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Valuing Fisheries Depreciation in Natural Resource Accounting

The Pelagic Fisheries in Northeast Peninsular Malaysia

SHZEE YEW TAI, KUSAIRI MOHD. NOH and
NIK MUSTAPHA RAJA ABDULLAH
Department of Natural Resource Economics, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor D.E., Malaysia

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Abstract. In this paper, an approach based on the net present value method is used to account for the changes in the value of fisheries resources. Changes in the value of fisheries resources can occur between successive years' catch as well as between current and optimal levels of catch. These changes need to be accounted for in the national accounting system to reflect the 'true' net national income that is sustainable. The approach outlined in this paper is desirable as it allows the estimation of the depreciation value of fisheries resource with limited biological information. The application of the approach to the pelagic fisheries in Northeast Peninsular Malaysia (NEPM) showed that the resource depreciated in value over most years from 1982 to 1993. These depreciations correspond to increased fishing effort. In addition, pelagic catches in NEPM from 1982 to 1993 were lower than the optimal levels of catch due to overfishing. Thus policies aimed at reducing fishing effort can provide improvement in both the potentially higher capital values of the fishery resource and the earning potentials of the fishing industry in NEPM.

Key words: depreciation, fisheries resource accounting, optimal catch, pelagic fishery, present value

JEL classification: Q22

1. Introduction

As the measure of economic performance of a country, the Net Domestic Product (NDP) has been criticized for its failure to incorporate the value of natural resources and environmental degradation (see for example Hartwick 1990, 1991; Hung 1993; Maler 1991; Repetto et al. 1989). This omission has important implications, particularly in resource-dependent economies, for it provides inaccurate signals for policy makers to exploit and even deplete the natural resource base to achieve rapid rates of economic growth. This may result in illusory gains in income in the short run, but permanent losses in the wealth of a nation in the long run as exemplified by the tin resources in Malaysia.

Conceptually, the importance of accounting for environmental degradation and natural resource depletion in order for countries to seek environmentally sound and sustainable strategies for growth and development cannot be ignored. However, difficulties arise in practice for making actual estimates and valuations. This is because many ecological processes are still poorly understood and the relationship between the economic system and the environment of a country is not clear cut. Thus, for a resource-dependent country like Malaysia, valuation of natural resource depreciation poses a major challenge in the country's effort to attain optimal sustainable economic growth.

The difficulties in valuing natural resources mentioned above can be demonstrated by the marine fisheries resource in Malaysia. The marine fisheries resource provides several benefits to the Malaysian economy. From the perspective of food security, the resource is very important as fish is a major protein source for the country's population, constituting about 60% of total animal protein consumed. The average annual per capita consumption of fish is approximately 40 kg per year, which is relatively high compared to other Asian nations. The fishery sector is also an important contributor to employment (1.3% of the total labour force in 1994) and revenue (1.61% of 1994 GDP) to the country (Fisheries Department Malaysia 1995).

In addition to the above, marine fisheries resources also provide other services, notably recreational activities and the protection of species diversity. However, valuation of these services is not without difficulties. In marine recreational activities, fisheries resources constitute only a part of the total recreational value, albeit an important part. The aesthetic value of the marine environment and the excitement, as well as experience, of fishing are equally important considerations in valuing marine recreation (Copes and Knetsch 1981). For these reasons, it is more appropriate to include the value of marine recreational activities in the valuation of marine environment. With regards to protecting the biodiversity of marine flora and fauna, even though there appears to be some links between marine species and medicinal and health benefits, these links to date are not fully and firmly established. Hence, it is premature to attempt to compute the value of marine biodiversity protection.

This paper, therefore, outlines an approach for valuing changes in the marine fisheries stocks in Peninsular Malaysia, ignoring the values from recreational activities and marine biodiversity preservation. This approach will be presented in the next section. In Section 3, the application of the approach as illustrated with the pelagic fisheries in the northeast Peninsular Malaysia is discussed. The conclusions will be presented in Section 4.

2. The Approach

Two major methods have been developed for valuing depreciation of natural resource stocks (Crowards 1996; El-Sarafy 1989; Landefeld and Hines 1985; Repetto et al. 1989; Solorzano et al. 1991). These methods include: (1) the present value of future rents (or net revenues) associated with the resource; and (2) the net price or rent per unit of the resource multiplied by the changes in the resource stocks (Landefeld and Hines 1985). In this paper, the present value approach will be used to value the depreciation of fisheries resource as recommended by the United Nations Statistical Office when market values for transactions in resource stock are not available (United Nations 1979). In addition, the net price method which assumes that actual use is optimum reflects the change in the value of natural resource resulted from extraction along an optimal path of growth where the prices reflect the Pareto efficient shadow prices. However, the assumption of optimality for actual exploitation of the fisheries resources in Peninsular Malaysia may not be met. Hence it is more appropriate to use the present value method for estimating the depreciation of the resource.

In the present value method, all expected future rents associated with the fisheries resource are discounted to the value in the present period. The central focus in this approach is the concept of fishery rent. Fishery rent can be defined as the return or supernormal profit[1] that can be derived or earned from the fish stock. This fishery rent is represented by the equation as follows:

$$\pi_t = p_t H_t - c_t E_t \tag{1}$$

where π_t denotes the rent accruable from a fishery stock, p_t is the price of output, H_t is the sustainable catch[2] attributed to a given level of fishing effort E_t, c_t represents the unit cost of fishing effort and subscript t is the time period. If a constant level of fishing effort E_t is exerted onto the fish stock, and if we assume that the price of output and the unit cost of inputs used remained unchanged, the present value of the sustainable fishery rents *ad infinitum* at that level of effort, V_t, which represents the resource value of the fishery can be written as:

$$V_t = \pi_t / i \tag{2}$$

where i is the constant prevailing social discount rate. In practice, fishing effort is likely to change from one period to the next.[3] The change in the present value of the resource between periods (t – 1) and (t), $V_t - V_{t-1}$, will then represent the value of a net change in the resource stock (the depreciation value) as shown below:

$$(V_t - V_{t-1}) = (\pi_t - \pi_{t-1})/i \tag{3}$$

where $V_t = V(H_t, p_t, E_t, c_t, i)$ and $V_{t-1} = V(H_{t-1}, p_{t-1}, E_{t-1}, c_{t-1}, i)$.

The resource value of a fish stock as shown in equations (1) and (2) is dependent not only on the catch but also on prices of fish and fishing inputs. These price effects are embedded in the calculated difference in resource values between periods. In order to value the depreciation due to stock changes only, these price effects must be removed (Cruz and Repetto 1992). For example, to compute the actual current year's stock depreciation value, the current year's resource value should first be recomputed using previous year's prices. The actual depreciation is then the difference between current year resource value recomputed using previous year output and input prices and previous year resource value. Since the same set of prices have been used in both periods, the difference reflects actual changes in resource value attributed to changes in stock only, uninfluenced by price changes. If we denote the resource value in period t valued at prices in periods (t – 1) and (t) as $V(H_t, P_{t-1}, E_{t-1}, c_{t-1}, i)$ and $V(H_t, P_t, E_t, c_t, i)$ respectively, the effect of prices on the resource value between two successive years is:

$$\text{Price effect} = V(H_t, P_{t-1}, E_{t-1}, c_{t-1}, i) - V(H_t, P_t, E_t, c_t, i) \qquad (4)$$

where H_t, P_t , E_t, and c_t are respectively catch, price of fish, fishing effort and unit cost of fishing for period t, and P_{t-1}, E_{t-1}, and c_{t-1} are price of fish, fishing effort and unit cost of fishing for period (t-1) respectively. The actual depreciation value due to changes in fishery stock will thus be equal to the difference between the value as computed by equations (3) and (4) above.

The depreciation value of the fishery resource as outlined above depends on the catch (H_t), which in turn depends on the level of fishing effort. However, most fisheries are not exploited at the optimal level of catch or fishing effort where the rents are maximized. From the policy perspective, it would be useful if the rate of catch in any period is compared to the optimal rate. The difference in the resource values between the two rates of catch will signify to policy makers the necessary policy adjustments to minimize the opportunity costs in the form of optimal sustainable economic benefits foregone by exploiting the fishery resource at the current rate (Hartwick 1990). Following Clark and Munro (1975) and by employing the Pontryagin's Maximum Principle, the fundamental equation for optimal exploitation of a fishery resource over time is as follows:

$$i = F'(X_t) - \{[C'(X_t)F(X_t)]/[p - C(X_t)]\} \qquad (5)$$

where $F(X_t)$ is the net natural growth of fish stock, $C(X_t)$ is the fishing cost function in terms of stock, p is the price of fish, i is the discount rate, and $F'(X_t)$ and $C'(X_t)$ are respectively the first derivative of the $F(X_t)$ and $C(X_t)$ functions. The solution to the above equation, X^*, can then be used to compute the optimal rate of catch and effort. The optimal fishery rent is then equal to the product of the price of fish and the optimal catch less the costs of optimal level of effort.

3. Application of the Fisheries Resource Valuation Approach

In fisheries resource valuation, it is necessary to estimate the sustainable catch from a fish stock. Ideally, this should be done on a stock-by-stock basis. However, there are approximately seventy commercial species of fish landed in Peninsular Malaysia, thus making the estimation of the sustainable catch by species virtually impossible. For practical purposes, the fisheries resources in Peninsular Malaysia can be classified into four main species groups, demersal, pelagic, crustacean and mollusks and into four major regions, the northwest, northeast, southwest and southeast regions. Species group classification is justifiable since fish within each species group exhibits many common characteristics. The regional classification is based on varying degrees of fish landings and different industry structures as well as economic infrastructures, rather than based solely on biological considerations (Nik Hashim 1988). In this paper, the pelagic fisheries group in northeast Peninsular Malaysia (NEPM) is chosen to illustrate the application of the above fisheries valuation approach. It should be noted that the approach can be similarly applied to all species groups in all regions. The overall change in the values of the fisheries resources in Peninsular Malaysia is then equal to the aggregate sum of the changes of all the species groups in all the regions.

3.1. Sustainable catch estimation for the pelagic fisheries in NEPM

Unlike other resources, fish cannot be counted directly. The productivity of fisheries resources is generally estimated through the use of quantitative models. Fisheries resources are renewable and the productivity of a given fish stock is influenced by a myriad of factors. The biological factors such as recruitment and individual growth will increase the stock size while natural predation and mortality will reduce it. Climatic factors, including ocean currents, the surrounding conditions of the ecosystems and a multitude of other naturally occurring phenomena will determine not only the species mix, but also the growth and reproduction rates of a fishery stock. The productivity of a fish stock is also affected by the presence of human activities through the alteration of the quality of water through pollution, destruction of coastal ecosystems, and disruption of marine food chains. The use of inputs or fishing effort, the dynamics of fishing effort and the management regulations will also affect the productivity (Tai and Heaps 1996). However, taking into account all these factors when estimating the changes in the productivity of a fish stock is not possible due to the constraint of data availability. Hence, surplus production models are generally used in fish stock assessments because this group of models can be estimated using only catch and effort data which are generally available. Surplus production models ignore the intricate biological processes within a fish stock by assuming that the stock can be treated as an aggregate biomass. If all other factors remain constant, the aggregate biomass of a fish stock will decline when the pressure exerted on the resource through fishing effort increases.

In the surplus production model, the biomass of a fish stock at time t, X_t will grow as follows:

$$dX_t/dt = F(X_t) - H_t \tag{6}$$

$F(X_t)$ may be interpreted as the natural rate of growth or as the rate of investment to the stock of natural capital, while H_t is the rate of harvest or the rate of withdrawal. In the fishery literature two types of functional forms, the Logistic and the

Gompertz, are commonly used to represent $F(X_t)$ as shown in equations (7) and (8) respectively.

$$\text{Logistic form:} \quad dX_t/dt = rX_t[1 - (X_t/K)] - H_t \tag{7}$$

$$\text{Gompertz form:} \quad dX_t/dt = rX_t \ln(K/X_t) - H_t \tag{8}$$

where r is the intrinsic growth rate and K is the environmental carrying capacity. The basic difference between the two functional forms is that the Logistic is symmetrical while the Gompertz is not. For the rate of harvest, it is generally assumed that $H_t = qE_tX_t$ where q is the catchability coefficient and E_t is the fishing effort.[4]

The estimation of the parameters of equations (7) and (8) involves nonlinear techniques. However, if we define $U_t = H_t/E_t$ as the catch per unit effort, equations (7) and (8) can be transformed such that ordinary least squares technique can be used. These parameters have been estimated following the procedures by Schaefer (1957), Fox (1970), Schnute (1977), and Clarke, Yoshimoto and Pooley (1992).[5] The sustainable harvest of the fish stock can be determined given the values of the parameters r, q and K if steady state equilibrium prevails, i.e. $F(X_t) = H_t$. The sustainable harvest thus represents the surplus growth or long-run net changes in the fish stock at a certain level of fishing effort. The sustainable harvest equations for the Logistic and the Gompertz forms are:

$$\text{Logistic:} \quad H_t = qKE_t - (q^2K/r)E_t^2 \tag{9}$$

$$\text{Gompertz:} \quad H_t = qKE_t\exp[(-q/r)E_t] \tag{10}$$

with the parameters and variables as defined earlier. The values of r, q and K for the pelagic fisheries in Northeast Peninsular Malaysia were obtained from Tai et al. (1996). These parameter values were estimated following the Clarke, Yoshimoto and Pooley (1992) model, corrected for first degree autocorrelation using the Cochrane-Orcutt procedure. The CYP model provides the best estimates compared to those from other models. This model uses catch and effort data adapted from the Annual Fisheries Statistics published by the Department of Fisheries of Malaysia from 1969 to 1993 for the estimation of the parameter values. Substituting the value of $q = 0.0006562$, $K = 115419$mt and $r = 1.5165$ into equation (10), the sustainable catch equation for the pelagic species in northeast Peninsular Malaysia is obtained as follows:

$$H_t = 75.738E_t \exp(-0.0006562E_t/1.5165) \tag{11}$$

For a particular level of fishing effort, the sustainable catch of the pelagic resources in northeast Peninsular Malaysia can be estimated from the above equation. The level of fishing effort and the corresponding sustainable catch from 1982 to 1993 are shown in Table I.

Table I. Standardized fishing effort, sustainable catch, ex-vessel price, cost per unit of effort and total fishing cost for the pelagic fisheries in Northeast Peninsular Malaysia, 1982–1993.

Year (1)	Effort[a] ('000 days) (2)	Sustainable catch[b] (mt) (3)	Price[c] (RM/mt) (4)	Cost per Unit Effort[d] (RM/day) (5)	Total Revenue[e] (RM mil.) (6)	Total Cost[f] (RM mil.) (7)
1982	842	51709	3303	65.58	170.80	55.21
1983	968	56286	2982	69.45	167.84	67.20
1984	1130	61279	3086	72.06	189.11	81.45
1985	849	51980	3099	75.13	161.09	63.77
1986	1143	61636	3165	75.67	195.08	86.50
1987	1826	73264	3072	75.85	225.07	138.49
1988	1950	74154	3371	77.74	249.97	151.62
1989	1643	71355	3323	79.99	237.11	131.43
1990	2339	75165	3828	82.42	287.73	192.82
1991	2912	73028	4306	86.03	314.46	250.52
1992	2129	74925	4472	90.08	335.06	191.79
1993	2252	75145	4629	93.32	347.85	210.12

Notes:
[a] Adapted from the Annual Fisheries Statistics, Department of Fisheries Malaysia, 1982–1993.
[b] Estimated from equation (11).
[c] Adapted from the Annual Fisheries Statistics, Department of Fisheries Malaysia, 1982–1993. US$1= RM2.5.
[d] Calculated from survey data by Tai et al. 1995.
[e] Column (3) times Column (4).
[f] Column (2) times Column (5).

3.2. Depreciation of the pelagic fisheries stock in NEPM

As discussed earlier, the primary focus of fishery resource accounting is to value the depreciation of the resource hitherto not accounted for in the conventional national accounts. Based on the approach outlined above, to arrive at the depreciation value of a fishery resource, it is necessary to calculate the annual sustainable resource rent.

In determining the economic rent in each year, the ex-vessel price of the pelagic fish is used since it is the price directly received by fishers. It is assumed that price changes at other levels of the marketing chain will be transmitted to the ex-vessel price in the long run. The ex-vessel prices of selected pelagic fishes are published in the Annual Fisheries Statistics. The average of these prices in each year from 1982 to 1993 is shown in Table I. Multiplying the annual ex-vessel price with the sustainable catch estimated from equation (11) at the given level of fishing effort each year will yield the annual sustainable revenue as shown in Table I.

The total cost of fishing is the product of the exogenous cost per standard effort and total standard effort. Published time series data on the cost per unit of standard effort are not available. Thus, a survey was conducted in May and June 1995 to obtain the fishing cost data. Fishing boats in the major fishing centers in northeast Peninsular Malaysia, namely Bachok, Tumpat, Kuala Besut and Kuala Trengganu were sampled according to a stratified random framework. Stratification was done according to the types of vessels and gears, as well as tonnage classes of the trawlers and purse seiners based on the annual list of boats maintained by the Department of Fisheries. The sample represents about 15% of total boats listed in the directory. In the survey, data pertaining to operating, fixed, labour and opportunity costs were collected. Operating costs include expenses on fuel, ice, food and maintenance of vessels and gears. Fixed costs pertain to items such as depreciation of fixed fishing assets, insurance premium, license fees and other administrative expenses. The opportunity cost is the cost of keeping capital and labour inputs in their present use.

In order to generate the cost per unit of standardized effort for the pelagic species in the NEPM region, adjustments have been made to the data obtained from the survey in 1995. First, the cost per vessel data from the survey for various gear types was adjusted by the general consumer price index to the 1993 figures. These figures are then multiplied by the number of vessels of various gear types in 1993 to obtain the total cost for each gear type. Summing up these costs by gear types and then dividing by the total standardized effort in 1993, the overall cost per unit of standardized effort for 1993 is obtained. However, there exist differences in the cost per unit of standardized effort for each species group because fishing effort directed to catching these species groups differ. In order to obtain the cost per unit of standardized effort for the pelagic species group, the overall cost per standardized effort is adjusted by multiplying it with the ratio of landings of the pelagic species to total landings in 1993. This adjustment factor is used because data on effort directed to the pelagic species are not available. Finally, the cost per unit of standardized fishing effort for pelagic species in 1993 as computed is adjusted by the general consumer price indices to generate the cost series for 1982 to 1992. This series is shown in Table I. The time series for total fishing cost between 1982 and 1993 is generated by multiplying the cost per standardized effort series by the series on standardized effort as shown in Table I.

The annual sustainable rent for the pelagic species in NEPM is equal to the annual sustainable revenue for a given level of effort less the total fishing costs, as shown in Table II. This rent will be sustainable if fishing effort remains unchanged. Thus, by capitalizing the rent in each period at an assumed social discount rate of 5% per annum, the present value of rent can be calculated for each period. However, fishing effort was not constant between succeeding periods. The difference between the present value of the sustainable rents over two succeeding periods for given effort, as shown in equation (3), will thus show the long-run change in resource rent between these periods. In addition, as discussed previously, the

Table II. Annual sustainable rent, present value, price effect and change in present value of annual rent for the pelagic fisheries in Northeast Peninsular Malaysia, 1982–1993 (RM mil).

Year (1)	Annual sustainable rent[a] (2)	PV of sustainable rent[b] (3)	Price effect[c] (4)	Change in PV rent[d] (5)
1982	115.61	2321.16	–1735.66	–198.17
1983	100.63	2012.52	–437.06	128.42
1984	107.66	2153.12	68.76	71.84
1985	97.32	1946.45	–38.38	–168.30
1986	108.59	2171.78	69.24	156.10
1987	86.60	1731.91	–142.78	–297.09
1988	98.38	1967.57	369.69	–134.03
1989	105.70	2113.99	–142.64	289.06
1990	94.90	1897.90	644.83	–860.92
1991	63.97	1279.41	489.12	–1107.61
1992	143.29	2865.76	75.71	1510.64
1993	137.73	2754.54	89.78	–201.00

Notes:
[a]Column (6) in Table 1 minus Column (7) in Table 1.
[b]Estimated from equation (2) using a social discount rate of 5% per annum.
[c]Estimated from equation (4).
[d]PV_t minus PV_{t-1} from Column (3) minus Column (4).

change in resource rent between two periods is caused not only by changes in the catch and stock but also due to changes in the prices of output and costs of fishing inputs. Thus, the effects of price changes on resource rent (the price effect as shown in equation 4) need to be excluded. The resultant calculations as shown in Table II will thus truly reflect the changes in the value of the fish stock.

The results in Table II show that the pelagic resource in NEPM depreciated in value in seven of the twelve years under evaluation from 1982 to 1993. This depreciation should be accounted for in the national income statistics. Otherwise, the Net Domestic Income figures will be underestimated for those years when the value of the fish stock appreciates, and overestimated for those years when the value of the fish stock depreciates. An important relationship emerging from the analysis is that there appears to be an inverse relationship between the level of fishing effort and changes in the value of the fish stock. In particular, decreases in the fishing effort from the previous year's level from 1987 to 1993 have caused the fish stock to appreciate in value and *vice versa*. This implies that for the appreciation of the value of fish stock, the policy of reducing the level of fishing effort should be actively pursued.

Table III. Estimated bioeconomic optimal levels of effort, catch and rent for pelagic species, Northeast Peninsular Malaysia, 1982–1993.

Year (1)	Effort (thousand days) (2)	Catch (mt) (3)	Rent[a] (mil. RM) (4)
1982	1403	67606	131.272
1983	1289	65245	105.047
1984	1287	65201	108.474
1985	1259	64556	105.488
1986	1269	64799	109.045
1987	1245	64227	102.887
1988	1296	65408	119.723
1989	1264	64681	113.817
1990	1346	66479	143.519
1991	1399	67524	170.401
1992	1393	67416	175.970
1993	1393	67405	182.042

Note:
[a]Estimated from equation (12).

3.3. Optimal pelagic fisheries rent in NEPM

As discussed earlier, comparison of the capitalized current sustainable rent and the optimal resource rent will determine the optimal rent accruable from the fishery or the optimal opportunity costs foregone by exploiting the fishery resource at the current rate. For the pelagic fisheries in NEPM, the sustainable catch function is of the Gompertz form as shown in equation (11). If we assume that $H_t = qE_tX_t$ and the total cost function is equal to the cost per unit of effort c, times total effort, i.e., $C_t = cE_t$, then $C(X_t) = cH_t/qX_t$. With these assumptions, the equation for the optimal exploitation of the pelagic fisheries resource in NEPM (equation (5)) becomes:

$$\ln(K/X_t) - 1 - (i/r) + (cr/pqX_t) + (ci/pqrX_t) = 0 \qquad (12)$$

where the value of the environmental carrying capacity (K), the intrinsic growth rate of the pelagic stock (r), the catchability coefficient (q) as given previously, i is the social discount rate = 0.05, p is the ex-vessel price, c is the unit cost of standardized effort, and X_t is the stock. Substituting the values of price and the unit cost of standardized effort for a particular year and solving equation (12), the optimal stock size X_t^* as well as the optimal catch (H_t^*) and effort level (E_t^*) for the relevant period can be determined.[6] The optimal rent per period is equal to the price times the optimal catch less the unit cost of effort times the optimal effort. The optimal levels of catch, fishing effort and annual rent for the pelagic fisheries in

Table IV. Estimated discrepancies between present value of annual rent and optimal rent for pelagic fisheries in Northeast Peninsular Malaysia, 1982–1993 (RM mil).

Year (1)	PV of annual rent[a] (5%) (2)	PV of optimal rent[b] (5%) (3)	Difference in PV rent (5%) (4)
1982	2321.16	2625.44	–304.28
1983	2012.52	2100.94	–88.42
1984	2153.12	2169.48	–16.36
1985	1946.45	2109.76	–163.31
1986	2171.78	2180.90	–9.12
1987	1731.91	2057.40	–325.49
1988	1967.57	2394.46	–426.89
1989	2113.99	2276.34	–162.35
1990	1897.90	2870.38	–972.48
1991	1279.41	3408.02	–2128.61
1992	2865.76	3519.40	–653.64
1993	2754.54	3640.84	–886.30

Notes:
[a]From Column (3) Table 2.
[b]Column (4) Table 3 divided by 0.05.

NEPM from 1982 to 1993 are presented in Table III. Depending on the ratio of unit cost of effort and price, the optimal levels of effort hover around the range of 1.2 to 1.4 million days, while the optimal catches and optimal annual rents were in the range of 64 to 67 thousand mt and 102 to 182 million RM respectively. Capitalizing the optimal rents at 5% social discount rate, the present value of the optimal rent is obtained as shown in Table IV. Comparisons of the present value of current and optimal rents revealed that the present value of the optimal rent is much higher than the present value of the current rent in all years from 1982 to 1993, as shown by the negative differences between them. This implies that it is possible to increase the value of the pelagic resources in NEPM from the current level. A comparison between the current and optimal levels of effort in Table V shows that the former is much higher than the latter from 1987 to 1993. This implies that the optimal values accruable from the fisheries can be achieved if fishing effort is reduced from the current level for this period.

4. Conclusions

It has been recognized that ignoring changes in the value of natural resources in national income accounting will distort the measure of long-term sustainability of social welfare of a country. This distortion is particularly important in resource-dependent countries where natural capital stocks are depleted in order

Table V. Comparison of current and optimal levels of fishing effort and resource rent for pelagic species, Northeast Peninsular Malaysia, 1982–1993.

Year	Percentage difference	
	Effort[a]	Rent[b]
1982	+66.63	+13.55
1983	+33.16	+4.39
1984	+13.89	+0.76
1985	+48.29	+8.39
1986	+11.02	+0.42
1987	–31.82	+18.81
1988	–33.54	+21.69
1989	–23.07	+7.68
1990	–42.45	+51.23
1991	–51.96	+166.38
1992	–34.57	+22.81
1993	–38.14	+32.17

Note:
[a]Column (2) in Table 3 minus Column (2) in Table 1 divided by Column (2) in Table 1 times 100%.
[b]Column (4) in Table 3 minus Column (2) in Table 2 divided by Column (2) in Table 2 times 100%.

to fuel economic growth and development. Even though heavy depletion of natural resources in these countries may provide short-term relief to problems of unemployment and poverty, this strategy may not sustain income and welfare growth in the long-run. It is therefore important to value the extent of natural resource depreciation in order to adequately reflect these values in national income accounts when assessing economic performance. These adjustments will hopefully encourage the implementation of policies to enhance economic growth without severely jeopardizing and depleting the natural resource base. However, a major challenge in practice lies in making actual estimates and valuation because many ecological processes are still poorly understood and the relationship between the economic system and the environment of a country is not clear cut. In this study, a practical approach to value the depreciation of fisheries resources has been implemented. The approach involves valuing fisheries resource rent by the present value method and deducting it from the national income figure. This approach requires only time-series data on catch, effort, fishing costs and prices routinely collected in most fisheries in the world and thus is desirable for fisheries accounting studies where biological information is limited.

The pelagic resources in northeast Peninsular Malaysia is used to illustrate the application of the approach outlined in this study. The results showed that an inverse relationship existed between the depreciation of pelagic resources and increased in fishing effort in northeast Peninsular Malaysia. This implies that to avoid fishery resource depreciation, management measures should be aimed at fishing effort reduction. Furthermore, the pelagic resources in northeast Peninsular Malaysia were exploited far beyond their bioeconomic optimum level. There exists tremendous potential for the improvement of the resource and rents potentially generated from the fisheries if fishing effort can be drastically reduced. The potentially higher rents from the fishery foregone by not achieving the bioeconomic optimum targets should be treated as costs (or shadow prices) of the resource stocks, which have been largely ignored in the conventional system of national accounts.

The study also revealed that management policies narrowly focused on current output should give way to long-term sustainable resource strategies. In particular, strategies that help to reduce the intensity of fishing effort need to be actively pursued. In this regard, the Malaysian Government policy of imposing a moratorium on new fishing licenses to inshore fishermen is a move in the right direction. However, other policy effort needs to be considered in order to further reduce fishing effort. The curtailment of fishing effort can be done by attrition of fishing vessels, either by non-replacement of aging vessels or by accelerated attrition through a vessel buy-back scheme. Other forms of effort-reduction strategies such as encouraging and facilitating fishers to seek employment outside the fishery sector and to impose higher fees on vessel license could be explored. The former strategy may be more acceptable to the fishers, especially in the present period when the rate of economic growth in the country is high and alternative employment opportunities are available. In addition, this strategy may help to alleviate the balance of payment deficit problem currently experienced in the country by replacing foreign workers with the displaced fishers, thus reducing the outflow of income through repatriations by foreign workers. The strategy of imposing higher license fees is aimed at forcing fishing enterprises to internalize the resource costs and driving out marginal fishing units to increase economic gains from the fishery resource.

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Notes

1. Supernormal profits are profits earned after deducting total costs (including the normal returns or opportunity costs) of all inputs used.
2. In valuing the depreciation of fishery resource, we are concerned with changes in the values of equilibrium fish stocks. The sustainable catch function depicts the long-run relationship between catch and equilibrium stock. Hence, it is more appropriate to use sustainable catch and rent in estimating the depreciation of fishery resource.

3. In the context of Malaysian fisheries, licenses are issued to control the number of vessels and types of gear used. Even though vessel and gear limitations are imposed, fishing effort may still change when fishers manipulate the number of days fished, which is the measure of fishing effort in the empirical analysis of this paper.
4. Fishing effort is a composite input used in catching fish. It comprises the gears, vessels and all other inputs such as labor, fuel, ice, etc. In a tropical fishery such as that in Peninsular Malaysia, a variety of different gears and vessel sizes are used. These vessels and gears will exert different pressures on the fish stock. Thus, appropriate choice and standardization of units of fishing effort is crucial to reflect the relative change in the fishing power of vessels and gears.
   The relative fishing power for vessels and gears used in fishing can be estimated as follows (Robson 1966; Gulland 1983):

$$\mathrm{Power}_{jt} = U_{jt}/U_{st}$$

   where Power_{jt} is the estimated fishing power of vessels using gear type j; U_{jt} is the average catch per vessel using gear type j; and U_{st} is the average catch per drift net vessel which is used as a standard. Once the fishing power of vessels and gears has been estimated, the standardized fishing effort in number of drift net days can be calculated as:

$$E_t = \sum_j (\mathrm{Power}_{jt} T_{jt} V_{jt})$$

   where E_t is the aggregated standardized fishing effort at year t; T_{jt} is the average fishing days of vessel using gear type j at year t; and V_{jt} is the number of vessels of gear type j operated at time t.
5. The procedures for estimating the parameters as outlined by Schaefer, Fox, Schnute and Clarke, Yoshimoto and Pooley are as follows:

$$\text{Schaefer:}\quad U_t = a - bE_t \quad \text{where } a = qK, \text{ and } b = q^2K/r$$
$$\text{Fox:}\quad \ln U_t = a - bE_t \quad \text{where } a = \ln(qK), \text{ and } b = q/r$$
$$\text{Schnute:}\quad \ln(U_{t+1}/U_t) = a + b[(U_t + U_{t+1})/2] - c[(E_t + E_{t+1})/2]$$
$$\text{where } a = r, b = rqK, \text{ and } c = q$$
$$\text{CYP:}\quad \ln(U_{t+1}) = a\ln(qK) + b\ln(U_t) - c(E_t + E_{t+1})$$
$$\text{where } a = 2r/(2+r), b = (2-r)/(2+r), \text{ and } c = q/(2+r)$$

6. From the optimal stock X_t^*, the optimal catch (H_t^*) and optimal effort level (E_t^*) can be estimated as follows:

$$H_t^* = rX_t^* \ln(K/X_t^*) \text{ assuming steady-state equilibrium where } H = F(X).$$
$$E_t^* = H_t^*/(qX_t^*).$$

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