Short Bio

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Sustainability of the Sardine Fishery in Zamboanga: A Bioeconomic Approach

Jovi C. Dacanay

Abstract

Overfishing is claimed to be a phenomena in the Philippine fishery. Coastal fishing countries have resorted to coastal management programs, among which includes the establishment of individual transfer quota schemes. Contrary to expectations, fishing countries have cooperatively established relatively effective international management plans for a few stocks of fish known as highly migratory species (HMS), such as tuna, mackerel and sardines. These successes have been sporadic and belated, but fishing countries have been able to curb effort targeting certain fish stocks, reducing the rate of extraction. This in turn has allowed the population, or biomass, of these stocks to rebuild to more productive levels. For instance, scientifically based catch limits have been adopted in some cases, along with quota distribution systems. Moreover, the development of trade-based monitoring and enforcement mechanisms has improved compliance, although the equitable implementation of such measures remains problematic to this day. The Philippines, however, is still in the process of reducing the rate of extraction in order to allow fish stock to reach their maximum size.

The maximum sustainable yield for Philippine capture fisheries was estimated at 1.9 million metric tons based on a scientific consensus since the 1980s. The central question of the study revolves around the following: Will a 1.9 million metric ton maximum sustainable yield for the Fishery in the Philippines sustain a commercially profitable sardine industry in Zamboanga? A consequence of this estimated maximum sustainable yield is that roughly a 128,250 (45%) metric ton annual yield for all deep sea coastal sardine fishing firms in Zamboanga city will have to be sustained or achieved.

The key area for study consists, therefore, is how a quota scheme would be successfully implemented given heterogeneity in the yield capacity of municipal and deep sea coastal fishing vessels, and, effort or labor hours devoted by fishermen. The technology involved in fishing has not changed significantly, thus, production processes have not altered. But man-hours devoted to fishing has increased, with the high possibility of exhausting fish stock. Currently, the Zamboanga fishery has opted for a 5-month closure.

The study uses the standard bioeconomic model formulated by Gordon (1954) and Shaeffer but adapted to incorporate a monetized yield function due to the inaccessibility of sardines biomass data. With the use of a representative firm's data on monthly yield per catcher vessel and price from 1996 to 2007, a monetized yield function was constructed and estimated using seasonality of catch and effort as explanatory variables. Anderson (1976) used the same variables in order to denote productivity of effort and technological capacity of the vessels. These variables would be akin to the use of capital and labor to explain yield, thereby using the production function to explain harvest. The regression estimation procedure yielded effort levels which would allow the participating firms to achieve a 4.3% net profit level while limiting catch to allow the fishery to maintain its planned maximum sustainable yield of 128,250 metric tons, an estimate from the 1.9 million metric tons for the Philippine fishery. The results show the feasibility of implementing an individual transferable quota scheme for the Zamboanga fishery, a more sustainable policy than the currently implemented 5-month closure of the Zamboanga fishery.

1. Introduction

Overfishing is claimed to be a phenomena in the Philippine fishery. Coastal fishing countries have resorted to coastal management programs, among which includes the establishment of individual transfer quota schemes. Contrary to expectations, fishing countries have cooperatively established relatively effective international management plans for a few stocks of fish known as highly migratory species (HMS), such as tuna, mackerel and sardines. These successes have been sporadic and belated, but fishing countries have been able to curb effort targeting certain stocks, reducing the rate of extraction. This in turn has allowed the population, or biomass, of these stocks to rebuild to more productive levels. In fact, many of the same distributional issues that plague other multilateral environmental regimes have been overcome within the HMS microcosm. For instance, scientifically based catch limits have been adopted in some cases, along with quota distribution systems. Moreover, the development of trade-based monitoring and enforcement mechanisms has improved compliance, although the equitable implementation of such measures remains problematic to this day.[1]

Area of Concern. The key area for study consists, therefore, in how a quota scheme would be successfully implemented given heterogeneity in the yield capacity of municipal and deep sea coastal fishing vessels, and, effort or labor hours devoted by fishermen. The technology involved in fishing has not changed significantly, thus, production processes have not altered. But man-hours devoted to fishing has increased, with the high possibility of exhausting fish stock.

The maximum sustainable yield for Philippine capture fisheries was estimated at 1.9 million metric tons[2] based on a scientific consensus since the 1980s. The central question of the study revolves around the following: will a 1.9 million metric ton maximum sustainable yield for the Fishery in the Philippines sustain a commercially profitable sardine industry in Zamboanga? A consequence of this estimated maximum sustainable yield is that roughly a 128,250 (45%) metric ton annual yield for all deep sea coastal sardine fishing firms in Zamboanga city will have to be sustained or achieved.

Problem Statement. Would an equilibrium level of effort be achieved in the open access fishery of Zamboanga given a restriction of having to operate the fishery in such a way as to achieve a maximum sustainable yield of 1.9 million metric tons for the Philippines or a consequent 128,250 metric ton annual yield for the Zamboanga fishery.

Limitations of the Study. The study is limited by data as only a monthly sardine yield of a representative company has been obtained. Besides the computation of an equilibrium level of effort can only be done for a single specie. Another is that sardines is a highly migratory small pelagic specie. Usual studies of maximum efficient yield have to consider the entire fishery as the specie concerned covers the entire coastal area of the Philippines. However, the yield data covers almost half of the coastal area of the Philippines, thus, enough area would be covered by the data.

Objectives of the Study. The study aims to: first, describe the representative firm's activity in the Zamboanga Sardine Fishery in terms of effort levels and yields through time; second, to determine the initial conditions on yield and effort which may encourage cooperation on the operationalization of an individual transfer quota scheme for the fishery.

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[1] Webster, D. G. (2007). "Leveraging Competitive Advantages: Developing Countries' Role in International Fisheries Management**."** ***The Journal of Environment Development***. Volume 16. 8-31
[2] Barut, Noel C., Mudjekeewis D. Santos, Len R. Garces. (2004). "Overview of Philippine Marine Fisheries." ***In Turbulent Seas: The Status of Philippine Marine Fisheries***. Department of Agriculture Bureau of Fishery and Aquatic Resources. pp. 22-31

Literature Review. The study follows the theoretical approach of Gordon (1954), Anderson (1976) and Turvey (1987) as all three authors make use of the standard production function as a basis to analyze the relationship between yield, effort and technology and the combination of all three factors to output restriction. This approach enabled the researcher to relate the fishery with competitive industry behavior as this relationship would denote initial conditions in the operationalization of individual transfer permits or quotas, a mechanism that directly regulates output or catch, and thus, indirectly restricts effort rather than technological factor inputs and vessel capacity. It creates property rights in the fishery. The study also incorporates the effect of specie migration, annual fecundity of the fishery, ocean currents, food supply, etc., through the inclusion of output or harvest seasonality into the production function.[3] This incorporation follows the result of the study done by Granada (2008) in her study of sardine fishery productivity in Zamboanga. An explanation of their approach shall follow.

2. Theoretical Framework

The study makes use of the standard bioeconomic Gordon-Shaeffer model for analyzing both positive and normative questions about exploiting a fishery. This bioeconomic approach implies that the study combines two elements: the biology of fisheries growth and decline and the behavioral consequences that flow from economic decisions made by humans, specifically, fishermen involved in the fishery. The economic analysis of the fishery incorporates the biological results explaining fish stock along with the interpretation of fish stock depletion in the form of a production function and corresponding effort levels or labor/man-hours. While fish stock is renewable, an increase in effort may eventually decrease available fish stock and cause the depletion and possible extinction of the specie. Thus, the analysis of the fishery entails the analysis of a depletable renewable resource, that is, the effort of one fisherman affects the yield of other fishermen and stock of fish or biomass. A production externality, therefore, happens.

The framework then would have to relate the fishery, with competitive industry behavior, and, diseconomies thereby comprising the areas which would provide the initial conditions to operationalize the restriction of effort to achieve maximum sustainable yield for the fishery.

The production function for the fishery. The optimum degree of utilization of any particular fishing ground is defined as that which maximizes the net economic yield, the difference between total cost, on the one hand, and total receipts (or total value production), on the other. Total cost and total production can each be expressed as a function of the degree of fishing intensity or, as the biologists put it, "fishing effort," so that a simple maximization solution is possible. Total cost will be a linear function of fishing effort, if we assume no fishing-induced effects on factor prices, which is reasonable for any particular regional fishery. We shall assume that, as fishing effort expands, the catch of fish increases at a diminishing rate but that it does so because of the effect of catch upon the fish population.[4]

The fishery and the fishing industry. There is a need to relate the firm[5] and industry in a common property fishery and to compare and contrast it to the standard analysis. Most of the previous work in this area (Gordon 1954, Anderson 1973) has been in

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[3] Granada, Ma. Lourdes Carmela Ciocon (2008). "How can we be sustained? A study on yields and seasonality for sardines production." A Masteral Thesis Submitted to the Industrial Economics Program of the School of Economics. University of Asia and the Pacific. (May 2008)

[4] Gordon, H. Scott. "The Economic Theory of a Common-Property Resource: The Fishery." ***The Journal of Political Economy***. Vol. 62. No. 2. (Apr., 1954). pp. 124-142.

[5] Gordon analyses the fishery in terms of a monopoly situation for the industry.

aggregate terms only. In the model developed by Smith (1968, 1969), however, the operation of the firm is directly taken into account. The analysis to be used would follow that of Anderson (1976) wherein the level of fishing effort is computed as the output of the individual vessels rather than on the catch.[6] This change in the frame of reference will make the analysis of vessels in a fishery strictly analogous to the standard firm-industry model and more important, more logical and empirically more useful. It is more logical because, as the discussion to follow will show, while vessels can directly control fishing effort, they can only indirectly control vessel catch rate. This model is empirically more useful because it allows for the use of biological and physical information in a form already provided by fishery scientists and fishery management organizations. As Gordon (1955) has pointed out in his now classic article, the unregulated fishery will, under normal circumstances, reach an equilibrium where industry profit is equal to zero. As long as a positive industry profit exists, vessels will be encouraged to enter the fishery and utilize the stock, and with common property there is nothing to prevent them from doing so.

The monetized sustained yield curve is ordinarily used as the long-run production function of the industry, called net benefit function. Therefore, the traditional analysis is necessarily long run in that it assumes complete stock adjustment to changes in the level of effort. Assuming that the price of fish (*PF*) and the cost of producing a unit of effort (*cE*) are constant, the profit function for the fishery is:

Net Benefit = (Total Revenue + Consumer Surplus) – (Total Cost – Rent)

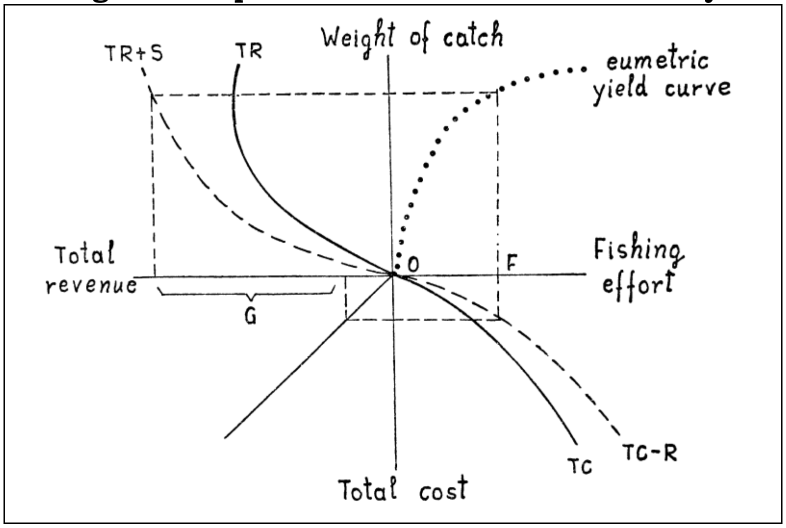
G = (Price of Fish * Weight of Catch) – (marginal cost * effort – rent)

$$G = (TR + S) - (TC - R)$$

From Figure 1, point F refers to the equilibrium level of effort such that net benefit is maximized whose level is G. Note that point F is also the point of maximum economic yield. Open access equilibrium, on the other hand, may reach up to the point where revenue is just equal to cost thereby allowing G to reach zero.[7]

[6] Anderson, Lee G. (1976). "The Relationship between Firm and Fishery in Common Property Fisheries." ***Land Economics***. Vol. 52. No. 2 (May, 1976). pp. 179-191
[7] Turvey, Ralph (1964) "Optimization and Suboptimization in Fishery Regulation." ***The American Economic Review***. Vol. 54. No. 2. Part 1 (Mar., 1964). pp. 64-76

Figure 1. Equilibrium Condition of the Fishery



Source: Turvey (1964)

As a first step in the integration of this analysis with the classical theory of the firm, consider the fact that production, and hence revenue, from the fish stock are essentially industry-wide phenomena. There is free entry into the industry. Total sustainable yield is a function of total effort and stock size. But since the latter is a function of effort, sustainable yield is determined solely by total effort given the ecological parameters. Therefore, as long as there are many vessels, each of which can provide only a small percentage of total effort, the vessels must take average catch per unit of effort as a parameter determined by the fishery as a whole. This is analogous to competitive firms taking price as a parameter determined by the industry as a whole. On the other hand, cost is a firm phenomenon. Neglecting crowding externalities, the cost of providing effort is determined by the scale (size of vessel) and level of operation (days of fishing, etc.) of the firm. The reason the traditional analysis uses a constant cost of providing effort is that it is essentially a long-run analysis which assumes that any change in the level of effort is the result of a change in the number of efficiently operating vessels.

Explanation of cost functions. The individual boat has no direct control over its catch in the same way a normal firm has control over its output. The vessel can, however, directly control its production of effort which, given the average catch per unit of effort as set by the interaction of the total fishery-wide level of effort and the size of the fish stock, will determine its total catch. All of this, of course, assumes that each boat cannot significantly affect the amount of total effort. As pointed out above, effort can be measured in standardized days fished, but in some cases, other measures such as days out of port, number of times nets are set and retrieved, number of traps that are tended, etc., each properly standardized, would be more appropriate.

Equilibrium Levels. Open-access equilibrium of the fishery will occur at the point where the average return to effort is just equal to the minimum average cost of producing effort by the representative vessel. If there were fewer vessels, the fishery-wide supply curve would shift to the left increasing the average return to effort. Each vessel would respond to this by increasing its level of effort until marginal cost equaled perceived price. The existence of greater than normal profits would, however, encourage entry of new vessels until average industry return is pushed down to the minimum average cost.

A necessary but not sufficient condition for the industry, thought, is that each fisherman tries to maximize yield at each level of effort. Therefore, mesh size and vessel capacity are chosen such that maximum yield would be attained. With this behavior, each fisherman harvests with the objective of maximizing net benefit, i.e. reaching the maximum economic yield. Maximum economic yield is where the value produced by the marginal unit of effort is just equal to the long-run marginal cost of producing it.[8] Assuming no crowding externalities, the long-run marginal cost curve of the fishery will be constant and equal to the minimum of the average cost curve of the representative firm, i.e., additional effort can be assumed to be provided by additional boats each operating at the minimum of their average cost curves.

As a final point, note that this model allows one to describe the long-run cost curve of the fishery. Open-access equilibrium effort will be produced as efficiently as possible because ultimately, any expansion will take place in the form of new units producing in an optimal fashion.

Event of an Externality in the Fishery. Fishery regulation is one of those spheres of economic policy where what is best to do depends on what can be done. The analysis is that of only one fish stock, fished from ports which supply a common market and which are equidistant from the fishing ground.[9] It is assumed that the port market is competitive and that there are no restrictions on entry into the fishery. These assumptions serve to make the exposition reasonably simple; their removal would not destroy the essential argument of the paper.

Fishing effort is a variable cost and that changes in mesh size will not significantly alter the cost structure. Determinants of the weight of catch, under these assumptions, are twofold, given constant natural population parameters. The first is the rate of capture of the fish liable to capture, which is proportionate to the amount of fishing effort. The second determinant of the weight of catch is the size or age at which the fish become liable to capture, that is, are recruited to the fishery. An increase in the catch of one fisherman, which is proportionate to the level of his effort, creates a diseconomy for other fishermen in the industry. An improvement in their ability to catch more fish would mean lesser amount of fish to be caught by other fishermen. Thus, the marginal private product of a fisherman with better yield capacity is greater than the marginal social product. If each fisherman would improve harvest capacity, then effort would shift further to the right of the yield curve, greater costs would be incurred as effort is proportional to labor cost, net benefit would decrease.

Mathematically, this relationship would imply that effort levels would be maximized up to the point that revenues would be equal to cost. This is achieved by fishermen adopting the most appropriate technology to improve catch. The linearized revenue function would be denoted by:

$$\text{Revenues} = f\,(\text{effort, seasonality, price ratio of Corporation with Zamboanga}) \qquad (1)$$

$$\text{Revenues} = \alpha + \beta_1 \text{ effort} - \beta_2 \text{ effort}^2 + \beta_3 \text{ seasonality} - \beta_4 \text{ price ratio} \qquad (2)$$

The monetized yield curve, also called the revenue function, is linear with respect to effort. A quadratic level of effort is also incorporated into the function in order to capture the behavior that revenues increase at a decreasing rate whenever effort is increase.[10] The incorporation of seasonalities and a price ratio captures the intent of fishermen to increase

[8] Anderson (1976)
[9] Turvey, Ralph (1964)
[10] Anderson (1976)

harvest capacity through lowering cost with better technology as well as scheduling harvest only when stocks are abundant.

Adapting the bioeconomic model of the fishery to the information available on the firm, sardine prices and the Zamboanga sardine industry would require an enumeration of certain assumptions. These are:

(1) Perfect competition as the market structure of the sardine industry in Zamboanga. Also, firms operate across the entire fishery as sardines are migratory and they harvest in areas where the sardines are in abundance.

(2) Price of sardines is exogenous to the industry, that is, no firm is dominant enough to influence prices

(3) Firms are operating in order to achieve sustainable yield, that is, they are operating along the yield curve

(4) Labor is an important input factor.

These assumptions imply that one can use the analysis of a representative firm in order to understand the dynamics of open access equilibrium, and, that an equilibrium level of effort may be reached.

3. Empirical Method

The abovementioned assumptions have empirical implications and are verified in the data:

(1) The absence of a dominant firm(s) and exogeneity of prices would imply that varying effort levels may converge towards a range of revenues. Reason: effort levels would range from the maximum efficient yield up to the open access equilibrium level of effort. From the data, it can be observed that most effort levels can be found within the Zamboanga yield of 117,000 to 134,000 mt. (See Figure 2)

(2) Labor is an important input factor and accounts for 69% of factor inputs for the deep sea coastal fishing industry (See Figure 3). The ability of fishermen to denote areas with abundant sardines is an important skill as seasonality of catch happens regularly in the representative firm's fishing grounds (See Figures 4a and 4b). The seasonality of the fishing grounds coincides with the seasonality of catch per vessel. However, during the month's of September and October, fishermen seem to be concentrating on Sulu, Basilan and Palawan in order to prolong the catch season up to October. Some fishing grounds do not show the same level of catch as the three areas mentioned.

(3) The top 2 firms in the industry contributed less than 25% of revenue market share as of 2005, and the next 6 contributed close of 50%, or, eight firms account for 75% of total revenues in the industry (See Figure 5). The top firms also do not differ in their range of prices during peak and off-peak seasons (see Table 1). This market share composition and pricing behavior do not seem to denote the presence of dominant firms, and,

(4) The representative firm's revenues also converge along a specific range of revenues. (See Figure 6)

Figure 2

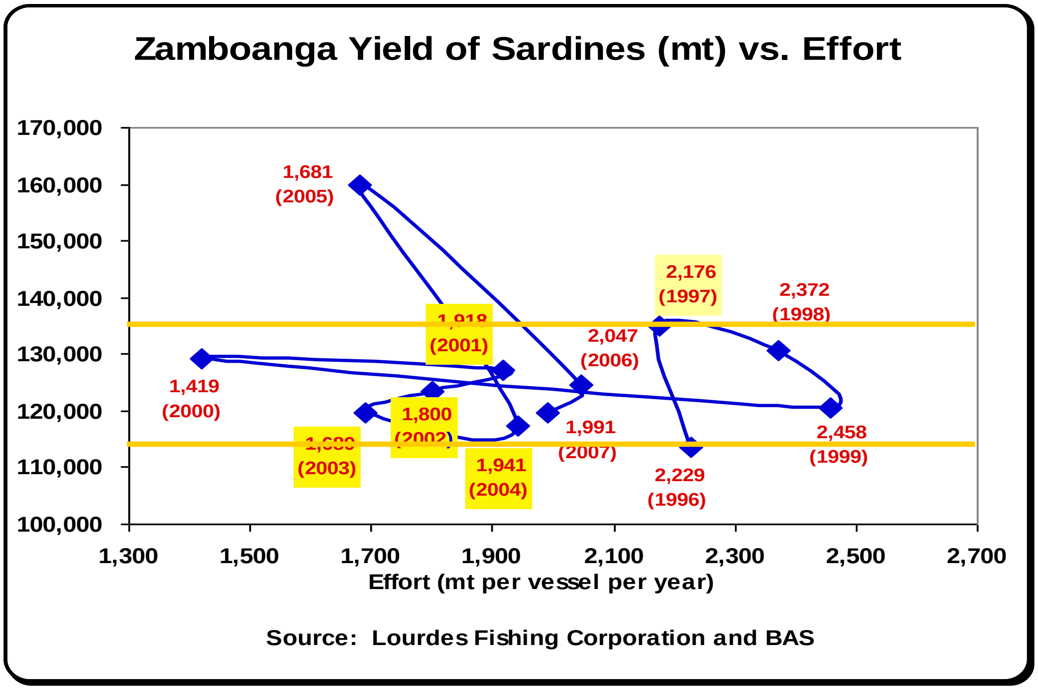
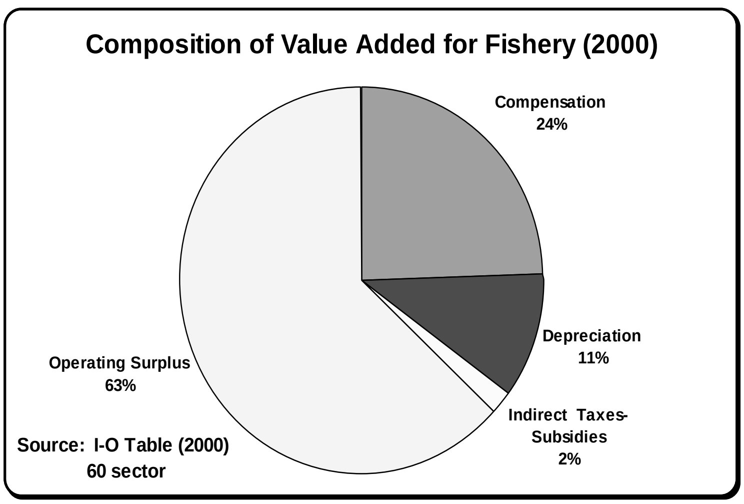


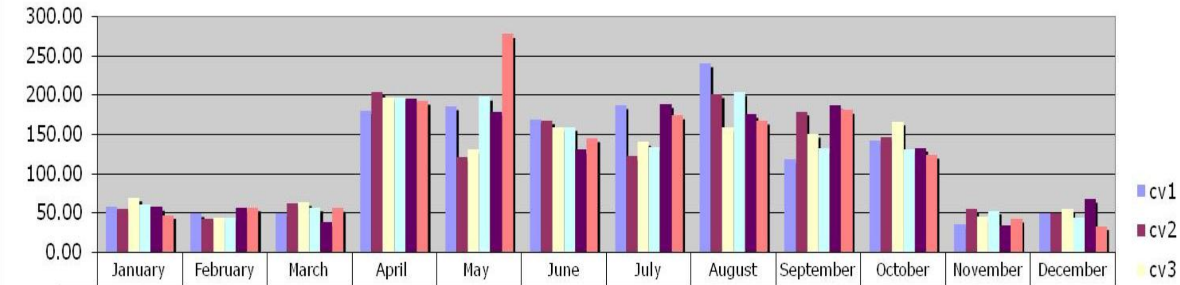
Figure 3



The seasonal indexes are shown in Figure 4a, wherein 100 is the average catch for each vessel for the entire period. Fluctuations that occur on the same month are usually referred to as seasonal factors in the industry, which may be due to the migration pattern of sardines and other fish species in those specific months. The column graph shows that the first three months of the year and the last two are usually below the average while the rest is highly above average. The peak clearly hit in April and August and lasts until October, while the lowest month occurs mostly in November which has the lowest index of only 34.99. In general, therefore, the seasonal pattern of sardines yield implies that on the average January to March and November to December volume of production is only 30-69% of the average for the year, or equivalently 30% less than the average.[11]

[11] Granada (2008)

Figure 4a. Seasonal Indexes of Catch or Harvest of the Six Catcher Vessels (CVs)



	January	February	March	April	May	June	July	August	September	October	November	December
cv1	56.94	49.12	49.74	180.11	184.88	168.60	186.54	239.72	117.16	142.06	34.99	49.16
cv2	54.66	42.70	61.60	203.57	120.13	167.06	121.68	200.35	178.45	146.01	54.18	49.46
cv3	68.90	42.85	63.00	196.68	129.84	158.01	139.99	158.07	149.93	165.82	44.52	54.39
cv4	60.30	43.99	56.56	196.80	197.29	158.64	133.68	203.13	131.35	130.50	52.61	44.19
cv5	57.21	55.99	37.43	195.06	178.02	130.25	187.97	175.37	186.12	132.41	33.66	67.43
cv6	46.92	56.42	55.85	192.02	276.90	144.36	173.47	166.69	180.32	123.36	42.16	32.50

Source: Lourdes Fishing Corporation

The seasonal index (See Figure 4b) for fishing grounds shows that the first three months and the last two months of the year are usually below the average months, while the rest especially April and August are above average. It also shows that the returns in yields in Sulu Sea is greater than the other fishing grounds for most of the months. All fishing grounds January to March and November to December yield low catch. For the low catch season, the fishing ground of the Visayan Sea shows that during lean months, it produces the greatest in terms of yields, especially in December and January. The rest of the fishing ground fairly produces the same in yields but it reveals that if the Sulu Waters is one of the most productive ground to catch during the peak months, it conversely shows to have the least production during the lean season of sardines catch. The fishing areas in Moro Gulf and Basilan Strait are also one of those waters that produces large catch during the peak season.[12]

The seasonality indexes and the trend of catch (see Figures 4b and 4c) show that Sulu Sea is an area with abundant biomass of fish. This in turn explains why the Sulu Waters is a target fishing ground to be closed down by the country's fishing agency.[13] The large area and depth of Sulu Sea also explains the reason for the abundance of catch. According to the Tropical Research and Conservation Centre, its reefs feature gradually sloping underwater terrain to vertical walls that drop to 1,000 meters compared to other fishing grounds with less depth such as the Basilan Strait. Moro Gulf's fishing ground exhibited cycles with peaks occurring in 1996, 1999 and 2005. The cyclical occurrence of the Southwest monsoon from September to October and the resulting migration patterns of sardines may explain this trend.[14]

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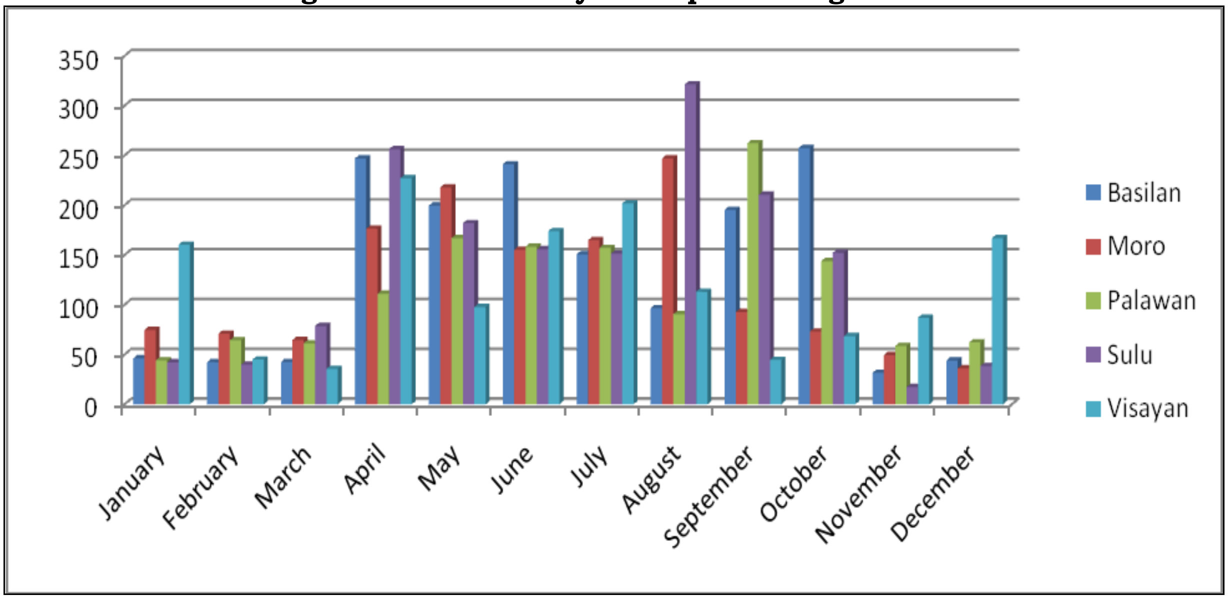
[12] Granada (2008)

[13] Wee, Darwin T. "Annual Sulu Sea fishing ban eyed." ***BusinessWorld***. April 22, 2008

[14] Granada (2008)

Figure 4b. Seasonality Index per Fishing Ground



Source: Lourdes Fishing Corporation

Figure 4c. Trend of Harvest per Fishing Ground

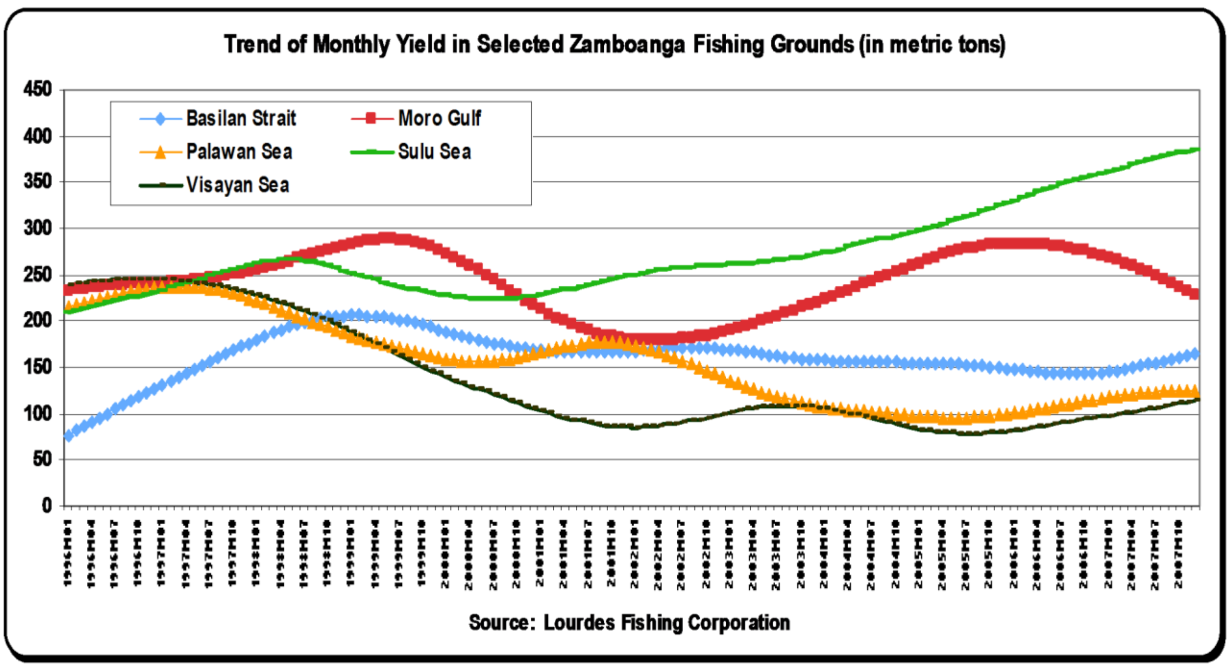
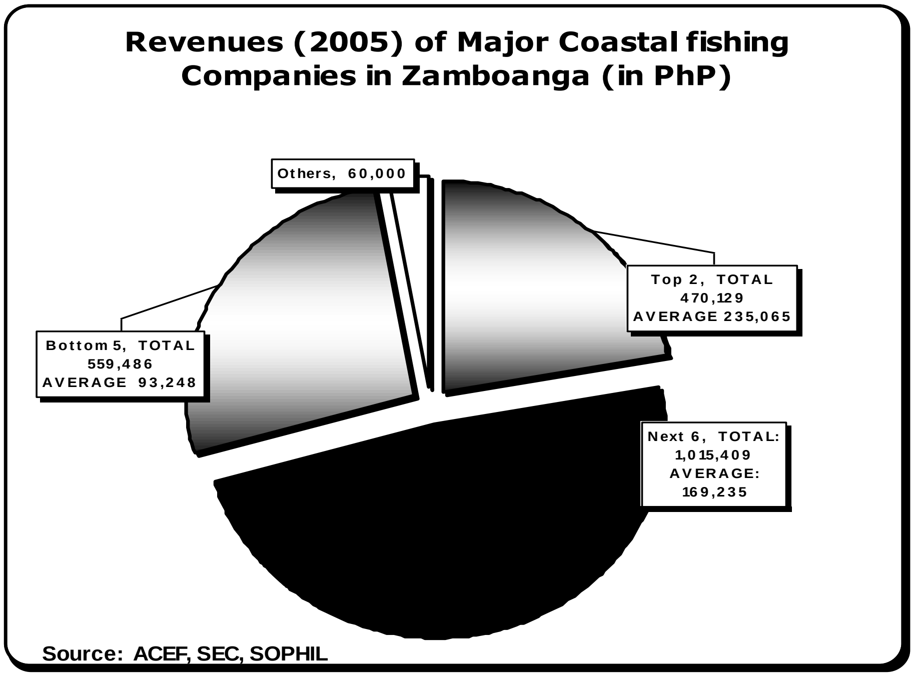


Figure 5



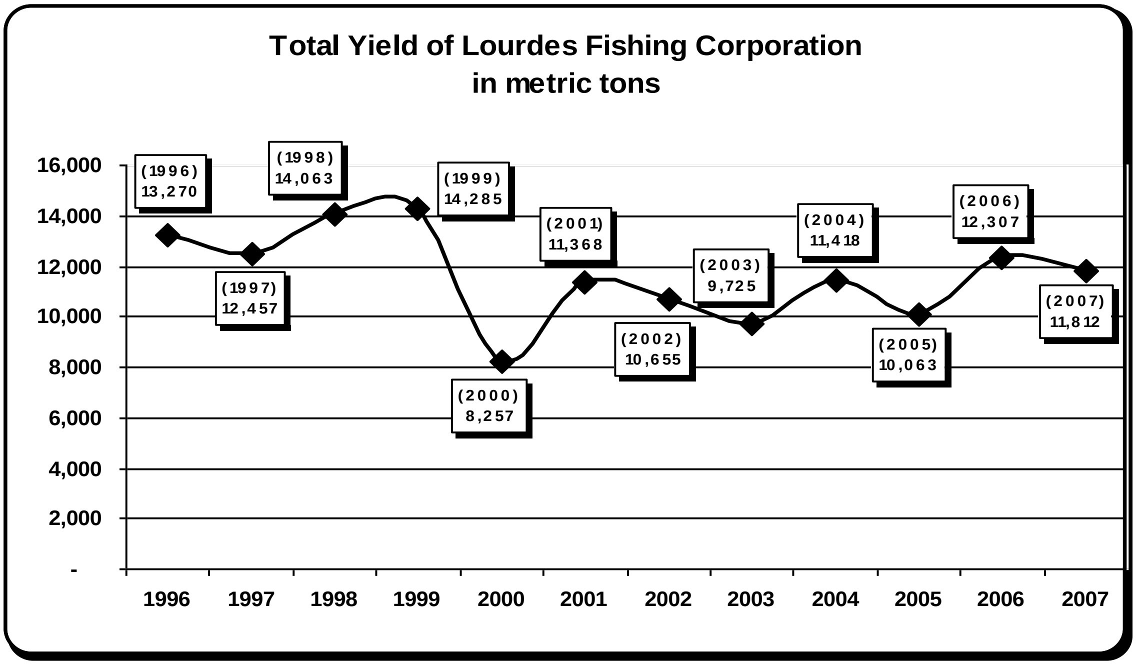
This market share composition in Figure 5 and pricing behavior in Table 1 do not seem to denote the presence of dominant firms. The analysis can therefore proceed with the assumption that perfect competition seems to be the prevalent market behavior of the industry participants.

Table 1. Selling Price of Fishing Firms to Canneries (1998)

Industry Players	Price Range (Php)	
	Off-Peak Season	**Peak Season**
YL Fishing Corporation	Php 12-14	Php 10-11
Mega Fishing Corporation (Mega)	PhP 12-13	Php 9-10
Oceanic Fishing Ventures	Php 12-15	Php 8-9
Zamboanga Universal (555)	PhP 12-16	Php 10-11
Century Fishing Corporation	Php 12-15	Php 9-11
Lourdes Fishing Corporation	Php 12-14	Php 9-11
Nany Fishing Corporation	Php 12-13	Php 9-10
E&L Fishing Corporation	Php 12-15	Php 9-12
Toprose Fishing Corporation	Php 12-14	Php 10-11
OLC Fishing	Php 12-13	Php 9-10
Jordan Fishing	Php 12-15	Php 10-11
Sugo Fishing	Php 12-16	Php 10-11
Merly Fishing	Php 12-13	Php 9-10
AMR Trade and Industrial (Ligo)	Php 12-15	Php 9-10

Source: ACEF, 2005

Figure 6



The converging range of revenues from 2000 to 2003 and 2006, for the representative firm, coincides with the range of revenues where most years of harvest converge to the total level of Zamboanga revenues. (See Figure 2).

With the abovementioned implications, the study can proceed to the estimation of the net benefit function. The variables used as are as follows:

(1) Zamboanga monthly yield (REVZAMBMILLIONS). Annual data was available from the Bureau of Agricultural Statistics. However, monthly yields are not available. Thus, the monthly trend of yield for the representative firm was used, using the market share of the representative firm as the estimator for the total Zamboanga yield. The yield function makes use of the estimated yield of Zamboanga multiplied by the peso value of sardines per kilo. The data is converted into peso millions.

(2) Effort per vessel per month was computed. (YIELDPRODVESMT). The capacity per catcher vessel was used as weights in order to compute a weighted average of monthly harvest for the representative firm. The effort function was computed using total yield of Lourdes Fishing. The effort variable was computed as a weighted average of yield per month per vessel, with weights depending on the gross tons of each catcher vessel (60mt, 70mt, 85mt, 106mt, 145mt, 182mt). Data for effort is therefore yield per month by vessel and capacity in metric tons. Catcher vessels stay on the sea for a year or two. Designated carrier vessels go back and forth from the coastline to their assigned catcher vessel. Those who man the catcher vessels are employed by the company. Some carrier vessels are owned by their respective fishermen, some are owned by the company.

(3) The seasonality index per fishing ground was used (SEASONALITY) in order to capture migration patterns of sardines as well as weather changes in the fishing grounds.

(4) The ratio of prices of the Corporation and Zamboanga (PRICECORPZAMB) was used as an indicator for marginal cost.

These variables shall be used in the structural equation that will denote the equilibrium levels of effort for the fishery. Doing a scatter plot of Zamboanga revenues with the effort variable indicated that a logistic production function (see Figure 7) can be achieved using monthly yields from 1996 to 2007. Variation in monthly yields as a function of depleting stocks had to be captured and this trend is not fully captured by the seasonality variable. The presence of seasonality per catcher vessel and fishing ground no longer allows the study to use a regression estimation procedure that will assume homogenous variance. Thus, the estimation procedure that had to be used should be able to correct the regression results against heteroskedasticity and autocorrelation so that the structural parameters or coefficients of the variables used would be able to compute the equilibrium effort levels.

The simulated scatter plot of revenues and effort has important characteristics: First, there is a change of trend at 100 mt of effort, referring to increasing slope. From the histogram of values for effort and Zamboanga revenues, one can observe that a large frequency of plots occurred within the range of 50 to 100 mt of effort with revenues also reaching at most Php 100 million. (See Figure 8). These are the harvest levels during low catch months. Second, a peak reached before 300 mt of effort has been achieved with an almost horizontal curvature of the function. This denotes that a range of effort levels can achieve the same level of revenues. All these characteristics have to be captured by the final regression equation. As a consequence, the curvature of the function at low levels of effort and revenues and the sudden increase would be captured by a semi-logarithmic regression. The function, however, has to reach a maximum level and flatten at a level of effort. This trend will be captured by allowing a quadratic form of the effort variable, i.e. effort^2.

The final regression estimation procedure, a generalized autocorrelation with conditional heteroskedasticity regression equation with normally distributed residuals (GARCH) shall be used. It must have a fit that is not significantly different from the simulation result. This procedure was chosen as it automatically corrects the problem of heterogenous variance through a step that estimates the variance of the data using variations of the lags and residuals of the dependent variable.

Figure 7. Simulation of the Yield Function vis-à-vis Effort

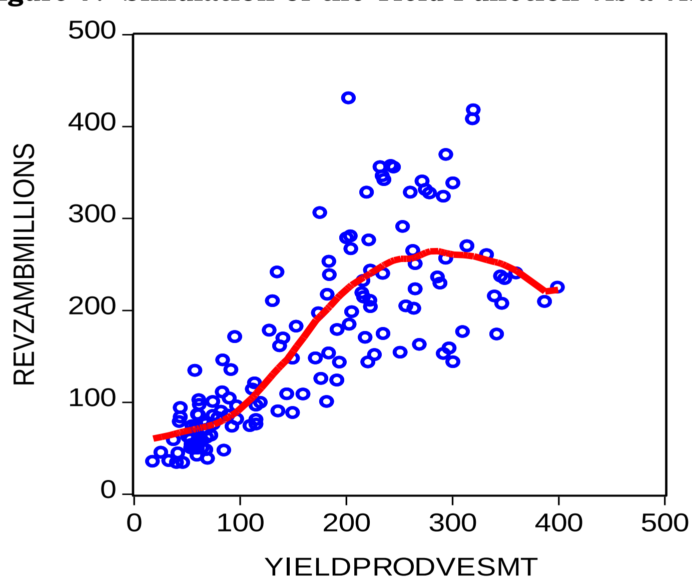
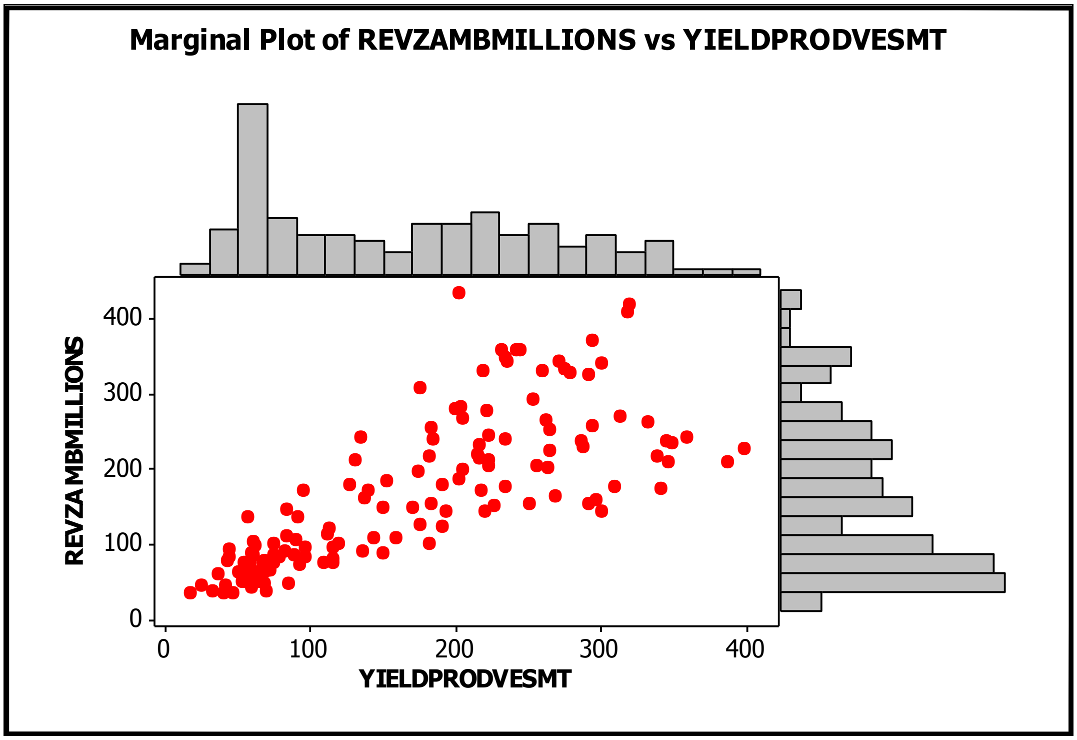


Figure 8. Scatter Plots with Histogram of Zamboanga Revenues and Effort



4. Analytical Results

The regression procedure obtained the following results. The data used consisted of monthly yield in metric tons. The representative firm accounted for 8% to 11% of total revenues from the list of 14 major suppliers of fish. Yield data is by fishing ground and catcher vessel. The estimated monetized yield function is shown, and acts as an average of maximum and minimum values of revenues per yield. The structural regression model using GARCH-Normally distributed errors, has a distribution which is similar to the simulated trend line. (See Figure 9) One can observe that revenues levels follow a range of values across the maximum effort level of 286 metric tons.

This corporation's cost function was also estimated, which is 0.8077 of the effort level (net profit from 1996 to 2007 is 9.33% of gross revenues, tax is 10% of gross revenues, thus marginal cost would be roughly 80.77% of total effort. And this level was estimated using the same variables in the estimation of the yield function. Costs flatten from 220 mt to 320 mt of effort. These levels of effort would register the highest levels of profit, as well. (See Figure 10) Another cost function was estimated using an increase in costs of 5%[15], with an ITQ, thereby decreasing profits to only 4.33%. Corresponding profit levels were obtained.

[15] This level was arbitrarily chosen, as the representative firm is actually obtaining a net profit level of 5 to 10%.

Figure 9. Estimated Revenue Function and Simulated Revenue Function

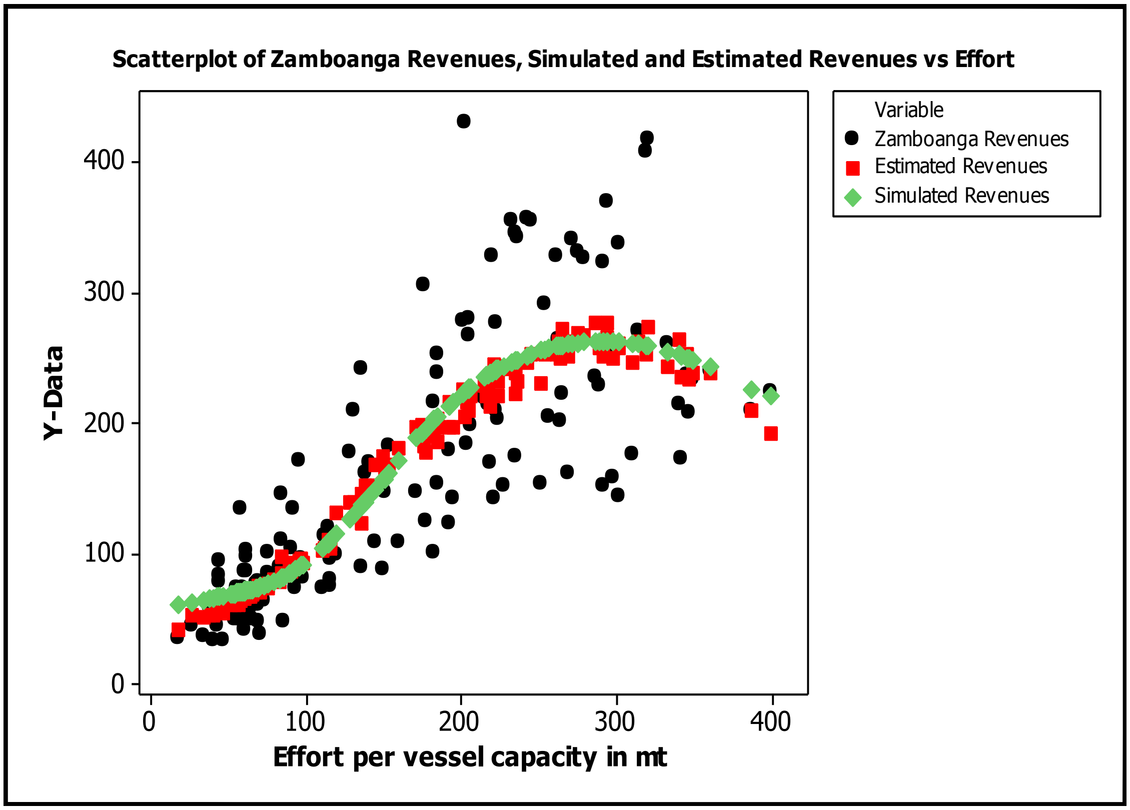


Figure 10. Estimated Revenue, Cost and Profit Functions (With & Without ITQ)

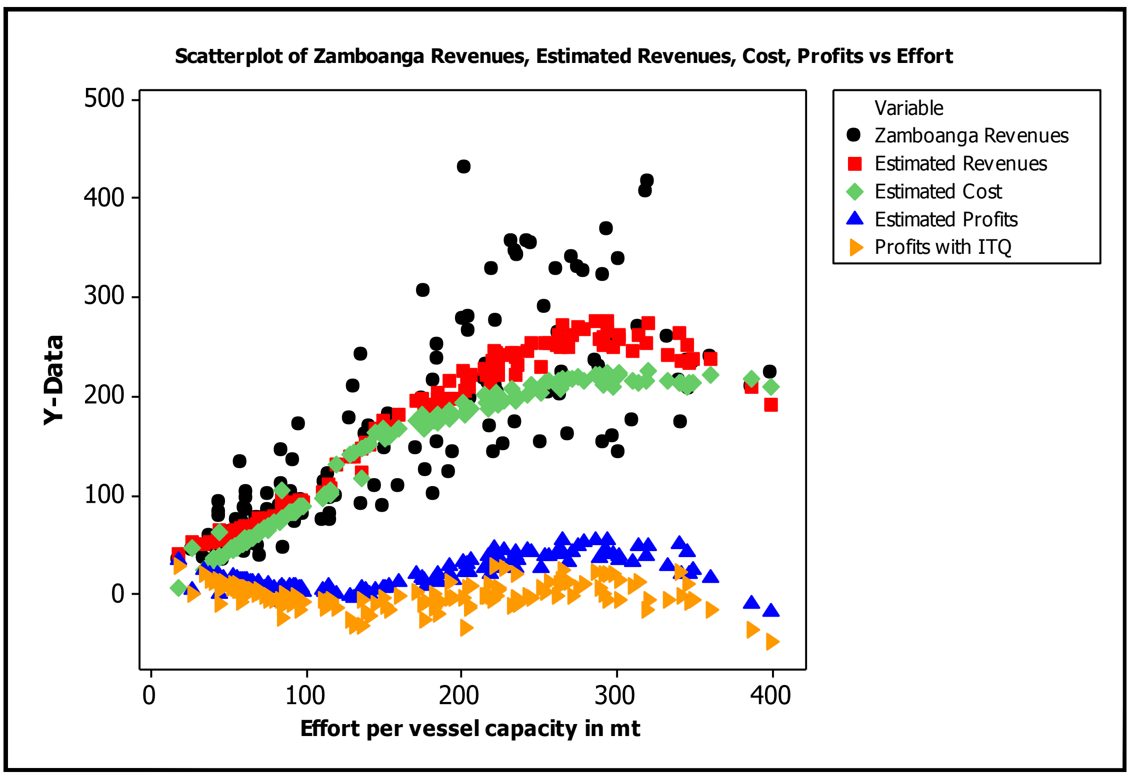


Table 2: Regression Results				
Dependent Variable is Logarithm of Zamboanga Harvest of Sardines (in PhP Millions) Method: ML - ARCH (Marquardt) - Normal distribution Sample: 1996M01 2007M12 Included observations: 144				
Explanatory Variables	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
C	12.77	7.01	1.82	0.069
Effort per vessel	0.013	0.001	10.94	0.000
Effort per vessel^2	-2.15E-05	2.54E-06	-8.46	0.000
Seasonality	0.139	0.073	1.91	0.056
Price ratio of Corporation and Zamboanga	-9.34	7.03	-1.33	0.184
Variance Equation				
C	0.037	0.015	2.49	0.013
RESID(-1)^2	0.412	0.118	3.50	0.0005
GARCH(-1)	0.203	0.165	1.23	0.22
R-squared 0.797		**Adjusted R-squared 0.786**		

The results show that all the variables chosen, significantly explain yield. Note that the p-value of the price ratio is 9% (as we are using a one-tailed test and the results have a default 2-tailed test p-value.) These coefficients shall be used to compute the equilibrium level of effort.

The equilibrium level of effort obtained from the equation is 297.24 metric tons. By getting the total derivative the estimated regression equation and calculating the maximum level with respect to effort, an equilibrium effort of effort would be achieved. The closest values to this level[16] are those obtained in the open access and MEY equilibrium levels of effort tabulated in Table 3. Maximum sustainable yield is at 286.52 metric tons, open access equilibrium is at 294.28 metric tons and the maximum efficient yield ranges from 221.76 to 263.14 metric tons. Note that the maximum sustainable yield also generates the highest level of profit, with or without an ITQ, followed by the open access equilibrium level. Note also that a linear cost function (cost function applied is just 80.77% of total effort) obtained lower profit levels, whereas the cost function which follows the seasonality trend, or the curvilinear cost function, obtained higher profit levels.

[16] Several effort levels come close to the actual computed value of 297.24. Thus, only those points which exhibited an estimated value which is not significantly different from the actual value were chosen. The final list are those included in Table 3.

Table 3: Equilibrium Levels of Effort							
MSY and MEY	Effort Level (in metric tons)	Profits (in PhP Millions)				Harvest or Yield (PhP Millions)	
		Profit with Linear Cost Function		Profit with Curvilinear Cost Function		Actual	Estimated
		Without ITQ	With ITQ	Without ITQ	With ITQ		
MSY (1)	286.52 (period: 2004.04)	41.44	10.80	54.19	23.54	235.71	276.26
Open Access (1)	294.28 (period: 1997.08)	41.41	8.09	54.18	20.86	256.30	276.03
MEY	263.14 (period: 2003.08)	39.26	4.87	45.28	11.09	264.58	261.75
	253.74 (period: 2004.08)	38.02	0.25	39.55	1.78	290.53	253.43
	221.76 (period: 2001.08)	36.48	0.59	39.80	3.91	276.03	243.15

Notes:
(1) Uses monthly weighted average of effort (effort per vessel and capacity). Effort levels were calculated from the monetized harvest function

5. Interpretation of Results

An ITQ can be operationalized. A maximum efficient yield (MEY) at effort level 263 mt per vessel per month would amount to 127,029 mt annual yield for all Zamboanga firms with each firm yielding a 4.3% monthly net profit level. At the open access equilibrium level of 294 mt per vessel per month, yield would reach 142,002 or 11% more than the MSY. But monthly net profits would increase to 7.6%.

The reported high level of yield of 229,000 metric ton harvest of sardines for the entire Philippines may be reaching 60% of the maximum sustainable yield for sardines.[17] However, the corresponding level of 127,029 annual metric ton harvest for Zamboanga, or close to 55% of the reported exploitative level of 229,000 metric tons seems to be a feasible level of allowable catch for the fishing industry. Obtaining this level can be profitable for the industry players.

It has to be taken into, though, that the analysis only includes the performance of the major companies in Zamboanga engaged in deep sea coastal fishing. It does not include the performance of municipal fishermen. A more comprehensive study would be required if an individual transferable quota (ITQ) scheme would be implemented and be operational.

6. Conclusion and Recommendation for Further Study

The operationalization of ITQ may have to allow participating fishermen to obtain a positive level of profits, and, a review of their harvesting schedules so as to maximize net benefits with the implementation of a restriction on output which increases the cost of harvest. The targeted output limit would be achieved only if the participating fishermen would share monthly yield. From the results of the study, it is enough that a representative firm share this information. A more reasonable level, however, may be reached if satisfactory information may

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[17] Wee, Darwin T. "Annual Sulu Sea fishing ban eyed." ***BusinessWorld***. April 22, 2008

be obtained from the biggest firm, Mega Fishing Corporation and a representative of the smaller firms, in order to ensure that harvest and effort levels would be captured by the net benefit function for the sardine industry of Zamboanga. With better information, the competitive behavior of the firms would be captured.

The initial result of converging revenue levels at varying effort levels may have to be verified with the inclusion of at least 2 other (one bigger or double the harvesting capacity, and, another smaller or half the harvesting capacity of Lourdes Fishing Corporation) representative firms. This is important as one has to capture the productivity of labor and vessels to the monthly yield.

The results call for a need to review productivity per vessel so as to increase yield without necessarily increasing cost. Capital equipment investment or an improvement in yield practices may have to incorporate seasonality and the investment of the current firms in sonar boats. This would mean that only the efficient cost firm would be able to compete when an ITQ scheme would be implemented in Zamboanga.

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