A bioeconomic analysis of demersal fisheries in the West Java Province: A comparison between the Java Sea and Indian Ocean

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Abstract. This research aimed to analyze the bioeconomic properties of demersal fisheries in the West Java Province, Indonesia, with a comparison between the Java Sea and Indian Ocean. The Fox production model and CY&P estimation procedure were used. The Maximum Sustainable Yield (MSY) is 158967.299 and 6854.656 tons for the Java Sea and the Indian Ocean, respectively. The Maximum Economic Yield (MEY) is 158952.622 and 6840.5 tons for the Java Sea and the Indian Ocean, respectively. The Marginal Revenue is 1490.31 USD per trip, and -516.89 USD per trip for the Java Sea and the Indian Ocean, respectively. The stock sizes are estimated at 893.5 and 278.1 tons, with zero net sustainable revenues. The stock sizes associated with the MEY level are 66050.28 and 4419.28 tons, with corresponding efforts at 71740.92 and 3137.75 trips. Net sustainable revenues at MEY level are 289649702.44 and 7686039.51 USD for the Java Sea and the Indian Ocean, respectively. The largest harvests are 15964.04 tons at 5% discount rate, and 6854.32 tons at 10% discount rate. The indication of overfishing found in the Indian Ocean at the current harvest level of 7180.44 tons is exceeding the MSY level. The current effort level of 5936.38 trips is more than the 50% discount rate effort level while the optimal level is between 10% and 20%. The current level of marginal revenue is negative. There is no indication of overfishing of demersal fisheries in the Java Sea. It is also suggested to include fishing costs to the standard fishery statistics.

Key Words: CY&P, discount rate, Fox model, MEY, small scale fishery.

Introduction. The fishery sector of the West Java Province, Republic of Indonesia, shared 0.97% of the Gross Regional Domestic Product, with a growth rate of 3.17% in 2017 (BPS 2018). The marine fishery subsector landed 231153 tons of fish in 2017, with the value of 719.95 million USD (MMAF 2018). The distribution of landings in the Java Sea are as follows: 39.13% pelagic fish, 34.36% demersal fish, 11.43% crustaceans, 8.74% mollusks. In the Indian Ocean, the composition is the following: 44.13% pelagic fish, 36.18% demersal fish, 7.68% crustaceans, 0.47% mollusks (DKP 2018a). The annual landings from 1996 to 2017 ranged from 33000 to 75000 tons in the Java Sea, and from 2269.5 to 7316.1 tons in the Indian Ocean, with an average of 52608.82 tons and 5722.14 tons for the Java Sea and the Indian Ocean, respectively (DKP 2018a).

The West Java Province is bordered to the north by the Java Sea, to the east by the Central Java Province, to the south by the Indian Ocean, to the west by the Banten Province, and to the northwest by the DKI Jakarta Province. Both the Java Sea and the Indian Ocean are part of a continental shelf (Figure 1). The fish captured here are landed in several fishing ports along its northern and southern coast.

The marine and fishery sector of the West Java Province absorbed the workforce of 97964 fishermen, 73540 fishermen in the Java Sea and 24424 fishermen in the Indian Ocean. This workforce utilizes 19105 units of fishing vessels, divided as 14598 vessels in the Java Sea and 4507 vessels in the Indian Ocean (DKP 2018b). 91.73% of those in the Java Sea are motorized and with an outboard motor with a tonnage of less than 10 GT.

For the Indian Ocean, the percentage is 94.7% (DKP 2018b). Thus, by law, these fishermen who use vessels of 10 GT or less are categorized as part of an artisanal or small scale fishery. The main gears employed are gillnets, seine nets, traps, hooks and lines, and trawls (DKP 2018b).

Demersal fish occupy the bottom of the seas. There are 37 species recorded annually by the marine statistics. Out of those, 14 species makes up 91% of the landed demersal fish consistently, namely: 1) giant catfish (*Netuma thalassina*), Jack trevallies (*Caranx* spp.), black pomfret (*Formio niger*), silver pomfret (*Pampus argenteus*), barramundi (*Lates calcarifer*), dorab wolf herring (*Chirocentrus dorab*), greater lizardfish (*Saurida tumbil*), tongue soles (*Cynoglossus* spp., *Pleuronectus* spp.), pony fishes (*Leiognathus* spp.), red snappers (*Lutjanus* spp.), tredfin (*Polynemus* spp.), croacker (*Nibea albiflora*), hairtails (*Trichiurus* spp.), stingrays (*Dasyatis* spp.) (DKP 2018b).

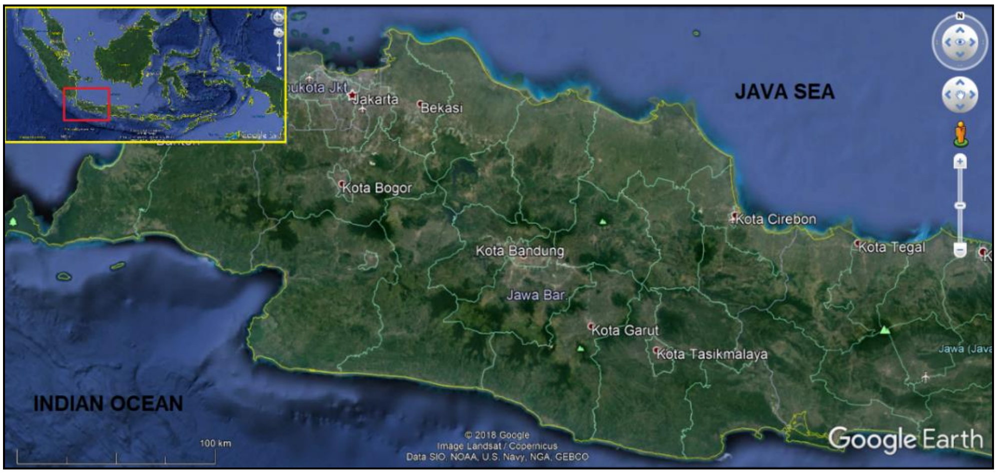

Figure 1. Map of West Java Province, Indonesia. Source: Google Earth.

Figure 2 shows the trend of demersal fish landings and their effort. From 1994 to 2017, the landings are increasing, both in the Java Sea and the Indian Ocean. It started at 34500 and 3070.5 tons in 1994 and finished at 72712.65 and 7180.44 tons in 2017 in the Java Sea and the Indian Ocean, respectively.

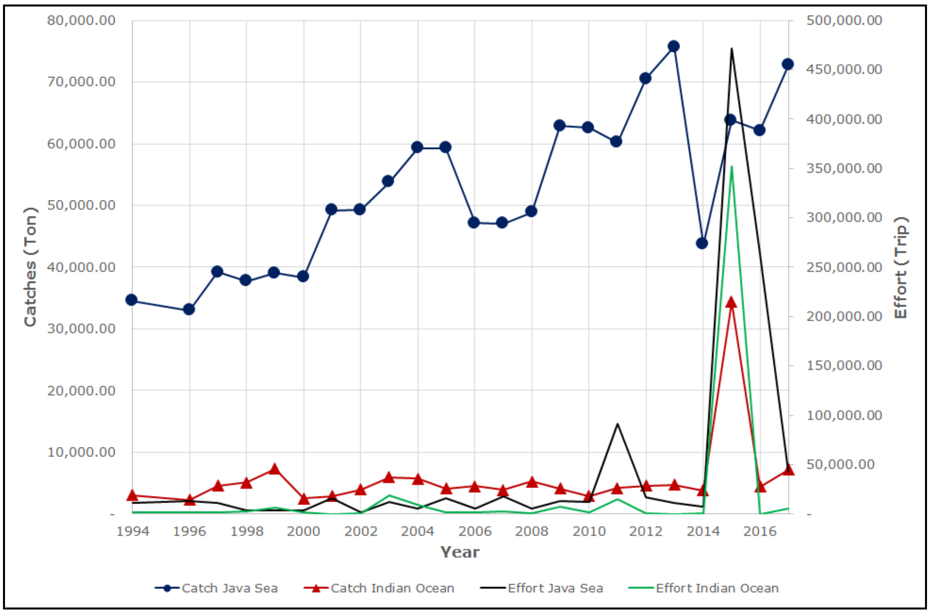

Figure 2. Landings and effort trend of West Java demersal fishery from 1996 to 2017. Source: DKP (2018b), processed.

The increase in landings also followed by an increase in effort, from 11107 trips and 1624 trips in 1994 to 42674 and 5936 trips in 2017 on the Java Sea and the Indian Ocean, respectively (DKP 2018b). This suggest that the fishing business was getting more difficult. This raised questions about the fish stock condition and the benefit to fishermen.

The fundamental purpose of fisheries management is to ensure sustainable production over time of fish stocks, preferably through regulatory and enhancement actions that promote economic and social wellbeing of the fishermen and industries that use the production (Hilborn & Walters 1992). As stated by King (2013), its purpose is to ensure that fish catches are ecologically sustainable in the long term and benefits to fishermen and communities are maximized.

The situation stated above called for fishery capacity assessment (Pascoe et al 2004). Fishery capacity assessment consists of two steps: performance analysis, which assesses how the fisheries are exploited, and the bioeconomic analysis, which assess the fish stock condition (Kirkley et al 1999).

The tools at the hand of the fisheries managers include bioeconomics. Fisheries bioeconomics is a field that integrates resource biology and ecology with the economics of fishermen behavior, considering space, time, and uncertainty dimensions. It provides insight into the complexity of marine fisheries (Anderson & Seijo 2010).

Stock assessment is a procedure utilizing various statistical and mathematical calculations to make quantitative predictions about the reactions of fish populations to alternative management choices (Hilborn & Walters 1992). It is part of bioeconomics; the other part is how the stock itself could be turned into an economic benefit for fishermen.

This research aimed to perform a bioeconomic analysis of the demersal fishery in the West Java Province. Similar studies had been performed by Jin et al (2012) for traditional fisheries in the Red Sea. The results could provide insights for fishery managers to answer questions about the fish stock condition and benefits for fishermen.

Material and Method

Types and source of data. This research represents a quantitative study, using a case study approach. The location of the research is the West Java Province, Republic of Indonesia. The time of the study was from October to November 2019. The focus was to determine the bioeconomic properties and to compare the demersal fisheries in both seas bordering the province, the Java Sea and the Indian Ocean. Both primary and secondary data were utilized. The primary data were the fishing cost, gathered through random field surveys of fishermen. The secondary data was the statistical fishery data obtained from the Marine and Fishery Affair Bureau of the Provincial Government of West Java (DKP 2018b). The measurement unit used was metric, and the monetary unit is USD, with exchange rate to the Indonesian Rupiah (IDR) of 1 USD = IDR 13451.22 in 2017.

Data analysis technique. The bioeconomic analysis of the demersal fisheries in the West Java Province was conducted in successive steps. First, the biological parameters were established; then, by combining them with economic data, the relevant bioeconomic properties were determined. The analysis technique was straightforward, with the same procedure used by King (2013), and, unless stated otherwise, all the following formulas were derived by algebraic manipulation. The biological production function followed the formula proposed by Fox (1970):

$$h = KqEe^{\left(-\frac{qE}{r}\right)}$$

Where: h is harvest (ton), K is the carrying capacity associated with the species being analyzed (ton), q is the catchability coefficient associated with the species being analyzed ($trip^{-1}$), E is the effort expended to gain the harvest (trip), e is the natural number, and r is the intrinsic growth rate associated with the species being analyzed ($year^{-1}$).

The three biological parameters above (K, q, r) were estimated using the CY&P regression method (Clarke et al 1992):

$$ln(U_{\tau+1}) = \frac{2r}{2+r} ln(qK) + \frac{2-r}{2+r} ln(\bar{U}_\tau) - \frac{q}{2+r}(\bar{E}_\tau + \bar{E}_{\tau+1})$$

Where U is the Catch per Unit Effort (CPUE), and E is the Effort. By finding the regression coefficient from time series data, the biological parameters are obtained.

By assuming static condition, where the rate of change of fish stock to time is zero, the Maximum Sustainable Yield (MSY) could be derived from the production function:

$$h_{MSY} = {Kr}/{e}$$

$$E_{MSY} = {r}/{q}$$

The Maximum Economic Yield (MEY) is estimated by combining the biological parameters with price (p) and cost of fishing (c) data. First, we estimated the Effort level by solving equation below using the iteration method, as outlined in Chapra & Canale (2014).

$$\left(1 - \frac{qE_{MEY}}{r}\right) pKqe^{\left(-\frac{qE_{MEY}}{r}\right)} - c = 0$$

The MEY is found by substituting the appropriate effort to the production function, which yields the following equation.

$$h_{MEY} = KqE_{MEY}\, e^{\left(-\frac{qE_{MEY}}{r}\right)}$$

The Total Revenue (TR) is the product of harvest and unit price, the total cost (TC) is the product of cost and effort expended, net sustainable revenue (π) is the difference between Total Revenue and Total Cost, Average Revenue (AR) is the Total Revenue divided by Effort, and Marginal Revenue (MR) is the first derivative of Total Revenue to Effort. All anterior formulas and the next 5 equations are dependent of fishing effort, E.

$$TR = p\left\{KqEe^{\left(-\frac{qE}{r}\right)}\right\}$$

$$TC = cE$$

$$\pi = TR - TC$$

$$AR(E) = pKqe^{\left(-\frac{qE}{r}\right)}$$

$$MR(E) = \left(1 - \frac{qE}{r}\right) pKqe^{\left(-\frac{qE}{r}\right)}$$

In dynamic conditions, when the rate of change of fish stock to time is considered, we wish to establish the optimal biomass/fish stock (x^*), harvest (h^*), and effort (E^*) that give maximum economic rent, at a certain discounting value (δ). Following the Golden Rule (Clark 1985), the appropriate relationships were derived. The next equations are credited to Clarke et al (1992). All statistical parameters are significant at a 5% level.

$$\ln\left(\frac{K}{x^*}\right) - \left(1 + \frac{\delta}{r}\right)\left(1 - \frac{c/pq}{x^*}\right) = 0$$

$$h^* = \frac{1}{c}\left[\left(r\ln\left(\frac{K}{x^*}\right) - r - \delta\right)x(-pqx^* + c)\right]$$

$$E^* = h^*/qx^*$$

Results and Discussion

Biological parameters. The biological parameters of demersal fish in the Java Sea and Indian Ocean are as follows (Table 1): the catchability coefficients are 0.00003354 and 0.00049331 trip^{-1} respectively, the carrying capacities are 177130.833 and 11280.187 tons, respectively, and the intrinsic growth rates are 2.4395 and 1.6518 year^{-1}, respectively. The CY&P model fitted the data with the R^2 value of 0.7 for the Java Sea, and 0.537 for the Indian Ocean.

Table 1

Biological parameters of demersal fish in the Java Sea and Indian Ocean

Location	*R^2*	*Catchability coefficient, q (trip^{-1})*	*Carrying capacity, K (ton)*	*Intrinsic growth rate, r (year^{-1})*
Java Sea	0.700489	0.00003354	177130.833	2.4395
Indian Ocean	0.537771	0.00049331	11280.187	1.6518

Bioeconomic properties. By combining the biological parameters above with commodity price and fishing cost, the bioeconomic parameters were obtained (Table 2). The commodity prices are from statistical data, whereas the fishing costs come from the field survey. From these data, the MSY and MEY were derived. The MSY of demersal fish for the Java Sea and the Indian Ocean are 158967.299 and 6854.656 tons, respectively, while the MEY of demersal fish for the Java Sea and the Indian Ocean are 158952.622 and 6840.5 tons, respectively. The actual harvests of demersal fish in 2017 in the Java Sea and the Indian Ocean were 72717.65 and 7180.44 tons, respectively. The fishing efforts committed were 42647.46 and 5936.38 trips for Java Sea and Indian Ocean, respectively.

Table 2

Bioeconomic parameters of demersal fish in the Java Sea and Indian Ocean

Location	*Commodity price (USD per ton)*	*Fishing cost (USD per trip)*	*Maximum sustainable yield (tons)*	*Maximum economic yield (tons)*
Java Sea	1090.13	55.37	158967.299	158952.622
Indian Ocean	707.62	164.50	6854.656	6840.5

The sustainable yield curve for the Java Sea was plotted using the three biological coefficients derived from the CY&P method (Table 1), as illustrated in Figure 3. The sustainable yield curve plots the theoretical yield as it changes following increase in fishing effort, with the top of the curve denoting the MSY. Superimposed on it are the actual catch and effort plots from 1996 to 2017. From 1996 to 2014, the yield and effort looked volatile, alternating between expansion and contraction, both in yield and effort. Increase in effort was followed by an increase in yield. In the next period, an increase in effort was followed by a decrease in yield. When efforts are reduced, the yield could be stagnant or increased. The ranges of effort were between 3000 and 20000 trips, and of yield between 33000 and 75000 tons. Changes occurred between 2014 and 2017, when a sharp increase in effort happened, but without significant increase in yield. In 2015, efforts increased by about 62 times, but an increase of only 1.45 time in yield compared to 2014 was observed. In 2016, efforts were halved from the previous year, and were followed by a decrease in yield. In 2017, the recorded fishing effort was even further decreasing, and there was a slight increase in yield. These indicated that the fish stocks were regenerating after a tendency of overfishing.

The Java Sea is an internal sea, which is practically enclosed by several islands: Java Island to the south, Sumatra Island to the west, Kalimantan/Borneo Island to the north. One could infer that the sea itself is relatively calm and the fish stock is denser than that of the open sea. These may explain that from 1996 to 2014, the fishing efforts were relatively low, rarely exceeding the MSY level. The exception was in 2011, when the effort slightly passed the MSY level, but not the harvest. The other exception was in 2015, when an extremely high fishing effort occurred, but without a significant increase in harvest. The subsequent years, 2016 and 2017, showed a decreasing effort, with practically stable amounts of harvest. It can be deduced that the fish stock was regenerating, so that the harvest was gained without much effort. Figure 3 shows that most of the harvest occurred at a low effort level and low yield. This is consistent with the fact that the majority of the fishing fleet is represented by small vessels with the size of 10 GT or smaller.

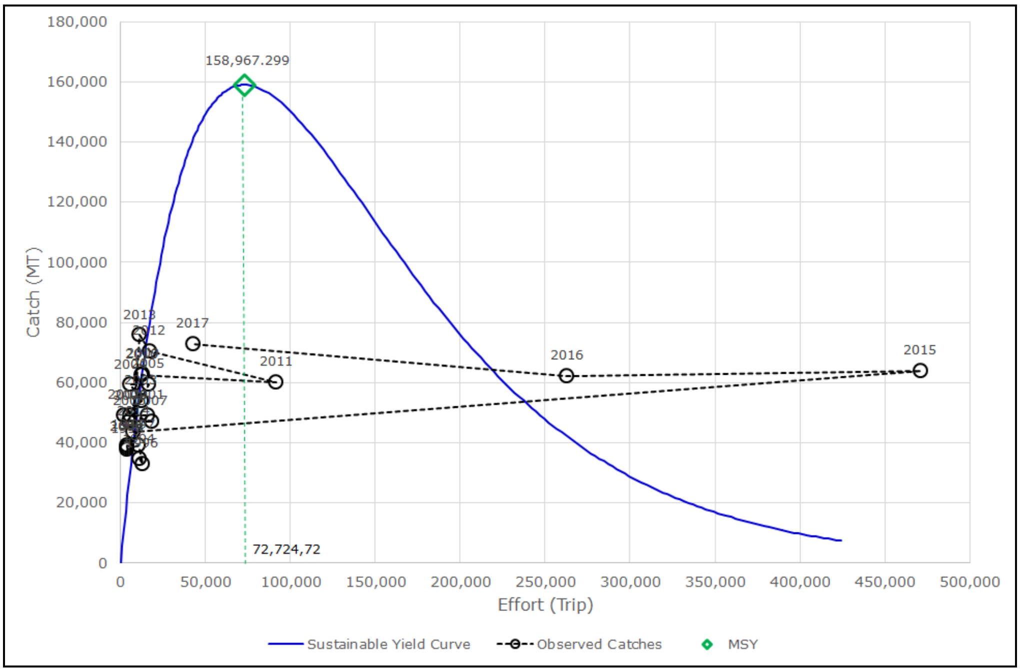

Figure 3. Sustainable yield curve of demersal fish of the Java Sea.

Figure 4 describes the sustainable yield and effort in the Indian Ocean, superimposed by actual data of catch and effort from the same time span (1996–2017). It could be seen that the observed catch and effort were more noticeable than those of the Java Sea, the yield-effort patter being spread across the yield curve, rather than being concentrated in a specific area. They encompassed almost the full range of theoretical effort in the location. Similar to the pattern of the Java Sea, there was a tendency of increasing effort and yield in one period, followed by decreasing effort and yield in the next period, and decreasing yield when effort was increased dramatically in the next period. The most noticeable trend could be seen in 2008, when the yield increased, but effort spent was less than in 2007. 2009 saw an increase in effort, but a reduced yield. 2010 saw a reduction of both effort and yield. 2011 saw an increase in both effort and yield. As in the Java Sea, these patterns of alternating increase and decrease of effort and yield indicated that the fish stocks were regenerating after a tendency of overfishing.

The rather erratic pattern of the observed catch–effort plot could be explained as follows. The southern part of West Java province is facing the Indian Ocean. Physically, the sea is rougher than the Java Sea. Since it is an open sea, the fish stock is thinner than that of the Java Sea. Combining these factors, the observed catch–effort pattern fluctuated easily when compared to that of the Java Sea. Most often, both yields and efforts were running back and forth, trespassing the MSY level. As we can see from Figure 4, the yields of 1999 and 2017 were exceeding the MSY level. The fishing efforts of 1999, 2003, 2004, 2009, and 2011 were exceeding the MSY level.

The relatively low amount of harvest, and the effort committed in the Indian Ocean resulted from several factors, including the small number of fishermen operating in the area, where are approximately 25% of fishermen from the entire province. About 90% of total fishermen in the West Java province are classified as artisanal or small-scale fishery, thus limiting fishing capacity and technology accessed in the fishing operations. The geographical factor of open seas should not be taken lightly when compared to the small tonnage of the vessel (10 GT or less), making fishing a challenging venture.

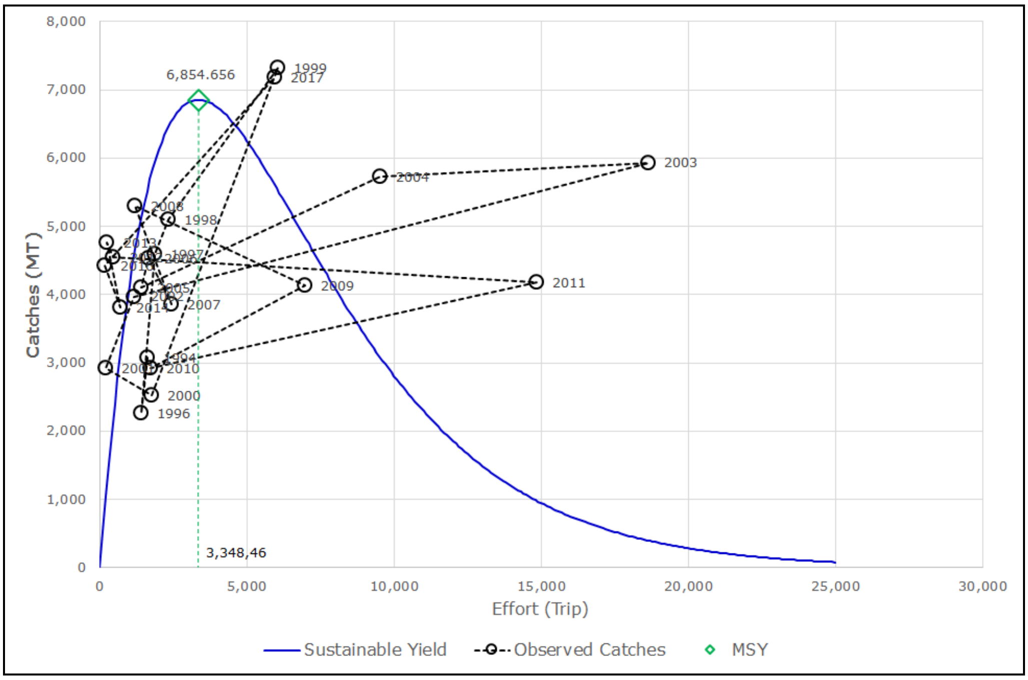

Figure 4. Sustainable yield curve of demersal fish in the Indian Ocean; MSY - maximum sustainable yield.

Table 3 shows the Average Revenue (AR) and the Marginal Revenue (MR). The calculations use the actual effort at 2017 level, 42647.46 trips for the Java Sea, and 5936.38 trips for the Indian Ocean. The AR for the demersal fishery of the Java Sea is 3603.45 USD per trip, and of the Indian Ocean is 668.79 USD per trip. The MR for demersal fishery of the Java Sea is 1490.31 USD per trip, and of the Indian Ocean is -516.89 USD per trip. The AR measures the average gain harvesting the fish in a single effort (trip). The MR measures the amount of change in revenue if the amount of effort is changed by one unit. A positive change in MR means that the increase in revenue is bigger than the increase in cost. A negative change in MR means that the cost of harvesting is more expensive than the revenue gained.

Table 3

The average and marginal revenue

Location	*Harvest (ton)*	*Fishing effort (trip)*	*Average revenue (USD trip^{-1})*	*Marginal revenue (USD trip^{-1})*
Java Sea	72717.65	42647.46	3603.45	1490.31
Indian Ocean	7180.44	5936.38	668.79	-516.89

Figure 5 illustrates the revenue and cost function of the demersal fishery of the Java Sea. The benchmarks are plotted as MEY, MSY, and Open Access (OA) (the point where the benefit is equal to the costs). As reference, the plotted of actual harvest in 2017 was used. The fishing effort at MEY is 71740 trips, at MSY it is 72724 trips, at OA is 384677 trips, and at present level is 42647 trips.

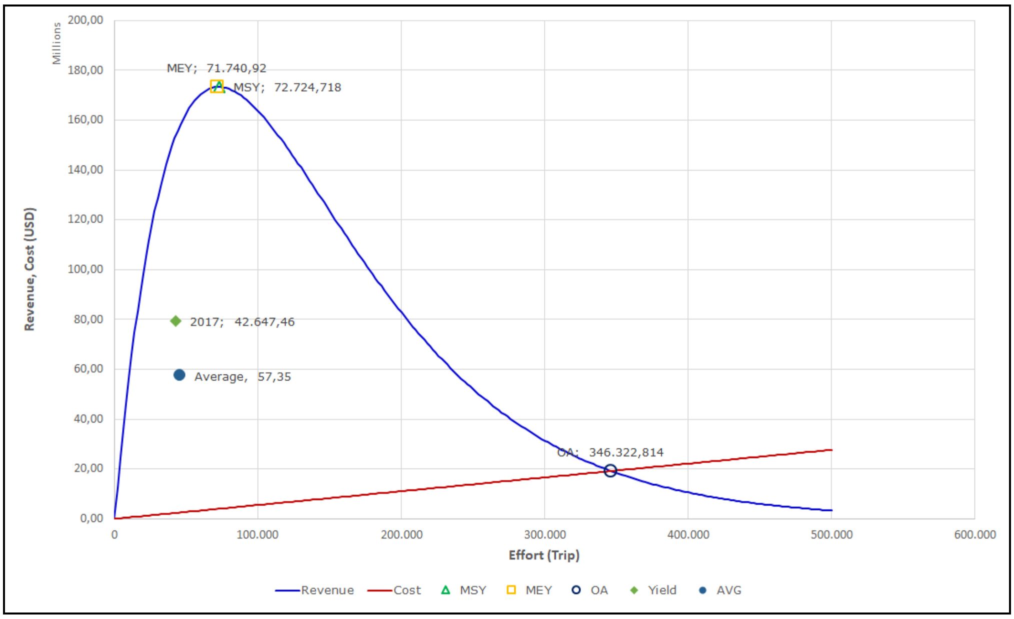

Figure 5. Revenue and cost function of demersal fish in the Java Sea; MEY - maximum economic yield; MSY - maximum sustainable yield; OA - open access; AVG - average.

Figure 6 illustrates the revenue and cost function of the demersal fishery in the Indian Ocean. The benchmarks are plotted as MEY, MSY, and OA. Also plotted is the actual harvest in 2017. The fishing effort at MEY is 3138 trips, at MSY is 3348 trips, at OA is 12399 trips, and at present level is 5936 trips.

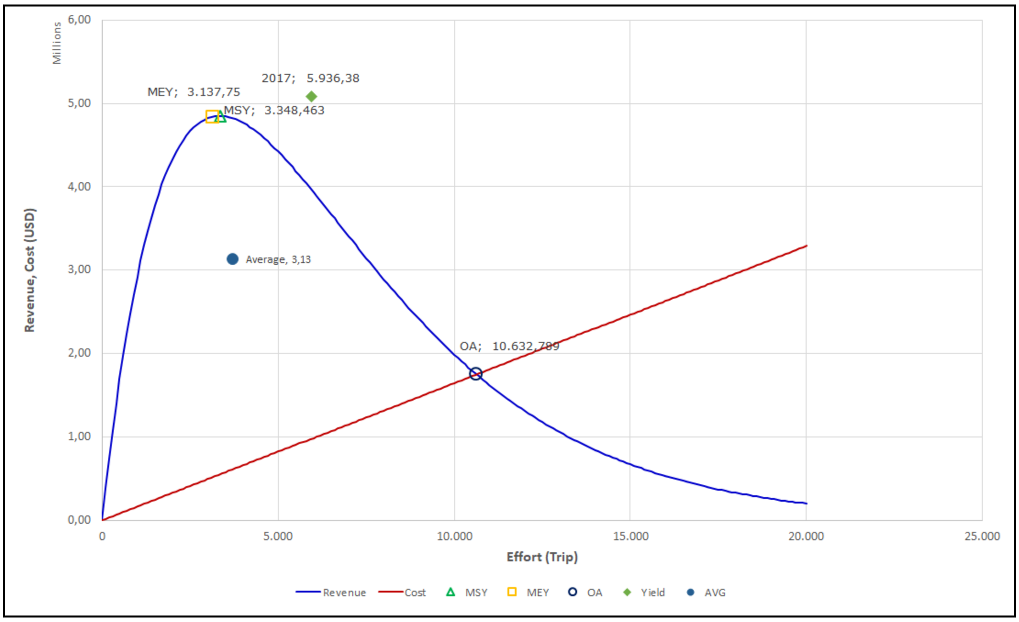

Figure 6. Revenue and cost function of demersal fish on the Indian Ocean; MEY - maximum economic yield; MSY - maximum sustainable yield; OA - open access; AVG - average.

From both Figures 5 and 6, it can be seen that the intersection of the revenue and cost plot marks the OA condition, where the revenue is equal to the cost. Therefore, the net sustainable benefit is zero.

Table 4 shows the dynamically optimal condition with various discount rates (δ). The MEY corresponds to the zero discount rate ($\delta = 0$), and the OA condition is denoted with the discount rate approaching infinity ($\delta \to \infty$). Such situations meant that the resource rent is totally dissipated, i.e. the Total Cost equaled the Total Revenue. On the Java Sea, the OA condition is met when Total Effort reaches 384676.88 trips. On the MEY condition, the Net Sustainable Revenue is 289649702.44 USD with the Total Effort amounting to 71740.92 trips. The Total Harvest reaches its peak at 5% discount rate, at 158964.04 tons, total effort at 73191.08 trips, with a net sustainable revenue of 289590512.88 USD. For the Indian Ocean, the OA condition is met when the Total Effort reaches 12398.72 trips. The MEY condition is met when the Total Effort reaches 3137.75 trips, leading to a Net Sustainable Revenue of 7686039.51 USD. The largest harvest is obtained with 10% discount rate at 6854.32 tons, and total effort at 3315.52 trips.

Table 4

Dynamically optimal condition with various discount rates (δ)

δ (%)	*Stock (ton)*	*Harvest (ton)*	*Effort (trip)*	*Total Revenue (USD)*	*Total Cost (USD)*	*Net Sustainable Revenue, π (USD)*
			Java Sea			
0	66050.28	158952.62	71740.92	293621710.26	3972007.81	289649702.44
5	64746.26	158964.04	73191.08	293642810.1	4052297.22	289590512.88
10	63469.04	158913.13	74640.03	293548754.02	4132519.64	289416234.38
20	60992.83	158634.63	77534.17	293034308.8	4292756.74	288741552.06
50	54153.00	156558.47	86184.26	289199162.4	4771677.72	284427484.67
∞	893.50	11529.72	384676.88	277002712.1	5562973	271439739.1
			Indian Ocean			
0	4419.28	6840.50	3137.75	8202200.05	516160.53	7686039.51
5	4303.21	6850.03	3226.87	8213621.45	530821.21	7682800.25
10	4190.78	6854.32	3315.52	8218773.22	545404.01	7673369.2
20	3976.40	6848.59	3491.35	8211900.15	574328.17	7637571.98
50	3409.63	6738.51	4006.24	8079901.91	659028.82	7420873.09
∞	278.10	1700.99	12398.72	7625878.16	792401.48	6833476.68

The utilization of a discount rate (δ) denotes an intertemporal choice. This means that there is an option whether to harvest the stock now (to gain current revenue) or to harvest later in the future. If the choice is to harvest later, the present stock is considered as an investment, which is deemed more valuable later than now. The discounting process reflects the actual action of the purpose of fishery management, which is to ensure that catches from the fish stock are ecologically sustainable in the long term and benefits to fishermen and communities are maximized. In simpler terms, it seeks the best value of δ that maximize the net present value of the fish stock.

The discount rate also reflects the risk of harvesting natural resources. Fish stock as a natural capital holds an inherent risk: is the stock more valuable in the future? Will the stock be there in the future? Does climate affect the stock? The fishing cost is seen as an opportunity cost. If the decision is to harvest later, the money would be used for other activities rather than being spent on fishing now. So, the question is which activity yields more benefit.

The value of discount rate varies between zero (0) to almost infinity (∞). The zero discount rate coincides with the sole owner condition, i.e. the MEY; whereas the near infinity coincides the OA condition. These are the two extreme ends of the value. In the OA condition, the net sustainable revenue could be set to positive by reducing effort. This action would likely attract new entries to the industry, induced by the possibility of positive revenue. Thus, the overall benefit would be again reduced to zero. In the zero discount rate, the present value of the stock is equal to the future value. Thus, since there is no difference between harvesting the stock in the present and in the future, the likely choice is to harvest it now. Soon, the effort level will likely be exceeded and it will reduce the benefit. In the end, there should be an optimal value of the discount rate that exists between these two extremes.

As Table 4 shows, the discount rate that gives the highest yield is 5% for the Java Sea, and 10% for the Indian Ocean, resulting in a moderate level of effort. The effort level at 5% discount rate is 73191.08 trips in the Java Sea, and at 10% in the Indian Ocean is 3315.52 trips. These levels of effort are slightly higher than the MEY level, but much lower than the OA level. For the Java Sea, the net sustainable revenue at 5% is not much different from that at the 10% level, but if we progress to 20%, the reduction in net sustainable revenue is more than twice the change between the 5 and 10% levels. For the Indian Ocean, the situation is similar. The effort could be reduced from 10 to 5% level or increased to 20% level, without a significant change in the net sustainable revenue. But if the effort is further increased beyond 20%, the net sustainable revenue drops significantly. As the discount rate also reflects the risk in an investment, a higher value bringing more risk, we could infer that fishing in the open seas (the Indian Ocean) is riskier than in the inland sea (the Java Sea).

Conclusions. This research performed a bioeconomic analysis on the demersal fisheries in the West Java province, with a comparison between the Java Sea and the Indian Ocean. Employing the Fox production model and the CY&P estimation procedure, the following properties were established: MSY values are 158967.299 and 6854.656 tons for the Java Sea and the Indian Ocean, respectively. The MEY values are 158952.622, and 6840.5 tons, respectively. The marginal revenues are 1490.31 USD per trip, and -516.89 USD per trip, respectively. The stock sizes are estimated at 893.50 and 278.10 tons, with zero net sustainable revenues. The stock sizes associated with MEY levels are 66050.28 and 4419.28 tons, with corresponding efforts at 71740.92 and 3137.75 trips in the Java Sea and Indian Ocean, respectively. Net sustainable revenues at MEY levels are IDR 3,896.142 billion and IDR 103.387 billion, respectively. The largest harvest is 158964.04 tons at 5% discount rate, and 6854.32 tons at 10% discount rate, respectively. An indication of overfishing was found in the Indian Ocean, where the current harvest level at 7180.44 tons is exceeding the MSY level. The current effort level at 5936.38 trips is more than the 50% discount rate effort level, while the optimal level is between 10% and 20%. The current level of marginal revenue is negative, being costlier to produce more fish than the benefit gained. There is no indication of overfishing of demersal fishery in the Java Sea. The survey of the cost of fishing should be performed periodically and integrated into the present fishery statistics. This improvement in fishery statistics would improve the bioeconomic analysis of the marine fisheries, and could also enhance the scientific support to the fishery management at the West Java Province, Indonesia.

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