THE MANAGEMENT OF THE TUNA SPECIES: THE CASE OF THE EASTERN TROPICAL PACIFIC*

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INTRODUCTION

Resources, whether they are renewable resources or non-renewable resources, should be properly managed over time. The biological resources which have a long history filled with the danger of extinction, especially need to be managed. Without proper management efforts, most of the valuable species would have already vanished or become commercially unexploitable. But, once the resources are managed properly at their early stages of extinction, they can recover by themselves.

Although claim disputes over fishery resources have a long history, the history of the conservation of the resources came into existence after the second world war. Recently, the disputes over fishery resources have paralleled the establishment of the national jurisdiction over ocean resources, beginning with the resources on the continental shelf, and concluding with the extension of the exclusive economic zones.

Even if the fishery resources are managed under the control of the resource adjacency countries, species on the high-sea are under no one's control. The management of the whale has been

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the conflict among whaling countries who have an interest in the scarce resources. Another difficulty of management comes from the existence of the internationally migratory species. They migrate freely from one territory to another, especially the tuna species in the Pacific Ocean, which migrate over this large territory.

The tuna species are very valuable resources for both developed and developing countries. For example, most of the tuna caught by South American countries are exported to the United States. Also, Japan is known as both an exporting and a consuming country of tuna products.

Large amounts of economic resources have been input into tuna catching and other related sectors of the economy in the world. Due to this increase of fishing efforts, some species have shown the signs of resource depletion. Proper management of the tuna species has become a very important topic of fishery resource economics.

Notwithstanding the important aspects of the tuna species management, only the Inter-American Tropical Tuna Commission has effectively worked as a management body. Judging from these circumstances, it is clear that extensive research should be done to determine the appropriateness of the present and future management schemes from the fishery economic point of view.

The purpose of this research paper is to analyze the management problem of the tuna species, especially in the eastern tropical Pacific area.

In Chapter 1, I will examine the necessity of the tuna species management based upon the recent statistical data. In Chapter 2, the fundamental economic model of the internationally exploited species will be developed and the effectiveness of a couple of management measures will be examined under the open-access situation.

In Chapter 3, the management objectives of the Inter-American Tropical Tuna Commission (IATTC) will be reviewed and examined based upon the Annual Report issued by the Commission.

In Chapter 4, I will summarize the nature of the property rights from the efficiency point of view. Six alternative approaches proposed by IATTC are reviewed and examined based upon the efficiency criteria of the property rights.

In the final section, I will summarize the results of my analysis.

CHAPTER 1

THE NEED FOR AN INTER-REGIONAL AND INTERNATIONAL MANAGEMENT SYSTEM FOR THE TUNA SPECIES

In this chapter, I will analyze briefly the recent situation of the world tuna industry using the statistical data shown below. Based upon this data, I conclude the necessity of appropriate inter-regional and international management of the tuna species, assuming overexploitation of the tuna species and overcapitalization of tuna catching vessels exist.

According to Joseph & Greenough (1979), tuna and tuna-like species are often grouped into three categories (Table 1).[1] The first category includes six major tuna species, making up about 75 percent of the world catch of tuna and tuna-like fishes. These are referred to as the principal market species: yellowfin, bigeye, albacore, northern bluefin, southern bluefin, and skipjack.

The second category, composing about 22 percent of the world catch, consists of species commonly referred to as secondary market species. These are generally the smaller and less heavily exploited species. Included, among others, are the bonito, black skipjack, and frigate mackerel.

The third category, the billfish, accounts for about three

TABLE 1

THE TUNA AND TUNA-LIKE FISH BY SPECIES

	1974 Catches	
	Weight (thousands of metric tons)	% Total
Principal Market Species		
Skipjack	755	34.0
Yellowfin	428	19.3
Albacore	234	10.6
Bigeye	162	7.3
Southern Bluefin	44	2.0
Northern Bluefin	33	1.5
Secondary Market Species		
Various Tuna-like	151	6.8
Spanish Mackerel	130	5.9
Bullet Tuna	115	5.2
Black Skipjack	51	2.3
Bonito	41	1.9
Bill Fish		
Istiophorids	49	2.2
Swordfish	23	1.0
TOTAL	2,216	100.0

SOURCE: Joseph & Greenough (1979), p. 6.

percent of the world catch of tuna and tuna-like species.

The tuna species is characterized by extensive migrations. Therefore, the catching vessels are also highly mobile, which in turn makes the management of the tuna species difficult without inter-regional and international cooperation.

Table 2 and Table 3 show the world catches of principal market species of tuna and the amount of catches by nations, respectively. As seen from Table 2, skipjack, yellowfin, and albacore are the three largest species which are widely exploited. We can also see from Table 3 that Japan has the largest catches. However, the size of the catches has been declining recently.

This deteriorating position of Japan is mainly explained by two factors. One, the increase in the tonnage of vessels in Korea and Taiwan.[2] Secondly, the increase in the catching capacity of the

TABLE 2

WORLD CATCH OF PRINCIPAL MARKET SPECIES OF TUNA
(thousands of metric tons)

SPECIES	YEAR			
	1973	1974	1975	1976
Bullet	57.9	50.2	37.1	46.3
	(3.8)	(3.1)	(2.5)	(2.7)
Skipjack	530.3	636.5	510.9	643.0
	(35.5)	(39.1)	(34.5)	(37.6)
Northern Bluefin	31.2	35.4	38.5	37.2
	(2.1)	(2.2)	(2.6)	(2.1)
Albacore	246.5	240.2	197.9	237.0
	(16.5)	(14.7)	(13.4)	(13.8)
Southern Bluefin	48.4	46.1	33.9	33.2
	(3.2)	(2.8)	(2.2)	(1.9)
Yellowfin	429.0	458.1	474.1	527.0
	(28.7)	(28.1)	(32.0)	(30.1)
Bigeye	148.4	162.0	188.9	185.7
	(10.2)	(10.0)	(12.8)	(11.8)
TOTAL	1,491.7	1,628.5	1,481.3	1,709.4

SOURCE: *FAO Yearbook of Fishery Statistics* (Vol. 42).

TABLE 3

CATCH OF PRINCIPAL MARKET SPECIES OF TUNA BY NATIONS
(thousands of metric tons)

Country	Principal Market Species Catch		
	1965	1970	1974
Japan	553.1	481.6	649.0
	(59.7)	(44.6)	(39.2)
United States	168.0	222.1	258.0
	(18.1)	(20.6)	(15.5)
Taiwan	25.3	103.4	91.0
	(2.7)	(9.6)	(5.5)
Republic of Korea	8.0	58.3	104.0
	(1.4)	(5.4)	(6.3)
Spain	38.4	41.1	93.0
	(4.1)	(3.8)	(5.6)
Others	132.8	171.7	461.0
	(14.0)	(16.0)	(27.9)
TOTAL	925.6	1,078.2	1,656.0

SOURCE: Saila & Norton (1974) and Joseph & Greenough (1979).

resource adjacent countries, such as Mexico, Costa Rica, and Ecuador, etc.[3]

Increases in the catches of tuna species have been based upon the increase in the demand for tuna products, in either raw or canned form. As seen from Table 4, the United States and Japan are the major consuming countries. Even though the tuna are caught by developing countries, most of them are exported to the developed countries, i.e., high income countries.

Lee (1974) estimated the demand function for tuna at wholesale level as to Japan. His estimation equation is as follows:[4]

TABLE 4

WORLD CONSUMPTION OF TUNA, BY COUNTRIES

(round weight, thousand metric tons)

Country	1960	1965	1969
United States	339.1	398.1	461.6
Japan	258.2	290.2	330.1
Western Europe	112.7	179.8	193.4
France	(31.8)	(41.6)	(50.5)
Spain	(23.9)	(41.1)	(29.4)
Italy	(40.1)	(53.3)	(62.6)
West Germany	(13.3)	(27.6)	(30.7)
Others	(3.6)	(16.2)	(20.2)
Subtotal	710.0	868.1	985.1
Others	53.0	55.9	95.9
TOTAL	763.0	924.0	1,081.0

SOURCE: Saila & Norton (1974), p. 28.

$$P = 138.73 + .00399NI - .278Q \quad (1)$$
$$(5.95) \quad (13.21) \quad (3.48)$$
$$R^2 = .900$$

where P is the average wholesale price, NI is the real national income of Japan, and Q is the average catch by Japanese boats.

Equation (1) shows that the national income is a very important factor in determining the demand for tuna. Saila & Norton (1974), also estimated the time trend in the catch of tuna and tuna-like species as shown below based upon 1952–70 data:[5]

$$C = 609.4 + 58.8T \quad (2)$$
$$R^2 = .977$$

where C is total catch in thousands of metric tons and T is time with 1952=1.

This equation shows that over the period the catch of tuna and tuna-like species went up about 58.8 thousand metric tons each year.

As seen from equation (1), the increase in the national income has a positive effect on the demand for tuna, which increases the production of tuna as far as there exists enough tuna resources. Because of the backward bending properties of the supply curve of the fishery production, the annual production will not increase if the resources are overexploited, even if the fishing efforts are high.[6]

Once the tuna resources are depleted, we will have significant economic loss for a long period in order to recover the resources to the catchable level. Therefore, the conservation of the tuna resources is required.

According to Fullenbaum (1970) and Gulland (1970), the estimated world maximum average sustainable yields, including bonitos and little tuna, are 2,570,000 metric tons and 2,060,000–2,750,000 metric tons, respectively.

If the production trend shown by equation (2) continues, we can assume that the midpoint (2,405,000 metric tons) of Gullan's range of estimated maximum average sustainable yields for tuna and tuna-like species will be reached in the early 1980s.[7]

According to Saila & Norton (1974), they point out the following characteristics of benefits to be gained from the exploitation of tuna and problems associated with them:[8]

(1) Income and employment gained in harvesting tuna.

(2) Income and employment gained in processing or transhipping tuna products.

(3) A source of protein as a consumption item.

(4) Foreign exchange gained through the export market.

(5) Possible payments or rent to be gained through licenses or taxes.

(6) A trade-off item through which to obtain benefits in

areas such as concessions relative to international trade of other products; access to marine minerals, military objective, or other fish species.

(7) There will soon be adequate fleet capacity among the nations now actively fishing for tuna to harvest the maximum average sustainable yeild of the major tuna stocks.

(8) Processing segment of the world tuna industry is probably more concerned about obtaining a stable supply of good quality tuna at the lowest possible cost than about which nation or nations own the fishing vessels.

(9) The natural distribution and migratory behavior of the tuna stocks relative to limits of national jurisdiction complicate the decisions relating to the management of the stocks and wealth distribution.

Because of the migratory nature of tuna resource stocks and vessels, the management of tuna should be at least interregional, as well as international.[9] I will discuss the problems of the management of the tuna species in detail in a later chapter.

CHAPTER 2

THE FISHERY MODEL OF INTERNATIONALLY EXPLOITED SPECIES

The purpose of this chapter is to analyze the various policy measures under an open-access situation. First, we will examine the properties of the model of internationally exploited fishery resources. Then, the impact of various policies will be examined.[10]

In the following, we use the notations listed below.

E_i =fishing effort of country i $(i=X, Y)$

F_i =tuna caught by country i $(i=X, Y)$

F =total tuna caught

π_i =net revenue from tuna caught in country i $(i=X, Y)$

TC_i=total costs of fishing in country i $(i=X, Y)$

We assume that two countries (X and Y) are the exclusive users of the tuna stock with the sustainable yield curve as shown in equation (3).[11]

$$F(E_X, E_Y) = a(E_X + E_Y) - b(E_X + E_Y)^2 \tag{3}$$

The amount of each country's catch will be proportionate to the effort, in relation to total effort, thus obtaining the catch function as in (4):

$$\begin{aligned} F_X(E_X, E_Y) &= \frac{E_X}{E_X + E_Y}[a(E_X + E_Y) - b(E_X + E_Y)^2] \\ &= aE_X - bE_X^2 - bE_X E_Y \\ F_Y(E_X, E_Y) &= aE_Y - bE_X E_Y - bE_Y^2 \end{aligned} \tag{4}$$

The net revenue function is expressed as the difference between revenue and total costs.

We assume, for simplicity, that the cost of catching tuna consists of two factors, i.e., private costs which are proportionate to the own fishing effort, and the external costs arising from foreign entry as suggested by C. Lee (1974).

The total costs are shown as in equation (5):

$$\begin{aligned} TC_X &= (c_x + \beta_x E_Y) E_X \\ TC_Y &= (c_y + \beta_y E_X) E_Y \end{aligned} \tag{5}$$

where c_x and c_y are the marginal costs associated with the direct fishing efforts belonging to each country. The terms, $\beta_x E_Y$ and $\beta_y E_X$ show the external diseconomies, such as congestion costs, due to the foreign country's entry into fishing grounds.

Combining equations (4) and (5), we have the following net revenue functions:

$$\begin{aligned} \pi_X &= aE_X - bE_X^2 - bE_X E_Y - (c_x + \beta_x E_Y) E_X \\ \pi_Y &= aE_Y - bE_X E_Y - bE_Y^2 - (c_y + \beta_y E_X) E_Y \end{aligned} \tag{6}$$

In the following, we only treat the case of the open-access situations, i.e. $\pi_X = \pi_Y = 0$.

Setting $\pi_X = \pi_Y = 0$ in equation (6), we have equation (7) which determines the E_X and E_Y simultaneously.[12]

$$\begin{aligned} bE_X + (b+\beta_x)E_Y &= a - c_x \\ (b+\beta_y)E_X + bE_Y &= a - c_y \end{aligned} \tag{7}$$

Rewriting equation (7) by matrix form, we have equation (8).

$$\begin{bmatrix} b & b+\beta_x \\ b+\beta_y & b \end{bmatrix} \begin{bmatrix} E_X \\ E_Y \end{bmatrix} = \begin{bmatrix} a-c_x \\ a-c_y \end{bmatrix} \tag{8}$$

Suppose the congestion coefficients β_x and β_y are equal, then we can see the relationship between E_X and E_Y as shown in Figure 1. If the marginal cost of country X, i.e., c_x is greater than that of country Y, i.e., c_y, E_X and E_Y can be written as shown below:

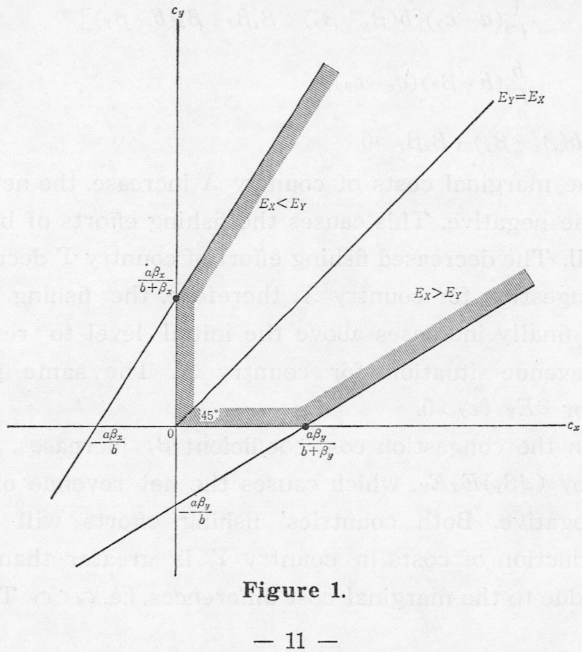


Figure 1.

$$E_X = \frac{b(\delta) + \beta(a - c_y)}{2\beta(b+\beta)} \tag{9}$$

$$E_Y = -\frac{b(\delta) - \beta(a - c_y - \delta)}{2\beta(b+\beta)} = \frac{-b(\delta) + \beta(a - c_y) - \beta\delta}{2\beta(b+\beta)}$$

where $\delta = c_x - c_y > 0$, $\beta = \beta_x = \beta_y$.

When the marginal cost of country X is greater than that of country Y, the fishing effort of country X should be increased to restore a zero net profit situation in comparison to the $c_x = c_y$ ($E_X = E_Y$) case.[13]

As to the properties of equation (9), we have the following:

$$\frac{\partial E_X}{\partial c_x} = \frac{b}{\Gamma} > 0$$

$$\frac{\partial E_Y}{\partial c_y} = \frac{b}{\Gamma} > 0$$

$$\frac{\partial E_X}{\partial \beta_x} = \frac{1}{\Gamma^2}[-(a - c_y)\Gamma + (b + \beta_y)\{b(c_x - c_y) - \beta_x(a - c_y)\}] \tag{10}$$

$$= -\frac{1}{\Gamma^2}(a - c_y)[b(\beta_x + \beta_y) + \beta_x\beta_y + \beta_x(b + \beta_y)]$$

$$+ \frac{b}{\Gamma^2}(b + \beta_y)(c_x - c_y),$$

where $\Gamma = b(\beta_x + \beta_y) + \beta_x\beta_y > 0$.

If the marginal costs of country X increase, the net revenue will become negative. This causes the fishing efforts of both countries to fall. The decreased fishing effort of country Y decreases the cost of congestion for country X, therefore, the fishing effort of country X finally increases above the initial level to restore the zero net revenue situation for country X. The same procedure happens for $\partial E_Y/\partial c_y > 0$.

When the congestion cost coefficient β_x increases, the cost increases by $(\Delta\beta_x)E_XE_Y$, which causes the net revenue of country X to be negative. Both countries' fishing efforts will decrease, but the reduction of costs in country Y is greater than that of country X due to the marginal cost differences, i.e. $c_x < c_y$. Therefore, the reduction of country Y's fishing effort is less than that of country X's required to restore the zero net revenue. So, the congestion costs for country X are not large enough to offset the reduction of country X's fishing efforts. Finally, the level of fishing effort which will restore the zero net revenue situation will be attained below the level of initial fishing efforts for country X.

(1) The effect of the imposition of a landings tax.

In the following, we will discuss the effects of a change in the price level, as well as the imposition of a landings tax.

Let P_X and P_Y denote the price of tuna in the markets of country X and Y, respectively. And let t_x and t_y be the landings tax which are imposed upon the tuna. The landings tax, given price levels, reduce the net revenue of each country by the ratio $(1-t_i)$, $i=X, Y$.

Equation (6) is modified by introducing the price and landing tax as shown in equation (11).

$$\begin{aligned}\pi_X &= P_X(1-t_x)[aE_X - bE_X^2 - bE_XE_Y] - (c_x+\beta_x E_Y)E_X \\ \pi_Y &= P_Y(1-t_y)[aE_Y - bE_Y^2 - bE_XE_Y] - (c_y+\beta_y E_X)E_Y.\end{aligned} \tag{11}$$

Setting both π_X and π_Y equal to zero, and assuming E_X and E_Y are positive, we have the systems of equations as shown in (12′):

$$\begin{aligned} bE_X + \left(b+\frac{\beta_x}{P_X(1-t_x)}\right)E_Y &= a - \frac{c_x}{(1-t_x)P_X} \\ \left(b+\frac{\beta_y}{P_Y(1-t_y)}\right)E_X + bE_Y &= a - \frac{c_y}{(1-t_y)P_Y}. \end{aligned} \tag{12′}$$

By using matrix form, we can write (12′) as (12).

$$\begin{pmatrix} b & b+\dfrac{\beta_x}{(1-t_x)P_X} \\ b+\dfrac{\beta_y}{(1-t_y)P_Y} & b \end{pmatrix} \begin{pmatrix} E_X \\ E_Y \end{pmatrix} = \begin{pmatrix} a-\dfrac{c_x}{(1-t_x)P_X} \\ a-\dfrac{c_y}{(1-t_y)P_Y} \end{pmatrix} \tag{12}$$

Rewriting equation (12), we have equation (13):

$$\begin{bmatrix} b & b+\Gamma_x \\ b+\Gamma_y & b \end{bmatrix} \begin{bmatrix} E_X \\ E_Y \end{bmatrix} = \begin{bmatrix} a-\Gamma_x\cdot\theta_x \\ a-\Gamma_y\cdot\theta_y \end{bmatrix} \tag{13}$$

where $\theta_x = c_x/\beta_x$, $\theta_y = c_y/\beta_y$, $\Gamma_x = \dfrac{\beta_x}{(1-t_x)P_X}$, and $\Gamma_y = \dfrac{\beta_y}{(1-t_y)P_Y}$.

Solving equation (13) for E_X and E_Y, we have

$$E_X = \frac{1}{\Delta}[b(a-\Gamma_x\cdot\theta_x) - (b+\Gamma_x)(a-\Gamma_y\cdot\theta_y)]$$

$$= \frac{1}{\Delta}[-(a+b\theta_x)\Gamma_x + \theta_y(b+\Gamma_x)\Gamma_y] \tag{14}$$

$$E_Y = \frac{1}{\Delta}[-(a+b\theta_y)\Gamma_y + \theta_x(b+\Gamma_y)\Gamma_x]$$

where $\Delta = -b(\Gamma_x+\Gamma_y) - \Gamma_x\Gamma_y$.

Differentiating E_X and E_Y with respect to P_X,

$$\frac{\partial E_X}{\partial P_X} = \frac{1}{\Delta^2}\Big[\{-(a+b\theta_x)+\theta_y\Gamma_y\}\frac{\partial \Gamma_x}{\partial P_X}$$

$$\cdot\Delta - \{-(a+b\theta_x)\Gamma_x + \theta_y(b+\Gamma_x)P_Y\}\frac{\partial\Delta}{\partial P_X}\Big]$$

$$= \frac{1}{\Delta^2}[b(a+b\theta_x+b\theta_y)\Gamma_y]\frac{\partial\Gamma_x}{\partial P_X} < 0, \tag{15}$$

where $\partial\Gamma_x/\partial P_X = -\dfrac{\beta_x}{(1-t_x)P_X^2} < 0$.

$$\frac{\partial E_Y}{\partial P_X} = \frac{1}{\Delta^2}[\{\theta_x(b+\Gamma_y)\}\{-b(\Gamma_x+\Gamma_y)+\Gamma_x\Gamma_y\}$$

$$-\{-\Gamma_y(a+b\theta_y)+\theta_x(b+\Gamma_y)\Gamma_x\}\{-b-\Gamma_y\}]\cdot\frac{\partial\Gamma_x}{\partial P_X}$$

$$= -\frac{\Gamma_y}{\Delta^2}(b+\Gamma_y)[b\theta_x + (a+b\theta_y)]\frac{\partial\Gamma_x}{\partial P_X} > 0.$$

From equation (15), we have the impact due to the price rise in country X holding the price of country Y constant. The increase in the price of country X makes the net revenue of country X positive. Due to the behavior of country X and country Y, fishing efforts of both countries will increase. Increased effort in country Y raises country X's congestion costs and the net revenue of country X becomes negative, which in turn will deteriorate the fishing effort of country X. The final situation results in the fishing efforts of country X falling below their initial level, while those of country Y are above their initial level.

In order to examine the effects of the imposition of a landings tax,[14] we have to calculate $\partial E_X/\partial t_x$ and $\partial E_Y/\partial t_x$. In equation (15), putting $\partial \Gamma_x/\partial t_x$ and $\partial \Delta/\partial t_x$ instead of $\partial \Gamma_x/\partial P_X$ and $\partial \Delta/\partial P_X$, and noticing the sign of the respective derivatives:

$$\frac{\partial \Gamma_x}{\partial t_x}=-\frac{-\beta_x}{(1-t_x)^2 P_X}>0$$

$$\frac{\partial \Delta}{\partial t_x}=-b\left(\frac{\partial \Gamma_x}{\partial t_x}+\frac{\partial \Gamma_y}{\partial t_x}\right)-\Gamma_x\frac{\partial \Gamma_y}{\partial t_x}-\Gamma_y\frac{\partial \Gamma_x}{\partial t_x}.$$

Therefore, we have the opposite sign for the effects of the imposition of a landings tax.

$$\frac{\partial E_X}{\partial t_x}=\frac{1}{\Delta^2}[b(a+b(\theta_x+\theta_y))\Gamma_y]\cdot\frac{\partial \Gamma_x}{\partial t_x}>0$$
$$\frac{\partial E_Y}{\partial t_x}=-\frac{\Gamma_y}{\Delta^2}(b+\Gamma_y)[a+b(\theta_x+\theta_y)]\cdot\frac{\partial \Gamma_x}{\partial t_x}<0. \qquad (16)$$

Due to the imposition of the landings tax in country X, country X's net revenue will become negative, which will decrease the fishing efforts in both countries. The decreased fishing efforts of country Y will reduce the costs of congestion for country X, which increases the net revenue of country X making it positive. Finally, the fishing efforts of country X increase above the initial equilibrium level, but, at the same time, the fishing efforts of country Y decrease below the initial level.

Next, we examine the effects of introducing a licensings fee. The licensings fee is imposed on the efforts of each country, therefore, increasing total costs. Denote the per unit licensings fee as l_x and l_y, respectively. Net revenue functions will be as shown in (17).

$$\pi_X=P_X(1-t_x)[aE_X-bE_X^2-bE_XE_Y]-(c_x+l_x+\beta_xE_Y)E_X$$
$$\pi_Y=P_Y(1-t_y)[aE_Y-bE_Y^2-bE_XE_Y]-(c_y+l_y+\beta_yE_X)E_Y \qquad (17)$$

The solution to (17) can be obtained by interchanging θ_x and θ_y by θ'_x and θ'_y, in (14), where

$$\theta'_x=(c_x+l_x)/\beta_x \text{ and } \theta'_y=(c_y+l_y)/\beta_y.$$

The effect of increasing the licensings fee can be obtained by examining the signs of $\partial E_X/\partial l_x$ and $\partial E_Y/\partial l_x$.

$$\begin{aligned}\frac{\partial E_X}{\partial l_x}&=\frac{1}{\Delta}\cdot[-b\Gamma_x]\frac{1}{\beta_x}<0\\ \frac{\partial E_Y}{\partial l_x}&=\frac{1}{\Delta}\cdot[b\Gamma_x]\frac{1}{\beta_x}>0.\end{aligned} \tag{18}$$

In this case, the economic implication is as follows: Increases in the licensings fee cause the net revenue of country X to become negative, which decreases the fishing efforts of country X and country Y. Due to the decreased fishing efforts of country X, the congestion costs of country Y will decrease and the net revenue of country Y will increase. Due to this positive net revenue, the fishing efforts of country Y finally rise above the initial level, and the fishing efforts of country X fall below the initial level.

CHAPTER 3

THE EVALUATION OF THE TUNA MANAGEMENT OF THE INTER-AMERICAN TROPICAL TUNA COMMISSION

In this chapter, we will discuss the evaluation of the management of the Inter-American Tropical Tuna Commission (IATTC). First, we shall describe briefly the history and main policy objectives of the Commission, then we will discuss the measurement of fishing efforts and evaluate the present management policy.[15]

The Annual Report of the Commission (1977) describes the history and principal management objective briefly as follows:[16]

The Inter-American Tropical Tuna Commission operates under the authority and direction of a convention originally entered into by the Republic of Coasta Rica and the United States of America. The convention, which came into force in 1950, is open to adherence by the other governments whose nationals fish for tropical tunas in the eastern Pacific Ocean. Under this provision, Panama adhered in 1953, Ecuador in 1961, the United Mexican States in 1964, Canada in 1968, Japan in 1970, and France and Nicaragua in 1973. In 1967, Ecuador gave notice of her intention to withdraw from the Commission, and this became effective in 1968.

The principal duties of the Commission under the convention are (a) to study the biology, ecology, and population dynamics of the tunas and related species of the eastern Pacific Ocean with a view to determining the effects that fishing and natural factors have on their abundance and (b) to recommend appropriate conservation measures so that the stocks of fish can be maintained at levels which will afford *maximum sustainable catches* if and when Commission research shows such measures to be necessary."

For the fulfillment of these management objectives, reliable statistical data has to be gathered in order to pursue the research. They have been collecting the various data, such as the numbers of catches by species and area.

There are two important concepts for the measurement of fishing efforts. The catch per standard day's fishing (CPSDF) is used by the Commission's staff as an index of the relative apparent abundance of yellowfin and skipjack. And the catch per ton of carrying capacity (CPTCC) serves as an index to examine trends in economic efficiency for different sizes of vessels from year to year. The CPTCC is calculated by summing the catches for all ocean fishing areas and all regulation statutes and dividing by the total tons of carrying capacity for each size class.[17]

Another important thing to be mentioned is the standardization of catch rates to remove differences in catch rates among boats and circumstances that are the result of factors other than differences in the abundance of fish. We need to eliminate trends

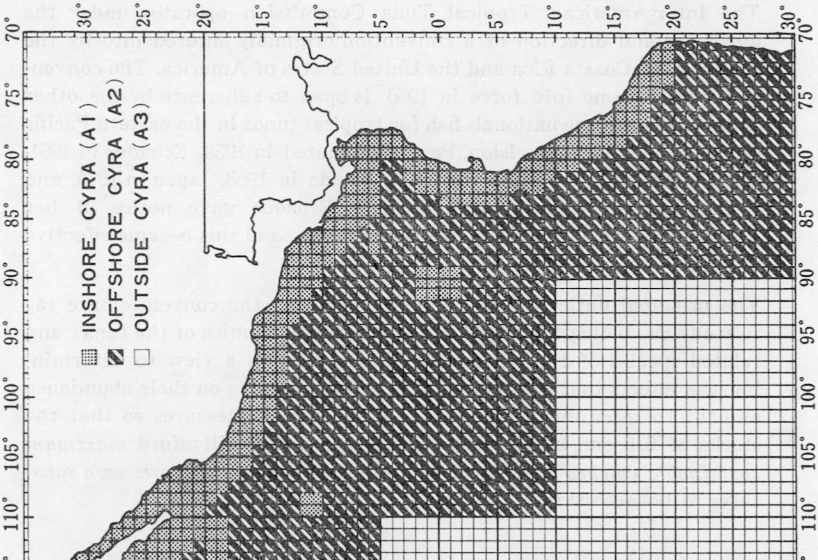


FIGURE 26. The eastern Pacific Ocean, showing the historical area of the fishery for yellowfin, A1, the more recently fished area within the Commission's Yellowfin Regulatory Area (CYRA), A2, and the area outside the CYRA, A3.

in catch rates that may be caused by the evolution of a fishing fleet and also, to eliminate variability in catch rates caused by interactions among the environment, fish, and fisherman.

Based upon these data collection procedures, the Commission proposed the management of the yellowfin species to the Commission Yellowfin Regulatory Area (CYRA).[18] They explained their reasoning as follows:[19]

> The fishery has operated in the area outside the CYRA (Figure 26, Area 23) since 1968 (Table 10). Essentially no fishing takes place during the first half of the year, primarily because the weather there is too bad. By the time the weather improves in May-June, the season is generally closed to unrestricted fishing in the CYRA, and many of the large vessels of the international fleet moves to the area outside the CYRA. *Tagging experiments have indicated that the rate of mixing between this area and the area inside the CYRA is low, so the yellowfin of the area outside the CYRA, to date, have been considered separately from those of the area inside the CYRA.*
>
> In 1969, the CPDF for class-6 purse seiners was greater than 20 tons, but since then, the CPDFs have been remarkably constant, between 10 and 13 tons (Figure 32). In 1969, 1970, and 1971 the effort was less than 2.6 thousand days, and the catches less than 30 thousand tons. During the 1972-1976 period, the effort and catches were nearly constant, the former between 3.5 and 4.1 thousand days and the latter between 41 and 51 thousand tons. In 1977 the effort and catch were lower than in any year of the 1972-1976 period, but the CPDF was about the same as those for 1970-1976. In the lower panel of Figure 32, it is clear that the catch in the area outside the CYRA has remained proportional to the effort. If the logistic form of the general production model expresses adequately the relationship between catch and effort for the area outside the CYRA, as discussed earlier for the area inside the CYRA, *then the fishery outside the CYRA appears to be operating on the underfishing side of the curve. Accordingly, at this time there appears to be no biological reason for placing limits on the catch or the intensity of fishing outside the CYRA.*

Based upon these judgments, the Commission decided to pursue the following policy measures for the conservation of the yellowfin tuna:

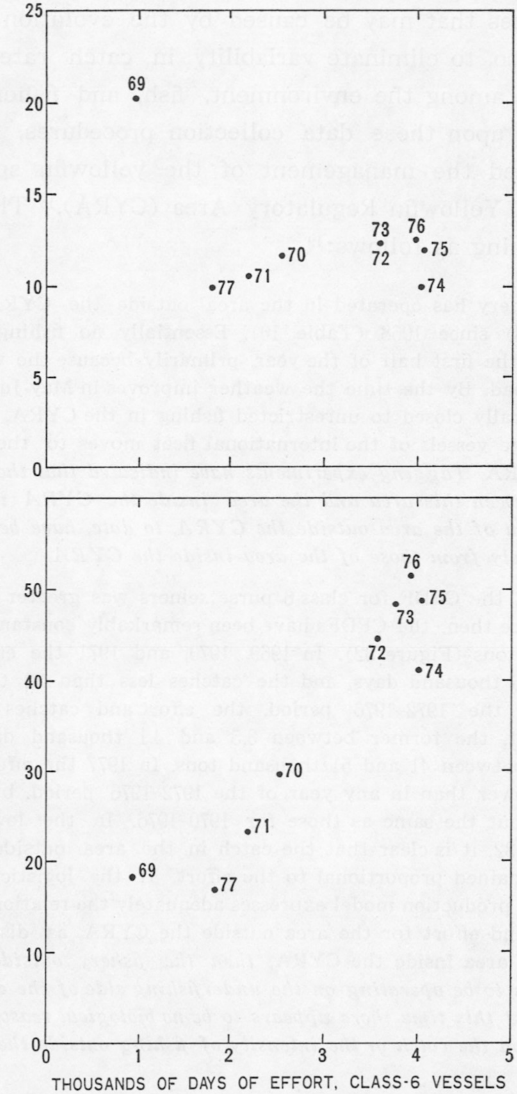


FIGURE 32. Relationship between catch per days fishing (CPDF) and effort (upper panel) and between catch and effort (lower panel) for yellowfin in the area outside the CYRA, 1969-1977.

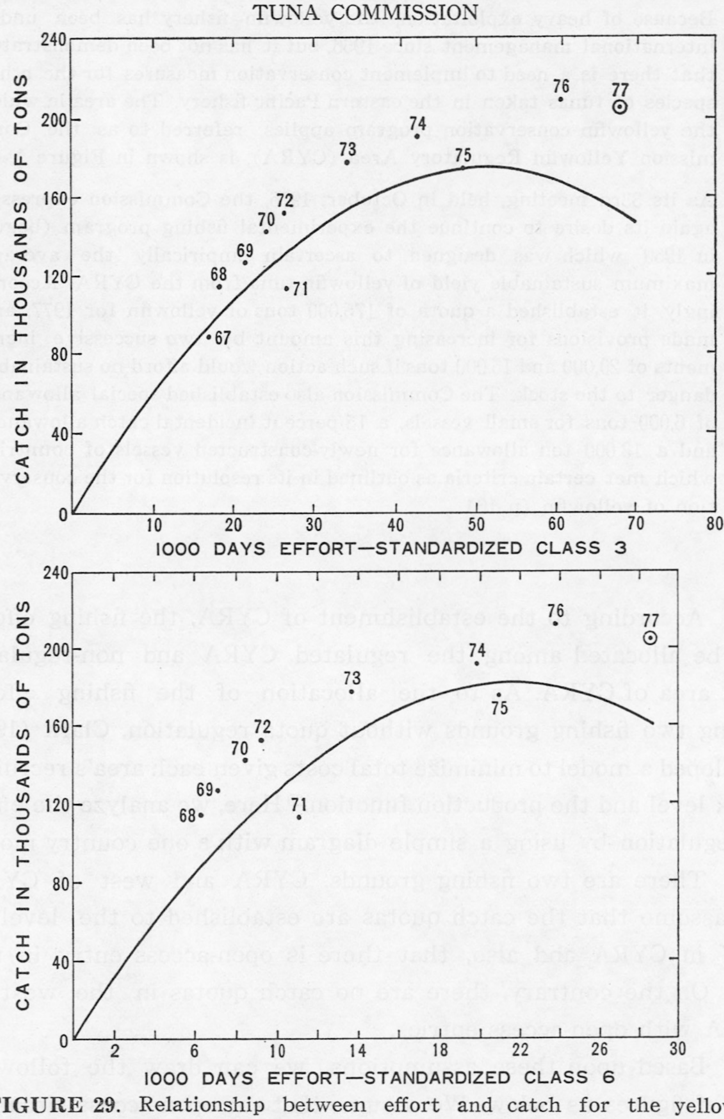


FIGURE 29. Relationship between effort and catch for the yellowfin fishery inside the CYRA, 1967-1977, standardized to Class-3 purse-seine vessels (upper panel) and 1968-1977, standardized to Class-6 purse-seine vessels (lower Panel).

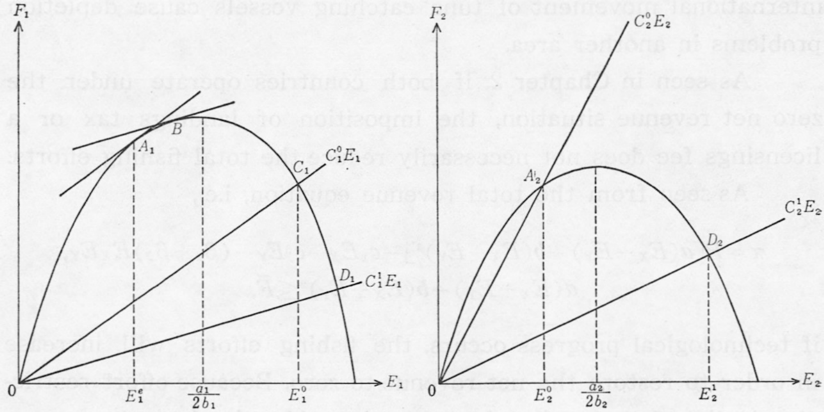
Because of heavy exploitation, the yellowfin fishery has been under international management since 1966, but it has not been demonstrated that there is a need to implement conservation measures for the other species of tunas taken in the eastern Pacific fishery. The area in which the yellowfin conservation program applies, referred to as the Commission Yellowfin Regulatory Area (CYRA), is shown in Figure 1.

As its 33rd meeting, held in October, 1976, the Commission expressed again its desire to continue the experimental fishing program (begun in 1969) which was designed to ascertain empirically the average maximum sustainable yield of yellowfin tuna from the CYRA. Accordingly, it established a quota of 175,000 tons of yellowfin for 1977, and made provisions for increasing this amount by two successive increments of 20,000 and 15,000 tons if such action would afford no sustainable danger to the stock. The Commission also established special allowance of 6,000 tons for small vessels, a 15-percent incidental catch allowance, and a 13,000 ton allowance for newly-constructed vessels of countries which met certain criteria as outlined in its resolution for the conservation of yellowfin (p. 16).

According to the establishment of CYRA, the fishing efforts will be allocated among the regulated CYRA and non-regulated west area of CYRA. As to the allocation of the fishing efforts among two fishing grounds without quota regulation, Clark (1976) developed a model to minimize total costs given each area's recruited stock level and the production function.[20] Here, we analyze the effect of regulation by using a simple diagram with a one country model.

There are two fishing grounds, CYRA and west of CYRA. We assume that the catch quotas are established to the level of MSY in CYRA and also, that there is open-access entry in this area. On the contrary, there are no catch quotas in the west of CYRA with open-access entries.

Based upon these assumptions, we can draw the following pair of figures as below. We assume that the open-access situation prevailed at point C_1 before the establishment of CYRA, and at A_2 in the west of CYRA, respectively. The purpose of quota



CYRA WEST OF CYRA

restriction is to keep MSY catch, therefore, the level of efforts reduce from E_1^0 to E_1^e if MEY prevails. Due to the imposition of quotas, each vessel behaves as efficiently as possible under the assumption that the technological progress prevails. Under this assumption, the total cost curve shifts from $C_1^0E_1$ to $C_1^1E_1$ which makes MSY A_1 approach MSY B.[21]

Once the catch quotas are attained in CYRA, the vessels move from CYRA to west of CYRA. Due to the technological progress of vessels which operate in CYRA, the larger and more efficient boats will operate in the west of CYRA, which will increase the fishing efforts from the initial point A_2 to D_2 in the long-run situation.

Judging from these circumstances, the existence of CYRA accelerates the overcapitalization of fishing vessels and causes depletion of tuna resources without appropriate conservation measures. Therefore, at least, the establishment of the quotas to avoid the overcapitalization of vessels should be introduced in the early stage of depletion of the tuna resources. Although without appropriate international regulation of the catching vessels, the international movement of tuna catching vessels cause depletion problems in another area.

As seen in Chapter 2, if both countries operate under the zero net revenue situation, the imposition of landings tax or a licensings fee does not necessarily reduce the total fishing efforts.

As seen from the total revenue equation, i.e.,

$$\pi = P[a(E_X+E_Y)-b(E_X+E_Y)^2]-c_xE_X-c_yE_Y-(\beta_x+\beta_y)E_XE_Y,$$
$$a(E_X+E_Y)-b(E_X+E_Y)^2 \leq \bar{F},$$

if technological progress occurs, the fishing efforts will increase in order to restore the net revenue to zero. Because effort restriction is difficult to handle when there is rapid technological progress, the Commission preferred to impose the catch restriction, i.e., total catch quotas. If we set up the quotas, such as at the level of $\bar{F}$, the fishing efforts should be allocated to satisfy the above equation.

In the Commission Regulatory Area, the allocation of fishing efforts is attained by the free-access system. Therefore, in this situation, the tuna resources are assumed to be purely common property resources with the conservation of tuna resources preserved.

In this situation, the rules of game are a first-come, first-served basis, therefore, the opportunity costs of not using new and efficient long-range fishing vessels is very high. There is an incentive for participants to use the modern technology competitively. In the long run, the fishing seasons become shorter and shorter, and there exists an overcapitalization of vessels. From the social point of view, this situation causes a social loss to the society and increases the peril of tuna resource depletion in other fishing areas.

From the regional point of view, the resource adjacent member nations are complaining about the present allocation system of tuna resources. They wish to establish a new regime for the management of tuna resources based upon the private property rights of the resource adjacent member nations. Another approach is to solve the present management deficiencies by extending the present overall quota system.

In the following, I will discuss the nature of the six major alternative management proposals by the Commission from the viewpoint of property rights and economic efficiency:

(1) control to 200 miles by individual coastal states;
(2) extension of the present eastern Pacific overall quota system;
(3) partially allocated quota (PAQ) management;
(4) regional coalitions;
(5) total allocation of the resources; and
(6) resource allocation by competitive bidding.

CHAPTER 4

THE PROPERTY RIGHTS AND TUNA RESOURCES

As discussed in the preceding chapters, tuna resources have a common property nature. Especially since tuna moves along the coastal regions as well as the high seas.

Salmon may be allocated to the country where they are raised originally, because the concerned country will allocate the resources necessary to conserve the salmon resources. But in the case of the tuna species, we cannot allocate them among countries by their country of origin.

In this chapter, we will discuss the nature of the property rights associated with the tuna species and examine management schemes such as the regional approach and the international approach based upon the argument done by Joseph and Greenough (1979) from the viewpoint of the formation of the property rights for the tuna species.

As to the economic aspects of the property rights, Posner (1972), Demsetz (1967), Cheung (1970) have already discussed the nature of the property rights from the economic efficiency point of view.[22]

Posner (1972) points out the three criteria for an efficient system of the property rights as below:[23]

(1) universality

(2) exclusivity

(3) transferability.

Universality means that all resources should be owned by someone as far as they are scarce resources. Even if the property rights are fully transferred.

Demsetz (1967) points out the important function of property rights in order to internalize the externalities. He discusses the nature of property rights in the hunting and agrarian societies. He also examines the benefits and costs of the formation of the property rights which internalize the externalities.

As to tuna resources, we cannot neglect the common property nature of the species. According to H. Scott Gordon (1954), the most important point is the common property nature of ocean resources being considered as everybody's property is nobody's property. He also refers to the nature of petroleum resources.[24]

J. Hirshleifer *et. al.* (1960) also discuss the nature of the common-pool resources especially focusing their attention upon water resources. They propose three solutions for efficient allocation of common-pool resources, i.e. (1) centralized decision making; (2) assignment of prorata production rights or quota; and (3) the imposition of "use" taxes.[25] They also emphasized the importance of the transferability and the perfect exchangability of quotas.

Steven N. S. Cheung (1970) examines the nature of the relationship among the structure of contract, the establishment of exclusive rights, property rights, and economic efficiency. He stresses the importance of the structure of the contracts which determine the distribution of income, though in the real world, the transaction costs cannot be neglected. He also assumes that economic efficiency will be attained by the contracts which are based upon exclusive rights, where the property is considered to be private property.

He also discusses the process of private property formation and refers to the costs of establishing the property rights, such as the policing costs generated by the non-exclusive uses of resources. He summarizes his analysis as follows:[26]

> Under private ownership of the fishing ground, the right to the rent (income) is exclusive, and a contractual arrangement will make rent a private cost of fishing production. With non-exclusive fishing rights and without collusion among fishermen, rent becomes a residual with every decision-making unit—a fisherman or a fishing firm—maximizing the portion left behind by others.

As to the costs of establishing property righits, he writes as follows:[28]

> The absence of exclusivity in property may be due to the absence of recognition by legal institutions of the exclusivity, or the costs of delineating and policing the limit of the rights being prohibitively high.
>
> The costs associated with the formation of property and of the subsequent contracts may be viewed in two stages. At one stage, without exchange, there are costs of defining and policing exclusivity,.... In our example of marine fisheries, the difficulty of assessing, quantifying, identifying and policing private fishing rights is evident.
>
> At second stage, there are costs associated with negotiating and enforcing contracts for the exchange or transfer of property rights. At least two reasons may be offered for the difficulty of separating the costs of this second stage from the first. One reason is that the income derivable from an exclusive right, or the gain of enforcing it, depends on the existence of transferability in the marketplace, for

without transfer the highest-valued option may not be realized. This implies that the lower the costs of contracting for transfer, the higher will be the gain of enforcing exclusivity. A second reason is that of enforcing exclusivity also depends on the existence of transfer and its associated costs.

In the following, we will discuss the nature of the property rights based upon the above arguments for six major management alternatives according to J. Joseph & J. W. Greenough (1979).

(1) Control to 200 Miles by Individual Coastal States

Joseph & Greenough (J & G) argue the effects of establishing a 200 mile coastal zone focusing their arguments on the movements of the species and vessels. Resource adjacent nations(RANS) want to maximize the tuna catches in their own coastal zones excluding fleets of all other nations from their coastal zone with the intention of developing their own fleets.

There are two important deficiencies in this management system. The first problem comes from the excluded non-RAN fleets which in 1975 took nearly 75 percent of the total yellowfin and skipjack catch in the 200 miles. If these fleets are excluded from the coastal area, they rush to the areas without restriction beyond 200 miles. This causes an overexploitation[28] in offshore areas as well as inshore areas due to the migratory nature of the tuna species. In addition, there will be competitive technological progress which accelerates the depletion of tuna resources.

The second problem comes from the moving nature of the fishing grounds from year to year. As long as each country's fishing ground is completely limited to her own coastal zone, those countries whose coastal zones are small have less chance of good harvesting even if they have many vessels, because the fishing grounds move from one coastal zone to another year by year. Therefore, even if they want to develop their own fleets, they cannot continue their investments due to this catch uncertainty.

Therefore, there is an underutilization of resources in the inshore area, overexploitation in the offshore area, though in total, there prevails an overexploitation and overcapitalization.

Instead of this system, RANS considered licensing systems which would allow each others' vessels to purchase licenses. This strategy would preserve access for themselves through the 200-mile zone with significantly limiting competition from the non-RAN fleet.

Instead of a licensing fee based on registered net tonnage, they can collect a catch tax or participant fee that would be based upon actual catches. In any case, the enforcement costs are expensive. They wish to impose high fees in order to exclude foreign vessels.

J & G summarize their arguments as follows:[29]

> In conclusion, creation of exclusive fishing zones can hardly be considered an acceptable approach to tuna management. It fails to satisfactorily resolve the catch distribution problem, and it makes management of the resources impossible. With no management, damage to the resources as a result of overfishing is quite possible and economic hardship virtually inevitable for all concerned. With drawbacks of this magnitude, the problem of enforcement that would face the RANS need not even be discussed.
>
> In summary, while effective management is theoretically possible if license fees are very low and do not impede fleet movement, such low fees would be unacceptable to RANS for both economic and philosophical reasons. On the other hand, high licensing fees would inhibit fleet movement, encourage uncontrolled fishing beyond 200 miles, and make management impossible. Declining catches, possible overexploitation of yellowfin, and economic chaos for all would result under these circumstances. Thus, in terms of solving the catch distribution problem, licensing by individual nations seems just as unpromising as maintaining entirely exclusive national fishing zones.

Posner pointed out three criteria for an efficient system of property rights: (1) universality; (2) exclusivity; and (3) transferability. Due to the migratory nature of the tuna species, the universality condition is not satisfied in the high sea area, and the exclusivity condition is only satisfied in the coastal area. The three conditions are satisfied from the viewpoint of regional exclusivity of resources, but not from the global management of tuna resources.

Therefore, in this case, the property rights are not efficiently established. There is no incentive for the conservation of tuna resources because the opportunity costs of not catching the tuna in certain coastal areas this year will be the catches of other countries at different fishing grounds, including the area outside of 200 miles.

As Cheung suggests, the contractual agreements such as licensing contracts are important determinants of income distribution. If the fees are high enough to discourage the entrance of foreign vessels, there are unexploited resources in the coastal regions but resource depletion in the near future due to the overexploitation in the offshore area. Without efficient vessels, RANS lose present as well as future income. But, if the fees are so low as to encourage overexploiting coastal resources, RANS loses both the present and future incomes.

Protecting property rights by coastal states may be costly because they need the policing and enforcement costs. Also, it is very difficult to calculate the benefits of establishing exclusive rights for tuna because of the difficulties of assessing and quantifying the tuna species. Therefore, it is difficult to evaluate the net benefits of establishing an exclusive 200-mile fishing zone for tuna resources management.

(2) Extension of Eastern Pacific Overall Quota System

As discussed in Chapter 3, the existing IATTC management system which established overall catch quotas within the CYRA was initiated in 1966. The open-access situation prevails within the CYRA. Generally, RANS have been against this allocation system because their claims to allocations are fundamentally based upon resource adjacency. Against RANS, the non-RANS argue that there are no claims for RANS to occupy the special allocations for migratory tuna resource.

Notwithstanding its high policing and enforcement costs, Ecuador, Peru, Costa Rica, and Mexico have announced licensing systems in their 200 mile zones. For non-RANS, the negotiating and compensating costs became higher in order to be compatible with the establishment of property rights by RANS for tuna resources. Therefore, the eastern Pacific fishing can no longer be considered an open-access fishery due to these changes of environments.

Judging from these circumstances, it is clear that the overall quota management agreements of the IATTC type cannot be successfully negotiated without special quota allocations for RANS.

They conclude their analysis as follows:[30]

> In conclusion, it does not appear that the existing overall quota management system in the eastern Pacific or any modification of it can adequately resolve the catch distribution problem. The RANS, generally speaking, want adjacency-based allocations, and at the same time, some are restricting access to the resource by imposing high license fees. The non-RANS would like to do away with allocations altogether and operate the fishery strictly on an open-access, overall quota basis. Both sides are in a strong bargaining position—the RANS because they control access to important parts of the resource, and the non-RANS because their fleets dominate the harvesting sector and they control the markets. If the catch distribution problem cannot be resolved, it hardly seems likely that the related problems of excessive fleet growth and enforcement can be effectively dealt with. Under these circumstances, it appears that the continued success of the present IATTC management program is increasingly jeopardized.

As seen from the above arguments, the extension of the present quotas system does not hold with the three efficiency conditions of the property rights. And even if the special allocation were considered, efficiency would not be attained without establishing the transferability of quotas in whole fishing grounds.[31]

(3) Open Access with Participant Fees and Resource Adjacency Allocation (PAQ Management)

As discussed above, there have been conflicts between RANS and non-RANS as to the property rights for tuna resources. The formers claim the resources adjacent nature, while on the other hand, the latter stresses the common property nature of tuna resources. To reach a compromise to these conflicts, a new approach called "partially allocated quota" management, or simply, PAQ Management is considered. According to J & G, the features of this system can be described as follows:[32]

> Management would be based upon access to all resources and would be administered by an international agency that sets overall catch quotas, issues international licenses, partially allocates the catch to coastal nations, collects participant fees based on catches, redistributes resulting proceeds among nations, and provides for enforcement and control of fleet size. The distinguishing feature of such a management system is that the overall quota would in some way be partially allocated among RANS in recognition of their adjacency to the resources.

As to the partial catch allocation, many RANS believe that allocations should be based upon resource adjacency, however, the United States, one of the most powerful non-RANS, wants to allocate resources according to historic RAN catches and present RAN harvesting capability.

One of the most important assumptions is that allocations are non-transferable guarantees of access, rather than transferable property rights.

There are several problems to be solved for the management to be operatable. First, the question of how to allocate to RANS arises. Either recent average catches by the entire international fleet in the national 200-mile zone or recent catches by coastal state fleets within their own 200-mile zones could be utilized.

Second, how to collect and redistribute the participant fees. The participant fees provide a source of funds for support of international management including scientific studies, monitoring of fishing activities (collection of data on catch, effort, size composition, fleet composition, etc.), enforcement and surveillance, collection and disbursement of participant fees, issuance of international licenses, and general administration. The problem which is difficult to solve is, who can be benefited from the distribution of the high-sea proportions. If we assume that the resources in the high-sea belong to the common heritage of mankind, the situation becomes much more complicated. Other aspects which should be considered are as follows:

(1) Procedures for determining when to close the open season; (2) skipjack management when yellowfin catches are controlled and partially allocated; (3) transitional changes in RAN and non-RAN fleets associated with the adoption of PAQ management; and (4) control of fleet growth.

In this system, even the tuna resources in the high sea are under control of the international agency, therefore, the universality condition is satisfied. The exclusivity condition is satisfied for the participants. But the transferability condition is not assumed, therefore, some RANS who do not have the ability to catch the amounts assigned by the authority do not have the chance to trade their excess catch quotas with other countries. Due to the open-access nature of the fishing grounds, the overcapitalization of vessels is inevitable. And the redistribution problem is very difficult to determine, even within participants. If they include the common heritage of mankind concepts, the situation will be far from being solved.

(4) Regional Coalitions

If there is a gain from cooperating with each other, then regional coalitions will be formed. Some of RANS form coalitions for securing stable annual catches, since the annual and seasonal availability of tuna is highly variable. A RAN coalition could have motivations for issuing licenses to produce income. But, if the purpose of the coalitions is to control the fleet size or to manage the overall species, then coalitions of RANS and non-RANS are required.

In any case, the management system will be inefficient from the viewpoint of property rights if established without the international property rights, as discussed in the PAQ management system.

(5) Total Allocation of the Resources

The historical examples of total allocation of marine resources such as fur seals, whales, and haddock, show that the actual or imminently threatened depletion of a resource is one possible motivation for adopting a total allocation system.

Another factor which motivates the adoption of a total allocation system is the guarantee of catches, which reduces the uncertainty and risk of the catches.

As to the criteria for allocation, there are two main criteria, i.e., resource adjacency and historical participation in the fishery as measured by both long-term and short-term catch histories.

The important feature of this system is that a nation can transfer their allocation to another nation; i.e., the transferability condition is satisfied. And also, given the quotas, nations would be discouraged from developing excess fleet capacity, which would solve the overcapitalization problem.

They conclude as follows:[33]

> When the advantages and disadvantages of totally allocating an overall quota are weighed against each other, it seems somewhat questionable that a successful agreement could be reached. Perhaps the most difficult obstacle would be to secure non-RAN agreement as to the size of their allocation. Even if such agreement could be secured, there would remain the serious problem of fishing by non-cooperating nations beyond 200-miles. Nevertheless, total allocation of the resources should certainly be given careful consideration.

In this system, the three efficient property rights conditions are satisfied. Especially, the transferability condition is satisfied. Therefore, once the allocation problem is solved, this management system works well except in regard to the allocation for new entrants.

(6) Resource Allocation by Competitive Bidding

In competitive bidding, the allocation of quotas or licenses is done byt he market mechanism which assumes the efficient allocation of resources.[34] If the property rights are established by an international management agency, then this system provides the most efficient property rights system. However, we have to consider the modification of these bidding systems in order to provide recognition to RAN claims for tuna resources.

SUMMARY

In Chapter 1, I discussed the necessity for appropriate inter-regional and international management of the tuna species.

Tuna and tuna-like species are grouped into three categories.

But the so-called principal market species make up about 75 percent of the world catch of tuna and tuna-like species.

As to the nature of the tuna catching and related industry, the entry by the developing countries, such as Korea, Taiwan, Mexico, Costa Rica, and Ecuador, etc., is becoming significant, even though Japan and the United States are two big producing and consuming countries.

The demand for tuna of the developed countries is usually closely related with their national income levels. As income grows yearly, the demand function increases at the same time. This increased demand causes the problem of overexploitation of the tuna resources and overcapitalization of vessels.

Once the tuna resources are depleted, we will have a significant economic loss for a long period before the resources are restored to the catchable level. Therefore, the conservation of the tuna resources is required.

Some authors estimated the amounts of the allowable catches, but the estimations showed wide ranges due to the difficulties of accurate estimation of the migratory natures of the species. The migratory natures of both the tuna and catching vessels also require regional and international management of the tuna species.

In Chapter 2, I analyzed the model of internationally exploited fishery resources, and then examined the impact of various policies. We assume that two countries X and Y are exclusive users of the tuna stock with the sustainable yield curve as shown below:

$$F(E_X, E_Y) = a(E_X + E_Y) - b(E_X + E_Y)^2,$$

where E_X and E_Y are the fishing efforts of country X and Y, respectively.

The amount of each country's catch will be proportionate to the effort, in relation to total effort, thus obtaining the catch function for country X and Y, as shown below:

$$F_X(E_X, E_Y)=\frac{E_X}{E_X+E_Y}\cdot F(E_X, E_Y)$$
$$=aE_X-bE_X^2-bE_XE_Y$$

$$F_Y(E_X, E_Y)=aE_Y-bE_XE_Y-bE_Y^2.$$

The net revenue functions π_X and π_Y are expressed as a difference between the revenue and total cost. The total cost consists of the direct fishing efforts of each country and the external congestion costs due to the foreign country's entry into fishing grounds. Therefore, we can write the following net revenue functions:

$$\pi_X=aE_X-bE_X^2-bE_XE_Y-(c_x+\beta_xE_Y)E_X=0$$
$$\pi_Y=aE_Y-bE_XE_Y-bE_Y^2-(c_y+\beta_yE_X)E_Y=0.$$

If we assume both E_X and E_Y are positive, we have a simultaneous linear system by dividing π_X and π_Y by E_X and E_Y, respectively. Solving this system for E_X and E_Y, we have the following equations:

$$E_X=\frac{b(c_x-c_y)+\beta_x(a-c_y)}{b(\beta_x+\beta_y)+\beta_x\beta_y}$$
$$E_Y=\frac{b(c_x-c_y)-\beta_y(a-c_x)}{b(\beta_x+\beta_y)+\beta_x\beta_y}$$

Due to an open-access and to the internationally exploited nature of the resources, an increase in the direct marginal cost also increases the fishing effort of the country in order to restore the zero net revenue situation. If we neglect the demand side, the technological progress decreases the fishing effort.

As to the effect of price change and the imposition of a landings tax, we have the following results by modifying the model discussed above:

The increase in the price will finally decrease the country's fishing efforts; on the other hand, it increases the opposite country's efforts. The imposition of the landings tax has the opposite results due to the decrease in net revenue; i.e., an increase in the fishing efforts of one country, but a decrease in the fishing efforts in the opposite country.

If we introduce the licensings fee, the fishing efforts decrease in the one country, but increase in the opposite country.

Judging from the above analysis, the overall impact of imposing landings tax and licensings fee are indefinite according to both positive and negative effects in each country. Although we neglect the demand side for the tuna, these two policies are not to be considered effective measures for reducing fishing efforts in the open-access situations.

In Chapter 3, I discussed the present management systems of the tuna resources conducted by the Inter-American Tropical Tuna Commission (IATTC). The principal objective for the conservation of the tuna resources is to maintain the stock of fish at the levels which will afford maximum sustainable catches if and when the Commission research shows such conservation measures to be necessary. The Commission established the catch quotas inside the Commission Yellowfin Regulatory Area (CYRA) based upon their tagging experiments which indicated that the yellowfin of the area outside the CYRA have been considered separately from those of the area inside the CYRA.

As to the area outside the CYRA, they decided that there is no biological reason for placing limits on the catch or the intensity of fishing outside the CYRA. This is because the maximum sustainable yield catches have not yet been attained at the present level, based on statistical data.

But we cannot neglect the facts that the catching vessels have the ability to move internationally to the fishing grounds where there exists no regulation for tuna catches. Based upon this fact, we know that, in the near future, there will be overexploitation of resources over maximum sustainable yield (MSY) outside of CYRA due to the open-access nature as well as overcapitalization of vessels. Therefore, as far as the maintenance of MSY is concerned, the Commission should include the outside of the present CYRA as a new regulation area setting up the catch quotas.

In Chapter 4, I reviewed the nature of property rights from the efficiency point of view, and also examined the six alternative management systems proposed by the Commission.

As to the nature of the property rights, Posner pointed out the three criteria for an efficient system of the property rights, they are (1) universality, (2) exclusivity, (3) transferability.

Demsetz pointed out the important function of property rights in order to internalize the externalities.

Hirshleifer *et. al.* discussed the nature of the common-pool resources, and they proposed three solutions for efficient allocation of common-pool resources, i.e. (1) centralized decision-making; (2) assignment of prorata production rights or quota; and (3) imposition of "use" taxes.

Cheung focused his arguments mainly upon the relationship among the structure of contract, the establishment of exclusive rights, and economic efficiency. He stressed the importance of the existence of transferability in the marketplace.

Next, I reviewed the six alternative management systems and examined their efficiency from Posner's three efficiency criteria.

The first alternative system whose aim is to control up to 200 miles by individual coastal states will cause overexploitation on the high sea and underexploitation in 200 miles if the non-resource adjacent countries (non-RANS) were excluded from the exclusive fishery zones. But in the long-run, the resources will be depleted due to the migratory nature of the species.

In this case, three efficiency conditions are satisfied from the viewpoint of regional exclusivity of resources, but not satisfied from the global management of tuna resources. Therefore, this system cannot be efficient.

The second proposal is to extend the present quota system. But the present open-access system is difficult to be admitted by the resource adjacent countries (RANS). The shortcoming of this system is that there prevails no transferability of quotas.

The third system is the so-called PAQ management system. This system is proposed in order to reconcile both non-RANS and RANS admitting their historical catch and property claims. By collecting the participans' fees and distributing them, they wish to fill the gaps which exist among non-RANS and RANS.

Due to the lack of transferability condition, this system also cannot be efficient.

The fourth system is regional coalitions, which also would be inefficient without the global transferability.

The fifth system is total allocation of the resources such as whole resources allocation. If the allocation method is successfully established, this system should be the efficient system because the transferability condition is satisfied.

The sixth system is the allocation by competitive bidding. Although this is the most efficient method, the problem is that there is no guarantee of benefits to RANS.

FOOTNOTES

1 Joseph & Greenough (1979), p. 5.

2 C. Lee (1974), pp. 32–34.

3 Joseph & Greenough (1979), pp. 30–31.

4 C. Lee (1974), p. 44.

5 Saila & Norton (1974), p. 35.

6 See C. Lee (1974), Chapter II and Anderson (1977), Chapter 2.

7 Saila & Norton (1974), p. 35.

8 *Ibid.*, pp. 41-43.

9 The United States Fishery Conservation and Management Act of 1976 (FCMA) excluded the management of tuna in the fishery conservation zone, see Knight (1978), pp. 28-29. See also Cole (1976), p. 54 and Christy & Alexander (1975), pp. 30-32.

10 As to the nature of the reguratory measures of fishery resources, see, Anderson (1977b) and Christy & Alexander (1975), pp. 25-27.

11 As to the model developed below, refer to Anderson (1973).

12 If either E_X or E_Y is equal to zero, this model reduces to the one country model. Therefore, we assume here that both E_X and E_Y are not zero. Equation (7) is derived by dividing equation (6) by E_X and E_Y, respectively. Solving (8) for E_X and E_Y, we have the following equations:

$$E_X=\frac{b(c_x-c_y)+\beta_x(a-c_y)}{b(\beta_x+\beta_y)+\beta_x\beta_y} \qquad E_Y=-\frac{b(c_x-c_y)-\beta_y(a-c_x)}{b(\beta_x+\beta_y)+\beta_x\beta_y}$$

Since E_X and E_Y are both positive, we have the following inequalities:

$$b(c_x-c_y)+\beta_x(a-c_y)>0 \qquad -b(c_x-c_y)+\beta_y(a-c_x)>0$$

Together with $E_X>0$ and $E_Y>0$ and $\beta_x=\beta_y$, we have the combination of c_x and c_y as shown in Figure 1.

13 For the internationally exploited species, such as tuna, the establishment of property rights is very difficult due to the migratory natue of the species. Even if country X conserves the species, the extinction of species will happen if country Y's fishing efforts increases in order to offset X's decrease. When both countries increase their fishing efforts to the point where the net revenue reaches zero, we can assume that they have increased their fishing efforts as far as their net revenues are positive. And, even if the concerned country's net revenue is negative, there is a motivation to increase its efforts to offset the opposite country's net revenue by increasing the external congestion cost for the opposite country.

14 As to the effect of a landings tax for the one country model, see Flagg (1977b).

15 The opinion of the spokesman of the American Tunaboat Association (ATA) was discussed in Felando (1977).

16 IATTC (1978a), p. 7.

17 *Ibid.*, p. 23.

18 At the present situation, there is no regulation for the skipjack species. We have the multispecies problem discussed by Anderson (1977, Chapter 4) and Clark (1976, Chapter 9). According to the Annual Report issued by IATTC (p. 55), the prediction of the skipjack population does not offer

accurate information, notwithstanding the extensive research done by staff. Therefore, we do not treat the multispecies problems, and only refer to the effects of quotas regulation for the yellowfin tuna.

19 IATTC (1978a), p. 53.

20 Clark (1976), p. 239.

21 Flagg (1977b) showed mathematically that as price increases relative to average cost per unit of effort, the difference between maximum sustainable yield and maximum economic yield decreases.

22 The income distributional aspect of the common property fishery resources is an important problem, see Christy (1972) and Oda (1968).

23 Posner (1972), p. 29.

24 Gordon (1954), pp. 424–25.

25 Hirshleifer *et. al.* (1960), p. 61.

26 Cheung (1970), p. 445.

27 *Ibid.*, pp. 449–50.

28 See also Miles (1977), p. 424.

29 Joseph & Greenough (1979), p. 47 and 52.

30 *Ibid.*, p. 57.

31 As to the arguments against the adoption of catch quotas system, see Bell (1978), pp. 157–158. The experience of International Whaling Commission (IWC) showed that the system of free competition for a fixed overall catch had almost all the defects of a competitive system, see Elliot (1979), p. 153. For the fishery resources management, Elliot also suggests an international agreement which requires the allocation of the total catch into national quotas so that each country can manage its own share properly (p. 155).

32 Joseph & Greenough (1979), p. 59.

33 *Ibid.*, p. 130.

34 Tollison & Willett (1976) discussed the concept of the ocean as the common heritage of mankind based upon public choice principles (pp. 91–96). But the problems are (1) how to treat the historical catches (2) how to share the revenues for competitive biddings for access to property rights in ocean claims. And also, some people have the skepticism about the "perfect intervention theory" of government, the "perfect regulation theory" of regulatory agency (see the comment made by Roland McKean on Tollison-Willett paper, p. 112).

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