Chapter 4

DATA STRUCTURE AND ESTIMATION PROCEDURES

4.1 Introduction

This chapter consists of five sections. The main objectives of the chapter are to describe the data, selection of parameters and estimation procedures used in the study. Section 4.2 is used to explain the data and its sources. Section 4.3 describes the measurement of variables used in deriving supply of and demand for the fish. Section 4.4 discusses the selection of the model and its parameters and estimation procedures. The last section provides a summary and concluding remarks.

4.2 Data and Data Sources

Both primary and secondary data are used in this study. Primary data were collected in order to describe fishing costs for the selected fishing unit and socioeconomic conditions in the fishing community. The primary data were collected by carrying out a cross-sectional survey in the study area during the period from August to November 1994. Respondents, who were fishing in the riverine, swamp and lake fishery resources, were chosen randomly from the updated list of fishers and asked a sequence of questions about their activities using a simple questionnaire (Appendix 4.1). All respondents were fishers. The questionnaire was aimed at obtaining information on existing costs and returns of fishing; catch and effort of the fishing units; and the socioeconomic background of the fishers. Apart from these methods, monitoring of selected fishing units operated at different types of resource was also undertaken. Monitoring was carried out in order to improve the quality of the data. Two regions, OKI and MUBA, were selected as study sites. These regions have typical inland fishery performance for South Sumatra in terms of hydrogeographical nature of the resources and their contribution to aggregate fish harvest or total catch of the province. Due to problems of accessibility to the study sites, and the fact that the patterns of inland capture fisheries in the study sites are relatively homogeneous, only 64 fishers were selected randomly for the sample.

Secondary data were obtained from various sources. Fishery data were collected from agricultural and fishery statistics for South Sumatra. Apart from these sources, various published and unpublished papers concerned with the inland fishery were also reviewed. Economic data were collected from various goverment publications (see below).

The data on catch and fishing effort for the fishing units used in the inland fishery are derived from *Buku Statistik Perikanan Propinsi Sumatra Selatan, Tahun 1968-1980* (Fishery Statistics of South Sumatra Province, Years 1968 to 1980[1]) and *Buku Tahunan Statistik Perikanan Tingkat Propinsi Tahun 1979 sampai dengan 1994* (the Annual Book of Fishery Statistics of South Sumatra Province, Years 1979 to 1994[2]).

Figures for per capita consumption of fish were obtained from *Laporan Tahunan Perikanan Propinsi Sumatra Selatan, Tahun 1978 sampai dengan* 1993 (the Annual Report of South Sumatra Fishery Services, Years 1978 to 1993[3]). However, these data are total fish consumption figures, rather than freshwater fish alone. Data on per capita consumption according to species or even freshwater fish group were not available.

Economic data, including price of selected commodities, such as freshwater fish, marine fish, beef and chicken, per capita income and consumer price index, were collected from various *Annual Report of the Fishery Services of South Sumatra* (Fishery Services of South Sumatra, 1979 to 1995), *South Sumatra in Figures* (Statistical Office of South Sumatra Province 1980a, 1985a, 1995a), *Economic Indicators of South Sumatra* (*Bappeda*, Regional Bodies of South Sumatra, 1992) and

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[1] From *Dinas Perikanan Sumatra Selatan* (Fishery Services of South Sumatra) (1982)
[2] From *Dinas Perikanan Sumatra Selatan* (Fishery Services of South Sumatra) (various years)
[3] From *Dinas Perikanan Sumatra Selatan* (Fishery Services of South Sumatra) (various years)

Gross Domestic Product of South Sumatra Figures (Statistical Office of South Sumatra Province, 1980b, 1985b, 1995b).

To satisfy the requirements for estimating the selected model, time-series data should be collected from the same sources. However, data were not available in this form. Another problem occurred when time-series data turned out to be inconsistent because of changes in the price basis. To overcome these difficulties, various other sources were used and a splicing technique applied to various time series. The splicing technique used in this study concerned adjustment of the consumer price index (CPI).

4.3 Measurement of Variables

4.3.1 Catch and effort

Catch data are represented by production data associated with fishing units. These data have commonly been recorded in fishery statistics from many regions. On the other hand, fishing effort data may not be directly recorded in the statistics. However, various studies have indicated that fishing effort may be represented by the number of fishing units, trips or days of fishing. Decisions about the type of data that may represent fishing effort are based on assumptions regarding the particular fishery being studied. In the current study, fishing effort is described in terms of the number of trips associated with fishing units.

Selected data, as described in Appendix 2.1, consist of three different types of inland fishery resources, namely: rivers, swamps and lakes. Historical data consist of 10 types of fishing gear related to number of units, trips and production from 1979 to 1994. The listed types of fishing gear are an official standardisation of fishing units which can operate over a wide variety of boat sizes and types of gear.

As discussed in the previous chapter, aggregate total catch derived from the riverine and swamp fisheries has contributed significantly to total catch from the inland capture fishery in South Sumatra whereas total catch from the lake fishery contributed only a relatively small proportion to the total for the province. Both swamp and lake fisheries in the study sites have similar characteristics in the sense that their patterns of receiving water throughout the year are similar. For these reasons, further analysis will consider only two types of fishery resource, the riverine and swamp fisheries. In other words, the swamp fishery data in this study consist of the sum of lake and swamp fishery data.

Data on fishing gear being used in the inland capture fishery in South Sumatra (see Table 4.1) record that gillnets, cast nets, hooks and lines and portable traps are widely used by fishers. Lift nets are used in such open water as rivers and swamps. Although the filtering barrier has been banned since 1991, fishers still operate with this type of prohibited gear in the riverine fishery. This indicates that law enforcement is still a problem in the study sites. The data show that the most important fishing unit in the study sites is the portable trap, followed by gillnets, then hooks and lines.

Using the two proposed groups of inland fishery resources presented in Table 4.1, the average numbers of fishing trips operated are illustrated in Figure 4.1.

The figures show that the highest number of trips related to fishing is for units which use the *bubu* trap (bamboo portable trap). This suggests that this type of fishing unit is widely used by fishers in the study areas. With this evidence, all recorded fishing units are simplified into a standard unit, the *bubu* portable trap, using the following procedure.

Suppose we have different types of fishing units 1, 2, 3, ..., N. The total catches of each fishing unit are catch_1, catch_2, catch_3, ..., catch_N. The corresponding efforts are effort_1, effort_2, effort_3, ..., effort_N. The CPUE_i represents the Catch Per Unit of Effort of fishing gear-i, which is calculated as follows:

$$(4.1) \quad \text{CPUE}_i = \frac{\text{Catch}_i}{\text{Effort}_i}, \qquad i = 1, 2, 3, \ldots, N\,.$$

Let fishing unit-1 be chosen as the standard fishing unit in the inland fishery. Then the standardised fishing effort of each fishing unit and total standardised fishing effort can be calculated by the following procedure:

Table 4.1 Average annual riverine and swamp fishery data of South Sumatra Indonesia, 1979 -1994

	Riverine			Swamp		
Fishing gear	Unit	Trip	Production (tonnes)	Unit	Trip	Production (tonnes)
Gillnets						
Drift gillnet	1,936	308,472	3,004.59			
	(12.0)	(13.4)	(14.5)			
Fixed gillnet	1,342	171,431	1,271.73	2,817	476,861	3,052.76
	(8.3)	(7.4)	(6.2)	(23.4)	(27.9)	(24.7)
Cast nets						
Anco	680	69,674	324.06	374	48,181	218.44
	(4.2)	(3.0)	(1.6)	(3.1)	(2.8)	(1.8)
Lift nets						
Serok	489	83,737	379.19	494	37,663	175.21
	(3.0)	(3.6)	(1.8)	(4.1)	(2.2)	(1.4)
Hook and lines						
Rawai	655	69,431	217.06	324	33,739	167.06
	(4.1)	(3.0)	(1.1)	(2.7)	(2.0)	(1.4)
Pancing	2,961	438,991	2,364.20	2,525	431,417	2,252.35
	(18.4)	(19.1)	(11.4)	(21.0)	(25.3)	(18.3)
Filtering barrier						
Jermal	776	149,278	2,549.27			
	(4.8)	(6.5)	(12.3)			
Portable traps						
Sero	1,435	237,816	5,162.66	1,228	147,027	2,839.20
	(8.9)	(10.3)	(25.0)	(10.2)	(8.6)	(23.0)
Bubu	2,931	446,434	2,598.03	3,349	488,598	2,665.51
	(18.2)	(19.4)	(12.6)	(27.9)	(28.6)	(21.6)
Other gear	5,820	774,417	5,381.86	4,256	532,133	3,632.79
	(36.2)	(33.6)	(26.1)	(35.4)	(31.2)	(29.4)
Total	16,094	2,303,247	20,655	12,018	1,707,021	12,338
	(100)	(100)	(100)	(100)	(100)	(100)

Note: - Figures in parentheses denote percentage of particular inland fishery resource total.

- Swamp data consist of the aggregate swamp and lake fishery data.

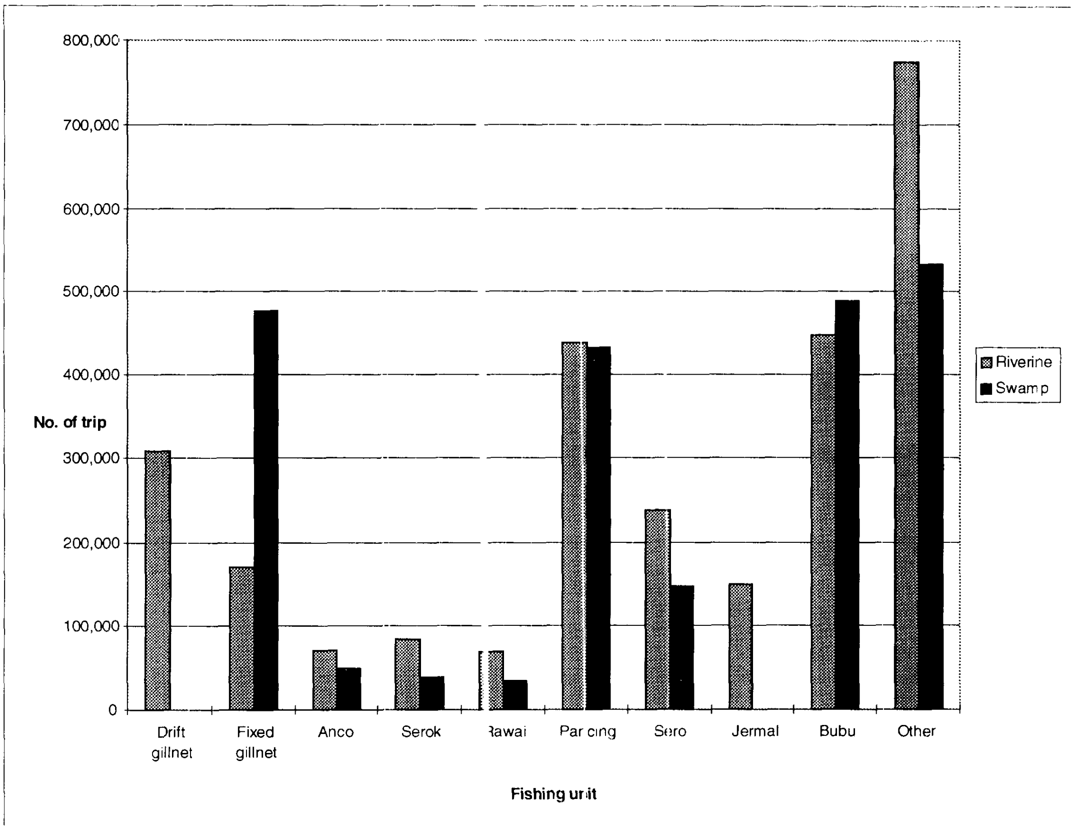

Figure 4.1 Average number of trips according to fishing unit operated in riverine and swamp fishery resources in South Sumatra, Indonesia

(4.2) $$\text{Effort}_J = \frac{\text{CPUE}_J}{\text{CPUE}_1}.\text{Effort}_1, \quad J = 2, 3, \ldots, N;$$

(4.3) $$\text{Total Effort} = \text{Effort}_1 + \sum_{J=2}^{N} \text{Effort}_J.$$

The total catch is calculated by summing up total fish caught by the standard fishing unit and other fishing units:

(4.4) $$\text{Total Catch} = \text{Catch}_1 + \sum_{J=2}^{N} \text{Catch}_J.$$

The catch per unit effort of standard fishing unit is calculated by dividing equation (4.4) by equation (4.3) as follows:

(4.5) $$\text{CPUE}_S = \frac{\text{Total Catch}}{\text{Total Effort}}.$$

Using the above procedure, the calculated standardised fishing effort associated with catch for the period between 1979 and 1994 is presented fully in Appendix 4.2 and is depicted in Figures 4.2a and 4.2b in terms of *Bubu* standardised units.

Both Figures 4.2a and 4.2b show that the standardised fishing effort fluctuated between 1979 and 1994 and tended to decrease. The largest fishing effort was in 1981, indicating that many small types of fishing unit were intensively used by fishers. Furthermore, the effort decreased sharply in the riverine fishery and decreased slightly in the swamp fishery. The decreasing number of trips may be explained by fishers reducing their activity because of a poor fishing season. Another explanation for the decreases over the period may be that recorded data on the inland fishery were changed to adjust to the national level format (local and provincial level fishery officers 1994, pers. comm.). With these perspectives, interpretation of the available data may not be precise.

Total catch derived from the riverine fishery was relatively constant between 1979 and 1994. The total catch increased in the swamp fishery. Given the data, it seems that both resources were capable of maintaining fishery production. However, this may not be the case, since observation indicates that harvested fish sizes are smaller than in previous years and some important species are reported to have disappeared.

Considering the technological efficiency of fishing units, catch per unit of effort in both of the resources indicated that the figures fluctuated and increased slightly. This may indicate that efficiency of fishing units increased over time. This may suggest sustainability of the resource is under threat.

The catch data in Figures 4.2a and 4.2b reflect aggregate freshwater fish instead of a single species of harvested fish. This is because data on particular species or even species groups are not available for the study site. Pauly (1979) and Pope (1979) have described such a problem in a mixed-species tropical fishery. They observed that when data were aggregated into major species groups, consistent trends in catch rate and yield became apparent. This was supported by Ralston and Polovina (1982) who based their studies on the multi-species tropical handline fishery in Hawaii. Similar procedures have been described by Hilborn and Walters (1992) where the dynamic interactions of mixed species were treated as aggregated fish stock and analysed using production models.

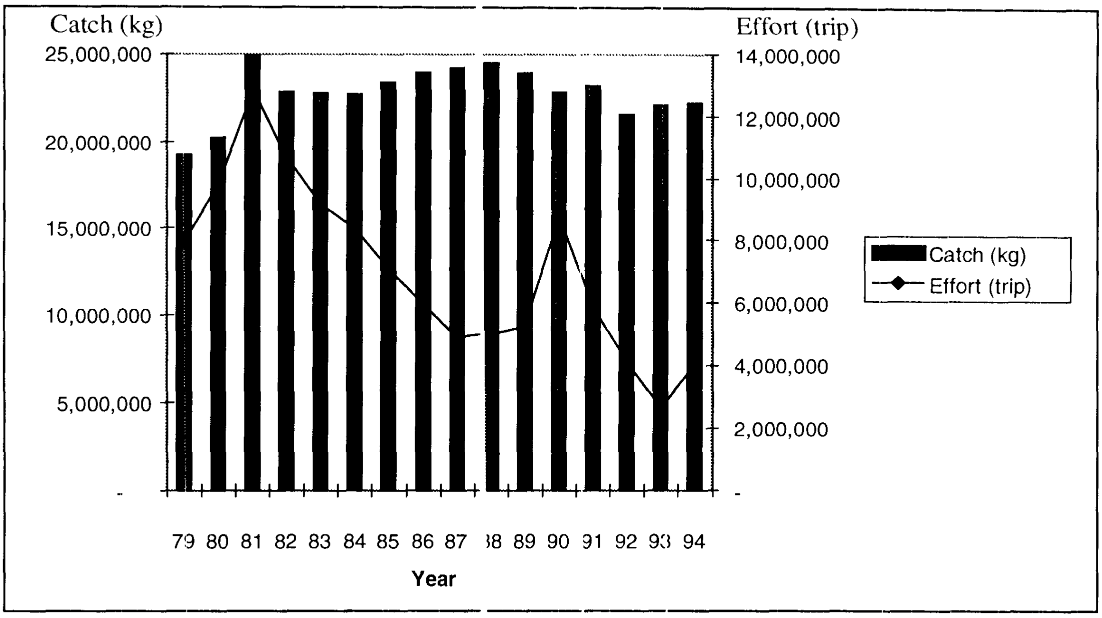

Figure 4.2a Standardised catch and fishing effort in terms of *bubu* portable trap in riverine fishery in South Sumatra, 1979-1994

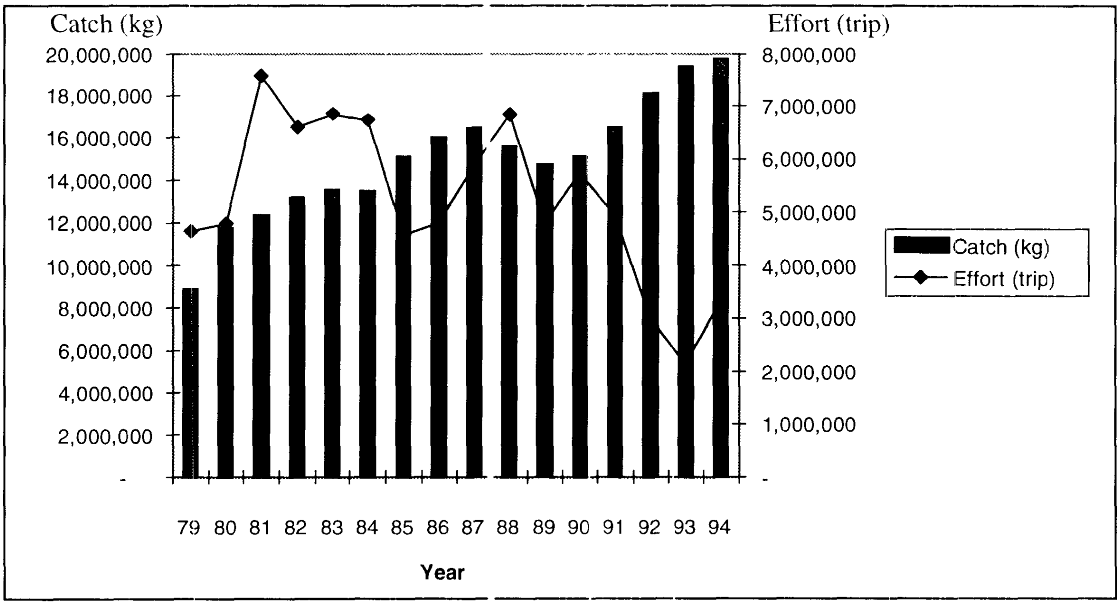

Figure 4.2b Standardised catch and fishing effort in terms of *bubu* portable trap in swamp fishery in South Sumatra, 1979-1994

4.3.2 Cost of fishing effort

The structure of operating costs per trip is comprised of fixed and variable costs. These operating costs reflect the method and intensity of fishing effort and the amount of capital invested in the study site. The fixed costs[4] are calculated in terms of the payment for leasing the resource and depreciation of both canoe/boat and gear used in the *bubu* fishing unit. The variable costs include the costs of bait and other accessory and actual labour costs. In this case, the actual labour costs reflect the opportunity cost of fishing in that region. All cost data are generated from cross-sectional surveys for two distinct types of resources, i.e., riverine and swamp.

Most fishers have a small canoe or boat and operate various types of fishing unit. These small boats and fishing units reflect capital investment by the fishers. The capital investment is usually valued at acquisition cost but in cases where the assets are not new, as in the fishing units in the study site, replacement cost is used as substitute. Another investment cost met by fishers is for leasing of a particular fishing ground. The estimated average investment cost, which can be categorised into three components, namely canoe/boat, fishing gear and lease of the resource, in terms of standard fishing unit, for entering the fishery are Rp. 370,000 (riverine) and Rp. 355,000 (swamp).

Table 4.2 shows the breakdown of investment costs of the *bubu* portable trap as a standard fishing unit in two different resources.

Given the above definitions, the average costs of fishing effort for the standard fishing unit (*bubu* portable trap) for the two types of resources in South Sumatra are Rp.2,973.57 (riverine) and Rp.2,631.48 (swamp), as in Table 4.3.

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[4] Another description of this type of fishing cost is used by Panayotou (1985) in which fixed costs are incurred irrespective of whether fishers operate their fishing units or not. This is because the costs are considered 'sunk' capital investment costs which cannot be recouped at short notice without large losses.

Table 4.2 Average investment costs of *bubu* portable traps in the inland fishery in South Sumatra, 1994

Investment component	Type of Resource	
	Riverine (rupiah)	Swamp (rupiah)
Canoe/boat	200,000	200,000
Fishing gear	120,000	120,000
Lease of resource	50,000	30,000

Source : Cross-sectional survey 1994.

Table 4.3 Calculated costs of fishing effort by bamboo fishing traps (*bubu*) in different types of resources in South Sumatra

Type of costs	Type of Resource	
	Riverine (rupiah)	Swamp (rupiah)
Fixed Costs		
Depreciation of canoe/boat	26.20 (0.9)	103.71 (3.9)
Depreciation of gear	1,184.21 (39.8)	936.00 (35.6)
Lease of resource	131.58 (4.4)	266.67 (10.1)
Variable Costs		
Operating costs (e.g. bait and other accessory)	631.58 (21.3)	325.00 (12.4)
Labour	1,000.00 (33.6)	1,000.00 (38.0)
Total costs	2,973.57 (100)	2,631.48 (100)

Source : Cross-sectional survey 1994.

Note : Values in parentheses are percentages.

4.3.3 Price of freshwater fish

Landing prices for freshwater fish were provided by survey respondents. Prices of harvested fish were mostly provided by small-buyers (*pengumpul*) based on the 'quality of fish' and 'species group'. However, the perception of fishers interviewed on the study sites was that fish prices are often decided on the basis of average prices and quality of harvested fish. The average actual prices of freshwater fish at the producer level are Rp. 1,215 per kilogram (riverine) and Rp. 1,125 per kilogram (swamp). The difference in prices between resources may indicate the quality of harvested fish from the river is better than from the swamp.

4.3.4 Annual prices and consumer price index (CPI)

Appendix 4.4 contains selected historical data for demand for fish for the region. The data include per capita consumption of fish, prices of freshwater fish and beef, and CPI in South Sumatra province. Prices were implicitly formed by dividing the value of total fish commodities by total quantity of the corresponding fish commodities. The consumer price index (CPI) is an index of general expenditure for the South Sumatran people and the data are adjusted to 988/1989 prices. Historical freshwater fish and beef prices and the CPI are plotted in Figure 4.3.

4.3.5 Annual fish consumption and per capita income

It should be noted that fish consumption is on the basis of average total fish consumed rather than species. This is because fish consumption data by fish species are not available in the region. Income per capita is adjusted for current market prices during the period of 1978 to 1993 (Figure 4.4).

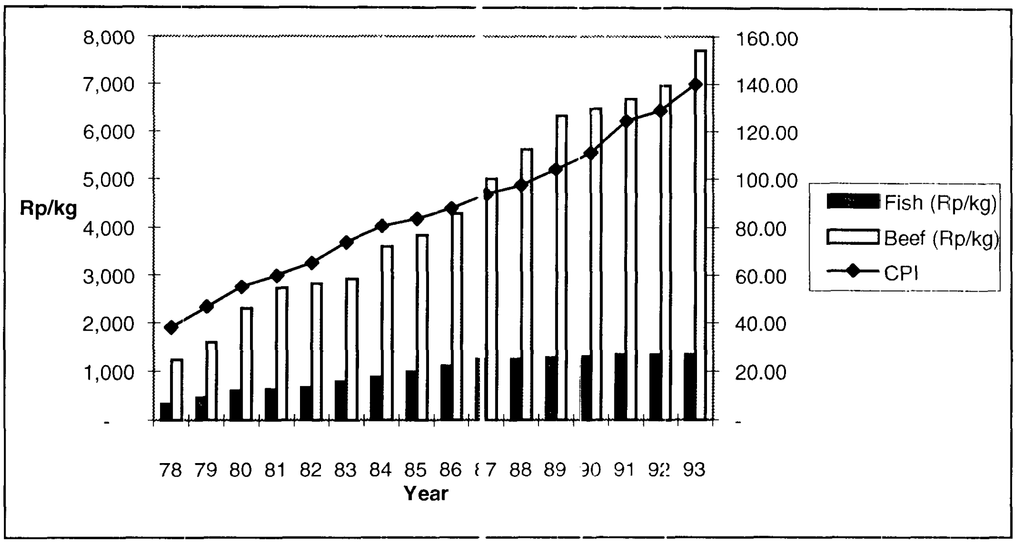

Figure 4.3 Annual freshwater fish and beef prices and CPI in South Sumatra, 1978 to 1993

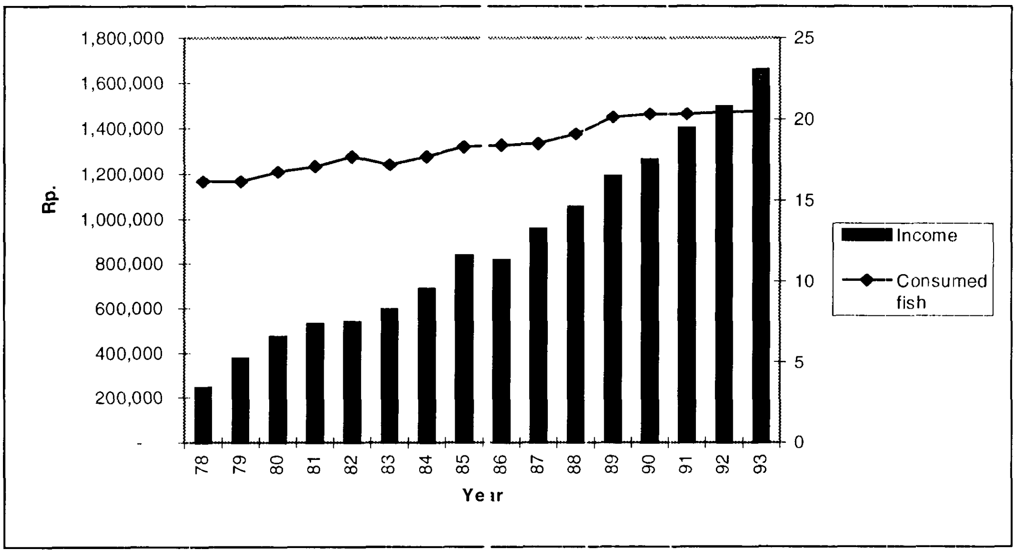

Figure 4.4 Annual per capita consumption of fish and income in South Sumatra, 1978 to 1993

4.4 Selection of Models, their Parameters and Estimation Procedures

Models, in general terms, are said to be simplifications of natural processes expressed mathematically (Punt 1988, p. 27). However, there are other sorts of models apart from mathematical ones. With regard to fisheries, the model is used to understand the history of these resources and make predictions about future states. This implies that the accuracy of the predicted model depends critically on the assumptions and simplifications upon which it is based. Predictions of how fisheries are likely to respond to alternative management actions would not be possible without developing models. For most possible models, there exists a definite trade-off between the realism of model specification and model data requirements.

4.4.1 Supply models, parameters and estimation procedures

Biological parameters for the fishery such as mortality, survival rates, growth rates and catchability coefficients are defined as quantitative properties of the system. These parameters are usually assumed to remain constant over some defined time-span of historical data and for the purposes of prediction. The most vital parameter in fishery stock assessment is fishing mortality. From this standpoint, an accurate measure of this parameter is important. In this study, the measurement is approached by applying surplus production models.

Perfectly correct values of fishing mortality in a particular fish stock are impossible to obtain. However, an estimate of the parameter may be made using historical data for fishing effort. As discussed in the previous chapter, it is assumed that the environment of the fishery system is stable over time. This is equivalent to assuming that fishing mortality is proportionate to the amount of fishing effort exerted by various fishing units. The proportion is widely defined as the 'constant catchability coefficient' in the literature.

By applying a simple model such as equation (3.5), the model implies that CPUE data are proportional to the biomass. Considering these assumptions, the selected surplus production model to be estimated is based on the Schaefer and Fox models represented by equations (3.11) and (3.14), respectively.

Applying these surplus production models (and further analysis) of the system, various fishing units used by fishers are standardised into a specific fishing unit on the basis of the fishing unit which is widely operated in that particular resource. In this case, the bamboo fishing trap (*bubu*) is selected to be the standard fishing unit.

Recall from equation (3.11) that the Schaefer surplus production model over time is given by:

$$\frac{Y_t}{E_t} = CPUE_t = a - bE_t$$

and the Fox surplus production model over time is given by equation (3.14):

$$\mathrm{Ln}\left(\frac{Y_t}{E_t}\right) = \mathrm{Ln}(CPUE_t) = a - bE_t .$$

The first equation shows that total catch (Y_t) at time t is a parabolic function of units of standardised fishing effort at t. This consequently requires a non-linear technique to estimate the parameters. Fortunately, this problem can be overcome by first computing catch per unit of effort at time t ($CPUE_t$) as shown above. This results in a linear relationship between $CPUE_t$ and E_t. After incorporating the error term, this equation (3.11) can be estimated using the Ordinary Least Squares (OLS) estimator.

A similar procedure can be applied to the Fox surplus production model in equation (3.14). With this procedure, the Fox model has a linear relationship between the logarithm of $CPUE_t$ and E_t.

Instead of applying the OLS estimator to each type of inland fishery resource, the estimation procedure actually employed was based on the data pooling technique explained by White (1993, p. 250), Gujarati (1988) and Griffith *et al.* (1993). That is, the CPUE and fishing effort data for each resource are 'stacked' in the data file and dummy variables are introduced to distinguish between different types of resource data. Following this manipulation of the data, the model is estimated using OLS.

As previously discussed, because of difficulties in measuring changes over time, it is often assumed that the catchability coefficient is constant. In most cases, the efficiency of fishing units has changed over a long period of time. In other words, harvest efficiency in the fishery should increase over time with adoption of new technology and with advances in knowledge of the biology of the fish stock. This implies that the catchability coefficient should also increase over time. From this viewpoint, the selected surplus production model is often modified to include a time trend. In this study, fishing mortality is proportional to effort, which measures the number of trips per year over the period 1979 to 1994. This means that the catchability coefficient (q) is a function of time. Hence, technological change may be approximated by introducing a variable 'time' (1, 2, 3, ..., T) in the model. Alternatively, a procedure for including technological change was introduced by Wallace, Lindner and Dole (1996). However, it has been pointed out by Sparre and Venema (1992) that surplus production models implicitly assume the catchability coefficient remains constant over the entire observed time period. This, in turn, suggests the use of relatively short data series in the surplus production analysis may be sensible.

Variables required for estimating the Schaefer and Fox surplus production functions are catch and effort. In this case, catch and effort are characterised as in the previous section. Given all of the above, the parameters 'K' (carrying capacity), 'q' (catchability coefficient) and 'r' (intrinsic growth rate of fish) are calculated based on estimated values of coefficients 'a' and 'b' in both the models.

Supply models of the fishery are derived using the above-estimated results. The 'traditional supply' of Gordon (1954) is considered to be long-run supply and is obtained by multiplying price of freshwater fish by the harvest function specified by Schaefer (1954) and Fox (1970). Derivation of supply for the fishery begins with expressing the relationship between catch and effort in terms of effort as a function of catch. Hence, the supply curve, which indicates marginal cost per unit of output and shows the quantity of harvested fish for sale by fishers at each price level, is determined.

4.4.2 Demand models, parameters and estimation procedures

The market structure for the inland fishery in South Sumatra consists of three levels, small buyers, wholesalers and retailers. However, the distinction between the existing three levels of market is not always clear. An integrated market model should be specified where supply and demand equations at all market levels are estimated simultaneously so the model explains interactions at all market levels (Tai 1992). Even though this approach seems to have advantages, it cannot be used in this study because of the complexity of small-scale inland fishery management in the particular area and lack of data.

The demand function for the fishery shows the marginal value that consumers place on various levels of catch. The demand curve, as with other products, is usually downward sloping, since market price usually falls as output increases. From data described in the previous section, demand for the fish in the study site is derived by using following model:

$$(4.6) \quad Q_t = f\left(PF_t,\ PB_t,\ CPI_t,\ I_t\right), \qquad t = 1, 2, 3, ..., 16$$

where Q_t : per capita fish consumption (kg/capita) at time t

PF_t : price of freshwater fish rp/kg) at time t

PB_t : price of beef (rp/kg) at time t

CPI_t : consumers Price Index at time t

I_t : income per capita (rp/cap/yr) at time t

This model assumes that the quantity of fish demanded is explained by own price (PF_t), price of the substitute (PB_t), income (I_t) and the consumer price index (CPI_t). Rather than using nominal prices and income data, real prices and income data were used. These were obtained by deflating nominal price and income data with the consumer price index.

When the model is specified in terms of an inverse demand function, with price on the left hand side, the major explanatory variables are consumption per capita, price of substitutes and income. Theoretically, fish price may also be influenced by numerous other factors, such as size and quality of harvested fish and seasonal variability. However, these factors are not explicitly incorporated into the model and their effects are captured in the intercept and error terms. Since these factors are not expected to be correlated with variables incorporated in the equation they should not be a source of bias in estimation (Griffiths *et al.* 1993).

As with all simple demand systems, the model is based on a representative consumer of freshwater fish in the region. In order to estimate the parameters of the model, the ordinary demand function is assumed to be one of the following forms, i.e., linear, semi-log or double-log, written as:

(4.7) $Q_t = b_0 + b_1 PF_t + b_2 PB_t + b_3 I_t$;

(4.8) $\ln Q_t = b_0 + b_1 PF_t + b_2 PB_t + b_3 I_t$;

(4.9) $\ln Q_t = \ln b_0 + b_1 \ln PF_t + b_2 \ln PB_t + b_3 \ln I_t$.

All of these functional forms are estimated using the OLS estimator.

4.5 Summary and Concluding Remarks

The tropical inland fishery of South Sumatra is very complex, comprising small-scale, multi-species and many types of fishing unit. A small-scale fishery implies that fishing-community households depend exclusively on fishing. Multiple species of harvested fish are produced by employing many types of fishing unit which may not be precisely reflected in the statistical data. Because of this problem, simplification of the inland fishery system is carried out by deriving supply from the fishery and demand for fish in the study region as single equations. For these purposes, primary and secondary data are used.

Primary data describe recent costs of fishing and socioeconomic conditions in the fishing community. Secondary data, combined with primary data, are used to derive supply and demand functions for the fishery in the study site. Given available data, in order to satisfy the requirements for applying the selected model, the following procedures are used. Many types of fishing gear are standardised into a single fishing unit which is widely used by fishers in that region. Mixed species of harvested fish are treated as an aggregate fish stock.

Supply models of the inland fishery are estimated by applying bioeconomic models from Gordon-Schaefer and Gordon-Fox and Copes. Demand for fish from the fishery is defined in terms of an ordinary demand function, which indicates that fish consumption per capita is determined by fish price, price of beef and income per capita. Empirical results based on these models are presented in the next chapter.

Chapter 5

EMPIRICAL RESULTS

5.1 Introduction

In this chapter, empirical results from the theoretical framework developed in preceding chapters are presented. It consists of five sections. Section 5.2 presents regression results for the selected model. Section 5.3 is used to develop bioeconomic models and define optimal resource allocation for the inland fishery in South Sumatra. This includes models based on fixed price and variable price assumptions. The discussion is also used to evaluate current conditions for the resource and define optimal resource use from both biological and economic perspectives. Section 5.4 provides 'base-case' biological parameters and their sensitivities to key variables. In the last section, a summary of the chapter and concluding remarks are provided.

5.2 Supply and Demand for the Fishery

5.2.1 Supply of fish from the fishery

Production function models for the inland fishery in South Sumatra with respect to different types of resources were estimated by linear regression (Table 5.1)[1]. These results consist of four possible models: Schaefer and Fox models with a time trend (1) or without a time trend (2). All the proposed models are based on the assumption that there are two different types of inland fishery resources in South Sumatra, riverine and swamp fisheries.

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[1] Complete regression results of the model are presented in Appendix 5.1.

Table 5.1 Regression results for selected supply model in each type of the fishery resources in South Sumatra

Description	Models			
	Schaefer-1	Schaefer-2	Fox-1	Fox-2
F-statistics	42.09	47.99	117.23	89.94
Degrees of freedom	28	29	28	29
R-square (adjusted)	0.80	0.75	0.92	0.85
Effort$^{1)}$ (b_i)	$-4.59(10^{-7})$ $(-5.21)^a$	$-6.29(10^{-7})$ $(-8.92)^a$	$-1.13(10^{-7})$ $(-8.19)^a$	$-1.59(10^{-7})$ $(-11.98)^a$
DESWLK$^{2)}$	$-2.78(10^{-7})$ $(-4.82)^a$	$-3.37(10^{-7})$ $(-5.68)^a$	$-7.57(10^{-8})$ $(-8.44)^a$	$-9.22(10^{-8})$ $(-8.21)^a$
TM$^{3)}$	0.12 $(2.80)^a$		$3.47(10^{-2})$ $(4.97)^a$	
Constant (a_i)	6.06 $(6.51)^a$	8.32 $(16.27)^a$	1.76 $(12.14)^a$	2.39 $(24.70)^a$

Note :

a) Values in parentheses are t-values.

1) Standard fishing effort in terms of bamboo fishing trap *(bubu)*.

2) Dummy variable for slope of fishing effort representing swamp fishery.

3) TM is a variable of time trend.

The surplus production model implicitly assumes that there is no change in the environment and that the food supply is limited so that the unexploited fish stock increases toward the maximum carrying capacity of the environment. In the inland capture fishery system, environmental change affects the food supply and hence the maximum fish stock changes. Fishing mortality is proportional to effort, which measures the number of trips per year over the period 1979 to 1994. This means that the catchability coefficient (q) is a function of time. In the surplus production model, the catchability coefficient is assumed to be constant. Therefore, Sparre and Vanema (1992) suggest the use of short-series data instead of long-series data. In contrast, for better estimation results, longer series of data are desirable to have as many degrees of freedom as possible. An alternative value for 'q' is taken into account by introducing a time trend as shown by the variable TM[2].

All the estimated coefficients for the proposed models are highly significant and have expected signs. The judgment of 'best fit' for each proposed model which is based on the value of adjusted R-square (coefficient of determination) indicates that fishing effort explains much of the variation in catch in each model.

In both models, inclusion of a time trend improved statistical performance. The estimated coefficients for the time trend variables have the correct signs and the values are significantly different from zero indicating that, during the period of the study, fishing technology has improved. However, further analysis will consider only the second models of Schaefer and Fox. This is because it is assumed in policy analysis based on surplus production models that technological change does not occur.

These models have linear relationships between catch per unit effort (Y/E, CPUE) and standardised effort (E) and the logarithm of catch per unit of effort (ln Y/E, ln CPUE) and standardised effort (E) for the Schaefer and Fox models, respectively. Based on statistical performance, the coefficients on the fishing effort and dummy variables are highly significant. The estimated coefficients also have correct signs. The calculated F-

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[2] Another procedure for inclusion of the variable time trend in the surplus production model has been applied by Wallace *et al.* (1996, p. 592) for the case of rock lobster in Western Australia, Tasmania and America. However, the results were unsatisfactory.

statistics for Schaefer models 1 and 2 are 42 and 48, respectively. For Fox models 1 and 2, the calculated F statistics are 117 and 90, respectively. These values are greater than the relevant critical values. All explanatory variables in the models are significantly related to catch per unit effort in a statistical sense and they are consistent with model assumptions. More than 75 per cent of the variation in catch per unit of effort is 'explained' by these variables.

Even though the estimated results indicate that the models performed well, the assumptions of zero rate of change in biomass all year and of an exact index of relative abundance in a surplus production model may not be biologically correct (Hilborn and Walters 1992). To overcome those problems, various approaches to estimating model parameters have been suggested by Polacheck *et al.* (1993) and Laloe (1995) such as effort-averaging methods, process-error estimators and observation-error estimators. Berck and John (1991) suggested an estimation procedure which combined methods of maximum likelihood and Kalman filtering to deal with the nature of the biological model of the fishery. However, examination of these alternative procedures was beyond the scope of this study.

From Table 5.1, the estimated production function for the inland riverine fishery specified by equation (3.11) and equation (3.14) is:

$$(5.1)\quad \frac{Y}{E} = 8.32 - 6.29(10^{-7})\,E \qquad \text{(Schaefer)}$$

and,

$$(5.2)\quad \mathrm{Ln}\left(\frac{Y}{E}\right) = 2.39 - 1.60(10^{-7})\,E \text{ (Fox).}$$

For the swamp fishery, the estimated production function is specified as:

$$(5.3)\quad \frac{Y}{E} = 8.32 - 9.66(10^{-7})\,E \qquad \text{(Schaefer)}$$

and,

$$(5.4)\qquad \mathrm{Ln}\left(\frac{Y}{E}\right) = 2.39 - 2.52(10^{-7})\,E \qquad \text{(Fox).}$$

The estimation of the supply function for the inland fishery is based on the analytical framework outlined in Chapter 3. The supply function can be derived by relating the fishery production function and total costs per unit effort for the fishing unit. Assuming a fixed price for freshwater fish and a constant cost per unit of fishing effort, the production function for the fishery is determined by the Gordon-Schaefer or Gordon-Fox models. Alternatively, the Copes model may be used to determine the 'true' supply function for the inland fishery.

Gordon-Schaefer model

As discussed previously, given a fixed price for freshwater fish, the total revenue curve shows the same curvature as the total sustainable yield curve. Applying a fixed price assumption means the price for each species is independent of the size of the catch. The estimated total, marginal and average revenues for the riverine fishery indicated by Schaefer are:

$$TR = 1215\ Y$$

$$(5.5)\qquad TR = 1215\left\{8.32\,E - \left(6.29(10^{-7})\right)E^{2}\right\}$$

$$(5.6)\qquad MR = 1215\left\{8.32 - 2\left(6.29(10^{-})\right)E\right\}$$

$$(5.7)\qquad AR = 1215\left\{8.32 - \left(6.29(10^{-7})\right)E\right\}.$$

For the swamp fishery, estimated total revenue, marginal revenue and average revenue are:

$$TR = 1125\ Y$$

(5.8) $TR = 1125\left\{8.32\,E - \left(9.66(10^{-7})\right)E^{2}\right\}$

(5.9) $MR = 1125\left\{8.32 - \left(9.66(10^{-7}\ \right)E\right\}$

(5.10) $AR = 1125\left\{8.32 - \left(9.66(10^{-7})\right)E\right\}$.

Estimated total, marginal and average revenues for both fisheries from the Gordon-Fox model can be derived using the same procedures as those used for the Gordon-Schaefer model. For this reason, the extension of the bioeconomic models proposed by Copes will be based on the results from the Schaefer model.

With the Schaefer model, total, marginal and average costs of fishing in the riverine fishery are:

(5.11) $TC = 2973.57\ E$

(5.12) $MC = AC = 2973.57$.

Similarly, for the swamp fishery:

(5.13) $TC = 2631.48\ E$

(5.14) $MC = AC = 2631.48$.

Hence, the sustainable yield curve derived from these equations is the long-run production function for the fishery. It shows the quantity of fish produced on a sustained basis at various levels of effort. Unfortunately, this model will not provide the true relationship between supply and inputs in a conventional economic sense, since it is based on effort instead of catch.

Copes Model

In the Copes model (Copes, 1970, Cunningham *et al.*, 1985) where fish price is allowed to vary, total cost is derived as a function of output. This is obtained by defining the production function for the fishery in terms of catch. Hence, for simplicity, the production function for the fishery based on the Gordon-Schaefer model is expressed below:

$$(5.15)\quad E = \frac{8.32 \pm \sqrt{\left\{8.32^2 - 4\left(6.29(10^{-7})\right)Y\right\}}}{2\left(6.29(10^{-7})\right)} \qquad \text{(riverine)}$$

and,

$$(5.16)\quad E = \frac{8.32 \pm \sqrt{\left\{8.32^2 - 4\left(9.66(10^{-7})\right)Y\right\}}}{2\left(9.66(10^{-7})\right)} \qquad \text{(swamp).}$$

Thus, given a fixed price for freshwater fish, total, marginal and average revenues for fishing in the riverine fishery are:

$$(5.17)\quad TR = p(Y)\,Y = 1215\ Y$$

$$(5.18)\quad MR = AR = 1215$$

and total, marginal and average revenues of fishing in the swamp fishery are:

$$(5.19)\quad TR = 1125\ Y$$

$$(5.20)\quad MR = AR = 1125\ .$$

Alternatively, when fish price depends on quantity of fish consumed, the price function will be the same as the inverse demand function. Estimation of this price function will be discussed in the next section.

Similarly to the above procedure, total, marginal and average costs of fishing in the riverne fishery are estimated below:

$$(5.21)\quad TC = 2973.57\left[\frac{8.32 \pm \sqrt{\left\{8.32^2 - 4\left(6.29(10^{-7})\right)Y\right\}}}{2\left(6.29(10^{-7})\right)}\right]$$

$$(5.22)\quad MC = \frac{2973.57}{\pm\sqrt{\left\{8.32^2 - 4\left(6.29(10^{-7})\right)Y\right\}}}$$

$$(5.23)\quad AC = \frac{2(2973.57)}{8.32 \pm \sqrt{\left\{8.32^2 - 4\left(6.29(10^{-7})\right)Y\right\}}}\,.$$

For the swamp fishery, estimated total, marginal and average costs of fishing are:

$$(5.24)\quad TC = 2631.48\left[\frac{8.32 \pm \sqrt{\left\{8.32^2 - 4\left(9.66(10^{-7})\right)Y\right\}}}{2\left(9.66(10^{-7})\right)}\right]$$

$$(5.25)\quad MC = \frac{2631.48}{\pm\sqrt{\left\{8.32^2 - 4\left(9.66(10^{-7})\right)Y\right\}}}$$

$$(5.26)\quad AC = \frac{2(2631.48)}{8.32 \pm \sqrt{\left\{8.32^2 - 4\left(9.66(10^{-7})\right)Y\right\}}}\,.$$

Thus, supply curves for fish from the riverine and swamp fisheries are represented by equations (5.23) and (5.26), respectively.

5.2.2 Demand for fish from the fishery

The law of demand means that the price of a good will vary inversely with the amount available in the market during a specific period. This occurs when prices are assumed to vary. For the purposes of this study it is necessary to change the frame of reference and to consider cost and revenue in terms of fish catch rather than purely in terms of effort. Specifically, since the demand curve is an average revenue curve, it is best to deal with average revenue and average costs associated with fish catch.

The estimated demand function for the fish is specified as double-log, semi-log and linear functions (Appendix 5.2). In the demand equations, fish consumption per capita is regressed against own price, price of beef and per capita income. The regression results for the demand function are given in Table 5.2, which reports only the double-log demand function version[3].

Table 5.2 shows the coefficients in the regression equation have signs consistent with demand theory. Over 92 per cent of annual variation in consumption of fish from this fishery is 'explained' by selected variables. Since the calculated F-statistic (61.98) is greater than the critical one (5.95), it can be concluded that the explanatory variables significantly affect the dependent variable. The value of the Durbin-Watson statistic in the model did not give any indication of serial correlation of errors. On the basis of t-statistic performance, the coefficients on prices of freshwater fish and beef are significantly different from zero. Per capita income is significantly different from zero at a lower level of confidence than that of prices.

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[3] The regression result reported in Table 5.3 pertains to real prices and income, specified in terms of a double-log form of demand function. This means that the elasticities for the selected variables are easily calculated. Ideally, inverse-demand functions or price functions should be used rather than quantity demand functions. However, estimates based on the price function were statistically inferior to those reported in Table 5.3.

Table 5.2 Estimated result of double-log demand function for fish in South Sumatra using 1978-1993 data

Independent Variable	Coefficient	Standard error	T-statistics value
LPFGC	-0.21786	0.0690	-3.156
LPBGC	0.32547	0.1057	3.079
LIGC	0.19281	0.1016	1.896
Constant	0.41046	0.6268	0.655

Degrees of freedom : 12
Adjusted R-square : 0.92
F-statistics : 61.98
SE of regression : 0.023
DW-statistic : 1.174

Note :

LCONS : Logarithm value of fish per capita consumption (kg/cap/yr).
LPFGC : Logarithm value of real price of freshwater fish (rp/kg).
LPBGC : Logarithm value of real price of beef (rp/kg).
LIGC : Logarithm value of per capita income (rp/cap/yr).

The own-price elasticity is -0.22, indicating that if fish prices increase by one per cent then quantity of fish consumed declines by 0.22 per cent. The positive sign and significant coefficient on the beef price variable indicate that beef is a substitute for fish in daily consumption in the region.

Further, income is relatively less important than prices in affecting fish consumption. This reflects that fish has traditionally been consumed by households regardless of their level of income. It is a staple.

Fish appears to be a 'normal' good since an increase in income increases per capita fish consumption. The elasticity of demand with respect to income equals 0.19 which is not very large when compared to other income elasticities associated with food. A 10 per cent increase in per capita income causes per capita fish consumption to rise by only 1.9 per cent.

Rearranging the demand function into an inverse demand function for fish provides a relatively simple and imperfect description of the demand for fish. Using the price equation, average value of the variables can be substituted to obtain the reduced form of the model[4]:

$$\mathrm{LCONS} = 0.41046 - 0.21786\ \mathrm{LPFGC} + 0.32547\ \mathrm{LPBGC} + 0.19281\ \mathrm{LIGC}$$

$$\mathrm{LCONS} = 3.43268 - 0.21786\ \mathrm{LPFGC}$$

$$\mathrm{LPFGC} = 15.757 - 4.590\ \mathrm{LCONS}$$

$$(5.27)\quad \mathrm{PFGC} = 6{,}964{,}646\ \mathrm{CONS}^{-4.59}$$

This is an inverse demand function for fish in the region. Note that consumption per capita is for aggregate fish consumption. Consequently, an interpretation of the model requires great care. Considering the average contribution made by freshwater fish in the total South Sumatra fishery accounted for 32.9 per cent[5], the calculated average freshwater fish consumption is only 6 07 kg per capita.

In the study site, it was indicated that demand for freshwater fish contributed little to aggregate food demand. Empirical results indicated that domestic demand for freshwater fish was not very sensitive to changes in per capita income. This means that consumers have tended to spend their additional income on non-freshwater fish items. The above indication may suggest that domestic demand for freshwater fish is perfectly elastic[6]. Consequently, the price curve will be perfectly 'flat'. This implies that the price of freshwater fish may not be affected by quantity demanded. Considering this argument, the price 'equation' for freshwater fish, as opposed to total fish, can be viewed as a constant. Thus, average revenue and marginal revenue are the same. Values for the cases of the riverine and the swamp fishery are:

(5.28) $P(Y) = AR = MR = 1215$

and

(5.29) $P(Y) = AR = MR = 1125$,

respectively.

5.3 Bioeconomic Models and Optimal Resource Yield

The optimal level of use of the inland fishery resource in South Sumatra can be determined from the estimated supply and demand equations discussed in the previous section. The optimal levels were measured in terms of maximising sustainable yield (MSY), maximising economic yield (MEY) and maximising social yield (MScY).

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[4] Note that the average logarithmic real price of beef and real per capita income during 1978-1993 are used in order to get the reduced form of the model.

[5] Production structure of the South Sumatra fishery is presented in Appendix 5.3.

[6] A similar case, in terms of demand for food, is observed by Helmberger and Chavas (1996). A commodity with many substitutes or some close substitutes may have price-elastic demand. This case has been argued by economists discussed in Tomek and Robinson (1990, p. 37).

Based on these results, the average level of effort during the study and the possible bionomic equilibrium in the South Sumatra inland fishery can be identified. Economic evaluation of policies for managing the fishery can be calculated using corresponding resource rent or profits. In further discussion, the management objectives for policy are said to be 'critical points'.

5.3.1 Gordon-Fox and Gordon-Schaefer models

Various critical points for the Gordon-Fox and Gordon-Schaefer models and the average actual capture during the period of study are presented in Tables 5.3 and 5.4, respectively. Total costs and revenues for each critical point are calculated using a similar procedure to that in equations (5.5) and (5.11). The resource rent or profit is defined as:

(5.30) $\pi_j = TR_j - TC_j$

where π is a resource rent or profit and j is a state of the critical point.

Both models indicate that the inland capture fishery in South Sumatra faced a problem of over-fishing from both biological and economic perspectives during the period of the study. This is because actual average effort was beyond both MEY and MSY levels.

Using the Fox model, estimated levels of fishing effort and catch in the riverine fishery are 6,472,492 trips and 24,900 tonnes for MSY and 3,763,186 trips and 22,002 tonnes for MEY. In other words, the Fox model indicates that the equilibrium level of fishing effort is only 52 per cent and 90 per cent for MEY and MSY, respectively, of the actual average effort.

Table 5.3 Calculated effort, catch, costs, revenues and profits of the inland fishery in South Sumatra Indonesia based on fixed price model and the Fox model

Critical condition	Effort (fishing trip)	Catch (kg)	Cost (million rp)	Revenue (million rp)	Profit (million rp)
Rivers:					
MSY	6,472,492	24,809,835	19,246.41	30,253.30	11,006.89
MEY	3,763,186	22,002,447	11,190.10	26,732.97	15,542.88
MScY	4,467,576	23,427,382	13,284.65	28,464.27	15,179.62
BES1)	12,053,074	19,578,261	23,787.59	23,787.59	0.00
BE2)	9,399,876	23,005,094	27,951.19	27,951.19	0.00
Actual (mean)	7,216,616	22,833,347	21,459.11	27,742.52	6,283.40
Swamps:					
MSY	4,120,347	15,851,057	10,842.61	17,832.46	6,989.85
MEY	2,450,024	14,136,809	6,447.19	15,903.91	9,456.72
MScY	2,950,910	15,077,954	7,765.26	16,962.70	9,197.44
BES1)	8,140,139	11,804,866	13,280.47	13,280.47	0.00
BE2)	6,170,370	14,433,073	16,237.21	16,237.21	0.00
Actual (mean)	5,414,912	14,830,000	14,249.23	16,683.75	2,434.52

Note :

1) Calculated by assuming that the opportunity cost in the fishing community is zero.
2) Calculated by including labour cost of fishing.

Table 5.4 Calculated effort, catch, costs, revenues and profits of the inland fishery in South Sumatra Indonesia based on fixed price model and the Schaefer model

Critical condition	Effort (fishing trip)	Catch (kg)	Cost (million rp)	Revenue (million rp)	Profit (million rp)
Rivers:					
MSY	6,711,324	27,350,322	19,956.59	33,230.64	13,274.05
MEY	4,696,088	24,834,296	13,964.15	30,234.42	16,270.27
MScY	5,373,804	26,264,030	15,979.38	31,910.80	15,931.41
BES[1)]	10,747,608	17,457,742	21,459.11	21,459.11	0.00
BE[2)]	9,392,176	22,986,250	27,928.29	27,928.29	0.00
Actual (mean)	7,216,616	22,833,347	21,459.11	27,742.52	6.283.40
Swamps:					
MSY	4,407,153	17,960,249	11,597.33	20,205.28	8,607.95
MEY	4,280,729	17,945,470	11,264.65	20,188.65	8,924.00
MScY	4,328,772	17,954,568	11,391.08	20,198.89	8,807.81
BES[1)]	7,245,991	10,508,169	11,821.69	11,821.69	0.00
BE[2)]	6,284,708	14,700,519	16,538.08	16,538.08	0.00
Actual (mean)	5,414,912	14,830,000	14,249.23	16,683.75	2,434.52

Note:

1) Calculated by assuming that the opportunity cost in the fishing community is zero.
2) Calculated by including labour cost of fishing.

These figures imply that the average level of effort should be reduced by 48 per cent in order to reach MEY and by 10 per cent to reach the MSY. However, in terms of the amount of total catch, these figures are not significantly different. The average catch data are 8 per cent below MSY and about 4 per cent above MEY.

Considering the bionomic (BE) level in the case of open access in an unregulated fishery, the estimated levels of fishing effort and catch are 9,399,876 trips and 23,005 tonnes, respectively. These figures are 30 per cent and less than one per cent above the averages, respectively. In other words, if the inland fishery is allowed to reach the level of open-access or bionomic (BE) condition, the average level of fishing effort will be increased from 7,216,616 to 9,399,875 trips. However, this increase in effort adds only 0.75 per cent to the catch.

These explanations are interesting because the change in fishing effort is not always followed by a change in catch in the same direction or proportion. A relatively large expansion of fishing effort yields only a relatively small amount of extra catch. This may be explained as follows.

As indicated by a 'bell-shaped' curve of the catch and fishing effort relationship (Anderson 1977, Ch. 2), an increase in fishing effort will be followed by an increase in catch. However, beyond MSY, further increase in effort will decrease the amount of expected catch. Since the curve is a sustainable yield curve, as fishing effort increases, the equilibrium level of the stock decreases, and, as the stock decreases, the natural growth which has at first increased will ultimately decrease[7]. Recall that sustainable yield equals natural growth. This means that the net natural increase in fish stock will be small at both low and high levels of fish stock, and, consequently, will reach a maximum at some intermediate level of fish stock. Hence, an increase in fishing effort causes a reduction in the equilibrium stock level but accelerates natural growth and, hence, sustainable yield increases. Beyond MSY, an increase in fishing effort causes reduced fish stock and natural growth and hence sustainable yield decreases. This means that as fishing effort increases, expected catch decreases.

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[7] Waugh (1984, p. 21) defined this phenomenon as a general law of population growth.

Fishing effort tends to increase in the absence of secure property rights. Economically, it can be said that fishers in these circumstances seek average rather than marginal productivity. Instead of maximising profit where marginal value of product equals marginal cost, they increase effort until value of average product equals marginal cost. This is because no individual owns the fish stock and can exclude others from it (Anderson 1977, p. 33). The revenue received by individual fisher per unit of effort is equal to the average revenue for the fishery as a whole. When an additional fishing unit enters the fishery, the revenue of existing fishing units will fall due to the change in average sustained yield caused by the increase in fishing effort. Marginal revenue from the fishery takes this into account but the average revenue does not. An individual fisher is only concerned with fishery average revenue because this is his/her expected return for each unit of fishing effort produced. He/she is not worrying over the effect of his/her fishing effort on marginal revenue from the fishery. Therefore, as long as there are profits, fishers increase fishing effort. This causes the bionomic equilibrium of the fishery to be greater than the optimal. In these circumstances the fishery is over-fished as rent is absorbed by excess fishing effort.

Profits at MSY and MEY account for 11,007 and 15,543 million rupiah, respectively, whereas actual average profits account for only 6,283 million rupiah. This means by reducing the average level of fishing effort to optimal levels, additional profits could be obtained from the fishery of 4,723 (MSY) and Rp. 9,259 (MEY) million rupiah.

The swamp fishery is similar to the riverine fishery. Levels of fishing effort generated by the model are 4,120,347 trips (MSY), 2,450,024 trips (MEY) and 6,170,370 trips (BE). The average fishing effort in the riverine fishery is higher than optimal levels, MSY and MEY. However, the figure is less than the bionomic level. Average historical effort needs to be reduced by 55 per cent to reach MEY and by 24 per cent to reach MSY. To reach the bionomic level, fishing effort is allowed to increase by 14 per cent.

Estimated catches are 15,851 tonnes (MSY), 14,137 tonnes (MEY) and 14,433 tonnes (BE). Given the average catch of 14,830 tonnes, reducing fishing effort to reach MSY and MEY increases the catch by seven per cent and decreases the catch by five per cent, respectively. Allowing fishing effort to increase from average historical levels to the BE point, would not increase expected catch. In fact, the estimated catch would be decreased by three per cent.

Resource rent accounts for 2,434 million rupiah in the average period under study. The estimated profits generated by setting the objectives of fishery at MSY and MEY would be 6,990 million rupiah and 9,457 million rupiah. These figures indicate that by reducing the average level of fishing effort to optimal levels, additional expected profits would be 4,555 million rupiah (MSY) and 7,022 million rupiah (MEY).

However, reduction in fishing effort implies that fishers may be forced out of fishing. This kind of solution is not popular or commonly applied in the case of small-scale fisheries in Indonesia. Appropriate policy actions in the small-scale fishery may be to set the objective of maximising social yield (MScY) so that the reduction in effort is less than for MEY.

Considering the MScY, the estimated fishing effort and catch are respectively 4,467,576 trips and 23,427 tonnes for the rivers and 2,950,910 trips and 15,078 tonnes for the swamps. The expected profits are 15,180 million rupiah (rivers) and 9,197 million rupiah (swamps). In other words, to generate profit with the optimal social yield objective, the fishing effort is allowed to increase by 20 per cent of MEY and hence estimated catch increases by 7 per cent. Estimated profits derived from the Fox model in selected critical points are depicted in Figure 5.1.

The optimal solutions derived from the Schaefer and Fox models are similar. However, in order to reach MSY, MEY and MScY levels, fishing efforts in the Schaefer model are at a higher level than in the Fox model. In the riverine fishery, the Schaefer model permits approximately 4 per cent, 25 per cent and 20 per cent higher levels of fishing effort at MSY, MEY and MScY, respectively, than with the Fox model. This implies that the reduction in fishing effort required to reach the optimal solution is higher with the Fox model than with the Schaefer model. The estimated

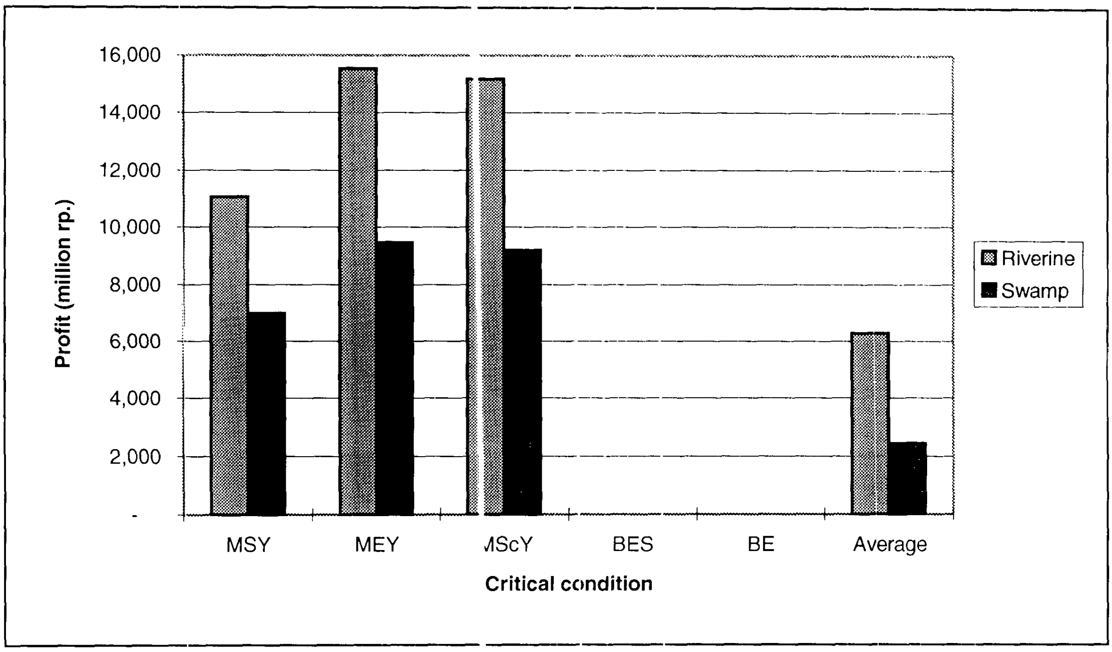

Figure 5.1 Estimated profits derived from the Gordon-Fox model in South Sumatra inland fishery

catch with the Schaefer model for each optimal resource is 27,350 tonnes (MSY), 24,884 tonnes (MEY) and 26,264 tonnes (MScY). These figures are 10 per cent, 13 per cent and 12 per cent higher than the MSY, MEY and MScY, respectively, of those generated by the Fox model. In line with this performance, biologists would usually prefer to use the Fox model instead of the Schaefer model since the Fox model seems to be more conservative. Graphically, levels of fishing effort specifying the various critical points based on Gordon-Fox and Gordon-Schaefer models are presented in Figure 5.2.

The Gordon-Schaefer and Gordon-Fox models may exhibit estimated profits at various critical points differently. With the former, total accumulated profits derived from the riverine fishery are 13,274.05, 16,270.27 and 15,931.41 million rupiah at the optimal options of MSY, MEY and MScY, respectively. In the swamp fishery, the estimated profits are Rp. 8,607.95 (MSY), Rp. 8,924.00 (MEY) and Rp.8,807.81 (MScY) million rupiah. The Gordon-Fox model generates relatively low figures. In the riverine fishery, estimated profits derived by this model are 17 per cent, 4 per cent and 5 per cent less than the Gordon-Schaefer at MSY, MEY and MScY levels, respectively. In the swamp fishery, however, the trend is not the same as above. The estimated profit derived from the Gordon-Fox model at MSY is 19 per cent less than with the Gordon-Schaefer model. At MEY and MScY levels, the estimated profits are 6 per cent and 4 per cent higher than the Gordon-Schaefer model.

The results indicate that the South Sumatra inland fishery was over-fished both biologically and economically during the period of study. If the management authority seeks to achieve either MEY or MSY they will have to substantially reduce effort.

A great reduction in effort may also reduce the number of fishers and create unemployment. Since the current situation indicates over-fishing, the authorities could impose regulations to maintain sustainability of the resource.

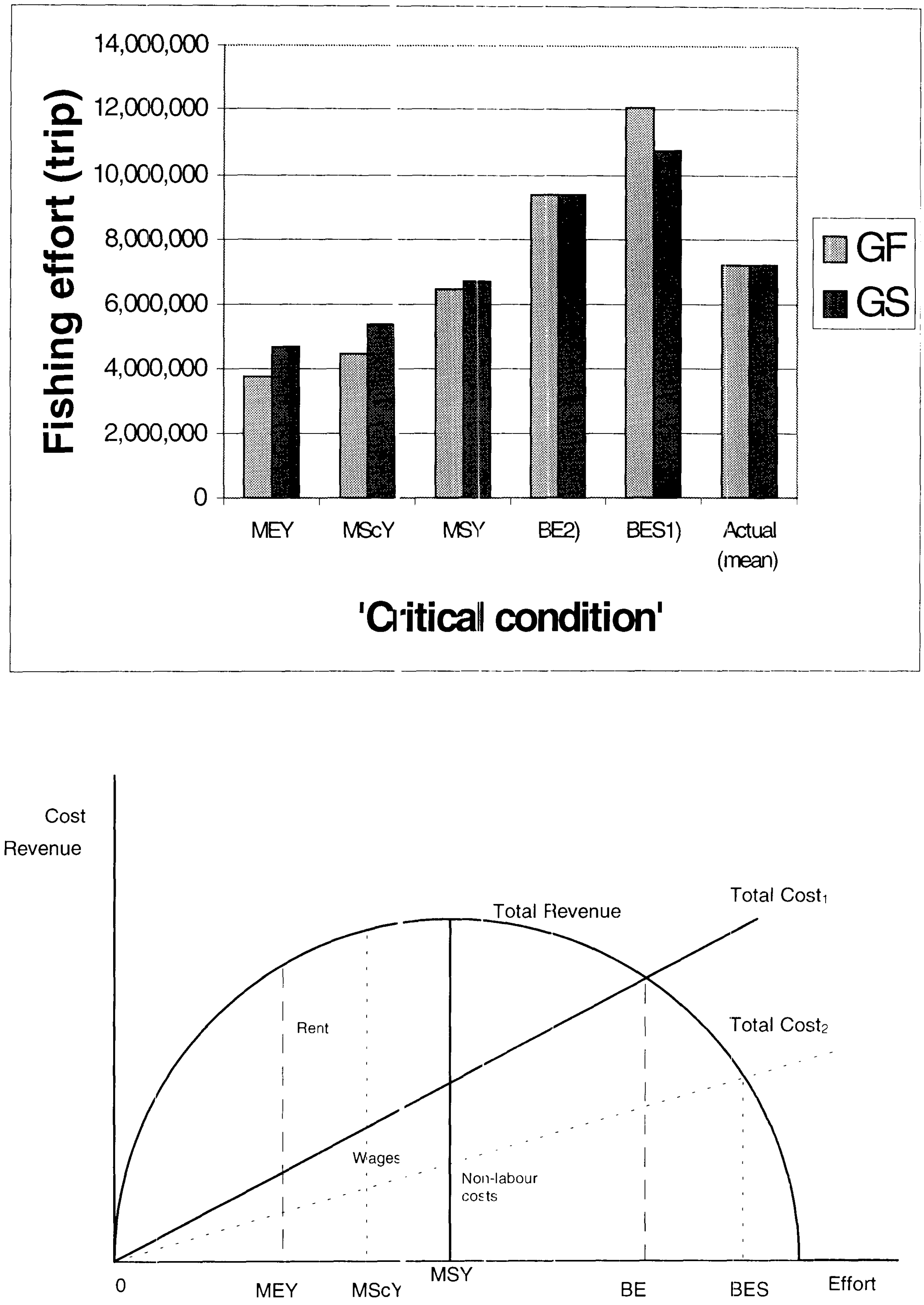

Figure 5.2 Various 'critical points' of fishing effort in South Sumatra inland fishery estimated by the Gordon-Fox and the Gordon-Schaefer models

The maximum social yield (MScY) takes the social aspect into consideration in determining the objectives of the fishery management. Fishers may have no alternative to fishing and hence the opportunity cost of fishers's time may be close to zero.

5.3.2 Copes model

As indicated in the previous section, the econometric results for the demand for fish from the region were difficult to interpret. This is because per capita consumption of the fish is an aggregate rather than single species or even group of freshwater fish. References for small-scale fishery, for example, Smith (1979), and observations during the study indicated that fishers have little control over marketing of their product. It was assumed that all the inland fishery production is consumed domestically so that demand for freshwater fish equals total production. With these assumptions, the price that the fishers receive may not be influenced by the quantity sold. Thus, in this case, employing the constant price of the Copes model is reasonable. Consequently, consumer surplus will be zero. Economic evaluation based on this model reflects the estimated profit. That is, the difference between total revenue and total cost at each 'critical condition'.

In the Copes model (Copes, 1970), the production function for the fishery is specified in terms of catch. The estimated levels of fishing effort, catch, total cost, total revenue and profit in each 'critical condition' of the model are presented in Table 5.5.

The level of effort which maximises social benefit is represented by the MEY condition which sets price equal to marginal cost. An unregulated fishery is represented by the 'bionomic' condition which sets average revenue equal to average cost. A monopoly may exist if marginal revenue is equal to marginal cost. The supply and demand for fish derived from the Copes model in riverine fishery are depicted in Figure 5.3.

Table 5.5 Calculated effort, catch, costs, revenues and profits of the inland fishery in South Sumatra, Indonesia, based on the Copes model1)

Critical condition	Effort (trips)	Catch (tonnes)	Cost (million rp)	Revenue (million rp)	Profit (million rp)
Rivers:					
MSY	6,606,547	27,467	19,645	33,372	13,727
MEY	4,662,019	25,087	13,863	30,481	16,618
MScY	5,315,956	26,419	13,038	32,099	19,060
BE	9,324,038	22,819	27,726	27,726	0
BES	10,631,913	17,270	20,983	20,983	0
Actual (average)	7,009,797	22,775	20,844	27,671	6,827
Swamps:					
MSY	5,052,362	17,342	13,295	19,509	6,214
MEY	3,091,839	16,470	8,136	18,529	10,393
MScY	3,551,736	17,342	5,795	19,509	13,715
BE	6,183,678	14,464	16,272	16,272	0
BES	7,103,472	10,301	11,589	11,589	0
Actual (average)	5,414,912	14,830	14,249	16,684	2,435

Note:

1) Calculated from the Schaefer model.

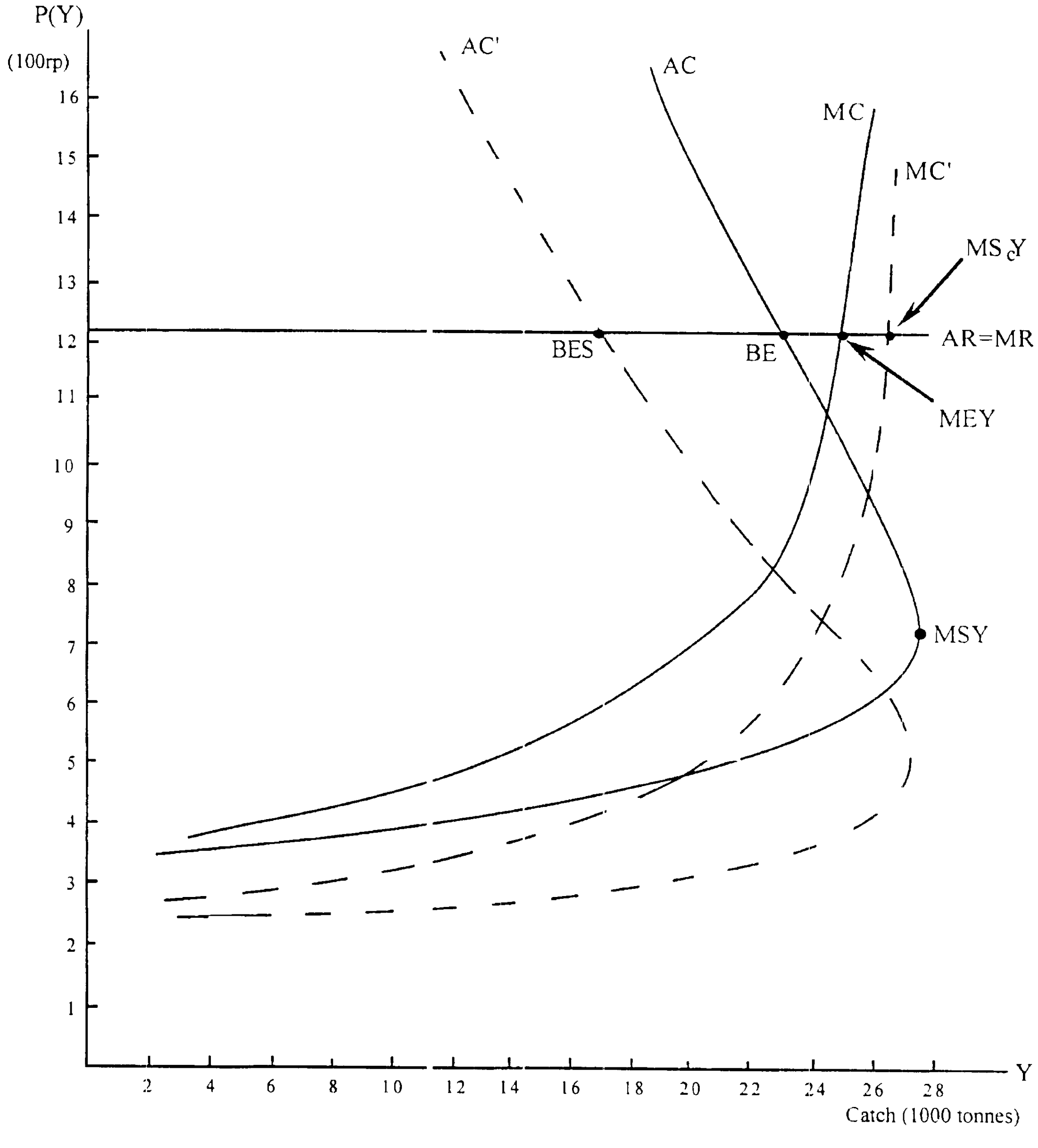

Figure 5.3 Supply and demand for fish derived from the Copes model in South Sumatra riverine fishery

5.4 Base-Case Model and Sensitivity Analysis

5.4.1 Rationale

The assumption of the Schaefer surplus production model in terms of: (1) no time lags between change in stock size and change in rate of stock increase, and (2) independence between rate of stock increase and age composition of the stock, may be approximated if the stock grow rapidly and the fish are relatively short-lived (Schaefer 1957 and Fox 1970). The empirical results were based on the historical data without information on whether the system was in equilibrium or not, consequently, precise biological parameters in terms of 'r', K' and 'q' should be estimated. Given estimated results of a_i and b_i from the Schaefer model, these biological parameters can be obtained using procedures from Fox 1970, 1975). The results were treated as 'base-case' constant biological parameters. For validation purposes, and for assessing the behaviour of the biological parameters in the fishery, sensitivity analyses were also conducted.

5.4.2 Estimation of biological parameters and initiation of the 'base-case' model

Based on the estimated results for a_i and b_i from the Schaefer surplus production model reported in Table 5.1, biological parameters for the fish stock were estimated using the procedure described by Fox (1970, p. 82-83; 1975, p. 26-27)[8]. The calculated estimates of the intrinsic growth rate (r_i) for the fish stock in the riverine and swamp fisheries were 1.397 and 2.861 respectively. The estimates of carrying capacity (K_i) for the fish stock in riverine and swamp fisheries were 78,621,512 and 25,007,179, respectively. The estimates of catchability coefficient (q_i) were $1.058(10^{-7})$ for the riverine fishery and $3.325(10^{-7})$ for the swamp fishery. These results for both the riverine and swamp environments are summarised in Table 5.6.

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[8] In this case, the integral method is applied as in Appendix 5.4.

Table 5.6 Estimated biological parameters of fish in terms of catchability coefficient (q), intrinsic growth rate (r) and carrying capacity (K) in different types of resources based on Schaefer models

Biological parameter	Riverine	Swamp
q (10^{-7})	1.058	3.325
r	1.397	2.861
K	78,621,512	25,007,179

These estimated biological parameters will be used as an initial condition for the system and considered as a ‘base case’ representing the existing situation for the inland fishery. Using the results derived from the Copes model, the stock size at the bionomic equilibrium was calculated. Hence, the overall base-case condition for the fishery is presented in Table 5.7.

Table 5.7 Description and values of model parameters and variables based on Copes model[a]

Parameter	Definition	Base Value	
		Riverine	Swamp
r_i	Intrinsic growth rate	1.397	2.861
q_i	Catchability coefficient	$1.058(10^{-7})$	$3.325(10^{-7})$
K_i	Carrying capacity	78,621,512	25,007,179
X_i	Stock size (kg)	23,141,131	7,034,846
E_i	Effort (day trip)	9,324,472	6,183,575
Y_i	Catch (kg)	22,820,553	14,463,960
p_i	Price of fish (Rp)	1,215	1,125
c_i	Cost of fishing effort (Rp)	2,973.57	2,631.48

Note:

i : The type of resources, i.e., i=1 (riverine) and i=2 (swamp).

a) The Copes model is derived from estimates of the Schaefer model.

5.4.3 Sensitivity analysis

With these biological parameters, sensitivity analysis was conducted to assess the behaviour of the model in response to parameter changes. The analysis was done by assuming changes in biological parameters. Results of the sensitivity analyses were expressed as changes in total catch and fish stock compared to the base-case model. Six sensitivity analyses were conducted by assuming: (1) changes in each biological parameter, and (2) combined changes in parameters described in Table 5.8.

Table 5.8 Sensitivity analysis of biological parameters of the inland fishery in South Sumatra, Indonesia

Case	Description	Parameter	Change
1	Intrinsic growth rate	r_i	-5%
2	Carrying capacity	K_i	-5%
3	Catchability coefficient	q_i	+5%
4	Combination of cases 1 and 3	r_i and q_i	r_i -5% q_i +5%
5	Combination of cases 2 and 3	K_i and q_i	K_i -5% q_i +5%
6	Combination of cases 1, 2 and 3	r_i, $K_i$and q_i	r_i -5% K_i -5% q_i +5%

The results of the sensitivity analyses are presented in Table 5.9. In general, the levels of stock size and catch were very sensitive to small changes in biological parameter values. Given the level of effort with the base case, stock size and total catch of both

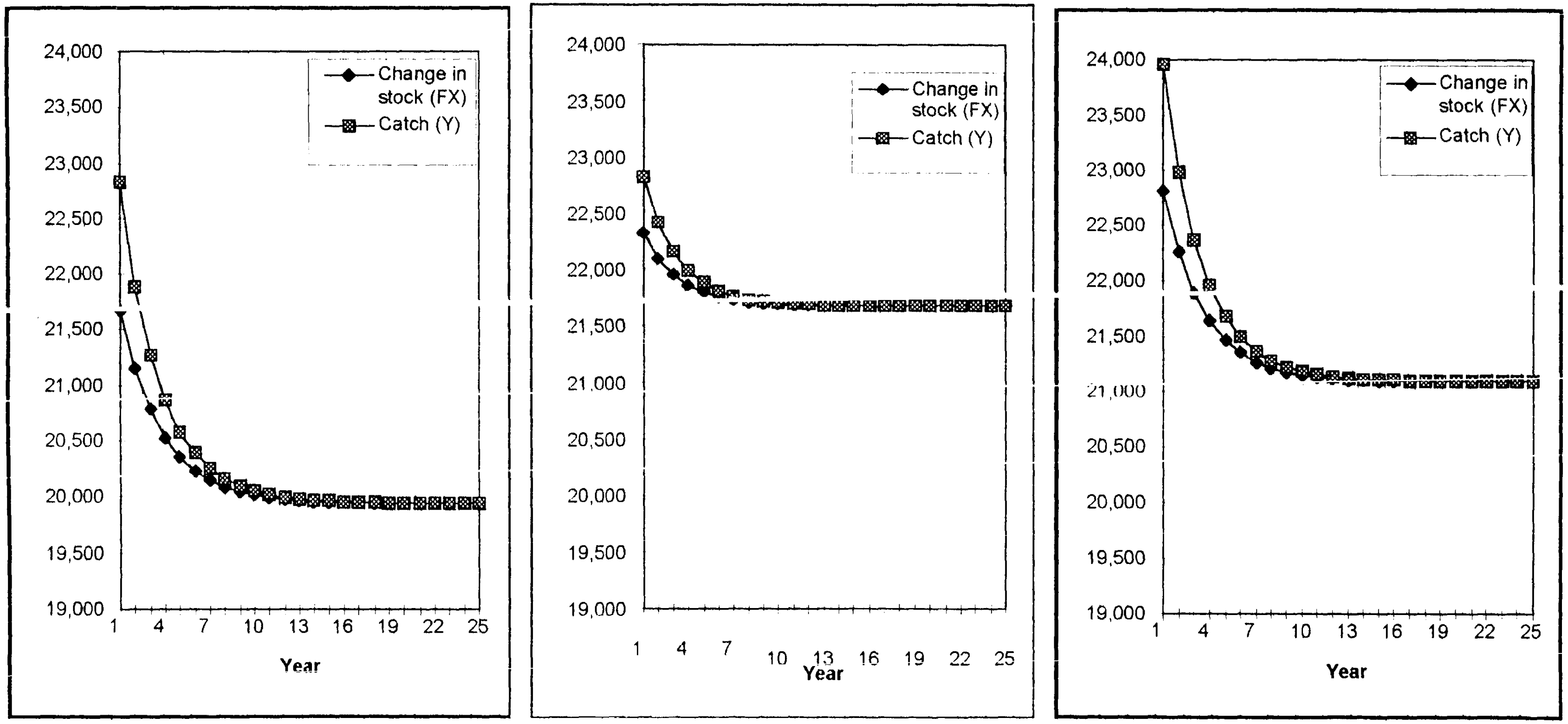
Table 5.9 Results of sensitivity analysis of biological parameters in terms of relative change in stock size and total catch

Case	Riverine		Swamp	
	Stock	Catch	Stock	Catch
1	-21.1	-21.1	-21.9	-13.4
2	-5.0	-5.0	-5.0	-5.0
3	-12.0	-7.6	-12.8	-8.4
4	-25.2	-30.1	-77.8	-52.0
5	-16.4	-13.4	-74.8	-45.6
6	-29.0	-33.6	-78.9	-54.4

resources were most sensitive to intrinsic growth rate of the fish stock (r_i), followed by the catchability coefficient of the standardised fishing effort (q_i) and finally by carrying capacity of the environment K_i). A reduction of 5 per cent in the base value of r_i results in proportional changes in stock size and total catch in the riverine fishery (-21.1 per cent), but not so in the swamp fishery (-21.9 per cent and -13.5 per cent). Changes in K_i caused proportional changes in stock size and total catch in the same direction (-5 per cent). The impact of changes in q in the swamp fishery was relatively higher than in the riverine fishery. This implies that effect of increasing the efficiency of the fishing gear used would be more destructive in the swamp than in the riverine fishery.

Figures 5.4 and 5.5 show the adjustment paths for changes in stock (FX) and catch (Y) resulting from changes in biological parameters in the riverine and swamp fisheries. The biological equilibrium is attained when catch is equal to surplus growth. From Figure 5.4, the longest time required to reach equilibrium in the riverine fishery was for a change in r (23 years), followed by a change in q (19 years) and K (18 years). Similarly, the time required to reach equilibrium in the swamp fishery was 19 years (r),

Figure 5.4 Adjustment trajectory caused by changes in biological parameters (r, K and q) in terms of change in stock size (FX) and catch (Y) in the riverine fishery

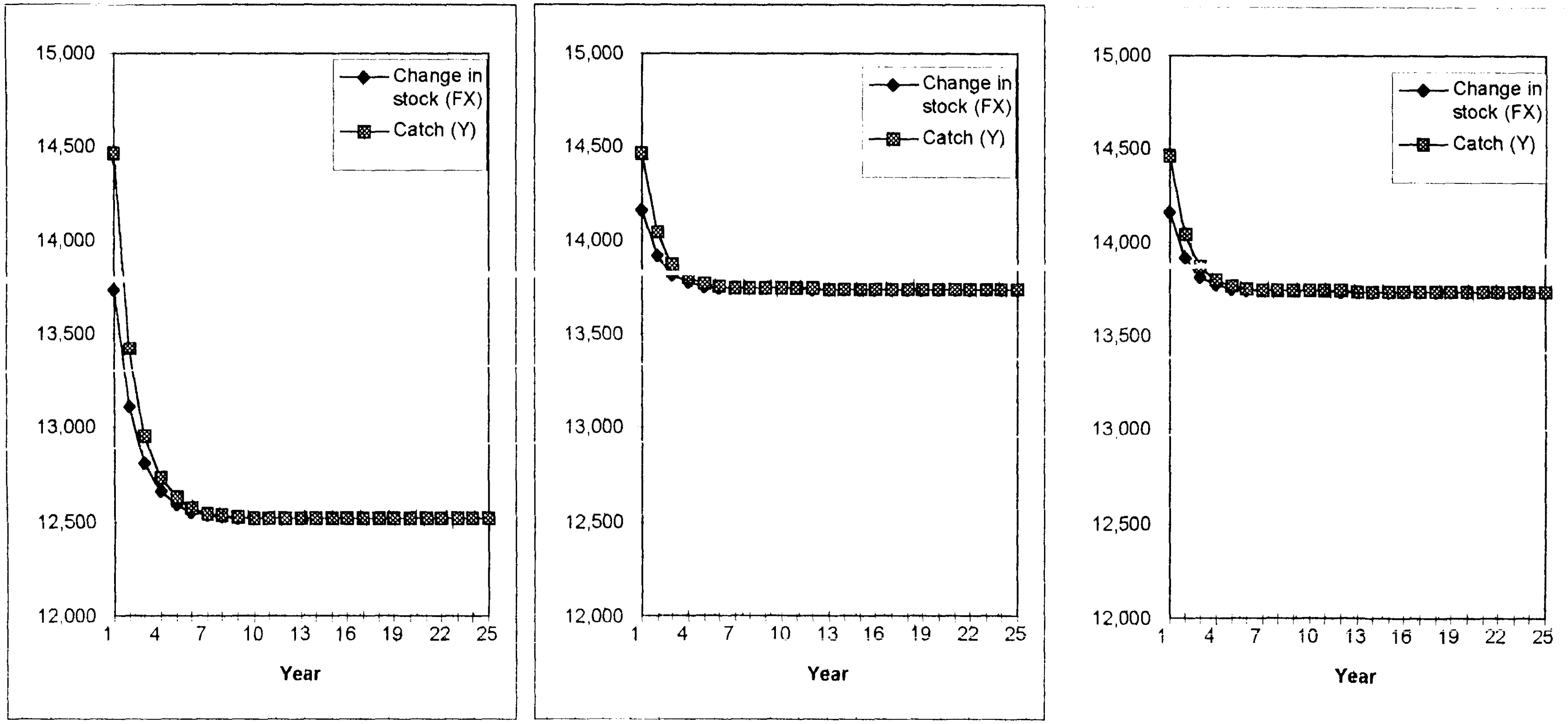


(a) Case 1: change in r

(b) Case 2: change in K

(c) Case 3: change in q

Figure 5.5 Adjustment trajectory caused by changes in biological parameters (r, K and q) in terms of change in stock size (FX) and catch (Y) in the swamp fishery



(a) Case 1: change in r

(b) Case 2: change in K

(c) Case 3: change in q

12 years (q) and 10 years (K) as in Figure 5.5. The swamp fishery requires a relatively shorter time to reach equilibrium than the riverine fishery. This may be explained as follows. Considering the characteristics of the fishery resources, the depth of water in the swamp fishery is highly variable. It is low or even dry in the dry season whereas the riverine resource contains water throughout the year. This results in a relatively more concentrated fish stock in the swamp during low water. In addition, fish stock recover easily from intense low-water exploitation during high water season, when fishing efficiency is low due to dispersion of fish in newly inundated areas. In the riverine resource, the fish stock is relatively stable since there is water throughout the year.

The effects of simultaneous changes in r_i and q_i (case 4) were considerably higher in the swamp fishery than in the riverine fishery. In the swamp fishery, stock size and total catch in the long run were reduced by 77.8 per cent and 52.0 per cent, respectively. In the riverine fishery, these changes resulted in a reduction in stock size of 25.2 per cent and of total catch by 30.1 per cent. Similar patterns were obtained with the combination of parameter changes in K_i and q_i (case 5). The effect of all biological parameters changing simultaneously (case 6) resulted in the largest changes in stock and catch, -29.0 per cent and –33.6 per cent in the riverine fishery, and –78.9 per cent and –54.4 per cent in the swamp fishery.

The results indicate that the estimates of stock size and potential catch are relatively sensitive to estimates of biological parameters. These results underline the importance of measuring these parameters as precisely as possible for management purposes.

5.5 Summary and Concluding Remarks

Given constant cost of fishing effort and price of fish, bioeconomic models based on the Gordon-Fox and Gordon-Schaefer approaches were developed. Both models indicate that the South Sumatra inland fishery during the period of the study was over-fished both biologically and economically. Bioeconomic models based on the Copes approach were developed by assuming constant and variable prices for fish. In the case of the small-scale inland fishery, it seems that the constant price model is appropriate, since the elasticity of demand with respect to price is infinite.

With the small-scale inland fishery, a social factor representing the opportunity cost of fishing was included in the bioeconomic model so that the objective of the fishery became maximisation of social yield. Given this objective, a reduction in the average fishing effort to achieve an optimal resource allocation was less than with the standard bioeconomic model.

Base-case biological parameters of the fishery were calculated from the coefficients of the Schaefer model. The intrinsic growth rate (r_i) is the most sensitive biological parameter in the specification of the stock and catch levels in the fishery, followed by the catchability coefficient (q_i) and carrying capacity (K_i). The issue of property rights will be discussed in the next chapter and a simulation will be undertaken and policy implications discussed in Chapter 7.

Chapter 6

THE FISHERIES RESOURCE ALLOCATION AND PROPERTY RIGHTS SYSTEM

6.1 Introduction

This chapter explains resource allocation in the inland fishery and the design of the existing fishing rights system. The nature of fisheries resource allocation in the region is explained in Section 6.2. Section 6.3 describes how the fishing rights system was developed and the last section provides a summary and concluding remarks for the chapter.

6.2 Fisheries Resource Allocation

Caddy (1996) pointed out that one of the most difficult processes in fishery management is allocation of the resource between various possible users. He observed that, unfortunately, there was only little theoretical consideration in the literature of such a relevant topic.

Fisheries resource allocation can be viewed as an 'action process' used by an authority to divide the rights to use a resource into separate rights which are then assigned to specified users (Regier and Grima 1985, p. 847). In this case, the term 'allocation' is used to refer to the rights of use of a particular resource and not to obligations that come with use of that resource. In many cases, when a fishery resource becomes scarce, a means of allocating the resource through the allocation of property rights is required. This has been the case for the inland fishery in South Sumatra.

In economic theory, the importance of property rights in resource allocation has been outlined by Furubotn and Pejovich (1972). They argue that the existence of a complete specification of individual property rights may deal with problems of uncertainty and promote efficient resource allocation. With private property, the open-access problem which often occurs in a fishery resource can be solved. Private property guarantees a secure and exclusive right to exploit the resource and provides an incentive to the user to utilise the resource at a rate that is socially optimal. However, this has been questioned by Tisdell (1987, p. 3) for the case of fishery resources. In practice, private property rights in inland fishery resources in South Sumatra, or even in other parts of Indonesia, may not exist. In other words, establishing an exclusive private entitlement may not be feasible or it may be impossible for owners to enforce such rights. This is because the cost of enforcing property rights or detecting property violations by unauthorised users may be relatively high. In addition, although private property rights may generate economic efficiency, the outcome may not be socially desirable. Alternatively, a form of common property rights may be appropriate in the inland fishery resource.

In the past, there has been confusion between open-access and common-property resources. One argument assumed that all commonly used resources are open-access so that the private property solution to the problem is feasible. However, Stevensen (1991) drew attention to the possibility that common property, in which the group exercises control over the balancing of benefits and costs of the resource, might also be a solution. This is because of particular resource characteristics in which the resources themselves cannot be physically divided up into individual units. In this case, multiple use of common property may provide a more appropriate form of rights than private property. Moreover, a specific social situation may require common property rather than private property. For example, in some traditional societies which have long depended on group use of the resource, the people may accept a common-property solution more readily than a private one (Runge 1981). In common-property systems users may have learned to limit resource use.

Rights to exploit the fishery resource informally or formally exist now in the inland fishery of South Sumatra. The rights involve licences issued by the authority to particular fishers or groups of fishers for specific periods of time to exploit particular fish resources.

Fishery resource allocation can be approached using the bioeconomic model of Schaefer and Copes. With the models, various possible means of allocating the resource can be examined using simulation. This is explained in the following chapters. Discussion of the design of the fishing rights system in the inland fishery of South Sumatra is presented in the next section.

6.3 Design of Fishing Right Systems

In order to illustrate the design of fishing right systems in Indonesia, a brief review of the laws and regulations of natural resources, particularly in the fishery resource, is provided. Studies on laws and regulations of natural resources in Indonesia indicate the government still strongly favours the control of resource management (Warren and Elston 1994, p. 8-16 and Susilowati 1996, p. 5). In most cases, law and policy formulation of Indonesian natural resources is based on a 'top-down' approach, although a 'bottom-up' approach is also being considered. However, there has been a long-established tradition in Indonesian culture for leaders to make decisions through a process of discussion (*musyawarah*) until unanimity (*sepakat*) is achieved. The intention is to formulate a solution in a way that ensures everyone is willing to accept the outcome, which is achieved either by altering the details of the proposal or by convincing reluctant members of the desirability of the proposal. In the circumstances where unanimity is not achieved, leaders are authorised to make a decision binding on all parties.

The constitutional foundation for fishery resource management is to be found in Article 33, paragraph 3, of the Indonesian constitution of 1945 (*Undang Undang Dasar 1945*) which states that: 'Land and water and the natural resource therein shall be controlled by the State and shall be utilised for the greatest benefits (welfare) of the people'. Kusuma-Atmadja and Purwaka (1996, p. 69) indicate that this constitutional provision is usually used as the legal basis for the nation's control over its natural resources including fisheries[1].

The explicit ideology of the Indonesian fishery laws and regulations at central government level (national), level I (province) and level II (regency) are implemented by the Directorate General of Fishery (DGF), and provincial and regional levels of the fishery services *(Dinas Perikanan)*, respectively. The DGF, which is under the Ministry of Agriculture, is responsible for formulating and implementing fishery management policies at national level. Basically, all fishery resources throughout Indonesia are state property and should be managed for the general benefit of the society. However, in practice, this frequently creates a condition of open access. At provincial level, which is also referred to as level I of local government, fishery policy formulation is the responsibility of provincial fishery services. At this level, implementation of fishery policies is carried out by fisheries services coordinated by the Provincial Office of the Agricultural Sector Ministry *(Kantor Wilayah Pertanian)* and the Provincial Regional Development Planning Board (*Badan Perencanaan dan Pembangunan Daerah Tingkat Propinsi*). At the regional level (level II of local government), fishery policy formulation is the responsibility of regional fishery services. Implementation of fishery policies at this level is coordinated by the Regional Development Planning Board level II. Even though divisions of Indonesian government for administrative purposes are classified into provinces (*propinsi*), regions (*kabupaten*), districts (*kecamatan*) and villages (*desa*), the fishery services below regional level do not have authority to formulate fishery management policy. The legal structure for fishery resource management is shown in Figure 6.1.

Warren and Elston (1994, p. 17) observe that policies and regulations at provincial level are dependent on central government. They further indicate that there has been little actual reduction in central government authority. This is despite an official policy shift toward decentralisation of management of natural resources to lower level authorities in the Sixth Five-Year Plan or *Rencana Pembangunan Lima Tahun VI*

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[1] Laws and regulations in Indonesia are broadly organised under three major categories forming a hierarchy of power, namely: constitutional foundation (preamble and body of the 1945 constitution), top government decisions (People's Deliberative Council, People's Parliament, and Presidential decisions and instructions) and ministerial decisions. These are illustrated in Appendix 6.1.

(*Repelita VI*, 1994-1999), which was prompted by the need to reduce administrative overlap and better distribute economic development. This is because during the previous five five-year plans (*Pelita I* to *V*), the Indonesian government maintained strong central control of fishery resources. Therefore, the impact of the recent shift in policy formulation and implementation in fishery management towards decentralisation is not a short-term target for the Indonesian government.

Many provincial fishery officials claim that centralisation of management deprive local fishery institutions of urgently needed income, encourage local enterpreneurs to operate without licences and ultimately act as a disincentive for implementation of fishery laws by local institutions. Accordingly, they believe that demands for central regulation conflict with the needs of regional or even provincial fishery management (local fishery officers 1995, pers. comm.). This is compounded by the fact that central fishery resource management institutions have not kept pace with changes in technology for exploitation of resources. As a result, management systems fail to address growing problems of fishery overexploitation, dissipation and redistribution of resource rents, and there are conflicts among different groups of resource users (Pomeroy *et al.* 1994, p. 342-44). Therefore, devolution of fishery management and allocation decisions to the local level may thus be more effective than the centralised scheme.

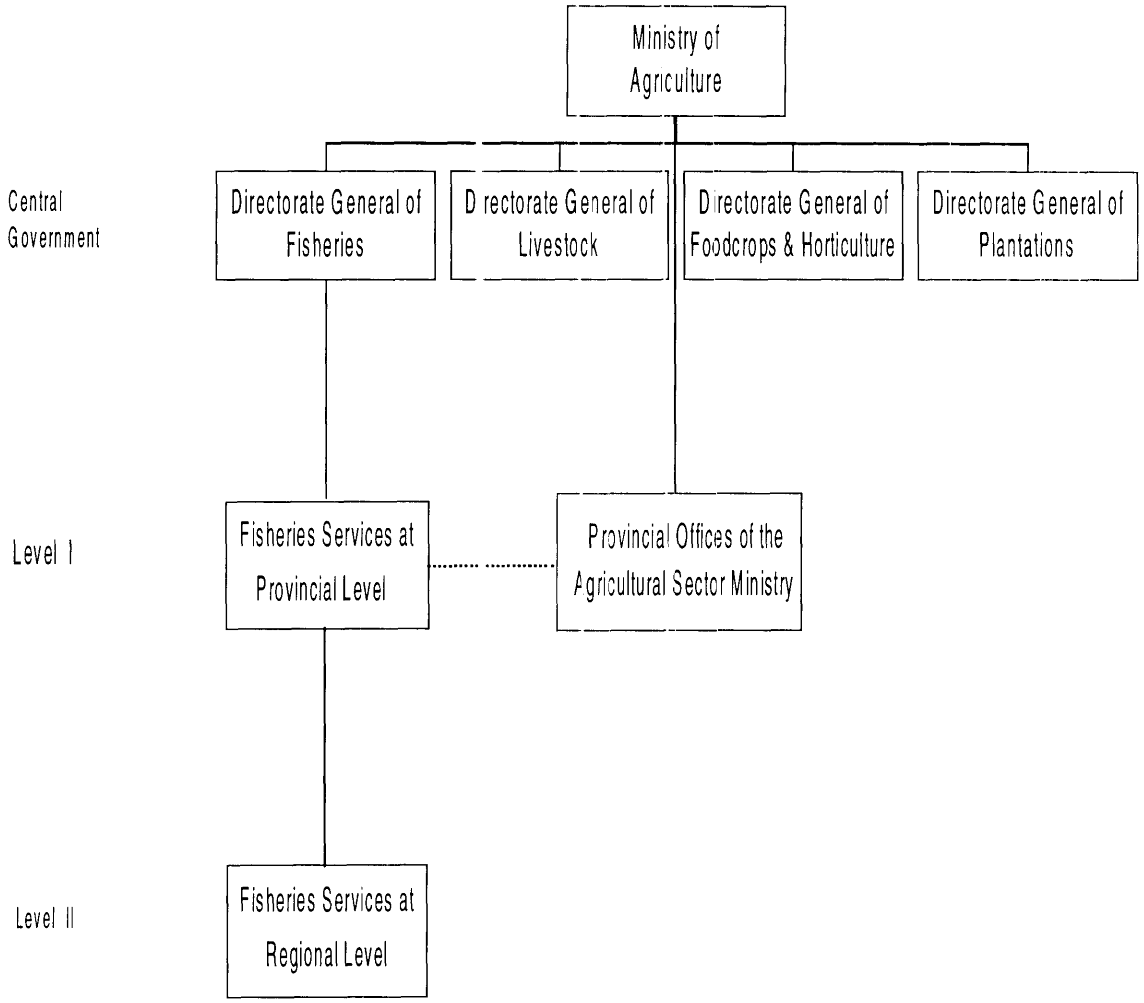

Figure 6.1 Legal structure for fisheries resource management in Indonesia

Basic categories of property rights in resources are widely defined by scientists. For example, Bromley and Cernea (1989) and Pomeroy (1994) use a fourfold classification: state property, private property, common or communal property and open-access property belonging to no-one. Under state property, the resource belongs to the government. Under private property, an individual or corporation can claim benefits arising from the resource. Under common or communal property, the resource is exploited by individuals as members of recognised groups. Under open access, specific claims on the resource have no security and access is open to all.

Property rights on fishery resources may arise formally or informally. Formal design of property rights occurs when such rights are created by the government explicitly for fishers. Informal property rights originate with the fishers, and are not usually recognised by government. These two types of property rights may overlap, complement or even conflict with each other.

Although several national laws were designed to protect the economic livelihood of small-scale fishers, in most cases fishers are threatened by competition from big investors in the fishery. This was, for example, illustrated by Susilowati (1997, p.18) in the case of the marine capture fishery. Prior to 1966, capture fisheries in Indonesia were operated on a small scale, depending on gear with limited efficiency to exploit nearshore water. With big investors in the fishery using fishing gear with a relatively high efficiency, the resource has been threatened and deteriorated. As a result, small-scale fishers are at risk. The small-scale fishers were unable to compete with medium- and large-scale investors. Even though action has been taken by government to protect small-scale fishers from competition from medium and large-scale competitors, for example, by banning operation of the trawl fishery throughout Indonesia in the early 1980s, they remain in a weak position. Moreover, observation during the study indicates that local level fishery officers at the provincial and regional levels are unlikely to take action to protect small-scale fishers (South Sumatra's fishers 1995, pers. comm.)

Several legislative Acts *(Undang Undang)*, such as legislation directly related to fishery, forestry and irrigation systems, exist to control and regulate the exploitation of natural resources in Indonesia. The Acts also establish principles for conservation and pollution control. With respect to the fishery resource, however, there are possible conflicts in terms of legal authority between different government institutions assigned to manage the resource. For example, the Basic Fisheries Act No. 9/1985 (*Undang Undang* No 9/1985) grants the Fisheries Directorate the authority to regulate all matters pertaining to fisheries resource management and exploitation. Within the forestry sector, there is a basic law concerning the conservation of living resources and their ecosystem. This law (*Undang Undang* No. 5/1990) grants the Forestry Department authority over all living resources including the fisheries. Hence, both regulations apply to the same resource, but with different perspectives. The fishery institutions have the right to manage the exploitation of particular species, whereas the Forestry Department has the rights to protect any threatened species. Possible conflict may also occur in terms of which organisation has the power to manage a particular fishery resource. In most cases, fishery institutions favour multiple-use reserves in the sense of dealing within commodity management and conservation with the same framework, while forestry institutions maintain a policy that emphasises conservation.

Indonesian fisheries law also recognises international rights of traditional fishing communities of other nations to fish within its fishery resource, but does not recognise the rights of its own small-scale fishery. Recognition by the Indonesian fishery law of international rights is where fishing grounds are between Indonesia and other countries. The lack of recognition of the small-scale fishing community, which is a high percentage of the community in general, constitutes a restriction to effective enforcement of national fishery laws, implementation of development policy and successful environmental management. Consequently, practical fishing rights systems in many fishery resources, supported by local regulations and respecting local sensibilities, are undermined.

Although many regulations exist, few of them are enforced. This is partly because of the limited enforcement capabilities of provincial or regional fishery services. Bromley and Cernea (1989) and Pomeroy *et al.* (1994) indicate that the essence for success of any fishery regulation is the system of incentives (rights) and sanctions (rules) for influencing individual behaviour of those who use and depend upon the resource. Another reason for weak enforcement of regulations may be that social pressure discourages the persecution of poor fishers. The regulation which is most strictly enforced is the purchase of the licence to fish which provides considerable revenue for the government.

6.3.1 Nature of traditional fishing rights

Zerner (1991) argues that there are no individuals or corporations which can claim full-ownership rights over any portion of fishery resources in Indonesia. This is because the government has claimed all resources as state property to be allocated for the benefit of society. However, in practice, fishery laws do grant significant partial-ownership rights in the form of concessions or licences to use the resource (Zerner 1990, 1991).

In Indonesia, there has been a long tradition of regulatory measures designed to protect the customary rights of small-scale fishers to exploit their traditional fishing grounds and to preserve fishery resources from destructive exploitation. These traditional fishing rights date back to the period of the Dutch colonial authorities when the law was established to serve the needs of fishery management[2]. Traditional resource-use rights of small-scale fisheries have been confirmed as an effective policy consistent with sound resource management. It is believed that such systems can provide relatively large social gains by improving incomes and employment opportunities for those employed in the fishery sector (Christy 1980; Nikijuluw 1997).

Traditional systems of fisheries management in Eastern Indonesia were viewed by Nikijuluw (1997) as a community-based fisheries management system (CBFM). The CBFM indicates that fishers have the opportunity and responsibility to manage their own resources. It is believed that such a system is more efficient than a centralised system in the sense that the required administration and enforcement costs are relatively low. Since the CBFM provides a sense of ownership over the resource, the

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[2] See, for example, Bailey (1986).

fishing community is encouraged to take responsibility in monitoring and regulation. This means that fishers have rights to access the area in order to extract potential benefit, protect the resource from other users, control future use through agreements and transfer ownership.

The CBFM practices based on traditional authority, whose organisational nature varies according to social organisation, occur in particular areas in Maluku, Irian Jaya, North Sulawesi and East Nusa Tenggara. By this property rights system, the fishery resource is managed by village (Irian Jaya and Maluku), by tribe (East Nusa Tenggara) and by community (North Sulawesi). The essence of this system is the collaboration between government and fishers in managing the fishery. In the case of Irian Jaya, for example, applicants for a formal licence require a recommendation from the village leader to allow them to fish. If the village authority agrees, then the applicants can proceed with their application to government (Fishery Services). In other words, without any recommendation from the village authority, the Fishery Services will not issue a fishing licence, although, by formal law, the Fishery Services may do so.

Unfortunately, the above traditional fishing rights are only valid for the case of the marine capture fishery. There is no evidence for the case of inland capture fisheries except those in South Sumatra, where a licence to fish is sold through an auction system.

As indicated in previous chapters, the inland fishery of South Sumatra is characterised by small-scale fishing activities and various types of fishing units. Many of these activities are unregulated through formal national, provincial, or regional level laws. Other diverse fishing units and fishing activities may be formally regulated under laws at a particular level; however, these regulations may not be implemented. This occurs because operation of these fishing units generates economic benefits. Also, local fishery services are reluctant to take action on the existence of unregulated fishing operations, given the relatively low level of investment and large number of small-scale fishers.

6.3.2 Organisation of the fishing community

The system of open auctions which are held every November-December is a type of management for the inland fishery resource unique to South Sumatra in Indonesia. Under this system, most inland fishery resources, comprising rivers, lakes and swamps, are divided up into defined physical units. The rights to fish in these auction units are sold by the district government *(kecamatan)* at competitive open auctions. Fishery management in terms of auction of commercial fishing rights has three objectives, namely:

(1) allocating specified units of fishing ground among fishers before the start of season, hence eliminating the possibility of disputes;

(2) conferring private property rights on fishers in order to create an incentive for them to maintain fish stock; and

(3) raising revenue for the government.

The system has been historically recognised in fishery management, which may reflect the organisation of the fishing community. The effectiveness of such regulation is in minimising possible conflict between fishers, and it has been recently reorganised to increase regional indigenous income (*Pendapatan Asli Daerah* or PAD) for the local government. In addition to this system, fishers are aware of restrictions announced by the fishery research agency on the use of poison, explosive substances and electrical fishing, and of total fishing bans on any resources deemed to be in 'reserve'.

Licences, which are similar to access through private ownership, are granted for 12 months. Typically, with this type of management, total fishing effort is limited by the number of fishers who lease each auction unit. This may be implicitly shown by the balance between individual or social commitments and by previous experience of the fishing pressure that each site in the fishery resource can sustain. With the current auction system, it is likely that there is no guarantee that fishers will be able to re-lease the same site next year and hence they exploit the site to the maximum before the end of the period of the lease.

The auction system in the inland fishery of South Sumatra is believed to be an effective means of management in dealing with such issues as access to the resource, with equity or social justice. Campbell and Haynes (1990, p. 16) pointed out that auctioning access rights has an advantage in the sense that administration costs are often low relative to the value of the right being sold and the access rights are sold to those best able to exploit the resource, in an equitable manner. However, the different objectives of resource users may reduce the effectiveness of this system. Moreover, the system does not protect the fishery against excessive fish mortality. The system has persisted up to the present time and undergone some evolution.

Initially, under the old *'marga'* system of local government, the annual auctions were apparently a fair and equitable means of regulating access to valuable fishery resources and reducing conflict in the fishing community. Most of the revenues from the auctions were paid directly to the community who actually owned the resources. Later, the emphasis on the objectives of managing the resource gradually changed from equitable resource allocation to increasing government revenue.

In 1983, the local *'marga'* system was replaced by a national system of local government which basically followed the 'Javanese village model'. This puts great emphasis on the hierarchical structure of government. With this new system, the role of *'marga'* is replaced by the district government *(kecamatan)*, which is representative of the auction authority (regional government). The revenues are paid to the officials authorised for that purpose at the regional office level which returns some moneys to the district government which, in turn, redistributes some moneys to village governments. Under such a system, the government imposes an additional charge on the winning bidders of 5 per cent direct tax on the price paid for a resource unit at auction. It is likely that the latter revenues are used for regional rather than local development.

Organisation of the actual auction itself has been gradually changed. Even though the auction system is still public and open to any bidder, the parties involved in the organising commitee are decided officially by government.

Another change has occurred in terms of the increasing involvement of middlemen, often government officials, who may buy the fishing rights at auction. The presence of this group of bidders eventually may cause small-scale fishers to lose money. This is because these groups will only seek a substantial profit from the system. They, in turn, sell the licence to the actual fishers, who may not have a chance to win the auction.

In addition to these changes, all bidders in auctions in the past were local residents. During the last decade, the presence of middlemen who are not from the locality has become significant. These people have no close village ties though they may be still based in the same region.

Regarding the auction procedure under the previous system (*'marga system'),* there was no reserve price set by the auctioneer. Hence, bids at auction began at zero and worked upwards. Currently, the initial price is set by the government at the previous year's price plus 10 per cent. If the auction units fail to sell at that price, then it may be purchased directly from the government, often at a reduced price. In this case, fishers have to make bids by letter to the head of the regional office.

6.4 Summary and Concluding Remarks

Licensing is an important management device for the fishery resource in Indonesia. This system is constituted by the Basic Fisheries Act (*Undang Undang* No. 9/1985). However, an exemption is given to small-scale fishers whose daily living depends on their catch. This is applied in the case of the inland fishery in South Sumatra. Basically, however, national regulations of fishery resources are very general, and frequently they cannot and/or do not bear much relationship to the patterns and problems that occur at the local level. This is compounded by the problem that current regulations appear to have little respect for the practices and customary rights of local fishing communities.

The conclusion that can be drawn from this chapter is that there is no guarantee of improvement of the standard of living for the fishing community and maintenance of sustainability in the fishery resource by changes in property rights through a single management objective. A framework to analyse economic benefits from the fishery through bioeconomic modelling is required. Therefore, in the following chapter, the 'base-case' condition in Chapter 5 will be modified and various policy options simulated.