The Application of Producer and Consumer Surplus Concept and Accounting Method in Estimating Losses Caused by Marine Pollution

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Abstract: Aggrieved fishers can sue for compensation for their losses due to pollution. Normally, the estimation of their losses is based on the loss of income compared between before and after the intervention. However, fishers are not the only one affected by the pollution. Fish consumers, who are non-fishers, are also losing in monetary term when fish prices increased in time of intervention and thereafter. Thus, the usual compensation procedure is considered lacking since it does not take into account the spill over costs onto the non-fishers. The application of producer and consumer surplus concept is being used to determine the societal losses as a whole. The alternative way of describing the impact of fish catch on society is using the concepts known as consumer surplus and producer surplus. By comparing these measures before and after a market disturbance, it is possible to quantify how society has been affected. Both concepts stem from the change in commodity price and the amount they are willing to pay if he or she is a consumer or the amount produced if he or she is a producer. Consumer surplus can be gauged from the demand curve that is econometrically constructed with the availability of time-series data on market price of the commodity and the quantity consumed. Similarly, the producer surplus can be obtained from the supply curve that is econometrically constructed using the time-series data on selling price and amount supplied. In addition to econometric method of obtaining the producer surplus, the accounting method offers a much easier way provided there exist, apart from time-series data on revenues, variable cost data. Between 1997 -2000, a huge land reclamation project was underway causing a significant impact on the marine environment in the coastal waters of South Manjung district in Perak, Malaysia. The fish landings data before and after the intervention were used for this study to gauge the fishing losses. The result shows that consumer and producer losses were RM 16.7 million and RM 13.3 million respectively. Producer losses can be also gauged by accounting method taking into consideration the total revenues minus the total costs that indicates the loss of RM 93.2 million. It is proposed that these figures as the guideline for the court of justice to make decision when awarding compensation to respective fishers. With respect to consumers, perhaps, the purpose of the compensation is to improve the fisheries resources, example by sponsoring the artificial coral reef project.

Keywords*:* compensation; consumer surplus; fishers; producer surplus; spill over

Introduction

In the process of polluting the environment, polluters impose spill over costs on others [1], [2]. Take the example of land reclamation project that dumps sand into a coastal area large enough to degrade marine environment resulting the destruction of rich fishing and nursery grounds and possibly the nearby mangroves area. Since fishers are dependent on fish to earn a living, they are obviously the most affected community. The low catches have resulted that their income being reduced. However, fish are also consumed by non-fishers that their scarcity has led the increase in market price which caused them to pay more than the price that was offered before the project. The description of the spill over costs on others is best demonstrated by the well-known economic theory of demand and supply [3],[4],[5],[6],[7].

Since fish are marketable goods, the market price method is used to estimate the economic value of ecosystem products or services that are bought and sold in commercial markets [8]. It values changes in either the quantity or quality of a good or service. The standard method for measuring the use value of resources traded in marketplace is the estimation of consumer surplus and producer surplus in market price and quantity data [8]. The definition of consumer surplus, as given by [9]. is: the maximum sum of money a consumer would be willing to pay (WTP) for a given amount of the good, less the amount he actually pays. Producer surplus and consumer surplus are the only practical means so far devised by economists for measuring welfare changes [10],[11]. By comparing these measures before and after a market disturbance, it is possible to quantify how society has been affected [12].

Although demand and supply curves emphasize the relationship between the price of a product and the quantity demanded or supplied, price is not the only factor that determines how much of product consumers will buy or producers will sell [13]. As pointed out by [14], three factors; the price of related goods, the income of consumers (buyers), and consumer tastes or preference that affect the demand curve and other three factors; technology available to producers, the cost of inputs (labour, machines, fuel and raw materials), and government regulation that affect the supply curve. With regards to the limits of this study, it was assumed the condition of *ceteris paribus*, other things equal at all the time. It means, other things were held constant that they did not affect the curves except the price.

The objective of this paper is to demonstrate the application of economic theory of demand and supply in the estimation of societal losses due to environmental pollution. Although the right to sue for compensation is still debatable especially in the question of *loci standi* [15],[16],[17],[18],[19],[20], it is the intend of this paper to show that losses can be enumerated by gauging the consumer and producer surpluses and could serves as guideline in awarding the compensation. For this reason, fisheries data (between 1992-2003) were extracted before and after a huge land reclamation project causing a significant impact on the marine environment in the coastal waters of South Manjung district in Perak, Malaysia. Another way of estimating losses is by accounting method which is straight forward and easily enumerated.

Materials And Methods

Econometrics was used to quantify economic relationship of the demand and supply data following a number of steps as suggested by [21]. The steps proposed are (1) specifying the models or relationships to be studied, (2) collecting the data needed to quantify the models, and (3) quantifying the models with the data.

Specifying the models

Demand and supply curves follow the equation $Y = \alpha + \beta X + \mu$, where Y is the price of a unit commodity, X is the quantity demanded or supplied, α is a constant or interceptor on the Y-axis, β is the slope coefficient of the curve and μ is the error term. Depending on the empirical sign of β, the demand curve hypothetically has a negative sign whereas the supply curve is positive. The signs of the slope advocate the demand and supply economic theory; that a negative slope means an inverse relationship between demand price and the quantity demanded and a positive slope means a direct relationship between supply price and the quantity supplied assuming everything else held constant, *ceteris paribus*.

Fig. 1 illustrates that before the intervention by polluters, fishers sold their catches at the equilibrium price P_1 by producing Q_2 amount of fish. By law of supply, P_1 is also the cost of producing the Q_2. Curve S_1S_1 and DD are supply and demand curves respectively. When the amount of fish caught is reduced as the consequences of the pollution, the supply curve moves upward as fishers incurred additional operation costs to produce fish and have to reduce the amount caught at Q_2. The law of the supply informed that as long as additional production of the commodity increases the profit of the producer, he will be interested in expanding the production but eventually a point is reached at which one additional unit supplied would increase the costs of production by an amount equal to its price, and the incentive to increase production disappears. The supply curve S_1S_1 then shifts upward to S_2S_2 and consumer is paying higher price than before at P_2. To produce Q_1 before the project, the cost incurred by fishers is P_0 but is increased to P_2 as additional operation cost to produce same amount of fish. Thus, the effect of the project is that consumer has to pay more than before, that is, an extra $P_2 - P_1$ and fishers earn P_0 which is less than P_1 after paying additional cost $P_2 - P_0$ of catching fish. Fishers will not attempt to increase the production more than Q_1 as at this point, the price of a unit additional amount of fish supplied will equal the costs of producing it.

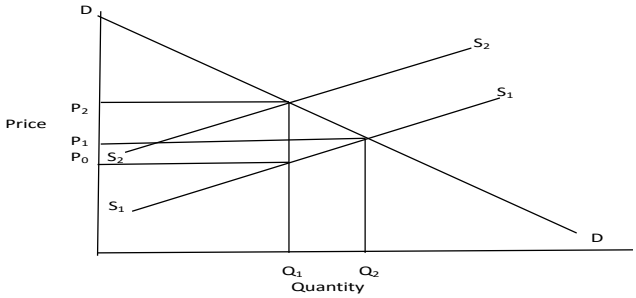

Figure 1: Supply and demand curves

Consumer surplus (CS) is given by the area under the demand curve DD but above the price level (Fig. 2). At price P_1, the area is denoted by equation CS = ½ [P_3 – P_1] [Q_2], or represented by the area $P_1P_3A_1$, where P_3 is the maximum price that a consumer is WTP. It illustrates that if fish price is increased to P_2, the CS would be smaller (area $P_2P_3A_2$). Thus, the consumer loss is given by the area $P_1P_2A_2A_1$. Conversely, the producer surplus (PS) is the revenue obtained from a good sold which is represented by an area above the supply curve but below the price level (Fig. 3). For example, at P_1, PS = ½ [P_1 – P_0] [Q_1] or represented by the area $P_0P_1A_1$, where P_0 is the minimum price a producer is willing to sell the commodity. An increase of price to P_2 would be an advantage to the producer as he/she would gain more as denoted larger area of $P_0P_2A_2$. Thus, as a result of price increase, the producer gain would be the area $P_1P_2A_2A_1$.

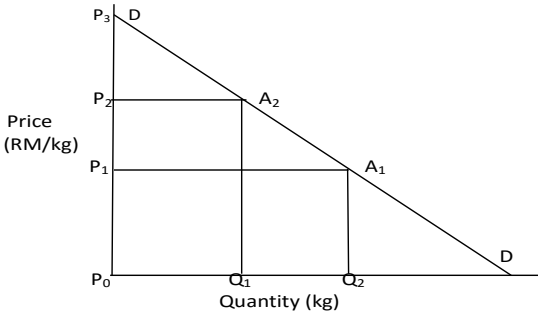

Figure 2: Consumer surplus and benefit loss of consumers

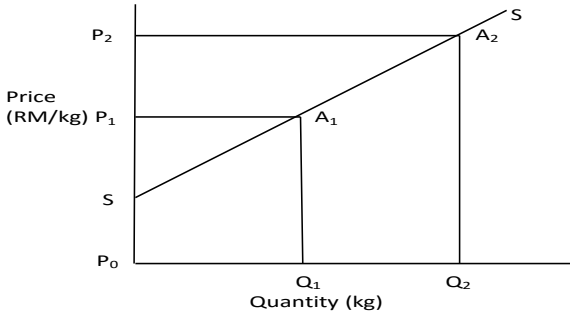

Figure 3: Producer surplus and benefit loss of producers

Econometricians use regression analysis to make quantitative estimates of economic relations that previously have been completely theoretical in nature [21]. Time series demand and supply data, were used to estimate the value of α and β. SPSS software was used to regress the collected data but few authors had provided a good descriptions of the regression techniques which are beyond the scope of this study [22],[23],[24],[25].

Data collection

This study makes use of the data collected by [26]. and data from the Annual Fisheries Statistics 1992-2003 available online at http://www.dof.gov.my/fishery-statistics. Table 1 shows the number of traditional vessels and the fishers where the latter was estimated by multiplying the number of vessels by two since it was the average number of fishers on each vessel [27]. Other data required for the construction of demand and supply curves are fish landings, actual amount of fish sold in the market, ex-vessel prices and retail prices. . As noted by [28], there was imported fish, particularly from Thailand, being sold in the local fish markets. The presence of imported fish may affect the price of local fish, particularly of the same species, but, the effect was considered minimal since the imported fish were sold frozen, contrary to the local fish that were sold fresh or chilled, thus they were priced independently. The marketing of frozen fish was still small, reflecting consumer preference for fresh fish [28]. With respect to the dissemination and pricing of fish, four assumptions were then made: (1) all fish landed were sold to the wholesalers who in turn disposed of them as alive, fresh or chilled, frozen, canned, cured, reduced or others; (2) all fresh or chilled fish were sold in the fish markets of South Manjung; (3) pricing mechanism between imported fish which were sold frozen and the local fish were independent, as were their demand and supply curves; and (4) the consumer benefits derived from fish other than those sold in fish markets was unknown or non-existence.

Table 1: Annual number of traditional vessels and fishers in South Manjung.

Year	No. of All Vessels	No. of All Fishers
1992	500	1,000
1993	525	1,050
1994	483	966
1995	511	1,022
1996	515	1,030
1997	455	910
1998	515	1,030
1999	529	1,058
2000	898	1,796
2001	802	1,604
2002	792	1,584
2003	770	1,540

(a) Fishing costs

Unfortunately, there are no annual data on operational fishing costs or the variable costs. Although Department of Fisheries [29], [30] and [31] surveyed fishing expenditure in Peninsular Malaysia, their findings were no longer relevant to the present needs. However, a socio-economic survey conducted by Fisheries Development Authority Malaysia (FDAM) in 1995 engaging fishers of Peninsular Malaysia concluded that the traditional fishers spent an average of RM40.60 per fishing trip [32]. Another operational cost evaluation was undertaken by [33] where the average cost accrued by both fishers using canoes and boats was RM77.50 per fishing trip. Considering the former survey was completed before the projects started up, while the latter was after the projects development, due to data constraints, this study adopted RM40.60 as operating cost of base year 1995 for the enumeration of operating cost of year 1992 through 1997 and RM77.50 as operating cost of base year 2002 for the enumeration of operating cost of year 1998 through 2003.

For a traditional fisher, his expenditures per fishing trip were mainly fuel cost representing 70% of the total variable costs, while others such as food and ice make up the remainder. As such, the use of Consumer Price Index (CPI) to estimate the fisher's annual variable costs based on known value in a particular year is appropriate. However, because consumers spend greater percentages of their incomes on certain index items more, say, on food and beverages than on apparel and upkeep, merely averaging all the indexes at face value to arrive at the all-items index would be misleading [13]. Therefore, in attempt to place more emphasis on the concerned variable costs, the CPI or appropriately denoted as CPI-FF in this study, consisted of price index for food (PI-Food) as published by the Department of Statistics Malaysia and price index for fuel (PI-Fuel) as was adopted to deflate or inflate the monetary value of the operating cost of the particular year. Thus, the weightings for PI-Fuel and PI-Food are 70%

and 30% respectively following the proportion of expenditure by the fishers and CPI-FF is derived by computing the summation of PI-Fuel * 0.70 + PI-Food * 0.30. The use of CPI for a similar purpose was described by [34] to inflate the 1997 fishing operating costs based on 1995 survey costs. Other CPI uses are to adjust wages, social security benefits, and tax brackets to correct for inflation [35].

(b) Fish price

The annual landing data preferred was the total amount of fishes caught by traditional fishers of South Manjung. It consisted mainly of fin fishes, prawns, shell-fishes and a negligible amount of trash fishes. Since the fisheries are multi-species and the prices fluctuate, fish prices were averaged annually following the grading system as stipulated by the DOF. Grade I group, the most highly priced fishes, were Chinese pomfret, silver pomfret, black pomfret, small pomfret, threadfin, Spanish mackerel, wolf herring, grouper and mangrove snapper; followed by less expensive Grade II fishes, such as longtail shad, shads/slender shads, red snapper, sweetlip, horse mackerel, and giant sea perch; and finally the least expensive, Grade III fishes represented by other fish species not included in Grade I or in Grade II such as anchovies, squids, crabs and jellyfish. Prawns, manure fish (sometimes termed as by-catch or trash fish) and shellfish each made up its own price grouping. In calculating the average fish price, several groups or species had to be ignored because, (1) species were not commonly caught by the traditional gears (trash fish, Grade III fishes such as anchovies, squids, crabs and jellyfish), and (2) the low priced shellfish that may distort the true average price if it was to be included in the average. Thus the annual fish price was averaged by the following equation, Pt = ΔPGrade 1(t) + ΔPGrade 11(t) + ΔPGrade 111(t) + ΔPPrawns(t) ÷ 4 where t is year 1992…, n=2003 and ΔP is the average fish price of Grade I, II, III and Prawns. As stated earlier, the Grade III fishes do not include anchovies, squids, crabs and jellyfish in the estimation of averaged price.

Quantifying the models

As the value of Y (price of a unit commodity) and X (quantity demanded or supplied) was obtained for each year, the demand and supply curves which follow the linear equation $Y = \alpha + \beta X + \mu$, were constructed. On the demand curve, the value α obtained was the maximum price a consumer is WTP (P_3) while on the supply curve, the value α was the minimum price a producer is willing to sell (P_0). By inserting all parameters obtained into the equations $CS = ½ [P_3 – P_1] [Q_2]$ and $PS = ½ [P_1 – P_0] [Q_1]$, the consumer surplus and the producer surplus was estimated respectively.

Accounting method

Producers' surplus can also be estimated by the accounting method. The net profit of fishers is the difference between total revenue and the total variable cost. The total revenue is the amount fishers get by selling their fish at a given price. This net profit is the producers' surplus and is given by PSt = TRt - TVCt, where TR is the total revenue, TVC is the total variable cost and t is the year 1992, 1993, 1994 …, n = 2003.

Results and discussion

The essence of data analysis is to determine whether the price and quantity demanded or supplied follows the law of demand and supply by fitting the relevant parameters onto the linear equation $Y = \alpha + \beta X + \mu$. If all conditions are justified, then consumer surplus and producer surplus are applicable by equations $CS = ½ [P_3 – P_1] [Q_2]$ and $PS = ½ [P_1 – P_0] [Q_1]$ respectively. Since the aim is to enumerate the difference of surpluses before and after the intervention, then net producers' surplus, NPS and net consumers' surplus, NCS is given by $NPS= \sum PS_B - \sum PS_A$ and $NCS = \sum CS_B - \sum CS_A$ where B is before intervention (year 1992-1997) and A is after intervention (year 1998-2003).

Table 2 shows the relationship between the ex-vessel prices and the fish landings over the 12-year period. The linear equation $P_t = 2.71 + 2.989*10\text{-}7Q_t$ is obtained where P_t is the ex-vessel price, Q_t is the quantity supplied and t is year 1992…, n = 2003. Since the relationship between the P_t and Q_t is genuine (r = -0.892, P= 0.024), $PS = ½ [P_1 – P_0] [Q_1]$ is applicable. Similarly by fitting the quantity of fish marketed, Qt and retail prices, P_t, as in Table 2, the linear equation , $CSt = ½ [8.318 – P_t] [Q_t]$ is obtained and again found to be genuine (r = -0.734, P= 0.024). Consecutively, the equation $CS = ½ [P_3 – P_1] [Q_2]$ is applicable. The scattergrams for both the retail and ex-vessel prices against quantity demanded or supplied are shown in Fig. 4 and Fig. 5 provide visual evidence of the linear curves.

Table 2: Annual fish landings, average ex-vessel prices and average operational costs of traditional fishing in South Manjung

Year	Total Fish Landing* (kg)	Average Ex-Vessel Price** (RM/kg)
1992	4,559,650.0	4.0
1993	4,105,000.0	3.62
1994	6,998,460.0	4.8
1995	7,216,680.0	5.1
1996	8,462,560.0	5.0
1997	7,109,070.0	4.77
1998	5,481,180.0	4.43
1999	4,395,940.0	4.1
2000	6,003,620.0	4.7
2001	5,518,590.0	4.43
2002	4,081,100.0	4.0
2003	5,636,210.00	3.9

Source: * Annual Fisheries Statistics, ** Fisheries District Office of Manjung

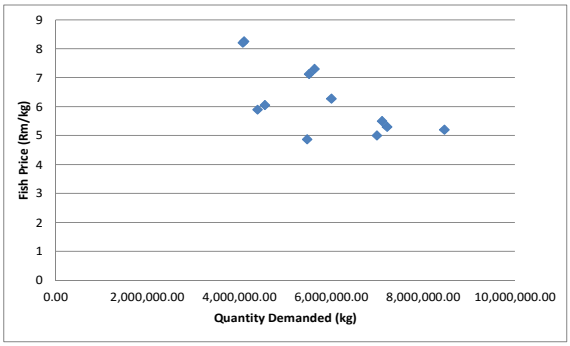

Figure 4: The scattergram of fish price (retail) against quantity demanded

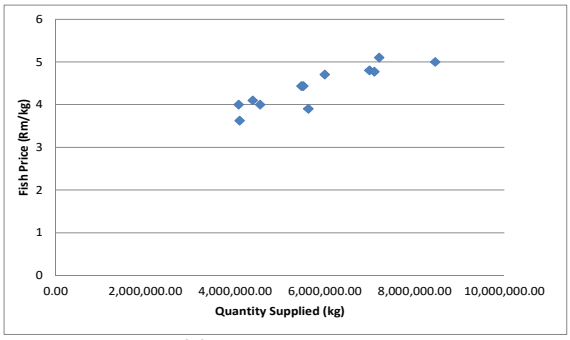

Figure 5: The scattergram of fish price (ex-vessel) against quantity supplied

Since P_0 = 2.71 and by fitting the annual price, Pt and quantity supplied, Qt, the annual PS is obtained as shown in Table 3. Thus NPS = RM 13,283,609.10 indicating the amount loss to fishers within the period of six years after the intervention. Table 4 shows annual CS after fitting P3= 8.318, retail prices and quantity marketed. The NCS = RM 16,715,424 indicating the amount loss to consumers within the same period.

Table 3: The difference of producer surplus before and after perturbation

Year	Quantity (kg) (Q_t)	Ex-vessel Price (RM) (P_t)	Producer Surplus (RM), $PS_t = ½ [P_t - 2.71] [Q_t]$
1992	4,559,650	4.0	2,940,974
1993	4,105,000	3.62	1,867,775
1994	6,998,460	4.8	7,313,391
1995	7,216,680	5.1	8,623,933
1996	8,462,560	5.0	9,689,631
1997	7,109,070	4.77	7,322,342
Total			$\sum PS_t$ = 37,758,046
1998	5,481,180	4.43	4,713,815
1999	4,395,940	4.1	3,055,178
2000	6,003,620	4.7	5,973,602
2001	5,518,590	4.43	4,745,987
2002	4,081,100	4.0	2,632,310
2003	5,636,210	3.9	3,353,544.
Total			$\sum PS_t$ = 24,474,436

Table 4: The difference of consumer surplus before and after perturbation

Year (i)	Retail Price- RM (P_t)	Quantity Demanded- kg (Q_t)	Consumer Surplus- RM (CS_t)
1992	6.05	3,009,369	3,412,624
1993	8.25	1,600,950	54,432
1994	5.0	3,709,184	6,153,536
1995	5.30	4,185,674	6,316,182
1996	5.20	4,654,408	7,256,222
1997	5.50	3,981,079	5,609,340
Total			$\sum CS_t$ = 28,802,337
1998	4.87	2,959,837	5,102,759
1999	5.89	2,154,011	2,614,969
2000	6.27	3,001,810	3,073,853
2001	7.12	1,048,532	628,070
2002	8.20	612,165	36,117
2003	7.30	1,239,966	631,142
Total			$\sum CS_t$ =12,086,913

The estimation of producer surplus by accounting method is as follows; the TVC of a particular year is given by TVCt = operating cost per fishing trip * 20 fishing days * 12 months * number of fishing vessels. For example, in 1992, there were 500 fishing vessels, each spending an average RM 39.87 for every fishing trip. Table 5.0 illustrates the estimated operating cost of each year taking into the account the CPI-FFs and the surveyed operating costs of year 1995 and year 2002. This study had also determined the average fishing trips per month to be 20 days or 240 days per year and be used throughout the years in question. The Ratio Method; $I_2/I_1 = P_2/P_1$ or the Price Adjustment Formula; $P_2 = I_2/I_1 * P_1$ [36] was used to estimate the cost in year of question. For example, in 1995 (CPI-FF=89.69), the fishing costs was calculated at RM 40.60 per fishing trip. In Price Adjustment Formula, P_2 is the cost to be estimated, I_2 is the index for the period of which cost is to be estimated, I_1 is the index for the period of known cost that is, in this case equal to 89.69 and P_1 is the known cost which is equal to RM 40.60. Therefore, to estimate cost in 1994 at CPI-FF = 88.82 ; P_2 = 88.82/89.69 * RM 40.60 = RM 40.21.Therefore, TVC1992 = RM 39.87 * 20 * 12 * 500 = RM 4,784,400. NPS for the years 1992 - 1997 was RM 150,564,580 compared with RM 57,292,913 between 1998 - 2003, indicating a loss of RM 93,271,667 as a result of the projects. (Table 6).

Table 5: Adjusted variable costs using the CPI

Year	Price Index for Food* (PI-Food)	Price Index for Fuel (PI-Fuel)	CPI-FF	Adjusted Variable Cost per day (RM)
1992	77.1	94.2	88.07	39.87
1993	79.9	94.2	89.91	40.70
1994	82.8	91.4	88.82	40.21
1995	85.7	91.4	89.69	**40.60**
1996	88.7	91.7	90.80	41.10
1997	91.0	91.7	91.49	41.41
1998	95.8	91.7	92.93	66.37
1999	98.5	91.7	93.74	66.94
2000	100.0	100.0	100.0	71.42
2001	101.4	108.3	106.23	75.86
2002	103.2	110.8	108.52	**77.50**
2003	105.1	112.5	110.28	78.76

Note: * From Ministry of Domestic Trade and Consumer Affairs Malaysia
In www.kpdnhep.gov.my/index.php?ch=20&pg=98&ac=170 dated 22 May 2015. Base year 2000=100.

Table 6: Accounting method: The difference of producer surplus before and after perturbation

Year/No.of Vessels (i)	Total Revenue (TR_i) RM	Total Variable Cost (TVC_i) RM	Producers' Surplus (PS_i) TR_i - TVC_i RM
1992/500	18,238,600	4,784,400	13,454,200
1993/525	14,860,100	5,128,200	9,731,900
1994/483	33,592,608	4,661,143	28,931,465
1995/511	36,805,068	4,979,184	31,825,884
1996/515	42,312,800	5,079,960	37,232,840
1997/455	33,910,263	4,521,972	29,388,291
$\sum PS_i$			150,564,580
1998/515	24,281,627	8,203,332	16,078,295
1999/529	18,023,354	8,498,702	9,524,651
2000/898	28,217,014	15,392,438	12,824,576
2001/802	24,447,353	14,601,533	9,845,820
2002/792	16,324,400	14,731,200	1,593,200
2003/770	21,981,219	14,554,848	7,426,371
$\sum PS_i$			57,292,913

Conclusions

Using catch data or rather the total revenues (Q_t * P_t) to describe the change in the economic well-being of the society is too simplistic, although it may provide some indication about the level of the economy, for example as it is commonly used to build a national's Gross Domestic Product (GDP). GDP is the total value of all goods and services produced in the country by the factors of production located in the country, regardless of who owns them [37]. It is a common practice of the DOF to describe the economic growth of fisheries in term of its contribution to the GDP. For example, the importance of fisheries as a food contributor in the agricultural sector is highlighted in its 18.24% portion to GDP [38]. Comparison was also made between the previous years as an indicator of how fisheries have been progressing. However, GDP does not measure all our society's production, and certainly doesn't provide a perfect measure of welfare, or well-being [13]. Moreover, according to [13], an increase in GDP does not always mean improve living standard, and similarly, a decrease in GDP is not always a cause for concern and corrective action. Therefore, it is difficult in making any meaningful inferences from GDP behavior without further scrutinizing of the data and apparently it may mislead many readers of the reports. GDP, as it has been advocated by DOF, is an inefficient methodology to explain society well-being.

The alternative way of describing the impact of fish catch on society is using the concepts known as consumer surplus and producer surplus. By comparing these measures before and after a market disturbance, it is possible to quantify how society has been affected [12]. Both concepts stem from the change in commodity price and the amount they are willing to pay if he or she is a consumer or the amount produced if he or she is a producer. Consumer surplus can be gauged from the demand curve that is econometrically constructed with the availability of time-series data on market price of the commodity and the quantity consumed. Similarly, the producer surplus can be obtained from the supply curve that is econometrically constructed using the time-series data on selling price and amount supplied. In addition to econometric method of obtaining the producer surplus, the accounting method offers a much easier way provided there exist, apart from time-series data on revenues, variable cost data.

In the absence of required data, the extrapolation method was used to generate data based on certain assumptions. For instance, although there were two studies providing cost data for particular years of fishing activities, the time-series data on the variable costs were absence in any other literature. Thus, annual cost data were extrapolated from the use of Consumer Price Index (CPI) acting as price deflator or inflator of the goods bought by fishers as their total variable cost. The use of CPI was relevant as goods bought by fishers were consumer goods (food, ice and fuel) rather than the use of Producer Price Index that according to [39], measures the average level of prices of goods sold by producers.

In this study, the demand curve for marketable fish of South Manjung was found to be represented by $P_t = 8.318 - 7.7E\text{-}07Q_t$ and the consumer surplus by $CS_t = ½ [8.318 - P_t] [Q_t]$. Likewise, the supply curve by $P_t = 2.71 + 2.989E\text{-}07Q_t$ and the producer surplus by $PS_t = ½ [P_t - 2.71] [Q_t]$. By substituting data collected on fish prices and catches into these equations, the annual surpluses were obtained for 1992 - 1997 to represent the before period and for 1998 - 2003 to represent the after period. The total surpluses of the after period were then subtracted from the total surpluses of before period.

One important aspect that is not discussed in this paper is the right of fishers and consumers to ask for compensation for their losses in the court of justice since they do not have the *locus standi* over the public property. Practically, fishers and consumers do not own the sea however; the government may charge the polluters to pay through the relevant legislations of which the amount suggested as estimated by this paper. Fishers' losses may then be compensated individually for it is to ease the burden of income's loss. However, it is proposed that the amount compensated for consumers' losses to be used in fisheries resources enhancement project such as the development of artificial reefs.

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3. FRGS Grant – Co-researcher titled ‘Estimation of formation mechanisms of ligand complex between heavy metals and organic matter and its impacts on aquatic food webs and biodiversity’ (2013-2016)
4. FRGS Grant – Research leader titled ‘The Study of Life Cycle, Habitats and Distribution of Siput Mentarang (*Pholas orientalis*) in Selangor, Perak and Kedah, Malaysia (2014-2016)

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