity to solve this problem. Whether or not the resource will actually be efficiently managed depends on whether or not that entity has the wisdom and courage to act on this opportunity.

2. SOME BACKGROUND

This paper analyses the impact of a range of alternative schemes for managing our continental shelf fisheries on real

national income, on real fisherman income, and on real fish consumer income. If we are to perform an income analysis for any particular group whether it be fish catchers, fish consumers, or the entire nation, we must first define just what we mean by the real income of this group.

One way of developing our definition of a group's real income is to imagine that we have drawn a black box about this group. Every member of society who is a member of the group whose income we wish to analyze is placed inside this black box. Any member of society who is not a member of this group is placed outside this black box. Thus, if we are interested in the income of a particular individual, we draw our black box around this single person. If we are interested in national income, we draw our black box around all Americans. If we are interested in the income of a particular state or town, we draw our black box around the residents of that state or town and exclude everyone else. If we are interested in the income of a particular profession, we draw our black box around the members of this profession and exclude everyone else.

For any black box, we define the total value of all the goods, priced at current market prices, which the inhabitants of that black box can consume, to be the real income of that black box.

Perhaps the easiest way of getting at the implications of our definition of real black-box income is to imagine that the black box is owned and controlled by a single personage--

Uncle Eph we might call him. Suppose the black box currently under analysis is a particular state. Uncle Eph is the not-particularly-benevolent despot who owns this state. Uncle Eph is interested in the total value, at present market prices, of all the goods he can consume with the output of the rather extensive resources he controls. Uncle Eph realizes that he can allocate his resources in an infinite variety of ways, some of which will allow him to consume a higher total value of goods than others. Uncle Eph, for reasons he chooses not to discuss, would like to make this market value of his consumption as large as possible.

His resources include not only the land and water, the buildings and roads, vehicles and vessels of his state, but also its present human inhabitants. We might regard this latter brand of resources as Uncle Eph's fingers, in that they both produce and consume. Uncle Eph has no particular feelings about his fingers. He isn't interested in whether one finger rather than another consumes a greater share of the total value of all the goods he consumes. He is only interested in the total. He considers himself better off if this total value is larger, worse off if it's smaller, regardless of the distribution of production and consumption among his fingers.

Notice that in attempting to maximize this quantity, Uncle Eph is ignoring the fact that any proposed change in the allocation of his resources will almost certainly make some of his fingers worse off and some better off. Uncle Eph simply doesn't care. He prefers the change if the total value of the

consumption of all his fingers is higher after the change than before. He will eschew the change if the total value is less. Our concept of black-box income ignores the distributional effects of any proposed change within the black box.

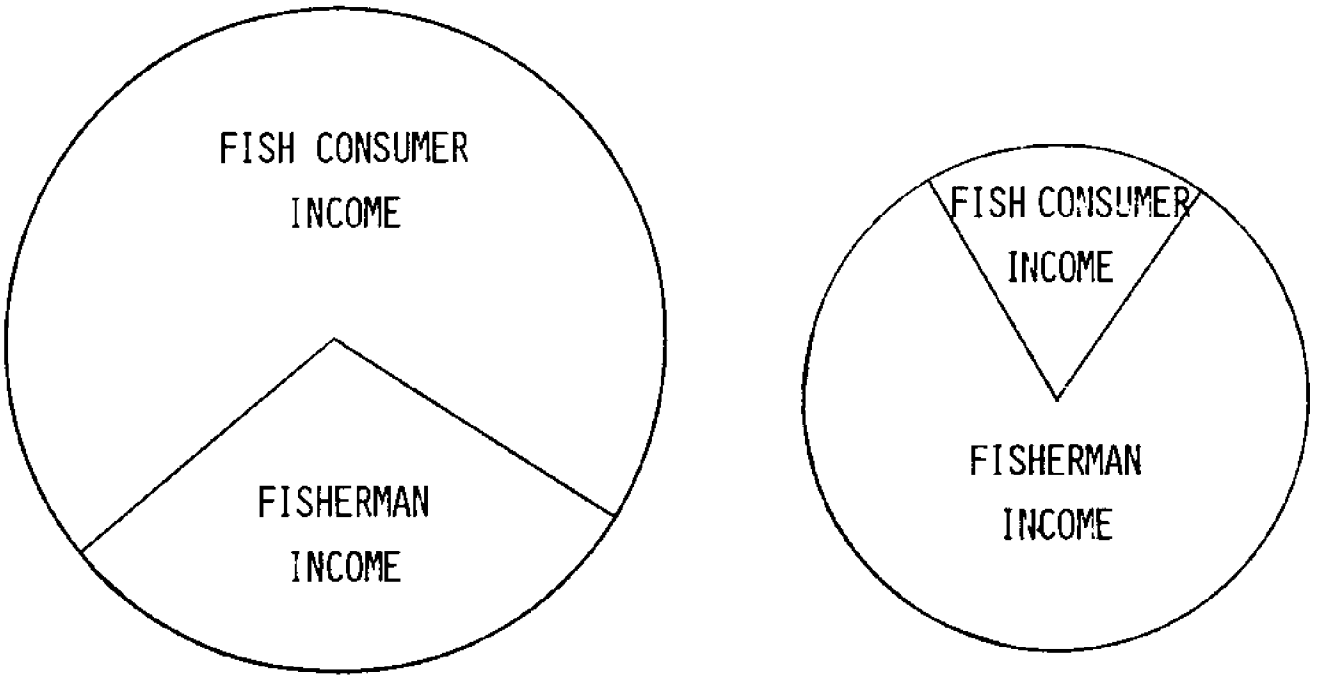
This limitation has obvious political implications, for what may be a net increase to the black box as a whole can affect a particular set of losers quite adversely. For example, real black-box income will be increased by a change which increases the real income of 90% of the black box's citizens by 10% and decreases the real income of 1% of the population by 70%, virtually wiping out this latter group.

There is another thing to notice about Uncle Eph. His is a provincial and basically selfish character. He only cares about his own ability to consume. He is completely indifferent to any effect, up or down, his choices might have on the income of entities outside the black box--the rest of the country, for example. Any change in income to someone who is not a member of the black box currently under analysis, no matter how large, is given no weight at all by our concept of black-box income.

Paradoxically, the fact that our concept of black-box income ignores the distribution of income changes within the black box and ignores any income change outside the black box is precisely the characteristic which allows us to think quantitatively about the economic conflicts inherent in fisheries management. To do this we need only analyze the same policy

alternative from the point of view of a number of different black boxes sequentially. Analyzing the same policy from the point of view of national income (the black box equals all Americans), then from the point of view of fishermen income (the black box is fishermen and fish processors) and then from the point of view of fish consumers (the black box is all Americans less the suppliers of fish), will reveal both where the second and third group have a common interest through their joint memberships in the first group and where they are in direct conflict.

The relationships can be illustrated by the pie analogy. Regard national income as a pie. The size of the pie represents the amount of national income. This income is consumed either by the fishermen or by the public (non-fishermen). In general, different fisheries management alternatives will affect both the size of the overall pie (national income) and the relative share of this income going to the fish supplier and fish consumers. Figure 1 schematically compares two hypothetical alternatives. Alternative A generates a higher national income than B, but B results in the fishing industry obtaining a larger proportion of the smaller pie, so that fish supplier income is actually higher under B than A. Obviously, both groups can theoretically agree to jointly attempt to make the pie as large as possible. After all, in theory a larger pie can always be redivided in such a way that everybody gets a bigger piece than with a smaller pie. But the two groups are in direct conflict when it comes to dividing up any given pie.



ALTERNATIVE A

ALTERNATIVE B

FIGURE 1: THE PIE ANALOGY

The only justification for this long-winded repetitiion of tautologies is that quite commonly these fundamentals are ignored in the public debate concerning the fisheries of the continental shelf. Often this debate proceeds as if there were some sort of conservation principle which dictates that the overall size of the pie is fixed, that the amount of national wealth realizable from a particular fishery resource is given and the only question is who is going to get what share of this fixed pie.

The fallacy in this line of thinking can be demonstrated by a simple yield-effort diagram , Figure 2. Figure 2 sketches a commonly postulated relationship between the amount of fishing effort and landings. The hump represents a situation in which at low level of fishing effort, measured in say boat-days, an increase in effort will increase yield. However, as more and more effort is applied, more and more boats fishing the same stock, the increase in yield with increase in effort drops off until at point MSY a peak yield is obtained. The level of landings at this point is known as the Maximum Sustainable Yield. Beyond this point, an increase in effort will actually decrease total landings as the decrease in population age and numbers associated with this additional fishing effort more than outweighs the additional fishing effort.

Assuming a competitive landed fish market, associated with any particular level of landings will be a market clearing price. The demand curve in Figure 3 hypothesizes such a rela-

tionship between amount landed and the price that amount can be sold ex-vessel. In the curve shown, I have postulated that consumption becomes satiated at high level of landings but in absolute terms becomes more sensitive to price at high prices--qualitatively not unreasonable assumptions at least in the premium fresh fish markets which tend to serve a rather narrow set of demands.*

It is a simple matter to combine Figures 2 and 3 to obtain Figure 4 which plots fishermen revenue against fishing effort. Fishermen revenue is simply yield times the market price at that yield. Assuming market price decreases with an increase in landings, the revenue curve will be steeper than the yield curve at low yields and less steep at high yields. Further, if the demand curve is inelastic at high yields, as the one in Figure 3 is, then in the vicinity of the Maximum Sustainable Yield, an increase in landings can actually decrease fishermen revenues. In this case we will have a local minimum in revenues in the region surrounding the MSY point as shown. The revenue curve can be double humped. There are a wide range of combinations of yield-efforts and price-landings relationships for which this is the case. This double hump has some very important implications for fishermen versus fish consumer income as we shall see.

The dotted line in Figure 4 is a hypothetical long run fishermen cost curve, total fishermen outlays as a function of

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* Lobsters are an exception primarily because they can be stored and shipped long distances with no loss in quality. Also for some species, their value in frozen block form may form a floor to price, turning the demand curve elastic at this low price.

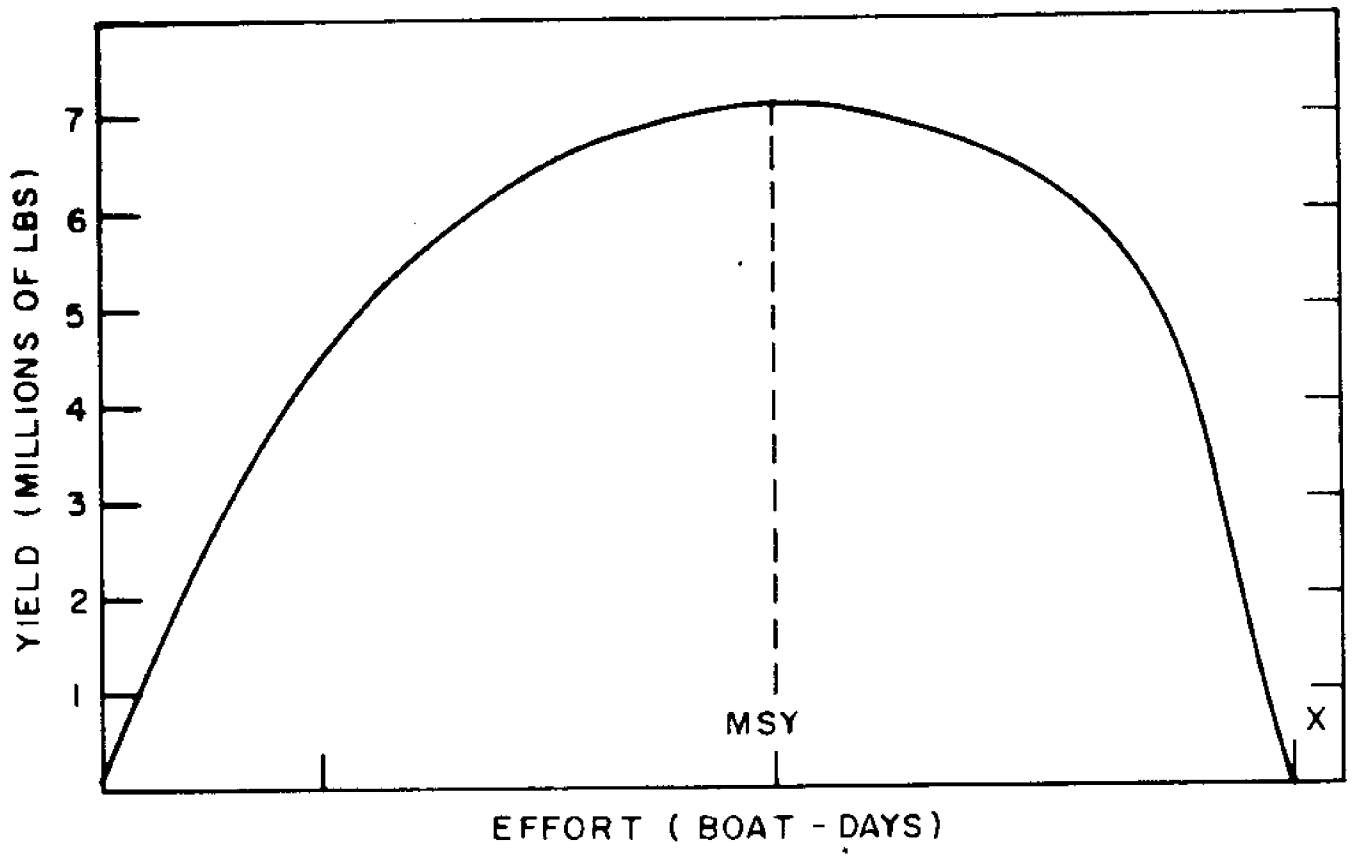

FIGURE 2 A HYPOTHETICAL YIELD - EFFORT RELATIONSHIP

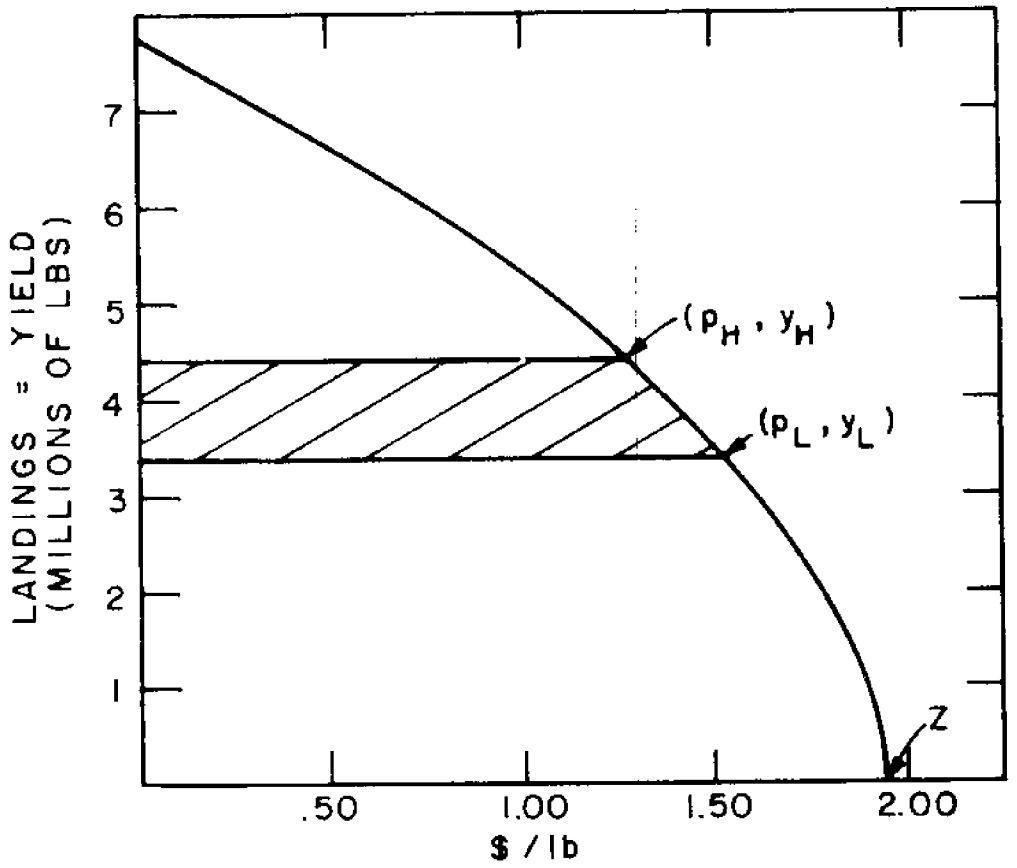

FIGURE 3 LANDED PRICE VS LANDINGS

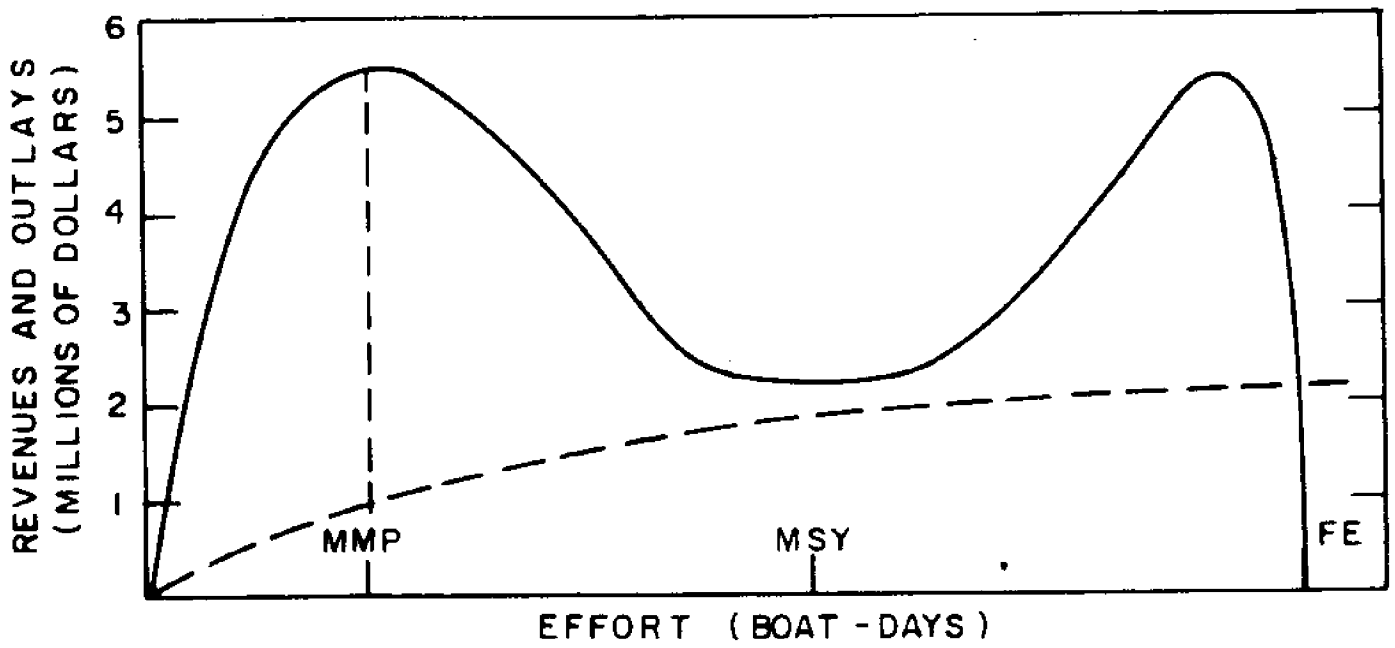

FIGURE 4 FISHERMAN REVENUES AND OUTLAYS

fishing effort.* This cost is assumed to be defined in present value terms and thus to fully include normal return to capital employed in this fishery. The difference between total revenue and total cost, so defined represents the excess profits of the fishing fleet, that is profits above the normal return to capital. Since some people will object to the adjective 'excess' and since some of the 'profits' will, given the lay system, actually be transferred to the fishermen themselves in the form of earnings above what they could obtain in alternative employment, we shall relabel this difference, the fishermen's surplus. This difference as a function of effort has been plotted in Figure 5. Like total revenues, it too can be double humped. However, these humps will be less symmetric than the revenue humps due to the differences in fishermen outlays between the right and left humps.** The peak of the leftmost hump, we shall call the monopoly profit maximizing (MPM) level of effort. If the fishery were owned by a single, selfish individual, who had complete control over its management and who wished to maximize his own income, this is the point at which he would operate. On Figure 4, it is the leftmost point where the slope of the revenue curve equals the

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* All the analyses in this paper will be static, long-run in nature. This limitation will obscure some of the most interesting dynamic phenomena in fisheries management. However, despite it, we will still be able to make our basic policy points.

** This asymmetry can be increased by differences in quality. At the right hand hump, the individual landed fish will be larger than at the left hand hump due to the older population distribution. In many fisheries, larger fish command a higher unit price.

slope of the cost curve.* Thus, it's always to the left of the Maximum Sustainable Yield point.

Another point of interest is that on the right hand side of Figure 5 marked FE for Free Entry. To the right of this point, the fishing fleet as a whole has a positive surplus, that is, it is making money above and beyond the normal return on capital; to the left of this point, the fleet as a whole is suffering losses. In the absence of absolutely any controls on entry, the level of fishing effort will tend to FE. If fishing effort is less than this amount, the boats will be making money and more boats will enter the fleet in an attempt to share this profit. If fishing effort is greater than this amount, the fleet as a whole will be losing money and the weakest boats eventually forced out of the fishery. FE is, then, the equilibrium effort and yield under free entry.

As shown, this 'equilibrium' can be quite unstable. Levels of effort slightly above the Free Entry point will generate sharp drops in yields, eventually forcing all but the most efficient operators into bankruptcy and off the resource. Assuming the resource is not completely wiped out, after a time, it will recover, the remaining operators will begin generating a positive surplus which in turn will attract new capital and the process will repeat itself. Given the dyna-

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* In the fisheries economics literature, this point is usually misleadingly called the Maximum Economic Efficiency (MEE) level of effort. This nomenclature is a result of fishery economists' persistent refusal to include fish consumer income in their analyses.

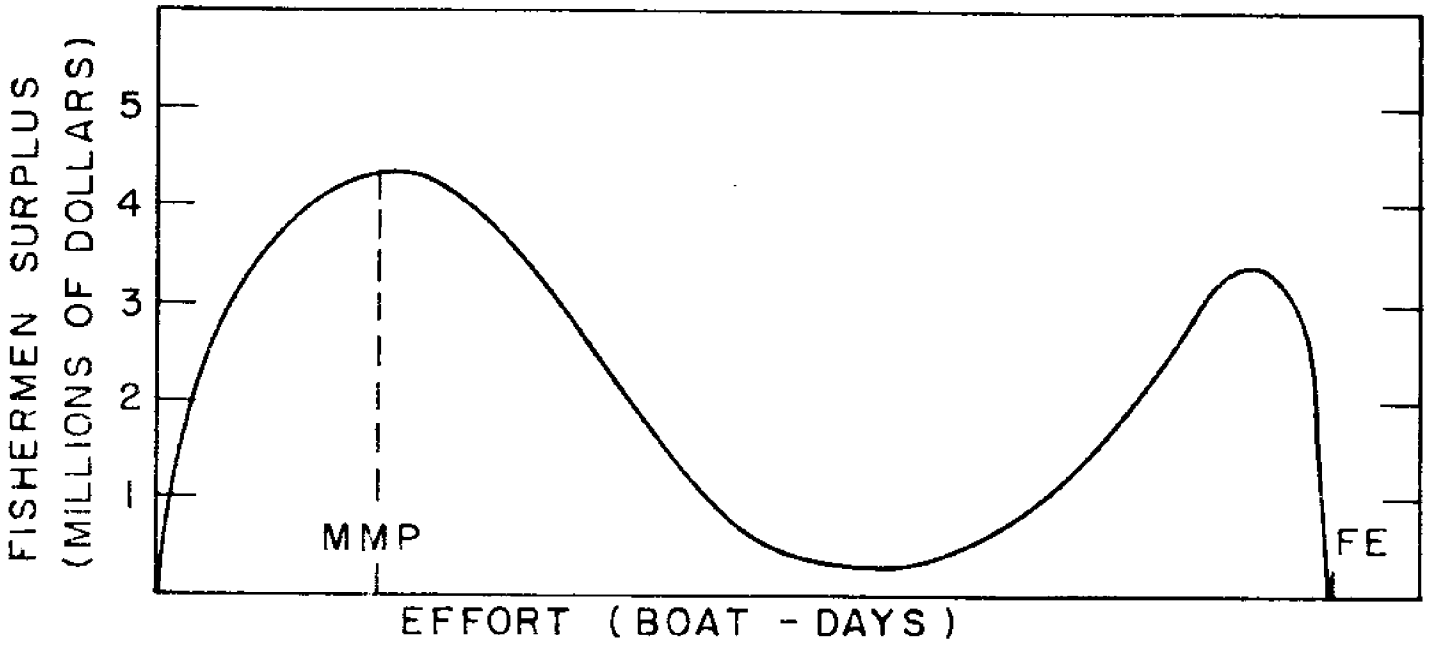

FIGURE 5 FISHERMEN SURPLUS VS FISHING EFFORT

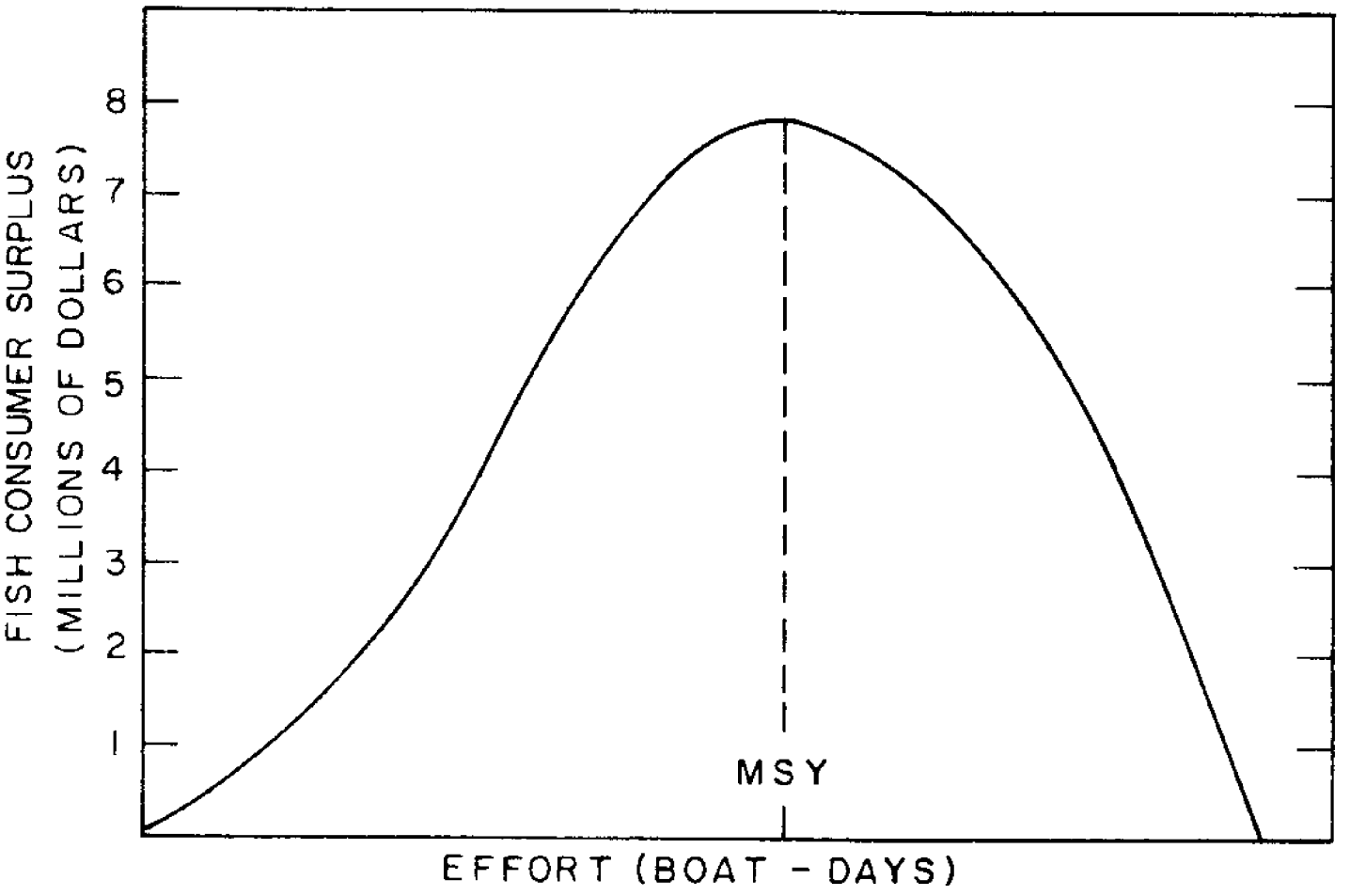

FIGURE 6 CONSUMERS SURPLUS VS FISHING EFFORT

mic response of fisheries to overfishing, the Free Entry point can easily be a very transitory equilibrium indeed. Nonetheless, it is a useful concept as long as we remember its limitations.

Fishermen are not the only group in whose income we are interested. If we wish to manage the resource in such a manner as to maximize national wealth, we must also consider the fishermen's customers, for after all they are Americans too. With any particular level of effort e, there will be a corresponding yield y(e), and price p(y(e)). If effort is very low, the yield will be low and the price high. Consumers will be consuming very little fish and paying a high price. If the level of effort is very high, the yield will be low, price high and once again the consumer will be eating very little fish at a high unit price. At intermediate levels of effort more fish will be landed (and consumed) and the price will be lower. Obviously, consumers' real income will be higher in the latter situation than in the first two. Not only will fish eaters be able to consume more fish but they will do so at a lower price. An approximate measure of the aggregate difference in consumer real income associated with changing from a low yield situation $y_L(e_L)$ to a higher yield situation $y_H(e_H)$ is given by

$$\int_0^{y_H(e_H)} p(y(e))y(e)dy(e) - p_H(y_H(e_H))y_H(e_H)$$

$$-\int_{0}^{y_L(e_L)} p(y(e))y(e)dy(e) - p_L(y_L(e_L))y_L(e_L)$$

The first term is the difference between what consumers as a whole would be willing to pay, if they had to, and what they will actually pay for the amount of fish landed in the high yield situation. The second term is the similar quantity for the low yield situation. The first term measures how much better off the fish consumers are in the high yield situation in real income terms over what they would be in a no yield situation. The second term measures how much better off the consumers are in the low yield situation over a situation in which no fish are landed. The difference in these differences then is the change in consumer real income associated with moving from a low yield situation to a higher yield situation, summed over all consumers. In terms of Figure 3 it is the hatched area under the demand curve between the lower and higher yields. The above expression can be simplified to:

$$\int_{y_L(e_L)}^{y_H(e_H)} p(y(e))y(e)dy(e) + [p_L(y_L(e_L))y_L(e_L) - p_H(y_H(e_H))y_H(e_H)]$$

If we are analyzing more than two fishery management alternatives, we will in general have more than two price-landing points which we must consider. In this situation, we must specify a baseline yield point against which all changes in fish consumer income can be compared on a systematic basis.

The specification of this baseline yield is arbitrary. One obvious candidate is the zero yield level, point z on the demand curve. The increase in real aggregate consumer income associated with any positive yield, Y, and its corresponding price p(Y) relative to zero yield is the area under the demand curve to the Northwest of (Y,p(Y)). This area is known as the consumer surplus CS(Y) associated with Y.

$$CS(Y) = \int_0^Y p(y) \cdot ydy - p(Y)Y$$

While the zero yield point is an obvious baseline against which to measure changes in consumer income with changes in landings, it does have one practical disadvantage. It requires that we know, or at least be able to approximate, the demand curve over the entire range from maximum yield down to no yield at all. In some fisheries, where we have experienced zero or near zero yields this may not be a problem. However, in many cases, we will be interested in, and have empirical data over, a much narrower range of yields running, say, from Maximum Sustainable Yield to Free Entry Yield. In such situations, a more workable baseline may be the status quo or the Free Entry level (which may be the same). The point is that it doesn't really matter. Since we are only interested in changes in consumer real income with changes in yield and price, we can relate these changes to whatever baseline we find easiest to use. Of course, once we've chosen a baseline yield

and price, we must maintain this same baseline throughout the analysis.

In Figure 6, we have chosen zero yield as the baseline. Figure 6 shows the consumers' surplus associated with the yield curve of Figure 2 and the hypothetical demand curve of Figure 3 expressed as a function of level of effort. Notice that in contrast to the fishermen's surplus curve the consumers' surplus curve is sharply peaked in the neighborhood of the MSY point and in fact the yield maximum and the consumers' surplus maximum occur at the same level of effort. Also, there is a roughly anti-symmetric relationship between the consumers' surplus curve and the fishermen's surplus curve. Clearly, we have a conflict between fish supplier income and fish consumer income. Fish suppliers will maximize their income at the MMP point where the slope of the revenue curve and outlay curve is equal, while consumer income will be maximized at the MSY level. If either the slope of the cost curve is high or demand is inelastic, the level of effort which maximizes fishermen income and that which maximizes consumer income can be quite different. Moreover, as shown, the differences in fishermen and consumer wealth associated with the differing philosophies toward management can be very large indeed.

One way of resolving this conflict is to ask what level of effort maximizes the sum of fishermen income and fish consumer income; that is, what level of effort maximizes national

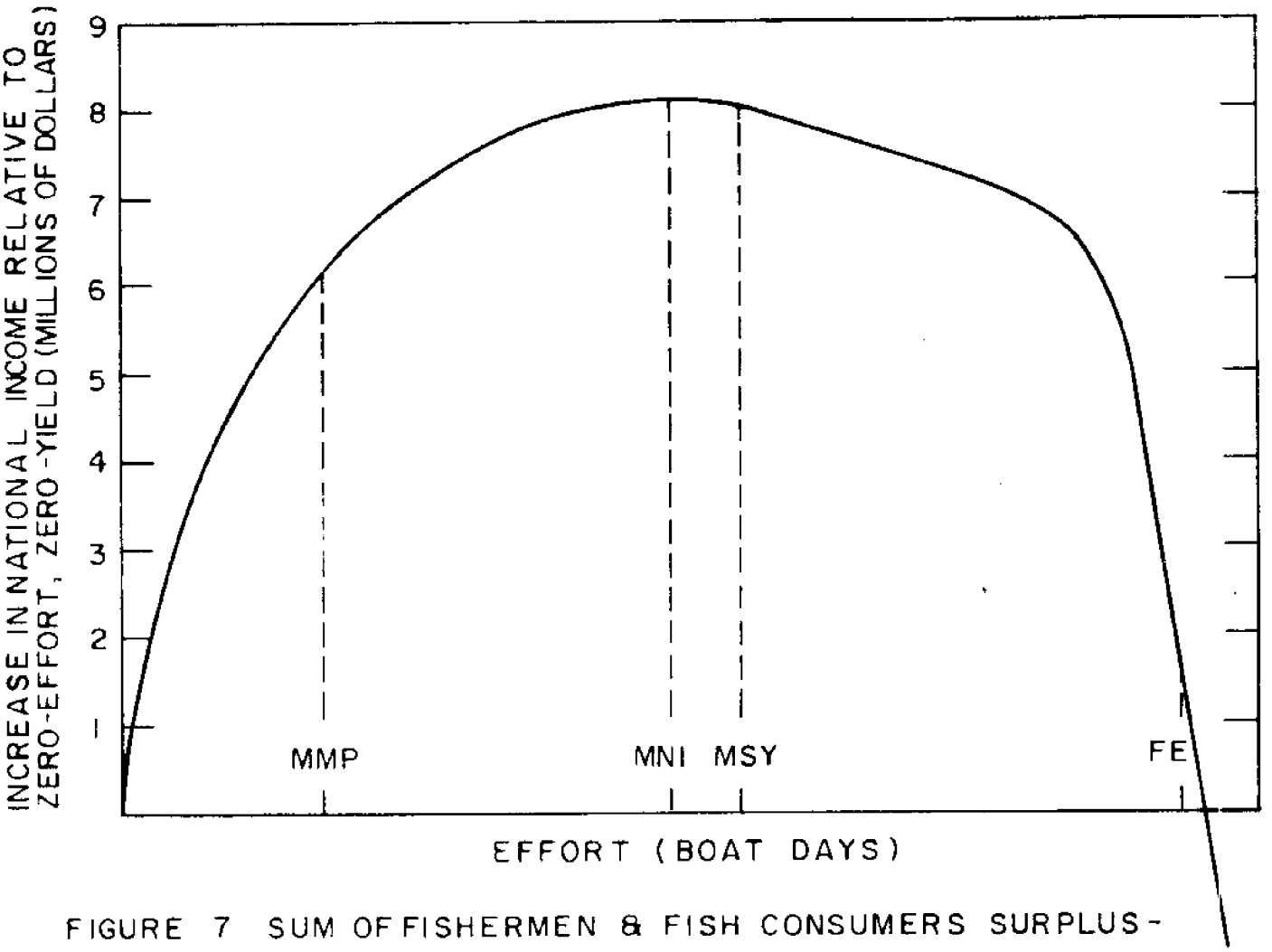

FIGURE 7 SUM OF FISHERMEN & FISH CONSUMERS SURPLUS - TOTAL INCREASE IN NATIONAL INCOME RELATIVE TO ZERO EFFORT - ZERO YIELD

income. In asking ourselves this question we are focusing on the overall size of the pie rather than on the individual pieces. Figure 7 plots this sum as a function of effort for the yield curve, demand curve, and cost curve of Figures 2, 3 and 4. Figure 7 is merely the sum of Figures 5 and 6. The first thing we notice is that the overall size of the pie is very definitely not fixed. By drastically overfishing or underfishing the resource, everybody loses. The level of effort at which the sum of fishermen surplus and consumer surplus is maximized we will call the MNI (Maximum National Income) point. This point will fall between the MMP level (maximum fishermen surplus) and the MSY level (maximum consumers' surplus). It will in fact be the point where the slope of the cost curve equals the market price. One way of obtaining insight on this point is to imagine that the fishery is divided up into a large number of 'fishsteads'. Each individual fisherman has complete control over the stock on his fishstead. His stock is somehow confined to his fishstead and no one else can fish it. Then in deciding how much of his stock to harvest each year, each fishsteader, in attempting to maximize his own profits, would compare the market price with the additional cost to him of his producing his most expensive unit, and harvest up to the level where the market price equals this marginal cost. In this situation, the aggregate level of effort would tend to the MNI point. Each fishsteader operating

individually would, unlike a single monoply owner of the entire resource, regard the market price as fixed or at least out of his control. Thus, he would not restrict output simply to raise price. On the other hand, he would be induced to cultivate and husband his stock in a manner to maximize his long term profits for he need not fear that someone else will harvest the stock that he is husbanding. This divvying up the resource and assigning private property rights to each segment is of course the solution that society came up with on land for exactly the same resource management problem we face in fisheries.* Unfortunately, establishing and enforcing private property rights to portions of a fishery is currently infeasible, or to put it more precisely, is for most--not all--fisheries extremely expensive.** Therefore, if we are to manage a fishery in such a manner as to maximize national income we will have to come up with management schemes which simulate the solution obtained on land by assigning private property rights to a large number of people and fostering (or at least not completely interfering with) competition among the numerous suppliers so created. Development of such alternatives is the subject of the second portion of this paper.

There is one more insight we can garner from our simple yield-effort, price-landings analysis. In one sense, our con-

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* See Hardin, "The Tragedy of the Commons" in deBell, G., "The Environmental Handbook", Ballantine Books, 1970, New York

** This need not always remain the case. The same thing was true of Western ranch land until the invention of barbed wire--probably one of the most underrated inventions of all time.

centration on the conflict between the level of effort which maximizes fisherman income and that which maximizes consumer real income is completely misplaced. As we have seen, under Free Entry, the yield will tend neither to the MMP nor MSY levels nor anywhere inbetween but rather to the Free Entry point which may be far to the right of either. At this point yield is low and fisherman costs are high. Fishermen are barely breaking even and consumers are obtaining an unnecessarily low quantity of fish at high price. Everybody is losing. Both fisherman and fish consumer income are lower than they need be, possibly much lower. National income is doubly strained by both low yield and the large amount of resources (men, vessels, and fuel) devoted to obtaining this low yield. In such a situation, it may be the case that both sides would gain by an agreement to move to any point between MMP and MSY. One can easily postulate situations where not only will national income, the overall size of the pie , be increased by such a decrease in effort but the real income of both fishermen and consumers increased as well.

However, it is important to point out a very major stumbling block that may be in the way of such an agreement. And that is the rightmost hump in Figure 5. Suppose, just suppose, that we do not have completely free entry to a particular fishery. Even with no regulation, there may be a number of subtle and not-so-subtle limitations to entry: lack of dock space and imperfect markets in dock space; familial and cultural nepotism in crew selection, careful husbanding of

monopolies on fishery knowledge and experience, successfully hiding the fact that surpluses are being earned. Suppose that under the influence of such barriers to entry, fishing effort has stabilized at slightly below the Free Entry level, that is, in the vicinity of the right hump in Figure 5. The fishermen, if nobody else, know they're doing pretty well. True, the situation is precariously unstable, easily upset by natural fluctuations in population, improvements in fishing technology, or new entrants. But it is the status quo. If such a situation exists, then it may be extremely difficult to get the fishermen to agree to the wholesale decrease in fishing effort required to adjust down to below the MSY point. For one thing, there are many points between the MMP level and the MSY point where fishermen income is less than it is in the vicinity of the right hump. Fishermen as a whole would be taking a big chance in moving from the known benefits of the rightmost hump to the unknown world of the leftmost hump and some fisherment would have to leave this profitable industry entirely with a certain loss in their individual income unless explicitly compensated.

Even if fishing effort has stabilized at the Free Entry point where the fishermen are barely breaking even, the rightmost hump still presents a very substantial barrier to reform. It is in the nature of reforms made in the political arena that it is easiest to move incrementally. In the case at hand, this would involve gradual reduction in the fishing effort as

the fleet naturally attrits under old age, etc. This might work as long as the fishermen noted that with each reduction in fishing effort, fishermen income imporoved. This would be the case while the fleet was moving from the Free Entry point to the peak of the right hump. However, from that point on each further reduction in fishing effort would result in a decrease in fishermen income as the increased yields dropped the market price. This decrease in fishermen income could be quite substantial and would continue until fishing effort dropped below the MSY point. Long before that happened we could be sure that the fishermen would be screaming bloody murder. In summary, the rightmost hump in Figure 5 may not only explain why so many fisheries have been able to maintain a relatively stable, although grossly overfished, condition but also presents the real world implementation of any effective resource management system with a very sizable political barrier. If the combination of yield curve and demand curve is such that a right hump exists, an incremental approach to reducing effort almost certainly will not work.

3. THE ALTERNATIVES FOR MANAGEMENT

From the point of view of near-term American fishery policy, perhaps the single most important feature of the last section is that nowhere in this discussion of fishery management problems does the word 'foreigner' appear. It was not

necessary to postulate foreign fishing effort to generate gross overfishing. We required only Free Entry for domestic fishermen. The basic problem is not the foreigner but the fact that no individual can obtain property rights to a portion of the fishery allowing him to cultivate and husband his stock.

If we throw the foreigners out, we would still have to come to grips with this basic problem for the domestic fishermen's surplus so generated will simply attract more domestic capital and men until we have reapproached the Free Entry level of effort and the profits disappear. The central issue is not the foreigner, its Free Entry to a resource over which private property rights cannot be enforced. Indeed McHugh has argued persuasively that the actual history of the management of the international fisheries, poor though it is, is better than the history of management of the purely domestic fisheries such as the soft clam, the hard clam, and the oyster.(1) Even if domestic fishing had to expand to regenerate the Free Entry level of effort, we can be sure that drawn by the momentary surplus associated with the expulsion of the foreigners, it would. And in many cases, they may not have to expand very far. Examination of possibly unreliable ICNAF figures indicate that U.S. fishermen are presently taking over 70% of all the high value species caught on the Georges Bank with the exception of scallops (2). The Georges Bank is an oft quoted

example of an extreme case of the inroads of foreign fishing.* Gates and Norton have estimated that the optimal number of boats that should be employed in the nominally international yellowtail flounder fishery is about sixty.(3) Currently, over 100 American boats fish this resource.

Obtaining complete control of the fisheries on our continental shelf then is only a prelude to management. It is an opportunity not a solution. If we wish to manage the resource in such a way as to maximize national income, to maximize the size of the pie, we will have to enforce effective, efficient control on entry. To get to the MNI point, we will have to come up with a system which simulates what would happen if it were possible to assign property rights to the resource to a large number of competing fishsteaders.

A number of alternative schemes for managing fishery resources have been tried or suggested. We will examine several of them and comment on their likely impact on the overall size of the national pie, and the splitting of this pie between fishermen and fish consumers.

3.1 Gear Restriction

Probably the most common form of control is gear

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* The great bulk of the foreign catch, with the important exception of Canadian scallopers, consists of lower value, pelagic species such as the herring. Catches of this fish may be affecting yields of the higher valued demersal species via the food chain but this has not been conclusively demonstrated.

restriction. It is also, with certain notable exceptions, probably the least attractive solution both from the point of view of national income and fishermen income. The primary thing to notice about this system is that in itself it does nothing about the Free Entry problem.* Fishing effort will still tend to the point where fishermen's surplus is zero, so the fishermen as a group are no better off than they would be under absolutely no control. It is true that the increased cost associated with the inefficient gear--the effect of the regulation will be to raise the dotted line in Figure 4--may shift the Free Entry point slightly to the left on the yield curve with an increase in yield. However, this is an unnecessarily costly means of cutting back effective fishing effort for it involves divesting more men, steel, and fuel to this activity than required. Any increase in fish consumer income associated with the higher yield will have to be netted against the opportunity value of these additional resources.

There is one set of exceptions to the above proscription against gear restrictions, and that is gear 'restrictions' which would be employed voluntarily by our industrious but imaginary fishsteaders in the cultivation and husbanding of their stock. The most obvious possibility is mesh limitations. In order to maximize the long-run return from his property, the

*Sometimes gear limitations are combined with restrictions on entry. A regulation that only old style vessels can be used and no more old style vessels can be built is a limitation on entry as well as a gear restriction and can generate fishermen's surplus.

fishsteader may decide to selectively harvest his crop by age and size. On land this is done as a matter of course in tree farming and elsewhere. In many fisheries, the most efficient means of performing selective harvesting may well be suitably chosen mesh sizes. If this is the case, then mesh limitations should be part of an efficient management scheme. In some fisheries crop rotation or fallow areas or seasons may be part of an efficient program. The basic idea is to ask ourselves what would our imaginary fishsteaders do with the resource voluntarily. They would certainly not use a mule (bugeyes and tongs) when a tractor (dredge) would be much more profitable.

3.2 Fixed Landing Payments

The dead loss to the nation associated with inefficient gear limitations can be illustrated by considering another possible management scheme, landing payments set by the government. The only possible plus associated with such gear restrictions is that by raising the fishing cost curve, it will shift the Free Entry point to the left with an increase in yield, decrease in price and hence an increase in fish consumer income. However, the same shift in the cost curve perceived by the fishermen could be obtained without gear restrictions but simply requiring a landing payment, from the fishermen to the government, for any level of effort, which is equal to the difference between fishing costs without the gear limitations

and those with the restrictions. As long as the landing payment cost curve was the same as the cost curve under the gear limitation, the same Free Entry point would be obtained, so consumer income would be the same as with the gear limitation. The fisherman would still be barely breaking even after making the landing payment so this income is unchanged. However, Federal taxpayer income would be increased by the amount of the landing payment reflecting the fact that the nation is achieving the new Free Entry point with a lower cost set of resources than it was under the gear limitations.

At this point, we have a three segment pie: fishermen, fish consumers, and Federal taxpayer. Note that in analyzing the size of the pie, one must be careful to distinguish payments which divert resources to the fishery and thereby prevent the nation from having the output of these resources in alternate employments from payments which are merely transfers of consuming power involving no necessary division of resources. The payments which the fishermen would have made for the additional men, steel, and fuel required by the inefficient gear limitation fall into the first category. They are true costs to the nation. The payments which the fishermen must make to the Federal government under the landing fee scheme fall into the second category. They are merely transfers. Hence there is a difference between the overall size of the national pie under gear limitations as opposed to the landing fee.

In summary, whatever the benefits of gear limitations to fish consumer income, the scheme is dominated by an equivalent cost landing fee system which will generate the same fishermen and fish consumer income as the gear limitation but will also generate a taxpayers' surplus due to the more efficient technology which will be employed without the limitation.

All three groups make out at least as well under the fee system and one of the groups better. The fee system is unambiguously superior to gear restriction. Unfortunately, under the fee system we will generally still be nowhere near maximixing the national income obtainable from the fishery. We still haven't faced up to the basic problem of Free Entry. We have merely shifted the Free Entry point slightly to the left. We must search further.

3.3 Total Take Restrictions & Quotas

The second most commonly employed device in actual fishery management is total take restrictions or quotas. It may also be the most patently illogical approach. The motivation behind this idea is simple-minded conservation. If we're overfishing, let's catch less fish. However, usually the problem is not that the yield is too high but that its too low. Generally, we are on the right hand slope of the yield curve and what we want to do is catch more fish by reducing effort. Total take restrictions might make some sense if we were on the right hand slope of the yield curve. Unfortunately,

pressures for regulation almost never arise until we're approaching the Free Entry point and yields are decreasing. It is worth noting that the fishery-wiped-out point, X, on the yield curve obeys very stringent limitations on take. And indeed situations in dying fisheries with quotas chasing yields down to zero are far from impossible. Some would argue that the Pacific sardine is a case in point.

In reality, most actual quota systems are not quite this stupid, but it was necessary to state the logical flaw in the approach starkly, since quotas seem such an obvious solution to so many. Actual quota systems, at least the better ones, attempt to account for the dynamics of an overfished population and by reducing catch now build the population up to the point where the quota can be increased in the future. But once again, since the scheme begs the Free Entry issue, the quota setter is faced with an inherently unstable situation. Suppose he is successful by carefully time sequencing his quotas in getting back to say the MSY level, whereupon the quota is fixed at that level. Now suppose a natural fluctuation occurs which temporarily reduces the population. The fleet will catch less than his quota, which is no longer an operational constraint and all the fishing effort will be directed at the remaining stock. If he is a particularly stupid, quota setter, he might congratulate himself that his quota is not only being obeyed, but by a comfortable margin.

A more alert quota setter will have to immediately enforce a sharp drop in the quota to avoid being forced back to the Free Entry point or possibly overshooting it with diastrous results. The basic problem with quotas is that it doesn't attack the basic problem, Free Entry. Therefore it is by necessity, a reactionary method--always trying to close the barn door after the horse has left.

Quotas failure to directly address the Free Entry issue generates another set of inefficiencies. Suppose that we somehow determined the yield which would be obtained under the coaxing of our friendly fishsteader and has set the quota at that level. Moreover, he has a sixth sense that keeps him a jump ahead of nature and he deftly adjusts this quota to natural fluctuations in an optimal, stabilizing function. We still have a serious resource allocation problem.

Whatever level the momentary quota is set at, there is still no explicit limitation on fishing effort. The restrictions on catch will normally generate surpluses for those fishermen who obtain the allowable catch, especially in periods where the quota is set a low levels. Hence, there will be a race to see who gets this legal catch. This race takes on a particularly obvious form in the Peruvian anchovy fishery where on the opening day of the legal fishing season the fleet streams offshore, fishes intensively until the total catch has reached the level thought wise by the authorities, whereupon the fishery is closed down and the men and vessels sit idle

for seven months or so. The same total catch could have been obtained by one-third the men and capital fishing year round. Under total take restrictions, the legal level of catch will not, in general, be caught by the least costly set of resources. These inefficiencies in resource allocation so generated can result in significant reductions in the overall size of the pie which are borne almost entirely by the fishermen, since market price will be set by total landings under the quota. Total take restrictions in themselves still do not directly face up to the Free Entry problem.

3.4 Boat by Boat Quotas and Licensing

To overcome the problems associated with simple total take restrictions, devices for preallocating the total take to specified units have arisen. One form that this can take is vessel by vessel quotas. This is the first alternative we have examined which involves a direct restriction on entry. If you can't obtain a quota, you can't fish. If the number of vessels assigned quotas is down near the national income maximizing number, this scheme will generate fishermen's surpluses, sometimes very handsome surpluses, for those units fortunate enough to be assigned quotas reflecting the increase in the size of the pie associated with moving towards a more efficient exploitation of the resource.

This is the first scheme that we have examined that theoretically could work given omniscient, omnipotent and

incorruptible administration. Its problems are basically administrative in nature. First of all, there is the problem of figuring out the optimal number and size of units. Secondly, the surpluses generated by an effective quota scheme are an open invitation to corruption in the form of kickbacks, post-government jobs, etc. In attempting to control this corruption, we will probably end up with an inflexible set of rules and guidelines heavily weighted toward the status quo and sharply biased against new, more efficient technology. Given the entrenched power of the present exploiters of the resource, they would undoubtedly be first in line for the quotas behind which protection, in the manner of all protected industries, they would become lazy and inefficient.

A distinct improvement over simple per-vessel quotas is transferrable quotas or licenses. In these systems, the person receiving the quota has the right to sell it to someone else. This means that someone who comes along with a new technology allowing him to catch the quota more cheaply will be able to buy in, for the inefficient present holder of the license will find he is more wealthy selling the license than continuing to fish. A transferrable license scheme is less likely to be biased toward obsolecent technology than a straight vessel quota. The problem of determining the optimal number and size of vessels, and controlling corruption will remain.

3.5 Competitive Bidding for Quotas

An improvement over licensing that will go a long way to solve the corruption problem and will also greatly reduce the need for the regulatory agency to determine the exact composition of the optimal fleet is competitive bidding for quotas. Such a system could take several forms. One form involves the regulatory agency deciding on the total catch for a particular year or season and announcing that anyone who wishes to bid for a portion of this catch should submit a sealed bid stating the amount he desires to bid for and the amount he is willing to pay for this quantity. It would be rather like a public forest auction. It would be wise to set a maximum on the percentage of the overall quota which any individual entity can bid for, say 10%. The purpose of this limitation is to prevent a single organization from cornering the resource and operating it as a monopoly. The agency would be required to take the high bids effectively eliminating corruption and arbitrary assignment rules. The winning bidders would by nature be the most efficient fishermen for they could afford to bid the most. The agency need not concern itself with the exact number or size of the vessels but rather leave it up to the winning bidders to work out however they liked. These quotas, once purchased, should be transferrable so that if one bidder had better fishing luck than expected and another worse, the obvious mutually beneficial exchange could take place.

The bid itself could take one of two forms. A lump sum amount paid up front, or a percentage of the net present value associated with the catch. The lump sum or bonus bid is administratively much cleaner but it does shift all the risks to the fishermen which may in time decrease the total level of the bids. Percentage profits bidding is an after-the-fact approach which offers one a reliable signal as to the competitiveness of the bidding, divides the risk between the public and the fishermen, but also will require a much greater administrative burden to determine what the net present value actually was and ensure only necessary expenses are reported. One form of bidding which definitely should not be used is royalty bidding; that is bidding on a percentage of the gross landed value. This scheme has the disadvantage that it generates a sharp discrepancy between fishermen's marginal cost and market price which will move the fishermen away from the MNI point.

All things considered, bonus bidding is almost certainly the way to go in any fishery in which the catch can be predicted with a reasonable amount of accuracy.

Competitive bidding will, of course, have one other important effect. Assuming effective competition is maintained among the bidders it will transfer the bulk of the fishermen's surplus--the income above and beyond what these same resources could earn ashore--to the Federal taxpayer. This shift will have no effect in itself on the overall size

of the national pie and may, through preventing inefficient allocation of the quota to individual units, increase it. However, it will have a very definite impact on fishermen income with obvious political implications. My own view is that the constituency of the Federal government is the nation as a whole and as such federal resource allocation policy should concentrate on maximizing the overall size of the pie and not on maximizing the income of small arbitrarily selected groups of suppliers exploiting a public resource. Others may not share such a naive position.

3.6 SUMMARY

In summary then, I find competitive bonus bidding for transferrable fishing rights to be the most attractive regulatory alternative followed in decreasing order by profits bidding, arbitrary per-vessel quotas, simple overall take restrictions and gear limitations. All of these are better than nothing; and unless Congress moves quickly to couple effective regulation with the 200-mile limit, we are doomed to repeat the mistakes of the past.

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