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Optimization of Pelagic Fishing Efforts in Muncar Area Indonesia

Ervina Wahyu Setyaningrum (Corresponding author) [1,2] *,Soemarno [1,3]
1.Environmental Resources Management Master Program, Graduate School, University of Brawijaya, Indonesia.
2.Department of Fishery Resources Management, Faculty of Fishery and Marine Sciences, University of 17 Agustus, Banyuwangi, Indonesia
3. Department of Soil Sciences, Faculty of Agriculture, University of Brawijaya, Indonesia
* E-mail of the corresponding author : vinayusuf05@yahoo.co.id

Abstract
Marine fisheries production in Banyuwangi is dominated by the Muncar contribution, about 94,03% of total fishing effort production. The catch fishes were dominated by species of the pelagic fishes which are catched by the Purse seine, Gillnets, and Liftnets. This study was conducted to analyze the optimum amount of catching devices in sustainable fishing efforts biologically, technically, social and economically, and environmental friendly. A descriptive-analytic study involved the Multiple Goal Programming method with the objective constraints of covering aspects of ecology, biology, technical aspects, social and economic aspects. Data were collected with the survey method and direct observations in the field, involving 63 fisherman of Purseseine, 51 fishermen of Gillnet and 20 fishermen of Liftnet. Results showed that the sustainability scenario, technical scenario and social scenario recommends a reduction in the number of Purse seine as many as four units, while the Gillnet plus 5 units, and Liftnet plus 27 units. Economical profit scenario recommends a reduction in Purse seine as much as three units, the addition of Gillnet as many as 15 unit and the addition of Liftnet as much as 16 units. Besides the addition of a total fishing efforts, the things that need to be done is to expand the fishing ground and improvement of the fishing business through the continuous improvement of human resources competencies.
Keyword: fishing effort, pelagic fishes, Purse seine, Gill net, Lift net

INTRODUCTION

East Java has a sea areas of 200,000 km2, inside are Bali Strait Waters with 1.777,92 km2, in the south is related to Indonesia-Samudera, and in the north is related to Madura Strait and Java Sea (DKP Banyuwangi, 2011).
Bali Strait of 960 mil-squares has the maximum sustainable potency to catch pelagic fishes wich is dominated by Lemuru (*Lemuru Sardinella*) amounted to 46.400 tons and in Muncar about 25.256 tons/year. Muncar is the largest fish-catching area in East Java province (BPPP, 2004).
Based on the fisheries production in Banyuwangi 2011, Muncar contributed about 94,03%. Results of the monitoring data in PPPI (Coastal Harbor for fish landing) indicated the 19 species of pelagic fishes. Species of the catch fishes are 'lemuru', 'tongkol', 'cakalang', 'tuna', 'layang', 'slengseng', 'kembung', 'tembang', 'teri', 'manyung', 'layur', 'petek', 'cumi-cumi', and 'cucut'. The catching devices are Purse Seine, Lift Net and Gill Net.
Some policies have been conducted to develop a small scale fishery businesses, as supplying working capital credits, investment of fishes harbor infrastructures and fishes landing place, improvement of equipment and catching technologies, a fuels price policy and others. These policies have induced the market economy, modernization of fish catch, increase in fishes production and commercial culture in coastal rural communities. Increased production of fishes catch results in various impacts, such as: (1) the more intensive use of fish resources, (2) the excess fishes catch, (3) concentration at the certain fishing ground, (4) more fluctuating price of fishes, and (5) fishery agribusiness are less developed (Cholik, 1996).
Over exploitated resource utilization occurs when fishing effort is larger than the Maximum Sustainable Yield. The existing catching-fisheries resources have been exploited excessively. However, it is estimated that marine fisheries resources as a stock of shrimps, demersal fishes, pelagic fishes and coral-reef fishes have been utilized 38% of its sustainable potencies. In some highly populated coastal areas showed that some of the fishes stock has suffered overfishing and the fishes stock have declined (Dahuri *et al*., 2008).
The fisheries development challenge is the sustainability of fishery resources. Fishery resource is the renewable resources, but the crucial thing is how much fishes can be catched sustainably for the future. "Sustainability" becomes the key to successful fisheries development in ensuring the sustainability of resources and the welfare of human communities (Fauzi and Anna, 2002).
Fisheries management correctly will hopefully provide optimum support to economic growth (pro-growth), improve income per capita (pro-poor), employment opportunities (pro-job), and conservation of natural resources and sustainable environment (pro-environment (Purwanto, 2011).

This study was conducted to analyze the amount of optimal catching devices in sustainable catching of pelagic fishes in terms of biology, ecology, technical, social, and economic aspects in Muncar Banyuwangi.

RESEARCH METHOD

Data Collection

Data were collected directly from the sources, observed the objects and note all of informations. Interview with the fishing-boat manager and fisherman covers aspects of the biology of pelagic fishes, technical and operational aspects, social aspects, economic aspect, and environmental friendliness of the catching devices.

The research population are fishermen around the Muncar coastal areas. The sampling method used is the purposive sampling, based on certain considerations; number of respondents 134 fishermen, consisting of 63 fisherman of Purse seine, 51 fishermen of Gillnet and 20 fishermen of Liftnet.

Data Analysis

Analysis of Biological and Ecological aspects

Analysis performed on this aspect, namely: (a). the kinds of the catched fishes on each type of catching devices for pelagic fishes (Purseseine, Gillnet, Liftnet); (b) value of diversity index calculated by Method of Shannon Wiener, with the formula:

$H' = -\sum pi \log_2 pi = -3{,}32 \sum pi \log pi$

Pi = Ratio of the number of the i^{th} fish species (ni) and the number of all of fishes species (N) (ni/N)

Categories valuation of the species biodiversity are:

$H' \leq 1$: Low level of biodiversity, lower distribution, lower stability of community

$1 < H' < 3$: Intermedier level of bio-diversity,moderate distribution, moderate stability of community

$H' \geq 3$: High level biodiversity, high distribution, stabil community.

Analysis of Technical Aspects

Data collection is carried out by the survey method and directly field observations. Data collected includes the following:

- the number of materials and tools used in catching operations.
- Oceanographic factors which affect the process of catching operation.
- The amount of fuel in each trip in units of liters, and it is accumulated in one month.
- Length of trip periode (return journey at sea) in units of days.

Analysis of Social Aspects

The Data collected includes:

- Opportunity conflicts on each fishing efforts (Purse seine, Gillnet, Liftnet); its indicators are the average number of conflicts that appear each month.
- The number of persons in each fishing operation.

Analysis of Economic Aspects

The Data collected includes the following:

- the value of the investment, i.e. the total price of the fishing devices (ship, ctching tools and supporting tools), in units of rupiahs.
- Operating costs of in every trips, its indicators are the amount of fuel per trip, the number of labor and its logistics, the amount and price of ice-stones and fresh water in each trip.
- The level of the profit, obtained from the amount of the catch per trip is multiplied with the price of fishes, reduced operational costs; and it is multiplied by the number of trips in a month.
- Fishing Income per month; it is calculated on the basis of profit-share that had been agreed between the manager (‘Juragan’) and the labor (‘ABK = Anak Buah Kapal’).

Multiple Goal Programming

Multiple Objective Goal Programming (MOGP) is a mathematical procedure in determining the optimal alternative activities by way of minimising the total deviation from the multiple goals, so as to obtain optimal solutions for achieving that multiple goals (Harahab, 2010).

The multiple Goals Programming can be formulated as follows:

Xj = X1, X2, X3

X1 : Purse Seine; X2 : Gill Net; X3 : Bagan .

The objective function is:

$$\text{Minimize: } Z = \sum_{i=1}^{n} P_i W_i (d_i^+ + d_i^-)$$

Objective constraint:

$$\sum_{i=1}^{n} a_{ij}X_j + d_i^- - d_i^+ = b_i$$

P_i = priority in achieving objective constraint
W_i = weight for objective constraint
d_i^+ = positive deviation from objective constraint for maximum target
d_i^- = negative deviation from objective constraint for minimum target
b = target should be achieved
i = 1, 2, …, m

Determination of priority goals is required to design the scenarios of alternative activities. The most important goal was set as a first priority , the next priority is assigned based on the importancy of those goals. In this study the most preferred is the sustainability of the eco-biological aspects in order to increase the amount of production, but still pays attention to the social and economic feasibilities.
The Optimization Model used is a linear adetif:
Objective function:
Minimize Z = DA1 + DA2 + DA3 + DA4
Constraint functions:
D1 + a11X1 + a12X2 + a13X3 <= b1
D2 + a21X1 + a22X2 + a23X3 <= b2
D3 + a31X1 + a32X2 + a33X3 <= b3
D4 + a41X1 + a42X2 + a43X3 <= b4
D1: bioecological aspect deviation
D2: technical aspect deviation
D3: social aspect devistion
D4: economic aspect deviation
X1 : Purse Seine catch fish
X2 : Gill Net catch fish
X3: Lift net catch fish
a11: bioecological aspects of Purse seine
a12 : bioecological aspects of Gill net
a13: bioecological aspects of Lift net
a21: technical aspects of Purse seine
a22 : technical aspects of Gill net
a23: technical aspects of Lift net
a31: social aspects of Purse seine
a32: social aspects of Gill net
a33: social aspects of Lift net
a41: economic aspects of Purse seine
a42: economic aspects of Gill net
a43: economic aspects of Bagan (Lift net)

RESULTS AND DISCUSSION

Results of survey and data analysis on ecological aspects, biological, technical, social, economic aspects; are subsequently used in the analysis of the Multiple Goal Programming to determine the optimum number of fishing devices in Muncar. The analysis by the Multiple Goal Programming involves three scenarios, i.e. Sustainability Scenarios, Scenarios of economic profit, and technical and social Scenarios.
The sustainability scenario is based on data of biology and ecology (type of fish catches of high economic value, a high quality fish, environmental friendly and biodiversity safety). Economic profit scenario based on data about the value of investment, running costs, profitability, income of fishermen per month; and marketing of catches.
Technical and social scenarios are based on the data of the technical and social aspects (methods of operation of the catching tools is easy, oceanographic factors that influence fishing effort, amount of fuel, long trip periode, chance of the conflict and number of fishing team member).
Result of analysis for each objective constraint (Biology, Technical, Social, Ecology and Economic aspects) in Muncar Banyuwangi are presented in Table 1.

Table 1. Result of analysis for each objective constraint (Biology, Technical, Social, Ecology and Economic aspects) in Muncar Banyuwangi.

Objective constraints	Catching fishes			RHS
	X1	X2	X3	
Bioecological aspects:				
Species of catched fishes which are high economic value (number of species)	4	4	5	28
High quality of fishes (orgaqnoleptic score)	5	7	4	9
Biodiversity (Diversity index)	0,46	0.53	0,50	2
Technical aspects:				
Simple operation of catching devices (number of materials and tools used)	15	5	10	29
Oceanographic factors influenced on catched fishes (kinds of oceanographic factors)	6	3	4	10
Fuels volume (Litre)	378	295	7	3.611.800
Trip duration (days)	1	3	1	28
Social Aspects:				
A high risk of conflict (average number of conflicts)	5	3	2	30
Number of ABK (person)	43	5	3	12.972
Economic Aspects:				
Investment (Rp)	940.868.254	141.470.980	19.822.500	293.091.944.902
Operational cost per trip (Rp)	2.305.159	1.524.569	32.850	1.518.294.504
Fisherman income per month (Rp)	3.492.398	1.622.886	2.193.638	2.422.832.020
Profit level per month (Rp)	1.230.082.271	27.522.457	3.283.200	2.516.620.702.344
Market coverage of fish (Km)	35	100	25	2.000
Number of catching devices (unit)	203	683	276	1.162

X1: Purse seine; X2: Gill net; X3: Lift net; RHS: *right hand side.*

Sustainability Scenario

This scenario prioritize the biological and ecological sustainability. The pelagic fishing should be taken place in time forever. The next priorities are the technical aspects, economic and social aspects. The optimal solution for this scenario is X1 = 199, X2 =700, and X3 = 303. The optimal number of Purse-seine operating in Muncar as many as 199 units, Gill-net as many as 700 units and Lift-net as many as 303 units. The number of fishing devices that is currently operating in Muncar is Purse-seine 203 units, Gill-net 704 units and Lift-net 276 units.

Pelagic fishes production in Muncar during 2011 to 2012 pointing out that fisheries resources utilization has exceeded the MSY. According to Irnawati et al. (2012) it is needed the fishery resources management which are better and more responsible.

Although the results of the economic analysis shows the Purse-seine is still feasible to operate, but its number should be reduced to 199 units or minus four units. This is because there is an indication of the decrease in Purse-seine catches, especially the 'Lemuru fish" (*Lemuru sardinella*). Fishing ground of the Muncar Purse-seine just around the Bali Strait, together with Purse-seine from other regions, therefor it should be a more sustainable management strategies.

The number of Gill-net can be plus 17 units, and Lift-net plus 27 units. The addition of Gill-net and Lift-net is not to be recommended by achieving maximum, and when done the addition should be based on studies of the potential fishing ground.

Economical Profit Scenario

The main priority of this scenario is to achieve economic profit on the pelagic fishing effort in Muncar. This scenario gives priority to pelagic fishing effort that generate maximum profit. The next Target is sustainability and technical & social feasibilities.

The optimum solutions is X 1 = 200, x 2 = X 3 = 698, and 302. Based on the economic profit, the optimum number of Purse-seine is 200 units, Gill-net as many as 700 units, and Lift-net as much as 302 units.

Based on the exixsting fishing devices in Muncar, it is recommended to reduce number of Purse-seine as many as three units, to add the Gill-net as many as 15 units, and to add the Lift-net as many as 26 units.

Although the main target to be achieved is the economical advantages of the fishing effort, other targets are the

eco-biological sustainability and socio-technical feasibilities. Besides the addition of a number of fishing effort, the important things should be carried out according to Rosalina (2011) are extending the fishing ground and improving the structure of fishery businesses through continuous improvement of human resources (HR). A number of the fishermen should be able to switch professions into the aquaculture farming and processing of fishes products.

Another improvement of livelihood for fishermen is required for fishermen who switched professions to aquaculture, and for the actor of fishing effort. According to Muhammad (2011), maximum sustainable utilization of the fishery resources for the short term can be done through improved technology, the production factor subsidies or increases in the fishes price. In the long run can be done by increasing alternative sources of income for fishermen, so the fishing pressure can be reduced by reducing the number of fishermen and fishing efforts.

Technical and Social Scenario

The main priority is the feasibility of technical aspects and social aspects. The goal of this scenario is 'simplicity' of the fishing techniques that can be done by many fishermen labor. Implementation of this scenario is expected to reduce unemployment in coastal areas of Muncar. The next Target is sustainability (biological and ecological aspects) and economic aspects.

The optimal solution is ; X 1 = x 2 = 199, 700, and X 3 = 303.

Results of this analysis are similar with results of the analysis based on the sustainability scenario.

The decision to reduce number of Purse-seine is considered rational. Purse-seine only operates in the region of the Straits of Bali just so it is considered to be the cause of over fishing. While the addition of a Gillnet and Liftnet can be done up to the optimum number. A Gillnet is a selective catching tools, while the Liftnet suggest the investment value and operational costs relatively low and can produce sufficient catches for fishermen.

Optimum 'meanings' depending on objectives to be achieved. According to Muhammad (2011), if the objective is to achieve the maximum production, the rate of fishery resources utilization should be not-exceed the maximum sustainable yield (MSY). If the objective is to achieve the maximum social conditions then the fisheries resources utilization rate should maximize the social outcomes (such as the jobs) (Social Maximum Yields, MSocY).

In terms of the development of the pelagic fishing effort in Muncar, Banyuwangi Regency, it is better to implement the policies which can alleviate any fishermen poverty, so that any development policies in fisheries resource management should be conducted in sinergistically, without exploiting fishery resources in excess.

CONCLUSION

Based on results of the Multiple Goal Programming analysis in optimizing catching devices of pelagic fishery in Muncar Banyuwangi, it is concluded that:

1. The allocation of total catching tools based on the pelagic resources sustainability scenario is similar to the social scenario and technical scenario, that is, a reduction number of Purse-seine four units, the addition of Gillnet 17 units, and the addition of Liftnet 27 units.
2. Based on the economic benefit scenario, the recommendation is a reduction number of Purse seine with three units, additional Gillnet of 15 units and additional Lift-net of 26 units .

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