수산경영론집, 제35권 제2호 2004. 12

# Subsidies: Are they really obstacles in achieving a sustainable fisheries development?

Lee, Sang-Go*, Kim, Do-Hoon**

〈 Contents 〉



## Ⅰ. Introduction

Many debates on subsidies in fisheries have been occurred in the world and a few studies potentially concluded that subsidies have allowed fishing efforts to increase, which caused ultimately fish stocks to be declined and/or depleted. Therefore, in order to stop the fish stocks declines they suggested that subsidies in fisheries should be eliminated. However, as Expert Consultation Group (FAO, 2000) pointed out, the explicit definition of fisheries subsidies has not been determined yet in spite of its commonly uses in former studies. In addition, none of the commonly used definitions of subsidies is adequate for a comprehensive analysis of subsidies' effects on trade and sustainability in fisheries and aquaculture.

접수 : 2004년 2월 9일　　게재확정 : 2004년 10월 2일
* Professor, Pukyong National University
** Senior Researcher, Korea Maritime Institute

Defining subsidies in fisheries is important to understand the role of subsidies in fisheries and should be made for a clear conclusion of the impacts of subsidies on the sustainability of fish stocks. In the studies of FAO (1993, 2001) and World Bank (1998), subsidies in fisheries were defined as the granting of money to an individual or firm by the government and government financial transfers that reduce costs and/or increase revenues of producers in the short-term. Therefore, only direct financial transfer by the government was considered as a definition of subsidies in fisheries.

However, according to the Expert Consultation Group (FAO, 2000), they had a broad definition of subsidies in fisheries by dividing subsidies in fisheries into four different sets.[1] Unlike defined by FAO and World Bank studies, subsidies in fisheries were defined, as shown in Table 1, to be government' s broad interventions for correcting distortions in market and production. Similarly, Schrank and Keithly (1999) defined subsidies in fisheries as a government action (or inaction) that modifies (by increasing or decreasing) the potential profits earned by the firm in the short-, medium-, or long-term. Based on those definitions, subsidies in fisheries can be defined as government' s whole activities affecting to market and production. As widely known, due to the characteristics of the fisheries, the intervention of government is inevitable and if the government' s whole actions in fisheries are defined as subsidies, not only financial transfer as defined in the studies by FAO and World Bank, but also management and enforcement activities by government can be defined as subsidies in fisheries.

1) Set 1 is government financial transfers that reduce costs and/or increase revenues of producers in the short-term that is exactly the same definition as FAO and World Bank studies defined. It includes grants to purchase vessels or to modernize vessels, income support payment and other. This definition excludes government interventions that affect trade and the use of fisheries resources. Set 2 is subsidies are any government interventions, regardless of whether they involve financial transfers that reduce costs and/or increase revenues of producers in the short-term. It includes tax waivers and deferrals, and insurance, loans and loan guarantees provided by government. Set 3 is the short-term benefits to producers that result from the absence or lack of interventions by government to correct distortions in production and markets that can potentially affect fisheries resources and trade. This includes the implicit benefits to producers associated with the lack of government regulations that would require producers to bear the costs that they impose on other parties, including costs on the environment and natural resources. Finally, Set 4 is subsidies are government interventions, or the absence of correcting interventions, that affect the costs and/or revenues of producing and marketing fish and fish products in the short-, medium-, or long-term.

**Table 1. Categories of Subsidies in Fisheries**

| Trade | Sustainability |
|---|---|
| Cost Reducing | Cost Reducing |
| Investment cost reductions | Capital expansion |
| Input price reductions | Labour cost reduction |
| | Misc. cost reductions |
| | Tax waivers & deferrals |
| | Loans & insurance cost reductions |
| Market interventions | Market interventions |
| | Fisheries science and management |
| Revenue Enhancing | Revenue Enhancing |
| | Output price support |
| | Compensation programs |
| Sales promotions | Sales promotions |
| | Equity infusions |
| Trade measures | Trade measures |
| Miscellaneous/Unspecified | Miscellaneous/Unspecified |
| Actions to reduce fishing effort | Fishing capacity reduction programs |
| Management and regulatory actions | Fisheries science & management |

With the concept of subsidies in fisheries, the removal of subsidies in fisheries ironically means the open access fishery where there are no regulations by government. In order to achieve efficient fisheries, government actions (=*Subsidies*) are necessary, various subsidies (=*Government's Actions*) should be utilized depending upon the specific situation of the fisheries. As a result, the subsidy can not be said 'bad' or 'good' itself. It depends upon the use of it in the specific condition of fisheries. If a type of subsidy is necessary for a sustainable fisheries development, it could be defined as a 'good' subsidy.

In addition to the definition of subsidies, the conclusions of the impacts of subsidies in fisheries made by the former studies have many problems. By simply comparing total fishing revenues and costs from the aspect of global scale or in a few countries, they made a conclusion on the relationship between the impacts of subsidies and the sustainability of fish stocks. More detailed quantitative analysis must be done in order to analyze the effects of subsidies on the fisheries resources.

This study is aimed at analyzing the impacts of subsidies on the sustainability of fish stocks using a dynamic bioeconomic modeling approach that was a recommended approach for estimating impacts of a subsidy on the sustainability of fish stocks by the Expert Consultation Grouper (FAO, 2000). Generally, so-called 'Green-lighting' subsidies[2] have been accepted to help the fishing industry to maintain a sustainable development. However, 'Bad' subsidies such cost-reducing subsidies as transfer of funds, tax exemption, price and income subsidies have been focused on the analysis of studies as a major problem. For this reason, we considered primarily 'Bad' subsidies and investigated their impacts on the sustainability of fish stocks.

Prior to the analysis, we have two tentative conclusions on the relationship between subsidies in fisheries and the sustainability of fish stocks. It is the decline of fish stocks has been derived not directly from fisheries subsidies, of course partially it contributed, but primarily from ineffective fisheries management and imperfect enforcement. The fisheries need interventions of government for its unique characteristics as industry (common property) and government implements fisheries management measures to regulate the fisheries efficiently. Based on implemented management measures, the variety of subsidies is utilized according to the condition of fisheries for a sustainable development. In order to analyze the impacts of subsidies, most of all, the operation of the implemented management measures must be analyzed on which the impacts of subsidies on the sustainability of fish stocks could be investigated.

Therefore, the first tentative conclusion is that if there are perfect control of effort and enforcement, subsidies do not have any negative impacts on the sustainability of fish stocks. That is, the current depletion of fish stocks has been primarily occurred by imperfect enforcement and inefficient management, not wholly by subsidies. The second tentative conclusion is that the subsidy is not good or bad itself. If the utilized subsidy is not fitting to the condition of fisheries, it could be considered as a 'bad' subsidy. Under the perfect control of fishing effort and enforcement, bad subsidies if necessary, on the contrary unlike the former studies concluded, could improve the fishing business condition and

2) According to the former studies, subsidies that reduce the level of fishing effort such as buy-back program, fishing permit repurchase scheme and subsidies that enhance the level of stock biomass like fishing ground cleaning are defined as good subsidies.

help to achieve a sustainable fisheries development. We first examined the change of fisherman' s behavior when subsidies are supported and compared it to the case where subsidies were not provided. Based on these fisherman' s activities, we investigated the impacts of subsidies on the fish stocks under open access. Without any control of fishing effort and enforcement, it was analyzed how subsidies affect to the sustainability of fish stocks. Then, we analyzed the impacts of subsidies under input control and output control, from which relationships between subsidies, management measures, and the sustainability of fish stocks were examined. More limitations in the former studies are investigated in Chapter 2 and detailed model assumptions, data, model results are explained in chapter 3.

## Ⅱ. Limitations in the former studies

Although detailed quantitative studies have not been done so far, a tentative conclusion made by the former studies [FAO (1993, 2001), World Bank (1998)] is that the subsidies in fisheries contributed directly to reductions in operating and

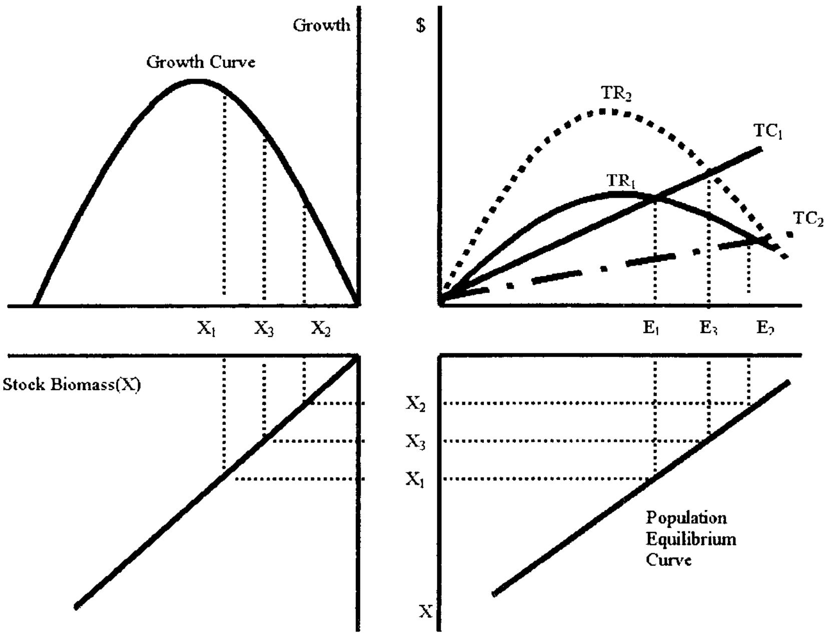


**Figure 1. The impacts of subsidies on the level of fishing effort and fish stock biomass**

capital costs and increases in revenues. Consequently, subsidies made the level of fishing effort increase and substantially cause over-fishing and over-capacity that are currently so common problems surrounding fisheries in the world.

That is, as shown in Figure 1, fishermen can expand the level of fishing effort ($E_1 \rightarrow E_2$) due to the reduced operating and capital costs ($TC_1 \rightarrow TC_2$) or they can increase the level of fishing effort from E1 to E3 due to the increased revenues ($TR_1 \rightarrow TR_2$) by subsidies. As a result, the fish stock would be decreased from $X_1$ to $X_2$ and $X_1$ to $X_3$, respectively.

In order to analyze the impacts of fisheries subsidies on the level of fishing effort and fish stock biomass, the former studies simply compared the global revenues and costs in the world fisheries. The world' s 3 million fishing vessels incurred total operating costs of $99.2 billion and gross fishing revenues amounted to $70 billion. $22 billion were less than operating costs, therefore in their conclusion, this difference was assumed the amount of subsidies transferred directly from government, which mainly caused the fish stocks to be declined or depleted.

As Milazzo (1998) pointed out, FAO' s work in 1992 and 1993 had a powerful impact on the problem of fisheries subsidies in the world. Its broad conclusions were widely accepted and many commentators assumed that the huge losses must have been covered by subsidies. However, the analysis of FAO on global fishing revenues and costs should be interpreted with a care. As Milazzo mentioned already, FAO studies didn' t define, categorize, or analyze the subsidies per se, but, simply inferred them from their study of global and revenues. Furthermore, although Milazzo himself distinguished his study from FAO studies by examining the specific types of subsidies utilized by each country, he also had a jump in the logic in the analysis of subsidies as much as FAO did. This is because he just showed that subsidies in fisheries account approximately by 20% to 25% of the sector revenues that caused overfishing and overcapacity problems. He loosely showed the amount of subsidies used in each country, but he didn' t consider the specific fisheries situations that a country faced. In addition, he failed to find a significant relationship between the specific condition of fisheries and the utilization of subsidies in a country. Moreover, he could not demonstrate the impacts of fisheries subsidies on the sustainability of fish stocks quantitatively as well.

Judging the impacts of subsidies in fisheries by global fishing revenues and costs has many controversial problems. Because it does not consider the specific fisheries situations that a country has. Different fishing conditions in every country will clearly alter the impacts of fisheries subsidies on the fishermen and fish stocks, even with the same contents of subsidies[3]. As widely known, the step of fisheries development of a country, the characteristics of fishermen, and the market structure vary in every country as much as physical ocean structures are different.

The primary problem or controversial assumption the former studies had is that they assumed that the global fisheries were homogeneous and so-called 'bad' subsidies would have the same impacts on the level of fishing effort and the sustainability of fish stocks. What is worse, they didn't include the importance of fisheries management regulations and enforcement when considering the impacts of subsidies on the fish stocks.

The fisheries, due to its unique characteristics as industry (common property), are managed by government and are regulated with a variety of management measures. Depending upon what measures are implemented, the impacts of subsidies on the fish stocks might be occurred differently. Therefore, most of all, the effects of management measures and enforcement on the level of fish stocks should be analyzed on which the roles and impacts of subsidies must be evaluated.

## Ⅲ. The impacts of subsidies on the sustainability of fish stocks

### 1. The relationship between subsidies and fisherman's fishing activity

Assume vessels are homogeneous and that fishing activities occur over a

3) In the case of Korea, most of fishermen use fishing loans for vessel building and they keep fishing activities even when they have negative profits that would occurred from reduced revenues by declines in fish stocks and increased costs. It is because even if they want to leave the fishery, they have limited mobility and lack of alternative employment and also because there are no alternative productive uses for vessels, once the vessel are built, they have no choice but keep fishing. This phenomenon surrounding on fisheries in almost countries might make global fishing costs exceed revenues statistically.

season of at most DMAX days. Let a vessel's trip harvest function for fishing effort, h(e), be

$$h(e) = q \cdot e \cdot X \tag{1}$$

Where, q is the catchability coefficient, X is the stock biomass, and e is the level of fishing effort (fishing days per trip). In addition, let the vessel's trip variable cost function for fishing effort, C(e), be as assumed by Anderson (2002) and Clark(1980),

$$VC(e) = a + b \cdot e + c \cdot e^2 \tag{2}$$

Then the marginal and average trip variable cost functions for fishing effort becomes as follows:

$$AVC(e) = a/e + b + c \cdot e \tag{3}$$

$$MC(e) = b + 2 \cdot c \cdot e \tag{4}$$

From the trip harvest function and variable cost function, a trip profit function ($\pi$) is:

$$\begin{aligned}\pi(e,X) &= p \cdot h(e) - VC(e) \\ &= p \cdot q \cdot e \cdot X - (a + b \cdot e + c \cdot e^2)\end{aligned} \tag{5}$$

Where, p is a price of fish. Trip profits are maximized when the first derivative of profit function for fishing effort (e) is equal to zero as the following:

$$\frac{\partial \pi}{\partial e} = p \cdot q \cdot X - (b + 2 \cdot c \cdot e) = 0 \tag{6}$$

$$e^* = \frac{p \cdot q \cdot X - b}{2 \cdot c}$$

And fisherman's season profit function is:

$$\Pi(e, T, X) = T \cdot \pi(e,X) - FC \tag{7}$$

Where, T is the number of trips over the season ($D_{MAX}$) and FC is an annual fixed cost.

In order to analyze the vessel dynamics, we used the entry/exit coefficient ($\eta$) assuming that the speed of entry and exit of vessels is proportionate to season profits ($\Pi$). If N is the number of vessels, then,

$$\frac{dN}{dt} = \eta\Pi \tag{8}$$

In addition, the seasonal number of trips (T) is calculated as:

$$T = \frac{D_{NAX}}{e^*} \tag{9}$$

When the stock biomass is X, marginal revenue (MR) equals $p \cdot q \cdot X$ and vessel employs the level of effort, $e^*$ if $p \cdot q \cdot X > r$, otherwise $e=0$. In other words, a fisherman maximizes the trip profit ($\pi$), using fishing days per trip, $e^*$ given by

$$\begin{aligned} e &= e^* \quad \text{if } p \cdot q \cdot X > r_i \\ e &= 0 \quad \text{if } p \cdot q \cdot X < r_i \end{aligned} \tag{10}$$

Where, r denotes the minimum average cost.

With cost-reducing subsidies such as labor cost reduction, miscellaneous cost reduction, and loans & insurance cost reduction, a fisherman changes his fishing activity. If the cost-reducing subsidy is $\alpha$, the price-increasing subsidy is $\gamma$, and

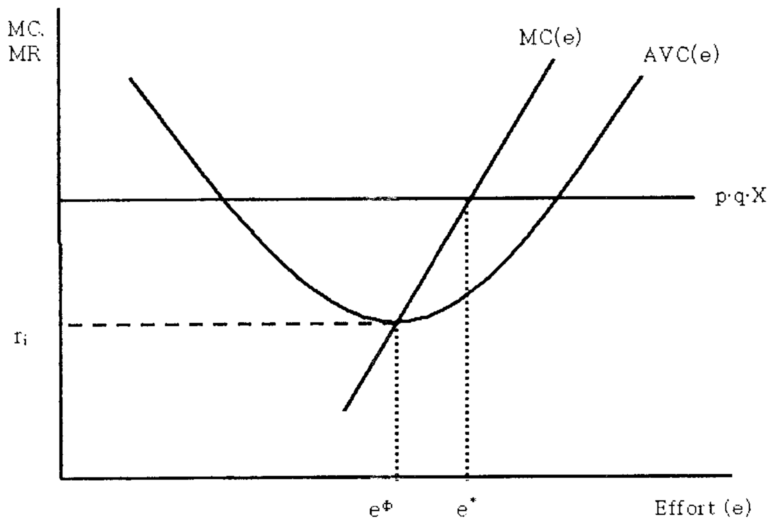


**Figure 2. The determination of the optimal level of fishing effort, e***

the subsidy such direct transfer of funds for shipbuilding is $\beta$, the total trip variable cost for fishing effort can be of the form:

$$VC(e) = [a + b \cdot e + c \cdot e^2] \cdot \alpha \tag{11}$$

Where, $\alpha$ is the effect of cost-reducing subsidies, therefore $\alpha < 1$[4]. And fixed cost can be also expressed as follows:

$$FC = FC \cdot \beta \tag{12}$$

Where, $\beta$ is the impact of the subsidy for shipbuilding and $\beta < 1$. cConsequently, the trip cost function with subsidies can be of the form:

$$\begin{aligned}\pi(e,X) &= [p \cdot \gamma] \cdot h(e) - [VC(e)] \cdot \alpha \\ &= [p \cdot \gamma] \cdot q \cdot e \cdot X - [(a + b \cdot e + c \cdot e^2) \cdot \alpha]\end{aligned} \tag{13}$$

Where, p is a price of fish and $\gamma$ is the effect of price-increasing subsidy ($\gamma > 1$).

Trip profits are maximized where the first derivative of the profit function for fishing effort (e) is equal to zero. That is,

$$\begin{aligned}\frac{\partial \pi}{\partial e} &= [p \cdot \gamma] \cdot q \cdot X - [\alpha \cdot (b + 2 \cdot c \cdot e)] = 0 \\ e_{SUB}^* &= \frac{[p \cdot \gamma] \cdot q \cdot X - \alpha \cdot b}{2 \cdot c \cdot \alpha}\end{aligned} \tag{14}$$

And the fisherman's season profit function is:

$$\Pi(e, T, X) = T \cdot \pi(e,X) - FC \cdot \beta \tag{15}$$

Where, T is the number of trips over the season ($D_{MAX}$), FC is an annual fixed cost, and $\beta$ is the effect of the subsidy such as shipbuilding. Consequently, the seasonal number of trips ($T_{SUB}$) is

$$T_{SUB} = \frac{D_{MAX}}{e_{SUB^*}} \tag{16}$$

Because the level of fishing effort (fishing days per trip), $e_{SUB}^*$, with subsidies

4) Of course, it can be possibly $\alpha > 1$ with the subsidies for fisheries management. However, as mentioned previously, this study focuses mainly on the effect of cost-reducing subsidies ('bad' subsidies). Therefore, $\alpha$ is assumed to less than 1.

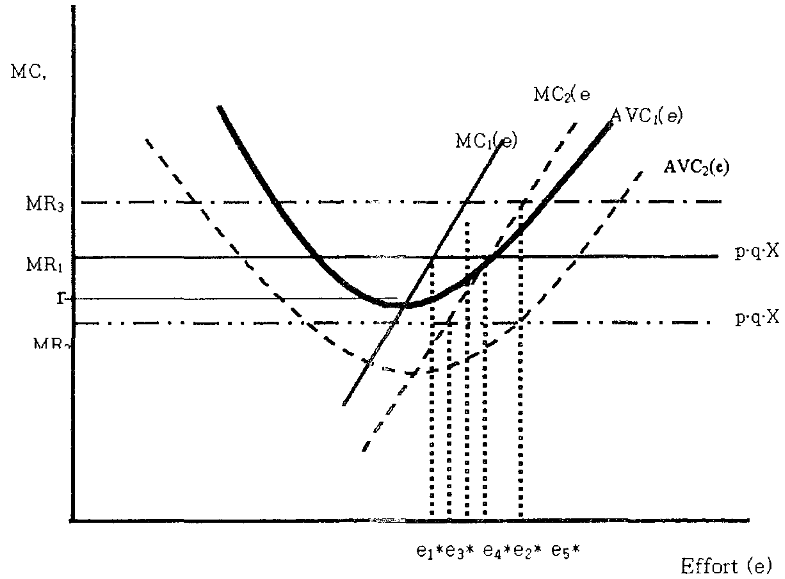


**Figure 3. The determination of an optimal level of fishing efforts by different type of subsidies**

(cost-reducing and price-increase subsidy) is greater than the level of fishing effort, e*, in the case of no subsidies, the number of trips, $T_{SUB}$ is smaller than the number of trips, T.

As shown in Figure 3, a fisherman can increase the level of fishing effort from $e_1$* to $e_2$* given the level of $MR_1$, due to the lowered costs by subsidies. Even when MR decreases ($MR_1 \rightarrow MR_2$), a fisherman can continue fishing activities with cost-reducing subsidies and the optimal level of fishing effort become $e_3$*. However a fisherman can' t continue fishing without subsidies ($p \cdot q \cdot X < r$). If price-increasing subsidies are s supported, the marginal revenue curve becomes $MR_3$ and the level of fishing effort increases from e1* to $e_4$* when cost-reducing subsidies do not exist. If both cost-reducing subsidies and price-increasing subsidies are provided, the level of fishing effort further could increases from $e_2$* to $e_5$*.

## 2. The impacts of subsidies on fish stock under open access

Under open access, fishermen have no right to exclude others from harvesting any fisheries resources. As Gordon (1954) pointed out, if the profits are generated from the fishery, additional vessels would enter, however total fishing efforts would be determined finally at the point where total revenue is equal to total cost. As analyzed in the relationship between subsidies and fisherman' s fishing activity, the level of fishing effort (fishing days) per trip ($e^*$) when there are no subsidies is determined as indicated in Equation (6). In addition, the level of fishing effort (fishing days) per trip ($e_{SUB}^*$) when there are subsidies is equaled to Equation (14).

Assuming the fish stock occurs between seasons according to the function of the growth, G(X), the fish stock decreases over the fishing season in response to the amount of catch, whereas increases over the season as the amount of growth increases. Therefore, the beginning fish stock size ($X_{t+1}$) in t+1 year can be expressed as follows:

$$X_{t+1} = X_t - N \cdot T \cdot h(e, X_t) + G(X_t) \tag{17}$$

Where, N is the number of vessels, T is the number of trips, h $(e, X_t)$ is a trip harvest function per vessel, and $G(X_t)$ is the growth function in year t. Following a Schaefer growth function, G(X) is of the form:

$$G(X) = r \cdot X \cdot \left(1 - \frac{X}{K}\right) \tag{18}$$

Where r is the intrinsic rate of growth and K is the carrying capacity. The data used in the dynamic bioeconomic model are summarized in Table 2.

**Table 2. Functions and Data used in the model and Different level of Subsidies Scenarios**

| Functions and Data | |
|---|---|
| Biological formulas and data | $G(X) = r \cdot X \cdot (1-X/K)$ |
| | $r = 0.21$, $K = 300{,}000$, $X_0 = 100{,}000$ |
| Trip production function and data | $h(e,X) = q \cdot e \cdot X$ |
| | $q = 0.00007$, $D_{MAX} = 50$ |
| Economic data | $TVC(e) = a + b \cdot e + c \cdot e^2$ |
| | $a = 1$, $b = 3$, $c = 3$ |
| | FC = \$700, price = \$5 |
| Dynamic vessel entry/exit | $dN/dt = \eta \cdot \Pi$ |
| | $N0 = 50$, $\eta = 0.01$ |
| **Subsidies Scenarios** | |
| Scenario A : The case with no subsidies | |
| Scenario B : The case with relatively small cost-reducing subsidies ($\alpha = 0.8$ and ($\beta = 0.7$) | |
| Scenario C : The case with relatively large cost-reducing subsidies ($\alpha = 0.8$ and ($\beta = 0.3$) | |
| Scenario D : The case with both large cost-reducing subsidies ($\alpha = 0.8$ and ($\beta = 0.7$) and price-increasing subsidies ($\gamma = 1.2$) | |

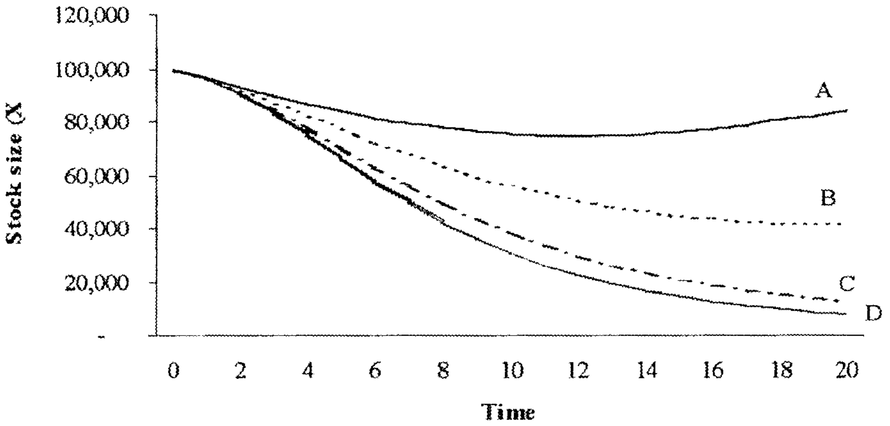


**Figure 4. The change in fish stock biomass by different level of subsidies**

The dynamics of fishermen' s activities and fish stock are that the change of fishing effort per trip is a function of marginal revenue and marginal cost, the change of number of vessels is a function of the seasonal fishing profits generated over the previous year. In addition, the change of fish stock is a function of the amount of catch and natural growth rate. Figure 4 shows the impacts of subsidies on the change of fish stocks during a 20-year period under open access, respectively.

Model results indicate that the fish stock biomass is estimated at 84,361 in the case of A, 42,167 in the case B, 13,201 in the case C and 8,198 in the case of D after a 20-year period. Besides, the number of vessels is 36 vessels in the case with no subsidies (A), 49 vessels in the case with relatively small cost-reducing subsidies (B), 76 vessels in the case with relatively large cost-reducing subsidies (C), and 81 vessels in the case with both large cost-reducing subsidies and price-increasing subsidies (D) after a 20-year period. It is surely confirmed that with supports of subsidies, the fishing effort could be increased and the fish stock biomass could be reduced.

In summary, under open access, the model result showed exactly the same as the former studies concluded tentatively. Such subsidies as cost-reducing and price-increasing subsidies cause the level of fishing efforts to increase, as a result the fish stock would be decreased and/or depleted. However, the fisheries in the world are commonly regulated with a variety of fisheries management measures such as largely input control and output control. As mentioned before, we have a tentative conclusion that the depletion of fish stocks has been primarily caused by the ineffective management and enforcement, not wholly by the subsidies. In order to prove this tentative theory, we ran more models to analyze the impacts of subsidies on the sustainability of fish stocks under the input and output control respectively. Specifically, a limited license regulation as the most typical one in input control and a TAC regulation as a representative of out put control are considered in the analysis.

## 3. The impacts of fisheries subsidies on the sustainability of fish stock under input control

Under the limited license regulation, the number of vessels is determined at a certain number of vessels and fishermen can harvest during the maximum season length ($D_{MAX}$). As analyzed previously, the level of fishing efforts (fishing days) per trip ($e^*$) and the number of trips (T) with no subsidies are determined as Equation (6). And the level of fishing effort (fishing days) per trip ($e_{SUB}^*$) and the number of trips ($T_{SUB}$) with subsidies are as indicated in Equation (14) and (16), respectively.

Because the level of fishing efforts (fishing days per trip), $e_{SUB}^*$, with subsidies (cost-reducing and/or price-increasing subsidy) is greater than the level of fishing effort with no subsidies, $e^*$. As a result, the number of trips, TSUB is smaller than the number of trips, T, given the season length ($D_{MAX}$). In the model analysis, 28 vessels are determined under the limited license regulation in order

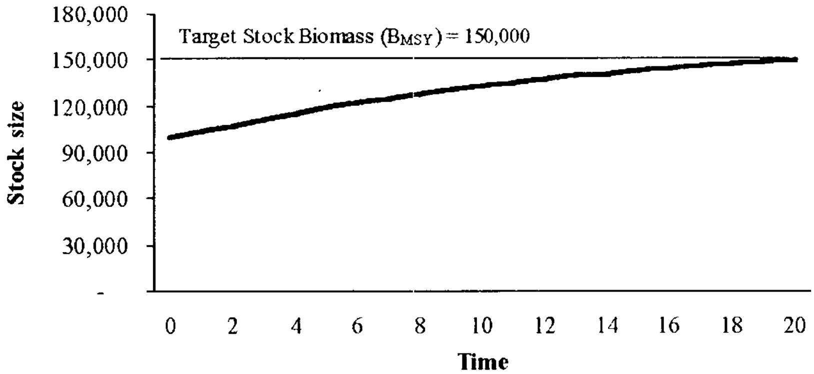


**Figure 5. The change in the fish stocks under input control**

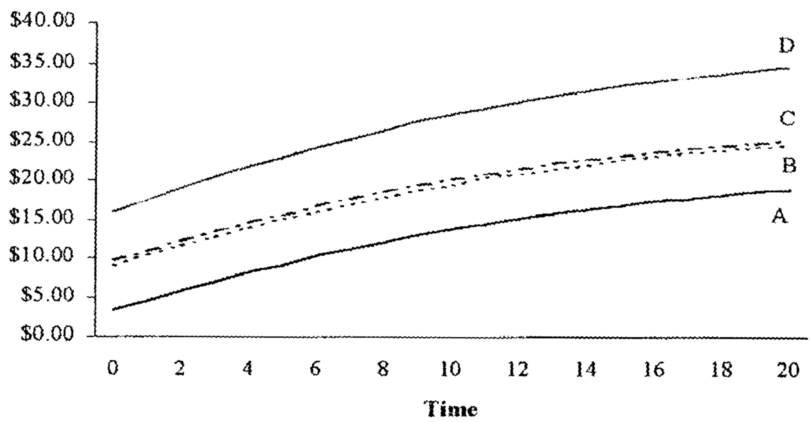


**Figure 6. The change in profits per vessel by different level of cost-reducing subsidies**

to achieve a target stock biomass ($B_{MSY}$ : 150,000) given the current level of stock biomass in a 20-year period. Figure 5 shows the change in fish stock biomass over time. If there were perfect control of fishing effort and enforcement, the change of fish stock is nothing to do with supports of subsidies and a target stock biomass can be achieved under any case.

Fishermen can increase their fishing efforts (fishing days) per trip with subsidies. However the number of trips over the season decreases due to the season length ($D_{MAX}$) under the perfect control of fishing effort and enforcement. That is, the total fishing efforts are the same under any case when with subsidies and with no subsidies if there were perfect enforcement. Subsidies could make fisherman' s income increase as shown in Figure 6. As the amount of subsidies increase, fishing profits increase as well. As a conclusion, subsidies would help fishermen to maintain viable fishing activities, especially when fishermen are at the subsistence level without adverse impacts on the fish stock.

Subsidies could be seemed to cause directly the fish stock to decline as the former studies concluded. However this is *only* when there is imperfect enforcement. If there were perfect control of fishing effort and enforcement, the subsidies do not cause the decline of fish stock. On the contrary, subsidies could improve the condition of fisherman' s fishing activity.

## 4. The impacts of subsidies on fish stock under output control

To analyze the relationship between management regulations and the subsidies on the sustainability of fish stocks, let' s analyze the impacts of subsidies on the sustainability of fish stock under output control. The impacts of subsidies were investigated under Total allowable Catch (TAC) regulation. For a more realistic analysis, the annual variable target TAC to achieve a target stock biomass ($B_{MSY}$) in a 20-year period was included in the model analysis. Following Hilborn and Walters (2001), an annual target TAC was assumed to be a linear function of the biomass over rebuilding period as follows:

$$TAC_t = a + b \cdot X_{t-1v} \tag{19}$$

Here, if $X_{t-1} > X_{min}(=a/b)$, $a + b \cdot X_{t-1}$, otherwise, TAC is determined at zero. Therefore, the target stock biomass given population dynamics and TAC rule can be expressed as Figure 7. The TAC rule is assumed to be TAC = −22,394 + 0.253 · X and the target stock biomass at the level of MSY given the growth function and the TAC rule is estimated to be 150,000[5] and Xmin is equal to 89,576.

Under TAC regulation, the level of fishing efforts (fishing days) per trip (e*) and the number of trips (T) with no subsidies are as follows:

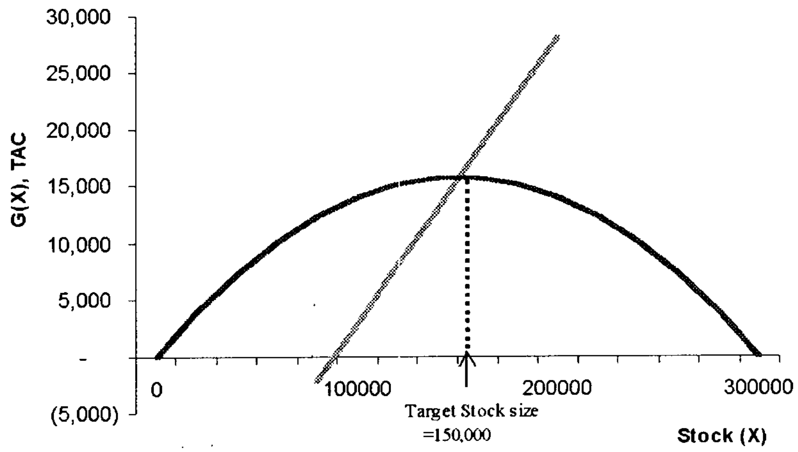


**Figure 7. A Target Stock Biomass and the TAC rule**

5) The target stock size is determined at the point where the growth function is equal to the TAC rule. In other words, Target stock size (X*) is that G(X) = TAC rule (a + b · X).
Therefore, $X^* = (r - b) + \sqrt{(b - r)^2 4 - a \cdot r / K} / 2 \cdot r / K$

$$e^* = \frac{p \cdot q \cdot X - b}{2 \cdot c} \tag{20}$$

$$T = \frac{TAC_t}{2^* \cdot q \cdot X \cdot N} \tag{21}$$

On the contrary, the level of fishing efforts (fishing days) per trip ($e_{SUB}^*$) and the number of trips ($T_{SUB}$) with subsidies are:

$$e_{SUB}^* = \frac{[p \cdot \gamma] \cdot q \cdot X - a \cdot b}{2 \cdot c \cdot \alpha} \tag{22}$$

$$T_{SUB} = \frac{TAC_t}{e_{SUB^*} \cdot q \cdot X \cdot N} \tag{23}$$

Because the level of fishing efforts (fishing days per trip), $e_{SUB}^*$, with subsidies is greater than the level of fishing efforts with no subsidies, e*, the number of trips, TSUB is smaller than the number of trips, T, given an annual target TAC ($TAC_t$).

If there were perfect control of fishing efforts and enforcement, the fishing profits in the fishery would increase as the fish stocks increase. Consequently, additional vessels would enter the fishery at the rate of entry/exit coefficient assumed in this model.

Figure 8 shows the change in fish stock over time under the TAC regulation. If there were perfect control of fishing effort and enforcement, the fish stock increases over time to a target stock size regardless of the amount of subsidies.

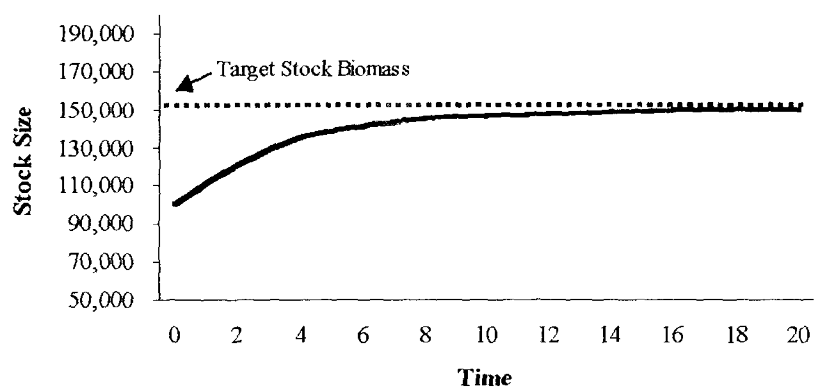


**Figure 8. The change in fish stock over time under the TAC regulation**

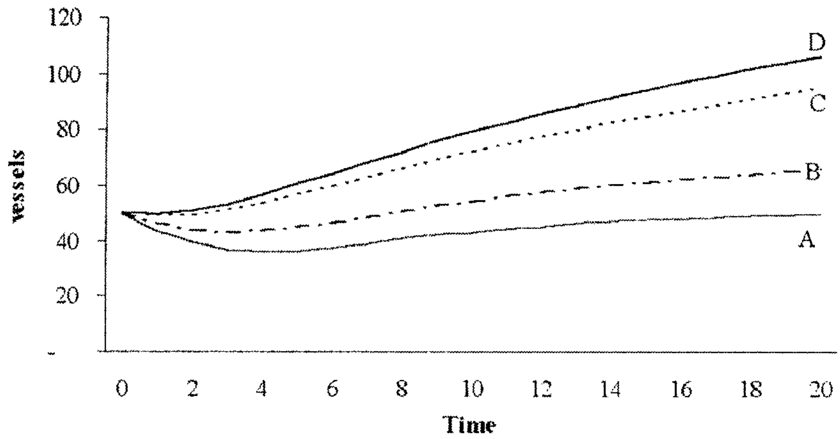


**Figure 9. The change in the number of vessels by different level of subsidies under output control (TAC)**

In other words, the fishing efforts per trip increase as the amount of subsidies increases, however the number of trips decrease to achieve an annual target TAC under the perfect enforcement. As a result, the target stocks biomass could be achieved regardless of the amount of subsidies. Figure 9 indicates the change in the number of vessels by different level of subsidies under the TAC regulation.

The number of vessels increase over time due to the increase in the stock biomass. Whereas the amount of subsidies increases, the more vessels could enter the fishery due to the reduced fixed cost and operating costs, and the increased price by subsidies as shown in Figure 9. As same as analyzed in input control, subsidies do not have any negative impacts on the sustainability of fish stocks. Instead, it makes the fisherman' s fishing profits increase and make more vessels enter the fishery, which could increase the opportunity of employment if there were perfect control of fishing efforts and enforcement.[6]

6) Under the IQ management regulation, a fisherman can have a quota share ( $=\frac{TAC_t}{N_t}$ ) and he can decide his own fishing activity with an allocated quota. If there were perfect control of fishing effort and enforcement, the stock biomass will increase to the target stock biomass as exactly the same as the result of TAC regardless of the amount of subsidies. However, the subsidies could help small-scale fishermen to maintain their fishing activities under IQ. One of shortcomings of IQ is that if the average variable cost is greater than the marginal revenue from a distributed quota, a fisherman can not continue to harvest. As a result, this might cause small-scale fishermen to leave the fishery.. But, fishermen could maintain fishing activities soundly with subsidies. On the contrary, it will help fishermen' s fishing activities to be viable and stable, and ultimately it can also lead to develop sustainable fisheries.

Fishermen might seek to increase avoidance fishing activities to maximize fishing profits under the fisheries regulations. If there were no perfect enforcement, fishermen would expand their level of fishing efforts, which prevents the management goal from achieving a target stock biomass. In addition, as the amount of subsidies increases, the stock biomass becomes much lower by making fishermen increase fishing efforts further. In conclusion, subsidies have negative impacts on the sustainability only if there are no perfect control of fishing effort and enforcement.

## Ⅳ. Summary and Conclusion

The studies investigating impacts of fisheries subsidies on the sustainability of fish stocks so far tentatively concluded that the subsidy like cost-reducing and revenue-increasing subsidies would lead the level of fishing efforts to increase. That might mainly cause the fish stock to decline and/or deplete by loosely comparing global fishing revenues and costs. However, they didn' t consider the characteristic of fisheries environment in a country such as the characteristic of fishermen and the steps of development of fisheries economy, just assumed that the condition of fisheries in the world are homogeneous. In addition, they failed to consider the relationship between the subsidies and the fisheries management regulations in analyzing the impacts of subsidies on fish stock. They didn' t consider the operation of fisheries management regulation for sustainability of fish stocks, they attributed the depletion of fish stock directly to subsidies.

We have analyzed the impacts of fisheries subsidies on the sustainability of fish stocks under the open access, input control, and output control with assumption that declines of fish stocks have been derived not directly from subsidies, but primarily from ineffective fisheries management and imperfect enforcement. According to results, fishermen could expand fishing efforts with a support of subsidies in the case of open access. It surely caused negative impacts on the sustainability of fish stocks. What is worse, as the amount of subsidies increased, the fish stocks were declined more seriously as the former studies of fisheries subsidy concluded. However, if there were perfect control in fishing efforts and enforcement under the management regulations, the fish stocks were not affected by subsidies. That is, the conclusion of former studies is true only there are imperfect control of fishing effort and enforcement under management regulations and under open access. On the contrary, subsidies could allow fisherman' s income and the number of employment to increase depending upon occasions.

In conclusion, the subsidies- especially 'bad' subsidies - do not directly cause the stock biomass to decline unlike the former studies concluded. When 'bad' subsidies are provided properly and necessarily in response to the condition of fishing industry and the characteristics of fishermen, it can have positive impacts on fishing income without having any adverse impact on fish stocks.

## References

FAO. *Marine Fisheries and the Law of the Sea: A Decade of Change-Special chapter (Revised) of the State of Food and Agriculture* 1992, Rome. 1993.

FAO. *Ad Hoc Meeting of Intergovernmental organizations on work programs related to subsidies in fisheries*, FAO Fisheries Report, No. 649, 2001.

FAO. *Expert consultation on economic incentives and responsible fisheries*, FAO Fisheries Report, No. 638, 2000.

World Bank. *Subsidies in World Fisheries*, World Bank Technical Paper, No. 406, 1998.

Kuperan K. and Nik Mustapha Raja Abdullah. Small-scale coastal fisheries and co-management, *Marine Policy*, 18 (4), 1994.

Hilborn R. and C. J. Walters, *Quantitative Fisheries Stock Assessment,* Kluwer Academic Publishers, 2001.

Pomeroy, R. S. Small-scale fisheries management and development: Toward a community-based approach, *Marine Policy*, 1991.

Anderson, L. G. Open access fisheries utilization with an endogenous regulatory structure: An expanded analysis, *Annals of Operations Research*, 94, 2000.

Schrank, W. E. and W. R. Keithly. The Concept of Subsidies, *Marine Resource Economics*, Vol 14, 1999.

Clark, C. W., Toward a Predictive Model for the Economic Regulation of Commercial Fisheries, *Can. J. Fish and Aqua. Sci.*, 37, 1980.

Quinn, T. J. and R. B. Deriso, *Quantitative Fish Dynamics*, Oxford University Press, 1999.

Subsidies: Are they really obstacles in achieving a sustainable fisheries development?

# 수산보조금 : 과연 지속가능한 어업발전을 위한 장애물인가?

이상고 · 김도훈*

## 요 약

지속적인 어업자원 이용에 대한 수산보조금의 역할을 분석한 기존 연구들은 단순히 세계 전체적이거나 국가별 총어업수입과 총어업비용만을 고려하여 잠정적으로 비용절감형 또는 수입조장형 보조금이 어획노력량 수준을 증가시켜 어업자원의 감소를 부추기거나 남획을 초래했다고 결론짓고 있다. 또한 어업의 특성상 어업에 있어서 각종 규제수단이 사용되고 있음에도 불구하고 이들 수단들의 효과와 보조금과의 관계를 분석하지 못함으로써 어업자원에 대한 보조금의 영향을 명확하게 설명하지 못하였다.

본 연구에서는 어업에 있어서의 각종 규제수단의 사용에 따른 보조금의 영향을 국제적으로 권고되고 있는 생물경제모델을 이용하여 분석함으로써 보조금이 어업자원에 미치는 영향을 살펴보았다. 분석결과에 따르면, 기존 연구들의 잠정적인 결론은 관리수단조치가 전혀 이루어지지 않거나, 이루어지더라도 불완전하게 어획노력량 등이 통제될 경우에만 타당한 것으로 나타났다. 반대로, 관리수단 하에서 어획노력량 등에 대한 감시 및 통제가 완벽하게 이루어질 경우에는 기존 연구결과와 달리 수산보조금이 어업자원에 부정적인 영향을 미치지 않는 것으로 분석되었다. 오히려 일반적으로 부정적인 것으로 취급되는 보조금의 경우도 어업상황에 따라서는 어업자원에 대한 부정적인 피해 없이 어업에 긍정적인 영향을 줄 수 있는 것으로 나타났다.

Key words : Impacts of fisheries subsidies, Imperfect fisheries management, Measures of fisheries management, Stock biomass