Fishery Regulation and Role of Cooperative Management

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Ⅰ. Introduction

In the early 1960's fishery in Korea has played an important role in its economic development contributing to one of food sources and staple exports. But early development of fishery has also brought early difficulties in the fishing industry. Overcapacity in terms of capital and labor has dangerously depressed the fishing industry and required a continuous revision of fishery regulation. This paper serves to provide a possibility of economically efficient management plan for Korean fishery.

Since Gordon's historic paper in 1954, an enormous amount of literature on scientific management of fisheries resources has been put forth. A number of concerns for fishery resources have been raised from the fact that fisheries are inefficiently exploited caused by the absence of property rights (Gordon 1954, Scott 1955). Many economists within the past three decades have proposed vraious regulatory schemes to avoid the inefficient use of resources. By now, regulation on fishery is universal all over fishing nations and fisheries.

Whereas most regulation is designed to depend on government involvement in the fishing activity, very little has been studied on the role of voluntary cooperation within fishing industry. The major reasoning for supportting cooperation within cooperative entity comes from the evidence that every proposal to fight against inefficient use of fishery resources has not been sucessful. In addition, recent studies(Obach 1980, Marchak 1984) outside the economic field show us a possibility of fishery resources being managed under cooperative scheme rather than being controlled under the complicated regulations by government such

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as tax, quota, or license programs. The coopertive plan, even though theoretically infant, can be justified to be a useful managerial plan.

This paper attempts to incorporate economic theories into the development of cooperative scheme for the management of fishery resources. For the purpose of analysis, let us first examine the traditional management. And next, let us suggest the potential role of cooperative program.

Ⅱ. Common Property of Fishery Resource

The theoretical rationale to protect fish stock by regulating fishing activities is justified by the fact that biological growth function of a species is invariably given, and thus is almost independent of human activities to improve the stock. Under the fixedness of its growth, economic rent is inevitably realized, either being depleted or maintained whether a proper care is taken or not. But the common property nature of fish is likely to cause the rent to be easily dissipated in the absence of contractual arrangements among interested parties.

As shown in Fig. 1 (Anderson 1977, p. 31) total revenue and total cost curve for a fishery are, for simplicity, drawn assuming that both the price of fish and marginal cost of effort to catch fish are constant. With no regulation, the equilibrium level of effort in the fishery will be Eo where total revenue equals total cost. As fishery to the left of Eo is profitable, fishermen are motivated to enter the fishery, unrestricted under open-access regime until their total efforts are expanded to Eo. But when the fishery is managed under a sole- owner, he exercises only a smaller level of effort, Em where marginal revenue equals marginal(average) cost keeping resource rent equivalent to rectangular area, MEEo Em. Unless fishing activities are restricted, it is self-evident that resource is dissipated because of the common property nature of the fishery resource.

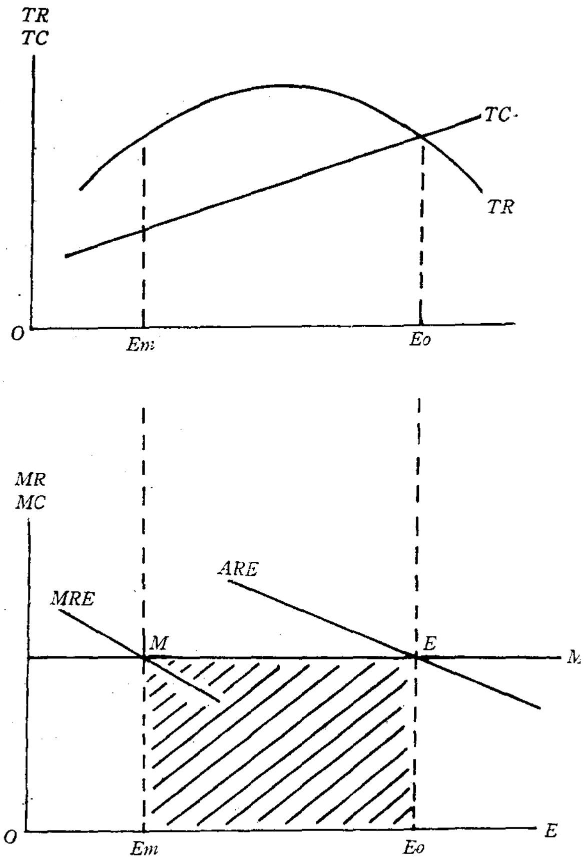

Fig. 1. Open Access vs. Maximum Econmic Yield

To avoid depletion of rent, a majority if economists advocate the establishment of managerial schemes while other economists of only a few, express the uselessness of regulation. They claim that the increasing difficulty and administration expenses coming from the enforcement may well go beyond the benefit therefrom (Chueng 1971, p. 70, Gould 1972, p. 401, Mchugh 1978, p. 185, Scott 1979, p. 727, Crutchfield 1979, p. 746, Kailis 1982). Among the economists who are in favor of management, a minority of economists contend that fisheries management be dependent on a market institution such as monopsony(Copes 1970, p. 75), or unions instituted(Cheung 1971, p. 64, Ciriacy-Wantrup 1971, pp. 40-41), rather than rely on government intervention.

But most economist agree to introduce a direct or indirect regulation on she fishing activities. Those who are in favor of an regulation were, on the one hand, encouraged by the Knight's idea(Knight 1924, p. 591, p. 606) that a new property right should be invented so as to draw a communal ownership to an end (Scott 1955, 1979). Some of them, on the other hand, favored an introduction of Pigovian taxes or subsidies to bridge the gap between private and social net benefits from the exploitation of fish.

The fundamental reasoning for introducing regulation, in short, has been justified by the fact that fishery resources are common property as claimed by Gordon (Gordon 1954, p. 124). But first of all we need to recollect the historical development of property rights. All resources that are now under a soleownership regime were at one time exploited in a common property framework. An enormous amount of literature on the property rights draws the conclusion that the establishment of private property right takes place when the benefit from holding on to it dominates over the cost necessary to protect it(Demsetz 1967).

Historically, communal ownership of land in medieval times and in the American Western Plaines had been transformed into private ownership of land, not by the appeal from economists with an effort of increasing welfare of society, but by the steady evolution of economic rationalization (Anderson & Hill, 1979) within society. This happened because costs associated with holding the title had continuously decreased while benefits therefrom had increased Demsetz (1967, p. 350) also supported the appearence of property rights by the relative advantage of benefits over costs, taking as an example the Indian fur trade. The same progress has been observed in the recent enclosure movement of oceans among nations (Ecker, 1979).

The benefit from fishery resources, however, are said to least likely exceed costs since fish is highly migratory and scattered over the wide ocean(Christy and Scott 1965, p. 6 Dales 1968, p. 62). The same argument on the disincentive nature of holding on the fishery resources was indicated by Gordon saying that "when the hunting resource is migratory over such large areas that it cannot be regarded as a husbandable by the society the land tenure remains communal" (Gordon 1954, p. 134) Unlike with land mineral, or forest, it is simply not feasible to impose individual private property rights with fisheries since the common resource cannot reasonably be divided into discrete pieces. In these cases, the role of cooperative institutional mechanism becomes potentially significant as will be explained in later sect!on.

Once a property right on land is likely to take place, the right was asserted in favor of the person who first cleared the land(Neale 1985). Just as the first person who cleared the land had a vested intrest in the management of land, fisherman have a vested interest in the occupation of fishery resources as long as they can protect the resources to their benefits as well as to society's well-being.

However, fishery resources had long remaind common not because society had no interest in property, but because it was in the interest of society that property be free to all citizens(Reich 1964, p. 779). Moreover, economists have spent their time trying to devise models of behavior for the firm and individual that would lead to socially optimal exploitation of fishery resources under conditions of communal externality, taking it for granted that fishery resources should be managed under public or government ownership. The only way to transfer a property right in these circumstances was to institute taxation, licensing or quota system within the traditional economic framework; otherwise a public enterprise was proposed to be formed (Keen 1983).

Stroup and Baden, instead, emphasize the role of voluntary organization which has a vested interest in the resources and claims title to them. They say that(Stroup and Baden 1983, p. 11:

> "On the American frontier, the first efforts to settle resource allocation claims emerged through the establishment of voluntary associations and the development of informal property rights to resources. Land Clubs, claims associations, cattlemen's associations, Wagon trains, and mining camps within which inividuals grappled with the allocation of water, land, livestock, minerals, timber, and even personal property all represent attempts to mitigate the problem associated with common ownership.… These groups often bylaws, a constitution, a management pact, a leadership selection process, and a procedure for handling disputes. In addition, outsider who attempted to interfere with a claim held by a member of the group were confronted by the association's considerable enforcement power."

In response to the continuous intervention by government into the utilization of fishery resources in Canada, Barrett and Davis, furthermore, express the importance of an invisible property right scheme among fishermen saying that(Barret and Davis 1984, p. 128):

> "The Task Force (Kirby Commission) ignores a growing body of information that identified

community-developed systems of informal property rights and relation which function effectively to regulate access to and management of coastal fishing ground"

Since efficiency is the main concern for the economic analysis on the exploitation of resources, traditional mothods of regulation may not be underestimated as long as they serve to extract resource efficiently. For the purpose of analysis, this paper is, in the first place, designed to conduct a detailed study to shed light on the performance of traditionally proposed shemes: communal-ownership, taxation, quota system, and licensing system. Next let us suggest an alternative program of instituting cooperative organization.

Ⅲ. Traditional Approach to Management

1. Sole-ownership

1) Static optimization

Suppose a fishery is run by a sole-owner. To simplify our argument let us assume the change in fish stock to take an usual growth function of the Schaefer(Schaefer 1954, 1957). Let te price of output(fish) be assumed constant in the presence of various competing species in landing market. Furthermore, the supply of inputs except fish stock is assumed infinitely elastic. Crutchfied and Zellner(1977, p. 225) succintly provides an optimal solution of the simplified model for the number of stock and effort. They build up the following equations.

$$Y = hXE(N) \quad \cdots\cdots (1)$$

$$TC = KNEj = KE(N) \quad \cdots\cdots (2)$$

$$dX/dt = aX + bX^2 - Y \quad \cdots\cdots (3)$$

where Y; total yield(harvest), X; stock size, E; amount of total effort, Ej; amount of individual effort, TC; total cost, K; unit cost of effort, N; number of vessels(or members), $h, a, b,$; parameters, and time subscript t is omitted for convenience.

The sole-owner maximizes profit, i. e.,

$Max. (TR\text{-}TC) = Max. (PY\text{-}KE)$ subject to eq. (3).

where P is price of fish. Under steady state condition that $dx/dt = o, i.e.,$ $Y = aX + bX^2$, $Max.$ $(11 = P(aX + bX^2) - K((a + bX)/h)$ yields the optimal level of stock size, $X*$, and the optimal level of total effort, $E*$ in the sole-owner's firm(or in the industry) as follows;

$X* = (1/2)((-a/b) + K/(Ph))$

$E* = (1/2)(a/h + Kb/Ph^2))$

As shown in Fig. 2, the sole owner's profitis maximized at $X*$ in terms of population, and $E*$ in terms of effort. The optimal level of stock lies above the maximum sustained

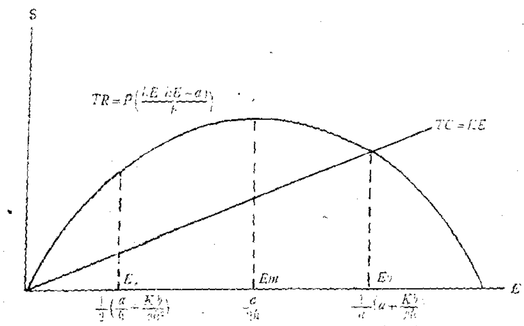

Fig. 2(a). Sustamed Total Revenue(TR) and Total Cost (TC) in terms of X

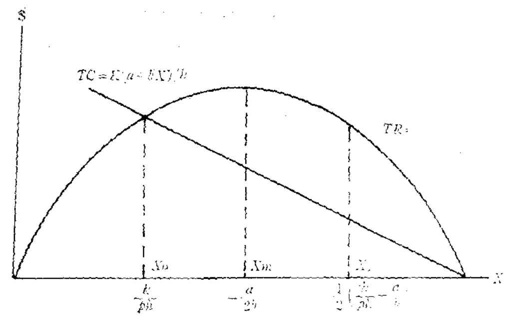

Fig. 2(b). Sustained TR and TC in terms of E

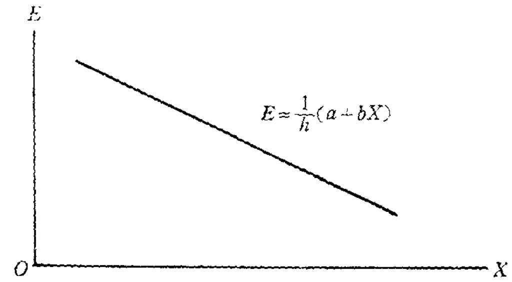

Fig. 2(c). Sustained Equilinrium between X and E

yield (MSY), *Xm*; likewise, the optimal level of effort lies below MSY, *Em*. The inverse relationship of sustained level between effort and population is shown in Fig. 2(c).

Let us compare the optimum under sole-owner with the equilibrium under an open-access or common property. The revenue in excess of cost at $X*$ attracts more fishermen or vessels to enter the idustry when the exploitation of resources is open to everyone. Of course, the existing fishermen expand their effort. These two forces increase total effort while the sotck size declines until total revenue equals total cost. Under an open access or common property fishery, the equilibrium level of stock size, Xo is $K/(Ph)$ while the equilibrium total amount of effort, Eo is $(1/h)(a+Kb/(Ph))$. Both levels are stable equilibrium. Total amount of annual rent being dissipated under an open access fishery amounts to,

$$(a-(b^2)/(2a)+(Kb)/(2Ph))\times((-Pb)/(2a)-K/(2h))$$

Which is the same with the shaded area in Fig. (1).

When the cost of catching fish, K is higher than $-ah/b$, the fishing operation is never attempted. As price of fish goes higher the optimal effort rises. Over-fishing in biologic sense is inevitable when K is less than $(-Pah)/b$ where maximum sustained yield is maintained.

When the resources are communally owned by a cooperative, it has been believed that the existing fishermen expand their effort until total revenue to each member equals total cost. As a result, their individually rational actions lead them to stay in econoimically inefficient point. The purpose of this paper is to formulate a possible solution wnich is economically efficient under cooperative scheme based on the assumption of super-rationality among fishermen.

2) Dynamic Optimization

The optimal size of stock as well as the optimal number of effort under static sense described in section 3. 1. 1 is not an optimal level both for the soleowner and society as a whole. Since fishery resources are regarded as one of capital goods, the theory of capital is naturally applied to find the optimum over time. Here we introduce optimal size of stock in terms of general form, and next apply the general form to specific type of our model.

The dynamic optimization proplem in this context is the following;

$$\text{Max. } \pi t \text{ Exp}[-rt] \; dt \;\; s. \; t. \;\; dx/dt = G(X) - Yt$$

where G is biologic growth function. The Hamiltonian denoted by H for this maximization with biologic growth constraint is, $H = \pi(Xt, \; Yt) + \lambda t(G(Xt) - Yt)$. For all t's the necessary condition that $dH/dYt = 0$, gives the optimum value while shadow price of the contraints, λt is the same as $-d\pi/dYt$. To find optimal path over time, shadow price of capitital (stoct) satisfies the following condition;

$$\begin{aligned} d\lambda t/dt &= r\lambda t - dH/dX \\ &= r\lambda t - d\pi t/dX - \lambda t G'(Xt) \\ &= (r - G'(Xt))\lambda t - d\pi/dXt \\ &= -(r - G'(Xt))d\pi/dYt - d\pi/dXt \end{aligned}$$

In steady state, *i.e.*, $dXt/dt = o$, and $d\lambda t/dt = o$, $(r - G'(Xt)) \, d\pi/dY - d\pi/dX = 0$, and $G(Xt) = Yt$. Therefore $G'(Xt) + (d\pi/dX)/(d\pi/dY) = r$ (Clark1985, P. 138)…(4) To exploit the resource optimally in dynamic, sense the left hand side of ep. (4) which shows the own rate of interest of the stock, should be equated with the social rate of discount. The left hand side equation has two components: the instantaneous marginal physical product of one capital associated with the investment in one unit of stock resulted from no harvesting $(G'(Xt))$ and stock effect $((d\pi/dX)/(d\pi/dY))$. The numerator of the marginal stock effect, $d\pi/dX$ is the profit gain for the investment; the denomiator $d\pi/dY$ is simply supply opportunity price of the investment (capital). In other words, stock effect shows us a gain(or loss) in profit from the investment of one unit of fish expressed in terms of real unit (Clark and Munro 1975, P. 96, Dasgupta 1982. P. 131).

Under the simplified model as was shown with eqs. (1) to (3) we can sustitute the growth equation, $G = aX + bX^2$, and profit function, $PY - KY/hX$ into the above result. The condition in general form of

$$G'(X) + (d\pi/dX)/(d\pi/dY) = r \qquad (5)$$

reduces to $a + 2bX + (KY/hX^2)/(P - K/hX = r$. The optimal level of stock,

$$X* = (bK - 2Phr + \sqrt{(bK - 2Ph + Phr^2) - 8bPhrK})/4bPh \qquad (6)$$

When $r = o$; in other words, the dynamic optimization is regarded as static one, the optimal stock under dynamic sense is the same with the opitimal stock in static sense as was shown in the previous section. The positive interest rate implies that dynamic optimization leads the stock level to a lower level than the static one does to the stock size because $dX*/dr<o$.

Up to now optimal level of stock under soleownership of resource and open-access level of stock were derived based on the traditionally assumed model. Next let us analyze taxation and quota systems which are geared to preserve optimal level of stock $X*$ in the previous section.

2. Taxation

1) Introduction

It is apparent that the resources are destined to be exploited in an inefficient way without an appropriate control. Uncotrolled exploitation of a common property fishery would lead to a smaller sustained yield. Competing fisherman in an open-access fishery would act myopically to determine his fishing level, taking into no consideration of keeping the interest of maintaining fish stock for the fear that fish that he leaves may be captured by other fishermen.

Many Economists empirically have examined how much the resource rents have been dissipated from the open access nature of fishing industry. As shown in Table 1, Christy estimates the overall amount of rent being dissipated in U. S. fishery is annually $ 300 millioms, $ 6 billions in terms of capitalized value.

Table 1. Amount of rents dissipated from fisheries Unit ; $ million

Reference	Area and Species	Annual amount of economic rent
Griffin et. al. 1976	Gulf of Mexico Shrimp Fishery	22. 6
Christy 1977	U.S. Fisheries	300
Clark 1977	Antarctic blue and fin whale	43. 5
Christy 1977	Yellowtail flounder, New England	10
Copes 1977	Australia Northern Prawn	4
Bromley & Bishop 1977	Pacific Salmon Fisheries	49. 5
Meany 1979	Australia Rock Lobster	7
Mackenzie 1979	Canada Atlantic Northern Cod Fishery	30
Cauvin 1979	Canada Inland Lake Winnipegosis	0. 2
Henderson & Tugwell 1979	Canada port Maitland, lobster	0. 2

One way to avoid exhaustion of rent is to introduce a tax on fishing industry. The idea of tax was proposed early by Scott(1957), and theoretically became common place by Scott

(1962), and was developed further by Smith(1969). When the assignment of a property right is either undesirable or implausible, an efficient allocation of resource is expected to be achieved by means of taxation (Pontecorvo et. al. 1977, p. 69, Fraser 1979, p. 760). Gord on(1953, p. 457) also proposes a tax scheme when the property right to an individual group is impossible or public authority who is in charge of the resource is unable to govern.

The introudction of tax system is justified on the two objectives: efficiency and equitable distribution. Since a fishery is one of industries, the objective should first on the efficiency. Thus an appropite rate of tax(royalty tax or tax on landings) converts the several types of externality that resides in an open access fishery into contractual costs to individual fishermen Crutchfied 1979, p. 744). The fishery then could take both the stock effect and congestional effect into account (Peterson and Fisher 1977, p. 690).

It is believed that efficiency can be achieved through the encouragement of an introduction of new method in fishing activity. Scott(1962, p. 49) said that the tax on fish instead of effort(vessel) would promote innovation, and encourage existing fishermen to adopt new method in fishing activity.

For example, in the regulation of the salmon fishery in Canada, the introduction of licensing system was intended first of all to force out those fishermen who were casual, part-time recreational and other fishermen whose opportunity costs associated with fishery were believed to be low. As a consequence, the licensing system adopted in Canada led the fishing industry to incur higher opportunity cost in a sense that the fishery was prohibited to those fishermen whose opportunity costs were low. To avoid the inefficient activity, a royalty or tax system was proposed to discourage the fishermen who caught fish at a relatively higher opportunity cost instead(Pearse 1972, p. 194).

The final argument in favor of the tax system is based on the distributional effect of tax revenue. Both the sole-ownership, quota, and licensing systems are blamed by the distributional unfairness. Cauvin (1979, p. 831) asserts that rent should be appropriated to the public sector accounts rather than to the accounts of the industry. Crutchfield(1979, p. 744) states that:

> "…limited entry program unaccompanied by and tax measure to carture a portion of the economic rent created may produce transfer of income and wealth in a direction that would be unacceptable to most people……management measures that confer sustantial gains in groups of private enterprisers and their employees at the expense of the general tax payer are not considered good form."

There are broadly two kind of taxes that could discourage either investment or overfishing; one is designed to reduce effort while the other is to give fishermen a disincentive to catch fish. Scott early proposed a tax on effort saying that "It seems that the best tax would be one levied on the fishermen or on total outfits. It should be levied at a rate which kept their number down to the required effort input;" (Scott 1957, p. 56). Both scheme could protect an efficient fishing activity; however, it is maintined that the choice must be based on the ability of each plan to enhance the overall objectves of the fishery (Wilson and Anderson 1977, p. 199).

But most ecconomists agree to introduce the tax on yield rather than the tax on effort on various grounds. Wilson and Anderson(1977, p. 199) attributes the relative weakness in the tax on effort to complexity of measuring composite index of inputs. Unless the effort is directly administered fishermen tend to report underestimate of total effort exerted by them. When the tax on effort is imposed on the directly measurable units of inputs, for example, number of vessels or tonnage of vessel, number of fishermen, and so forth, it distorts socially desirable combination of factors (Scott 1979, p. 734, Crutchfield 1979, p. 744) Furthermore a tax on catch is said to produce less variation in profit than a tax on effort (Wilson and Anderson 1977, p. 203). Final argument in favor of the tax on yield was based on the nature of fishing industry; that is, multispecies are usually captured by a single unit of vessel. Since species are to be managed in the way that effort is not excessive to dissipate rent total effort does not guarantee the optimal rate of harvest for each species.

The tax on yield can be classified by the object into two types: specific tax, and royalty. Royalty tax which is imposed on the total revenus in the landing market is said to be preferred in order for the technological improvement or rising price of fish to be reflected on the rate of catch. (Cooper 1975, P. 372). But it needs an explanation whether royalty tax is more attractive than the specific tax in point of economic efficiency. Meanwhile, the attempt to introduce royalty tax on landed value of British Columbia salmon to improve the Limted Entry system in practice received a negative response from the industry (Cauvin, 1979, p. 835).

Even though tax on ex-vessel landing is theoretically sound, practically simple, and straight forward in application and collection, it has also many serious weakness. First of all this scheme is unpopular among fishermen, because tax scheme precludes any financial gains to fishermen(Pearse 1981, p. 141). In order for a management plan to be successful it is necessary to achieve industry understanding and cooperation (Pontecorvo et. al. 1977, p. 59) ; as a consequence, tax scheme incurrs social cost which is needed for fishermen to understand and cooperate either voluntarily or involuntarily.

Secondly, it is indicated that tax would have to be perfecty adjusted to enforce all fishing units to operate at an efficient level. In other words, to maintain the fishery in a condition of maximum efficiency, the level of efficiency should be adjusted flexibly in the face of changing prices, cost and technolongy (Scott 1962, p. 43, Crutchfield and Zellner 1962. p. 105, Pearse 1981, p. 140, Under rigid and time consuming nature of imposing tax, in parallel with chagning economic environments, maximum efficiency is neither preserved nor easily achieved.

Thirdly, Scott (1962, p. 48) raises a question when the productivity of effort differs in fishing grounds. In other words, an identical tax rate on catch does not help to gap the difference between marginal product and private cost of effort. But the above argument holds only when the productivity of fishing grounds is identifiable. In most cases except non-migratory species, it is impossible to make sure that one fishing ground is more productive than the others.

Finally, it calls for precise and continuous analysis of the potential value of fish followed by data collection, econometric anaiysis, surveillance, and administration (Pearse 1981, p. 140). Continuous work by the authority, however, is also unavoidable when the other schemes are implemented.

With regard to the distribution of tax collection, economists agree that this revenues should be spent on covering the managerial cost incurred in the admistration of fishery resources or promoting research and development of the fishery (Potecorve 1977, p. 60, Cauvin 1979, p. 831). On efficiency ground, however, government expenditure should be spent on those sectors within nation which contribute to provide maximum benefit where fishing industry is not a sole beneficiary.

2) Optimal Tax

Let us examine the optimal tax under the simplified model in order to understand why tax plan is not an easy job. Since tax rate is charged to be equal to the shadow price of the stock,

eq. (5) can be rearranged to be

$$t=-d\pi/dY=(d\pi/dX)G'(X-r)$$

The above equation says that the imputed value of the untapped resource ($d\pi/dY$) should equal to the additional benfit from increasing stock ($d\pi/dX$) divided by net social rate of discount ($r-G'(X)$ (Dasgupta 1982, pp. 130-136). Thus, the optimal tax rate, $t*$ is

$$t*=(d\pi/dX)/(r-G'|X=X*=P-KhX|X=X*$$
$$=(X((a+bX)/hX/(r-(a+2bX)))|X=X* \qquad (7)$$

where $X*$ is the condition expressed in eq. (6). Eq. (7) says that price net of tax, $P-t*$, is,

$$P-t*=k/hX=KE/Y=AC.$$

Since the unit tax is imposed on the quantity caught, Fig. 3 shows diagrammatically the optimal tax rate under the framework of backward-bending supply curve(Copes 1970) with given average cost (AC) and marginal cost (MC) curves before tax Burden of tax plays a role of shifting AC curve upward(AC′).

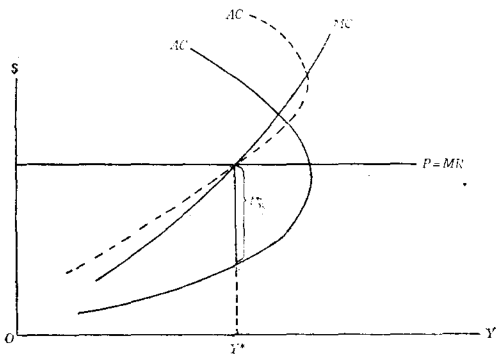

Fig. 3. Optimal tax rate(t)

Eq. (7) moreover tells us that as price goes up, tax rate should be adjusted to rise, while it is adjusted to decline when cost of fishing increases. When $r=O$, *eq.* (7) turns out to be

$$t*=(K(a+bX)/hX)/(-a+2bX)) \cdots\cdots (7)'$$

where X is $(bK-2Ph)/(2Pbh)$ which is evaluated under static optimum. Clark (1980, P. 1123) shows an optimal tax rate as $t*=P-(d\pi/dE)/hX$ which is the same as the eqs. (7) and (7)′ of the optimal tax rates. As eqs. (7) and (7)′ show, optimal tsx rate is dependent on the optimal size of stock. In other words, tax plan requires a predetermined level of stock, which may well be the most weakness.

3) Adjusted Price System

Another management scheme, an adjusted price system is expected to have the same effect on economic efficiency and equity grounds as the taxation on catch. This system was proposed by Copes (1970, p. 77) as one way to achieve optimal exploitation of resources. Olson(1973) later intended to apply this to a changing effort exerted to particular species or a group of species. McConnel and Norton(1978) renewed this system as an alternative to existing limited entry system by vessel(or fishermen).

This adjusted price system is designed to control the fishing effort by reducing the price received by fishermen for overfished species, and by increasing the price for under-exploited species(McConnel and Norton, 1978, p. 194). In most cases, commercial fishery resources are economically over-exploited and biologically over-fished. Thus the adjusted price system is targeted to reduce the effort of fishermen, discouraging them by lowering the price from that of the actual price realized in the market. The difference between the actual price paid by consumer in the market and the adjusted price received by fishermen in the landing market can be regarded as a tax on catch. The advantages and disadvantages of taxationary regulation, therefore, hold true for the adjusted price system as well.

One variant of the adjusted price system is the so-called monopsony scheme which is designed to give the fish consumer, usually a marketing board instituted to take on the role of consumer, a monopolistic power in purchasing fish at landing market. This system also creates a gap between the price received by fishermen and the price paid by the consumer. If the marketing board does not exercise a monopolistic power over the consumer in the consumer market, the economic implication of instituting a monopsonistic marketing board leads us to the same conclusion as the taxation.

3. Quota System

1) Introduction

Instead of restricting prices such as setting tax, instituting a monopsonistic board, or adjusting the price, the idea of imposing a direct restriction on the amount of catch has received considerable attention from economists and administrators. Since 1933, for example, the Pacific halibut has been managed under a quota system which allows fishermen to catch a fixed amount of fish for each fishing area and season. This system which is called the total allowable catch quota system, has been confronted with criticism on the ground that competition among fishermen leads to an early exhaustion of quota. Many economists have proposed an alternative system, called individual catch quota system or quantitative right system. The next two sections in this paper examine how the quota systems have developed, how they work, and what are the advantages they have over other systems. Then the third and final section will look for the equilibrium price of the unit quota and the limitation of quota system, once it is in the quota market.

2) Total Allowable Catch Guota System

The total allowable catch quota was first introduced in 1933 into the conservation and rehabilitation of the depleted Pacific halibut (Crutchfield and Zellner 1962, p. 33). But experience and economic theory have told us that system fails to bring an efficient management (Scott 1957, p. 55, Gordon 1954, p. 133 Cruthfield and Zellner 1962, Christy and Scott 1965, p. 15, Crutchield 1969, p. 268, Pearse 1981, p. 136).

As soon as this system was introduced, individual fishermen stepped up their effort to catch more fish because of the fear that the other fishermen might exhaust the given total quotas, as a result, each fisherman took fewer fish in a shorter period of time. The competion among fishermen led them to unload fish concentrated in the first quarter of the fishig season, which also lessened the quality of fish at the later quarters due to the need for freezing. Moreover, landings were concentrated in the ports nearest to the fishing grounds, which severely restricted an efficient allocation of effort between fishing seasons.

The imposition of the total number of catch allowed naturally accompanies the excess capacity in the industry in terms of vessels and freezing or storage facilities, Fishermen with similar gear and new fishermen enter the industry until the total quota is exhausted. The equilibrium level of effort is achieved where there no longer exists an opportunity for profit.

For simpliciity let us assume the number of fishermen is fixed by N and each fisherman is identical. At equilibrium $PY=NCj(Ej)$ where Cj stands for the total cost of j-th fisherman. Given the fixed number of quotas $\bar{Q}$, $P\bar{Q}=NCj$ since there is assumed to be no excess profit. Thus, Ej=inverse function of $[Cj(PQ/N)]$. Under the traditional model, total amount of effort by j-th fisherman

$Ej=P\bar{Q}/NK$. Individual fisherman will increase the effort until

$$Ej=(P(aX+bX^2)/(NK))\,|\,X=X*$$

where $X*$ is the optimal level of stock determined by the authority in charge of total allowable catch quotas. It is evident that competition among fishermen exhausts resource rent while stock of fish is biologically preserved.

3) Individual Catch Quotas

The assignment of the right to catch a designated amount of fish by an individual fisherman originates from the management prictices introduced in international fishery. Salmon fishing, for example, between the United States and Canada in their common area has been allocated on the basis of an equal share of catch between the two countries (Christy and Scott 1965, p. 209). Yellowfin tuna fishery in the eastern Pacific (Qulland & Rebinson 1973, p. 2049) and whales in the Antartic (Christy and Scott 1965, p. 209) are also examples of the quota system among participating countries. A national quota system in international fishery was proposed as a way bo achieve efficient managment of fish caught by many countries. Crutchfield (1969. p. 269-272) suggests that the national quota scheme in the cob and haddock fisheries of the North Atlantic Sea should replace the prevailing regulation of mesh and minimum size of fish. Individual quota system was introduced in Michigan for Lake Superior fisheries in 1975 and in Bay of Fundy for herring in Canada (Stokes 1980, p. 293).

It was not until 1973(Christy 1973) that an individual catch quota system or quantitative rights system seemed to be the most desirable management plan in domestic fisheries. Though this system in domestic fishery sounds new, it is actually an extension of international fishery applied to the management of domestic fishery resources. Furthermore the idea was an extension of policy to reduce the discharge into water (Dales 1968, p. 81).

Dales(1968, p. 93-97) proposes an establishment of the market for "pollution rights" which can be transacted between polluters. However, the individual catch quota system has begun to receive considerable attention from economists recently (Scott 1979, Crutchfield 1979, Molney and Pearse 1979, Wilen 1979, Pearse 1980, 1981). As Crutchfield and Zellner(1962) forecasted, open access fishery would envolve from a system of licensing to a guota system and ultimately into a taxation system.

An individual catch quota system in a highly developed form creates transferable and perpetual rights to specific quantites of fish by individual fisherman during a fishing season. Within this scheme, individual fisherman would maximize his benefit subject to the quota allowed. As a consequence, He employs the inputs in an efficient way (Crutchfield 1979, p. 749, Wilen 1979. p. 858, Pearse 1981, p. 141) since the fish (or capital) is limited by a quota and is no longer owned by other fishermen.

Instead of relying on scientists' limited data to determine optimal quotas, this scheme is said to have the advantage of collecting data from the fishermen's activities. Under the operational market of quotas, that is, the unit price of the quota reflects the variabilities in stock abundance as well as the demand and technological changes. Pearse (1981, p. 141) states that "It is uniquely resilient to changing conditions. If costs fall or fish prices rise, no automatic tedencies to expand capacity will result; the value of right will simply increase"

The most distinctive deficiency of this sysem, however, arises from the fact that the determination of the desired catch quota is strongly dependent on the accuracy and precision of assessment of the resource (Scott 1957, p. 55, Sissenwine and Kirkley 1982, p. 45). Because fish stock may sometimes vary in abundance by a multiple of initial estimate(Mc Hugh 1978, p. 179). For species regenerating in as short a period as squid and anchovy, for example, application of this scheme is impractical. When the authority in charge of total quotas fails to update the optimal quota, the resource is likewise not likely to be exploited efficiently. Because exces s accrues only to the holder of quotas.

Eventhough the authority, coserving the trends of quota price, collects a piece of usefull information it assumes a difficult task; identifying the changes in quota price due to changes in economic conditons from those due to changes in biologic conditions.

Pearse (1982, p. 143) (1982, p. 143) proposes a basic right or quotas initially set by the authorities for a minimum allowable catch. The actual available right or quotas are adjusted, depending on the stock abudance for each season. However, unless the indivudual has a fixed quota in advance, he is participate in the fishing operation, uncertain of the size of "his" capital. Moreover, how can the quota market be stablized, if stability of price in the market is desirable, under circumstances where the number of quota can be increased or decreased by the authority's discretionary action? Furthermore, discarding the fish caught would be unavoidable in order for the quantitative rights to be more avaiable(Mckellar, 1982 p. 358).

Another difficulty involved in a quantitative rights system arises from the possibility that the quota would be bought up by the large processing firms. In developing countries such as Korea, the wealth is highly concentrated around a few big companies, and these might attempt to speculate on the rights. They are at the present criticised even under no quota system for purchasing large amount of fish and storing them for a while, anticipating the rise of the price. There is no doubt that their speculative activity would be encouraged without a resonable tair trade rule practiced, if this system were introduced. Pearse(1981, p. 144) suggests that the number of quota allowed by one party be restricted to a reasonable amount (or rate). But we have to keep in mind that each regulation one after another involves an enforcement cost.

A regulation such as an ant-trust, adopted in the industrial might be applied; however, quotas themselves are operating commodities, easily transferable; likewise easily unnoticed, to the regulator. Therefore the attempt to avoid the quota from being owned by large firms would fail easily under the circumstances that the quota itself is a right, not a physical object like an factory plant.

Moreover fisherman falls into temptation to underreport the amount harvested and to upgrade the fish caught, taking only the best quality of fish and discarding the rest(Stokes 1980. p. 298). The gains from underreporting and upgraduiiby could be substaintial. Only the fishermen and buyer themselves know what has been thrown away or landed. As long as government excerises its ownership over fishery resources through tax or quota schemes, there is no other way but to dissipate some part of economic rent from the resource. Because for the schemes to be effective additional effort should be made with a considerable amount of cost.

4) Demand for Quotas

Now let us examine how the price of quota under this system is determined and what the demand for a quota seems to be. Let us denote the total quota allocated in the market by $\bar{Q}$. Also let us assume that each fisherman is allocated the same numer of quota. Then $\bar{Q}=\sum\bar{Q}j=N\bar{Q}j$, wheren is the existing number of fishermen. The assumption that each fisherman is given the same quota ($\bar{Q}j$), however, is irrelevant to the final solution for the price of that quota. Now let us denote the demand for quota of an individual by Qj.

Thus the net demand for quota can be expressed as $Qj-\bar{Q}j$.

As individual firm maximizes profit by taking the price of quota into accout, his profit function can be expressed as follows.

$$\text{Max. } (\pi i = PYj - Cj(Ej) - \lambda(Qj - \bar{Q}j))$$

where is the price of quota. Now let us assume that an individual exhausts his total quota, then the first order condition for the maximum is,

$$d\pi/dEj = P(dYj/dEj) - dCj/dEj - \lambda(dYj/dEj)$$
$$= (P-\lambda)(dYj/dEj) - dCj/dEj = 0.$$

Since $dCj/dEj = dCj(EJ)/dEj = dCj(\bar{X}, Yj)/dE = dCj(\bar{X}, Qj/dEj$, the above first order condition can be expressed in term of Qj as $dCj(Qj)/dEj = (P-\lambda)(dYj/dEj)$, which is the demand for the quota.

Under traditional model, the condition that $dCj(Qj)/dEj =$ and $dYj/dEj = hX$, leads us to the quota demand function where X is thefunction of Y or Q under the steady-state condition. Thus the demand for quota can be expressed as

$$X(Q) = K/h(P-\lambda) \text{ or } Q = X^{-1}(K/(h(P-\lambda))).$$

The equilibrium price of a quota can be derived, equating the total quotas $\bar{Q}$ with the total demand for quotas Q. That is

$$\bar{Q} = X^{-1}[K/(h(P-\lambda))], \text{ or } K/(h(P-)) = (X^{-1})^{-1}(\bar{Q}).$$

Therefore the equilibrium price of quota is,

$$\lambda^* = P - K/[(X^{-1})^{-1}(\bar{Q})h].$$

Given that $(X^{-1})^{-1}$ $(\bar{Q})$ is monotonically increasing with respect to $\bar{Q}$, the equilibrium price of a quota falls as the number of quotas rises. The above equation implies that the equilibrium price of quota depends on the number of quotas issued.

Let the price of fish is normalized to be one. Also let us assume that the initial level of stock is depleted to the point where the fishery is done under open-access with zero profit. For the quota system to be operative, the number of quota was forced to be set by $\bar{Q}_0$ as in Fig. 4. Under steady state condition, the final eqilibrium level of stock would be X'. During the transition from X'_0 to X', the price of quota might vary, caused by the stock effect. At X' the sustained level of stock, the price of quota,

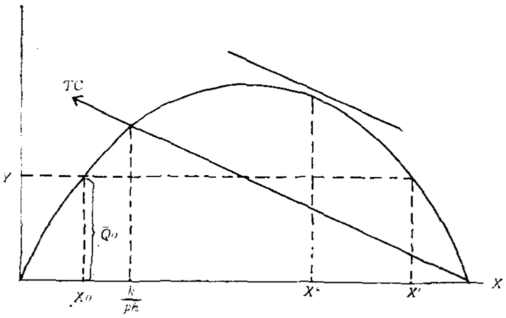

Fig. 4 Sustained Equilibrium Quota($\bar{\theta}_0$)

$$\lambda^* = P - K/hX' \text{ where } X' = (a + \sqrt{a^2 + 4b\bar{Q}})/(-2b).$$

The above result implies that the equilibrium price of a quota depends on the number of the quota issued or corresponding size of the stock; in other words, whether the price of quota is optimal or not depends on the precision of the optimal stock size. When the number of quotas is different from what is believed to keep optimal stock level, the price of the quota does not adjust itself for a while scheme fails to achieve the optimal harvest rate when it is different what is evaluated at the optimal stock size, the same failure takes place without a correct allocation of quota. In an extreme case, when $\bar{Q}=\infty$, the stock size is reduced to what is available in open-access fishery since the quota scheme does not contribute to bring us the optimal level of stock.

When a different tax rate was applied to different fishing ground, there would always be a temptation for the vessel to claim that all its catch comes from one or a few specific categories (Scott 1979, p. 737). It is true that tax evasion would take place under the tax system. But the same argument hoids true of the quota system. There would be a quota evasion(Crutchfield 1979, p. 749), when a fishing operation is done on mixed stock with single gear. It may be impossible to achieve the desired fishing mortality for one species without exceeding the desired mortality of another (Sissenwine and Kirkley 1982, p. 46) under both the tax and quota systems.

Finally we can not avoid the distributional effect of the tax and quota systems. When the initial quotas are sold by bidding in the market, the distribution of wealth under quota system is the same as that under the tax system. In Korea small scale vessels owned by many fishermen and large scale vessels owned by a few big firms, are engaged in catching the sames pecies. Once the quota system is introduced, the fishermen who are financially weak might be forced out of fishing operations. This is not because they are inefficient from society's standpoint in their fishing activities but because they are exposed to incompetitive market structure from the individual point of view. They usually engage in fishing operation under imperfect fund market where they borrow money at a higner rate and under more unfavorable conditions than the big firms do to participate in the bidding. Likewise, poorer fishermen also lack in the skills required to make use of every opportunity than richer ones do (Young 1983, p. 158). Evidently the quotas would be taken up under the imperfect fund market by the big firms under the present financial availability in Korea.

Unlike the United States and Canada where the part-time fishermen who have retired from regtlar jobs, are participating in fishery to enjoy fishing itself and to get some return, the liveiihood of fisheermen in isolated communities in Korea is neavily dependent on fishery. Theoretically they may sound efficient, but I do not expect either the tax or quota systems would be economically feasible in Korea. Even in Japan, which is a highly industrialized and rich coutry, the licensing system has been maintainad for a long time. The next section explains how the licensing system works and whether or not it is more valuable than the other.

4. Licensing System

Finally, let us consider the economic aspects of licensing systems. While taxes and quotas also serve to control access to fishery resources, license limitation is the most commonly known restriction directly exercised on fishing efforts. In this respect, limited entry, thus, is meant to be a license limitation in the minds of fishermen and fishery managers, License system directly limit the number of fishermen, vessels, tonnages of vessels, units of gerar, or a combination thereof. However, since the vessel is the core factor of production in a fishery (Crutchfield, 1979. p. 745), every lecense program associates the specific regulation with vessels.

License systems have an ancient neritage; they go back at least to the time when the king asserted his rights to the game in the forest(Fletcher 1965, p. 119). King were sustituted by the state, and game was replaced by fish. However, this paper is not intended to develop how the fishery right is established and transformed. In early regulations, liencsing was not intended to limit entry; it was used to identify fishermen as an aid to keeping tracking of fishing activities. (Needler 1979, p. 717, Young 1983, p. 133).

Historically license limitations were steadily instituted to reduce without difficulty the fishing efforts in a depressed fishery. So that these who already participated in the fishery could take advantage of entry linitation and supported it. At the same time those outside were not encouraged by the low rates of return into the fishery, and did hot protest the entry limitation on themselves (Keen 1973, p. 137). The attempt to introduce a license system in British Columbia's salmoon fishery in 1960's, as an exception, met rigorous opposition from the fishermen's union Because "it feared that the licensing scheme would not only put a new financial burden on fishermen, but also allow the processing firm, througn purchasing licensed vessels, to gain control of the fleets" (Pearse 1972, p. 181). However, once this system was introduces, most fishermen were in favor of keeping the system because their activity in the fishery was protected from outsiders. Moreover, the alternatives, tax and quota systems looked more unfavorable to their interest than the license system.

The license system in each fishery was adopted depending on the nature of fishery resources, fishing activity and the structure in the fishig industry. Sometimes, license limitation was intended to prevent "overcrowding" and "conflict" on the fishing grounds rather than to avoid "overfishing", and to maintain economic viability of the individual fishing industry (Keen 1973, p. 147-148). The license limitation in Japan came into force at a differnet stage of the devlopment of fishery. Kashanara put forth the following opinion:

> "in some cases, the system of limited entry was applied almost from the very beginning, as, for instance, in the salmon mothership fishery in the North Pacific. In these cases, the entry limitations were imposed while the fishery was still fairly profitable. In other cases entry was limited only after the fishery had become unprofitable". (Oka 1962, p. 213)

The development of the limited entry and its economic and social aspects has been widely studied in the literature(refer to Rettig et. al. 1979., Symposium on Policies for Economic Rationalization of Commercial Fisheries pp. 716-866). Still there are contradictory findings, for example, in the performance of license systems in Alaska and Canada (Adasiak 1979, Copes 1982, and Warriner and Guppy 1984) This paper is not intended to review the development of the license system in the fishery of each country. However let us concentrate on the importance of this system and the economic implications resulting from the enforcement. Current operative systems of the license system in fishing nations are summarized in Table

Table 2. Current Limited Entry Programes(Stoke 1980, p. 292)

Country	Stooks	Programme type
Australia	Rock lobster, northern prawn	vessel license
	Abalone	oersonal license
Canada	Pacific salmon herring abalone, groundfish	vessel license
	Atlantic lobster	vessel license
	Atlantic(Bay of Fundy) herring	individual quota
El Salvador	Shrimp	vessel license
Iceland	Shrimp	vessel license
Japan	Coastal, offshore, and Distant water fisheries	various
Koeea	Coastal, offshore, and Distant water fisheries	vessel and gearr
New Zealand	Scallops, rock lobsters Paua, eels mussles, oysters	vessel license
Nicaragua	shrimp, lobster	vessel license
Netherlands	Shrimp	vessel license
Norway	No specific stock	vessel construction license
South Africa	Shoal fisheries	vessel and processer license
UK	Herring	vessel license
USA		
Alaska	Salmon	vessel license
Califonia	Herring	vessel license (by lottery)
	Herring roe	vessel license (by competitive bid)
	Abalone	Personal license
Michigan	several great Lakes species	combination vessel license and individual quota
Ohio	Several Great Lakes species	vessel license (with substantial license fees)
Washington	Salmon	vessel license(moratorium only)
Wisconsin	Several Great Lakes species	vessel license

(2). Most countries implemented plans by licensing those who have engage historically in fishery and by excluding all others, or by discouraging part-time fishermen (Adasiak 1979, p. 773, Rogers 1979, p. 785, Meany 1979. p. 789).

Moreover. most countries issue licenses as a privilege to the issues not as a property, the transfer of which is in some cases restricted by law. As long as the privilege is exchanged at market at considerable amounts, the legal aspect of liensing is of no importance. One of the advantages of license programs is its simplicity in its administration since vessel or tonnage of vessel are easily identified (Asada 1973, p. 2094). Moreover, those fishermen who have licenses feel confident that the fishing region they have developed is not threatened by new entrants(Gulland 1974, p. 144). Since licenses have an exchange value, fishermen could easily get a loan from a bank, which on the one hand improves their financial sitution, on the other hand provides excessive capital in the industry (Keen 1973, p. 153, p. 154). Above all, license schemes were easily instituted due to less confusion than what other systems might give rise to (Crutchfield 1979, p. 749).

In response to genersally favoring guota systems, the proponents of license scnemes assert that quota systems can only work for specific stocks which can be located within a specific management and in which bycatches are low (Sinclair, 1983, p. 312). However, one of the fatal shortcomings of the license plan is that "it does not necessarily produce the same result as would-ownership. Because a licensed firm uses the fishery in common with other license firs and thus it does not have the same degree of exclusive use as does a sole-owner" (Cross 1980, p. 217).

Failure of licensing systems was already expected. It was believed that license programs would lead license holders into a competitive race to build larger and faster vessels in order to geta larger share of the total permitted catch eventhough such attempt would be self-defeating and might result in higher average costs for all boata (Crvtchfield 1977, p. 253). Evidence frem British Columbia salmfn fishery shows that limiting the number of licenses alone can result in little impact on fishing effort (Campbell 1973, p. 2073, Asada 1973, p. 2093, Fraser 1979, p. 60).

Fishing effort is a funclion of various inputs. The power of gear (or vessel). number of vessels, number of fishermen workers, and time spant on fishing all influence the amout of effort. Thus, for example, if the program licenses only a limited number of vessels, the goal of maintaining the fishery can be undercut by an icrease in power of the gear or time spent on fishing. Alternatively, if the program licenses only certain kinds of year to control power a fishery can become locked into existing inefficiencies and improvements are discouraged. It, thereofre, is difficult and administratively expensive to attempt a licensing program that successfully integrates all elements of fishing effort to control the catch.

In an economic sense, restriction of one or two dimensions of inputs will lead to more intensive use of others. Because of the flexibility in the combination of fishing technology. both theory and experience suggest that "restrictions on one or a few factore of production are not likely to succeed, in the long term, in preventing expension of fishing capacity" (Pearse 1981, p. 139).

When this system was instituted, most fishermen responded by expanding their effort by increasing the size of the vessel which was not restricted (Oka 1962, p. 214, Campbell 19 73, Pearse 1972, p. 194, Asada 1973, p. 2093.)

Theoretically, limitalion of entry on the inputs necessarly exhausts economic rent from the fishery. To put it in a different way, licenses can no longer hold value. Howerer real expriences snow that licenses are transferred at a considerable value (Fraser 1979 p. 758, Meany 1979, p. 795, Gulland and Robinson 1973, p. 2050). The presence of valuable licenses can be explaind by the invariability between inputs. But it is not likely that license value persists for a long periods since the fixed proportion beween factors can falsified with the development of fishing. (Keen 1973, p. 149).

Let the effort function has homogeneus of degree less that one in input factors. As shown in Fig. 5 each MCV shows the supply of effort when the number of vessels or size is fixed: likewise MC shows the industry curve when a marginal firm enters into the industry (refer to Varian 1978, p. 62). when the number of firm is one; i. e., a sole-owner is operating the fishery, the shaded area abid represents total value of license. However, when the marginal firm enters into the industry, the number of firms times the area efg is total license vailue. Total amount of resource rent being dissipated is the area glk while the inefficient use of inputs incur cost to society an amount equivalent to the number of firms times the shaded area gfl. Evidently, licensing system leads to additional misallocation of the input resources. The fact that license value for some species is marketed at considerable value in Canada or Alaska (Keen 1973, p. 153, Fraser 1978, p. 375, Adasiak 1978, p. 288) supports that MC curve is not approximately horizontal; as a result, fishing industry exhausts the opportunity value of inputs as well as resource stock.

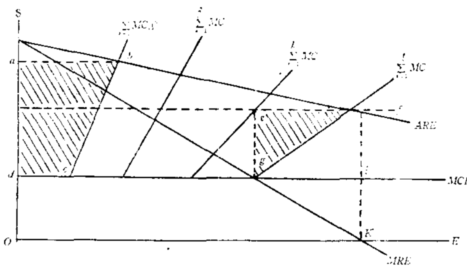

Fig. 5 License Value and Welfare Loss

For limited entry to be fruitful, government continuously imposes additional restrictions one after another. By now, most coutries have adopted a maximum number of licenses to be issued or declared a moratorium on new issuance of licenses. Each fisherman who is licensed is still put in the classical situation of a prisoner's dilemma. Fishermen have been familiar with the purpose of the management in fisheries through debates with officials or economists. Under prisoner's dilemma they are expected to realize that cooperative action among their fellows contributes to their benefit. For the conclusion to be more fruitful sociological studies on the behavior of fishing firms and members within commuities are required.

5. Enforcement Cost

Transaction costs such as information, contracting, and policing cost play vital roles in the establishment and management of public owned resources. Eventhough the contracting cost is not required, the other two costs, information and policing cost, in particular, are related to the exploiation of fishery resources. Whether a management sceneme succeeds or not depends on the relative magnitude of transaction costs associated with instituting various alternatives. Maximum economic yield is possible when the marginal benefits of a management system that controls excess effort and associated problems equal the marginal costs of implementing the system (Anderson & Hill 1979, p. 265). Government interference on the use of communal property can be justified only if its activity raises the net benefits of those institutional arrangements more than what individual rights (private activity) achieve. In other words, government ownership is called for as long as its activity is worth its costs.

A fisherman's decision under the assumption of rational behavior whether or not to commit a violation depends on whether he expects to lose more by breaking the law than by adhering to it. As was discussed in the previous section, introduction of the licensig system inevitably led to the expansion of vessel capacity, the impact of which made fishing activity inefficient.

Moreover, fishermen can be divided into two groups; commodity producer and subsistence producer (Marchak 1984, p. 169.). In Korea as well as in Canada, many fisheries are performed by small scale fishermen who are mainly concerned with subsistence itself rather than commodity production. These fishermen have suffered from the liensing scheme which required sizible amounts of capital investment in the fishing facilities to compete with other large scale fishermen(Copes, 1982). In a word, the widespreav licensing system has forced interested society members to chose the most efficient technology but with the economically least efficient way of production.

Experience tells us that the license programs adopted in most countries have changed year after year into more complicated forms of regulation one after another. Since fishermen outsmart the intention of official, they are running an endless race.

Both the tax systems and quota plans, first of all, require the information on the shape of the growth function as well as how technology and other environments surrounding the fishing industry would change. When there dose not exist any reasonable estimate of the optimum level of stock (or catch), transaction costs unavoidably rise due to imperfect information (Dahlman 1979, p. 143). It would be difficult to apply in fisheries where biological management is not geared to predeterminable quotas or tax rate but reqvires day-today fine tuning in opening and closing a fishery(Copes 1982, p. 232, Stokes, 1980, p. 300).

In addition, without any reasonable incentive or voluntary motives, fishermen may provide false information on place of cach if this alleviates the burden of regulation. Sometimes, to fight against goverment regulation, a fisherman sinks his vessel or buns surveillance vessels which try to investigate whether to investigate whether he is violatiing regulations or not (Apostle et. al. 1984. p. 163). Furthermore, as Stroup and Baden said, corruption within regulatory agency is still another possibility.

> "Institutional rules always allow governmental official some discretion in determining access to resources. Claimants, therefore, have an incentive to invest in activities that might produce administrative outcomes favorable to themselves. Under these circumstances, some corruption exists in every political system. Informational lobbying, potential shifts of campaign support, actual or threatened lawsuites, and even bribery can all be brought to bear at a cost by those who wish to gain favorable decisons from governmental policy makers who control the rights to resources".
> (Stroup and Baden 1983, p. 9)

It was indicated by Marchak (1984, p. 47) that the total cost of maintaining the west Coast fishery in Canada, including the salaries for the 1,200 employees of the Dept. of Fisheries and Oceans, is just about the same as the total market value of the catch. In Alaska, the establishment costs of licensing in 1983 was around $2.5 million while revenue from issuing of license was around $3.0 million (Young 1983, p. 161). In 1978 the province of Nova Scotia spent one dollar for each $62 earned through fish landing while the government of Canada spent one dollar for every $5.80 earned by fish landing in the marintime province(Davis and Kasdan 1984, p. 111) In the Costa Rica tune fishery, the enforcement cost which is expected to rise from the optimal level of surveillance to exclude foreign vessels accounts for 50% of the total rent from the fishery (Lepiz 1985).

Let the cost involved in the enforcement or administeration be dependent on the magnitude of stock, Xt. Then its cost M1Xt) can be expressed as a function of the stock size. The dynamic optimization problem, when the enforcement cost being taken into account can be written under traditional model as follows;

Max. $\pi = PY - K(Y/hX) - M(X)$

The own rate of interest turns out to be

$a + 2bX + (KY/hX^2 - M'(X)/(P - K/hX)$

where $M'(X) > 0$

The above rate implies that the optimal stock size should be less than the one without the enforcement cost. As the number of resources increase, the total enforcement cost increases while the cost from stock an infinite amount, the optimal stock size and effort reduce to the solution of open access. This is the fundamental reason why economists propose an absence of regulation in the pressence of enforcement cost (Cheung 1971, Gould 1972). However, as long as the enforcement cost is relatively small, the optimal levels are desired to be maintained by alternative schemes.

Eventhough the transaction cost are specified above in a simple way, these costs are "the opportunity cost of the world not being as nice as a place it otherwise might be"(Goldberg 1985, p. 399). From establishing either a tax, quota, or licensing on the fishing activity, society incurs the opportunity cost (value) of a voluntary cooperation among fishermen.

Ⅳ. Fisherman under Rational Behavior

At this moment let us pause to draw tentative conclusion with regard to the fisheries mangement. Each existing scheme, tax, quota, licensing system involves transaction costs in the form of costs associated with information, and policing the schemes. Every scheme either existing ones or one to be proposed accompanies transaction costs. However, the net benefit resulting from instituting each system shuld be compared with each other. The relative advantage over other systems in economic sense can be decided upon comparing these transaction costs.

The question is "Do we have to take a burden or transaction cost to get a rent which is believed to be relatively small?" The answer to this question dates back to Gordon's finding (Gordon 1954) that fishery resources are of common property nature. Why should fishery resources remain communally owned by citizens within society? It is not because the commercial extraction of these resources is unprofitable, resulting from prohibitive costs over benefits, but because government has, for a long time, exercised and is still claiming its right over the resources.

In response to Gordon's work, Scott firstly proposed a sole-ownership to manage fishery resources(Scott 1955). Fishing industry is different from the others in an economy in that the fising activiyties are not easily controlled and observed because the production is carried on at sea. Moreover, fishery is considered a highly risky business to a sole-owner. No sole-owner is willing to hold a title on the resources. What if the property right on these resources are entitled to those to those fishermen who have vested interest? Most citizens, other than fishermen, are not concerned with the fishing occupation and, thereby with fishery resources. Moreover, why at the same time should taxpayers who are the citizens in an economy, take the burden of cost involved in the enhancement of the fishery management? The person who is in charge of a property should pay policing costs to enjoy the possession of the property.

Most economists have worried about fishermen's behavior guided by individual rationality. Under these circumstances, competition among fishermen is believed to lead to inefficient use of the resoures endowed, which is a so-called externality problem (Dasgupta and Heal 1979, Ch. 3). The problem of externality can be remedied only if fishermen concerned voluntaily renter into an agreement that the resources should be managed by prudent activities. However, the traditional framework of economic analysis based the motive of human behavior of the narrowly-defined rationality (Hardin 1982, p. 10). The Nash-Bertrant's is based on the finding that each member in a fishery is expected to have an incentive to break the agreement once a formal structure of cooperation has been built in-so called a prisoner's dilemma.

Table 3 shows an example of payoff matrix of fisherme's game. A binding fishermen attains long-run sustained rent of $4, when other members keep a treaty. He is motivated to get short-run sustained rent of $4 from breaking the treaty. In this example the long-run rent from committing to agreement is less than the short-run rent from breaking the agreement. The same argument holds true to other fishermen. Since the individual fisherman is rational, the action of other resource user is believed to be irrelevant to his choice. While every pay-off except in the right bottom corner is Pareto efficient choice, the Nash equilibrium is achieved at the point of no conservation, and the core is at the point of conservation which is one of two idividually rational solutions i. e., $4 and $4.

Table 3. Fishermen's dilemma

a fisherman \ other fishermen	conserve	not conserve
Conserve	(4, 4)	(0, 10)
not conserve	(10, 0)	(1, 1)

As the experiences in real world show, the nations that catch transboundary resources always enter into an agreement to conserve the resources. Moreover, the advantages of joint cooperation to share transboundary stockween neighbors are so evident that in the log term, neighboring countries are expected to be bound to reach an agreement (Copes 1981, pp. 221).

In addition, many of the prisoner's games are dynamic or interative super games(Luce and Raiffa 1957, p. 97, Thompson and Faith 1981. p. 372, Hardin 1982 p. 165) in a sense that each fisherman engages in the repeated fishing activities rather than one time play of harvesting. In other words, their actions recur or are ongoing, so that there is not a single choice, but rather a sequence of choices to be made. Hence each fisherman's furture choices may be contingent, inded may be made contingent on other's current choices(Hardin 1982, p. 13)

Unlike the traditional assumption of player's reaction which is assumed given, Thompson and Faith assume that the reactions or institution an indivdual player faces are derived(not given). Therefore, 1) each fisherman is assumed to know with certainty the reaction function chosen prior to his strategy; 2) each fisherman, before taking a reaction, is assumed to communicate his strategy with others. Based on these two assumption, Thompson and Faith constructed a reaction function among players in sequence since a sequence is one subset of reactions which hold true in general. They concluded that choices formed undertwo assumptions always imply Pareto optimal choice (or core) (Thompson and Faith 1981, pp. 368-72).

Their conclusion can be concrasted with the traditional prisoner's dilemma where individual rational behavior leads to the Pareto non-optimal choice of (not conserve, not conserve) payoff from Tab. 3. Because under the assumptions of communication and perfect information on reaction functions, other fishermen in Tab. 3 while moving to a strategy and communicate it to the first mover, The second mover, other fishermen, rationally commit themselves to a strategy set of (4, 4) and (1, 1) in view of 'a fisherman's rational responses to As a result 'a fisherman', the first mover, always chooses a strategy of (4, 4) rather than the other choice of (1, 1). In this respect, the strategies of rather than a set of narrowly defined rational reaction function in such a way that the first player commits himself to the choice of (conserve) strategy.

A behavior is not rational if one, after considering all of his concerns, chooses to be placed in the poorer position. Furubotn and Pejovich succienty expressed prevalence of cooperation among participants saying that:

> "We feel that in most cases an unarticylated collusion between the players will develop, much in the same way as a mature economic market often exhibits a marked degree of collusion without any communic ation among the participants. This arises from the knowledge that the situation will be repeated and that reprisals are possible." (Furubotn and Pejovich 1972, p. 101).

Unlike the static prisoner's dilemma, the dynamic cooperative solutions offer no incentive to defect as explained in the above. This suggests that institutional rules of cooperation are self-reinforcing for every member to arrive at "core" solution which is impossible otherwise. In other words while static, one-time optimization would lead to dilemma, dynamic optimazation where the present choice takes account of future constraints, leads to an efficient solution in society's view point.(Hardin 1981, p. 3)

But the dynamic game is not without limitations. When the game is of fixed-duration, there can be no coor dination equilibrium. As long as rent from the resource is sustainably accrued to members, many person prisoner's dilemma as with 2-person prisoner's dilemma have coordination (core, equilibrium (Hardin 1982, p. 169). This implies that as long as fishery resource is owned by cooperative, each member commits himself to the efficient allocation of resource.

Ⅴ. Role of Cooperative Management

The traditional belief which I disbelive is that the nature of fishing activities is competitive and individualized, so cooperation among fishermen is not unlikely to arise. Pearse (1980 p. 58) emphasized the important role of cooperatives in Spain, France and Italy. Participatng members within cooperatives in Italy were observed volunytarily to cut effort. In France, the cooperative organization plays a legislative, executive and even judical function. The British angler from fishermen's cooperative played a role ofwatchdog(Dales 1968, p. 68). Ginter and Retting proposed a scheme which regulates the efforts of fishermen by themselves, saying that(Ginter and Retting 1978, p. 158) :

> Indeed, limited entry need not be instituted by some governmental unit to be effective. Among themselves fishermen can discourage participation in their fishery by outsiders or new guy, "his boat or his gear. Fishermen also organize to limit market access, from cliques, and use secret ratio codes"

The most recent paper which favors cooperative organization is Jentoft's (1985). Bnt his proposal is analysed in the centext of anthropological and social studies. Many socilogist and authropologists (McGoodwin 1980, Acheson 1975, Obach 1980. Pollnac 1980, Poggie 19 80, Hayward 1984) have played an important role in bringing cooperative organizations into the management of fishery resources. But extensive analysis by an economist of how it could work and be instituted, as far as I know, has never been put forth. This paper serves theoretically to develop a cooperative mechanism wich cooperation among members is voluntarily achieved.

Were individualized exclusion is not feasible due to transaction costs under open-access, why not provide for exclusion at cooperative level (Randall 1983, p. 145)? Instead, governments for long time have enacted law after that increases the divisions among fishermen, increases the overcapacity of the vessels, leads to promote resource depletion, and prevents fishermen from acting in their own collective interest. (Marchak 1984, p. 169)

In the U.S. cooperative organization is rare and scarcely recives popular acceptance strong "independent rationality. But the Cooperative Association in Baysea has played valuable role to improve the financial position of members, and to conserve stock as a by-production (Poggie 1980, pp. 21-22, Obach 1980, p. 48, McCay 1980, p. 36.) Some cooperatives have introduced an individual catch quota system to improve total earning to entire members. The only trouble in the cooperative is associated with government interference; it continuously asks to open the doors to outsiders (McCay 1980, p. 34-35) Government is always concerned with equitable distribution of rent among every citizen rather than among the members. Furthermore, government surprisingly has followed a policy of support for the large processor, while providing programs which keep the small boat sector alive but not viable, and dependent on large transfer payment in Canada (Davis and Kasdan 1984, p. 119)

My tentative proposition is that fishery resource should be endowed to a cooperative organization. On distriburitonal grounds, some might raise the question why should solely fishermen appropriate the rent from a fishery resource? Efficient allocation seems to demand that exchange costs be reduced by initially assigning the new right were it is finally expected to reside (Demsetz 1966, p. 66). Could it be justified in economic efficiency to give a property right to farmers instead of fishermen? An additional question still arises; how could the cooperative work? We have a useful theory of clubs (Buchanan, 1965) in the economic realm. Furthermore the experiences in the court tell us that decisions usually specify that the first user of the resource has ownership claim on the resource (Furuboth and Pejovich 1972, p. 1146). Minimum intervention from government should be respected unless the cause from the interference originates from economic grounds since we by now have collective goods or rent to be realized under the behavior of super-rationality.

The only role of government is to decleare that the rules of games among citizens must be changed whenever it is inherent in the games that fishermen of outsiders in pursuing their own ends, will be forced into a socially undesirable position. In my view point, it is not likely that government dclares so frequently that the rules of game fall into the nature fixed duration. The notion of cooperation among members can be extended to that of cooperation between members and outsider's even cooperation among those who have different gears and different species.

Now let us apply the "clup theory" to behavior of cooperatives. A clup is defined as "a voluntary group deriving mutual benefit sharing one or more of the following: production costs, the member characteristics, or a good characterized by excludable benefits."(Sandler and Tschirhart 1980, p. 1482) Therefore the members in fishing cooperative share the common interest of harvesting fishery. as well as protecting, preserving, or gathering information on resources they claim title to.

Even through 'theory of club was introduced to explain the size of members who share a common public good, it can be applied to the determination of size and level of harvest which they claim title to. Because the cooperative by itself, must make an effort to protect its resources since government already took its hands off the resource. Net rent per member is maximized when the net benefit (or rent) from additional entrance is equal to the additional cost resulting from that person's entire utilization of the rent shared.

In Fig. 6 the value of harvest is measured on the abscissa while total cost per member and total benefit per member are drawn on the ordinate, Benefit curve (B(X)) in the second quadrant shows average revenue per member when a certain fixed amount of harvest is desired. Likewise C(X) represents total cost per member for the given level of yield. As the size of member becomes large, congestion effect among member cause the total cost per member to rise in increasing rate. For example to produce X3 unit of fish, average revenue for each member falls while average cost also fall with less propertionately. Than the optimal size of member for all possible level of harvest is drawn as BC (X) in quadrant 4 resulted from marginal condition.

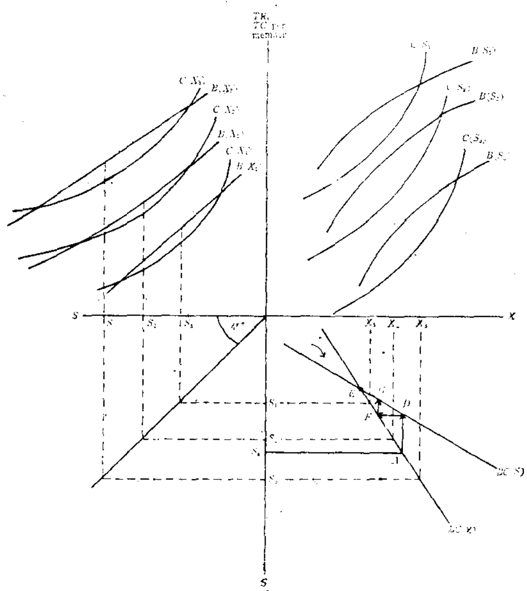

Fig. 6. Optimal size of member within cooperative

Likewise, total net benefit per member, B(X) for given size of member has an increasing fuction harvest level. Total cost per member to catch the given amount of fish rises in inceasing rate with respect to size of member because the stock effect has a backward-bending supply curve as shown Fig. 3. The optimal combination between size of member and level of harvest is drawn as BC(S) in the fourth quadrant. Finally optimal size of member and the optimal level of yield is obtained at point E where BC (X) intersects BC(S). When size of member for example is 4, a series shown by S4ADFG lead to the final point E. Equilibrium point E. does not guarantee either maximum sustainable or economic yield since we take information or enforcement cost into account.

Ⅵ. Conclusion

A number of economists within the past three decades have attempted to develop various schemes of regulation with view to maximizing rent from a fishery. However, very lettle has been studied on the role of voluntary cooperation among fishermen in the fishing industry.

Recent studies from outside the economic field emphasise the role of cooperatives in fishing communities. Sociologists criticize the fudamental assumption of individual behavior on which traditional economics are structured in frame. In Response to this criticism, economists have made a great effort to refine the "rationality" assumption to be more meaningful and plausible.

Even though fishery economists have a plentiful menu of tools for the resource to be managed in an efficient way, these tools are not without defect. Either quota or tax schemes call for precise and continuous analysis of the potential value of fishery resources followed by data collection, econometric work, surveillance, and administration. In an economic sense, restriction of one or two dimensions of inputs into harvesting activity leads to more intensive use of others. As a consequence, license programs have led the holders into a competitive race to build more complex types of inputs(gear, vessel, power, facilities) at the expense of efficiency.

Canada's experience shows that management problems emerge as soon as their innovative and costly attempts have been tried. There is always enough room for a fishermen to devise a devastatiny or counteractive contrivance which has not been expected by manager in charge of the resource. Limiting the number of licenses alone results in little influence on fishing effort.

Enforcement costs such as the information cost on biologic condition and policing cost sufficient to achieve the desired level are almost prohibitive. Under these circumstances, one alternative scheme I suggest, is based on cooperation among fishermen. Cooperation among fishermen who have vested interests in the exploitation of resource takes place since each fisherman plays an iterative and dynamic game of prisoner's dilemma. The only role of government is to announc ein advance that fishery resources belong to the cooperative organization where existing firms or fishermen work, so as for the game not to be of fixed-duration.

Since fishery resource is no longer public property owned by government, general citizens naturally do not need to take the burden of tax which is spent on enforcing partially successful regulation. Fishery resources are protected because fishermen are protecting while they are harvesting.

Information on the resources is easily obtained while a certain level of optimal number of fishermen bring forth the highest return to the average fishermen in a fishery. As a smaller number of fishermen are not sufficient to protect their rescurces and while a larger number of fishermen do not contribute to decrease policing costs, cooperation among scme would be maintained.

This paper serves to consider a potential role of cooperative organization which has a limited ability in Korea. Even though cooperative scheme has been neglected in the management of fisery resources, it is expected to recieve a considerable attention in the near future.

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