Evaluation of Fishing Zone around Outermost Small Islands for Sustainable Development - A Case Study of Marore and Kawio, Indonesia -

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1. Introduction

There are many outermost small islands in Indonesia. They are located in remote area from main islands and experience the lack of development. In order to increase the life standard of those remote islands, the production of Skipjack tuna can be proposed as the solution of sustainable development for those outermost small islands. Skipjack tuna is a migratory species and the determination of potential fishing zone is important.

This study is conducted to determine the potential fishing zone of skipjack tuna around Marore and Kawio, those are selected from remote islands as the case study area. Furthermore, the study discusses the feasibility of skipjack tuna production on raising the income of fishermen on those remote islands.

2. Research Method

Environmental data, which consist of sea surface temperature, density of chlorophyll-a as well as net primary production for year 2015, were obtained from © INDESO, 2013, a system implemented by CLS for Balitbang KP, all rights reserved (retrieved from http://www.indeso.web.id/).

2.1 Potential Fishing Zone of Skipjack Tuna

High resolution (1/50°) composite satellite Sea Surface Temperature (SST) and Chlorophyll-a concentration (SSC) were compiled to generate monthly data. Suitability analysis then was conducted by applying SST and SSC criteria of Zainuddin and Farhum (2010) which reveals that 27.5 – 32.5 ^{0}C of SST and 0.05 – 0.65 mg/m^2 of SSC are the preferred condition of skipjack tuna distribution, in which 29.5- 31.5 ^{0}C of SST and 0.15-0.35 mg/m^2 of SSC are criteria for the highest potential fishing zone of skipjack tuna.

2.2 Estimation of Biomass of Skipjack Tuna

Net primary production data of 1/12° spatial resolution was used on fish production model of Lalli and Parsone (1997) which is based on relationship between primary production and fish production through energy transfers between trophic level as described by following equation.

$$FP = PP \; x \; TE^{(TL-1)}$$

which; FP = Fish Production (mgC/m^2)
PP = primary production (mgC/m^2)
TE = transfer efficiency (15% for coastal area)
TL = trophic level (TL= 3 for skipjack Tuna)

Fish biomass (FB/abundance of skipjack tuna) are estimated based on conversion ratio of carbon to weight of 9:1 (Pauly and Christensen, 1995) as follow:

$$FB = FP \; x \; 9 \quad \text{(in ton)}$$

2.3 Method of Feasibility Study

Feasibility of skipjack tuna development on fishermen is calculated as

$$Profit = Total\ Revenue - Total\ Cost \qquad \frac{R}{C} = \frac{Revenue}{Cost}$$

while feasibility on fishing port construction is analyzed as follows

$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)} \qquad Net\ BCR = \frac{\sum_t^n B_t}{\sum_t^n C_t}$$

where NPV = the difference between the present value of benefits and cost
B_t = Final value of Benefit
C_t = Final value of Cost
FV (Final Value) = sum of principal and interest

3. Results of Feasibility Study

3.1 Fishing Potential Zone and Abundance of Skipjack Tuna

Surrounding waters of these islands are potential fishing zone of skipjack tuna thorough the year which are indicated by suitable areas for skipjack tuna fishing zone as shown by Figure 1. In addition, some parts of these waters were highly suitable for skipjack tuna fishing zone during January (3.29 km^2 = 0.57%), February (38.45 km^2 = 6.65%), March (97.22 km^2 = 16.82 %), June (3.74 km^2 = 0.65 %), even this highly suitable area achieved 577.82 km^2 (99.94 % of waters) in July.

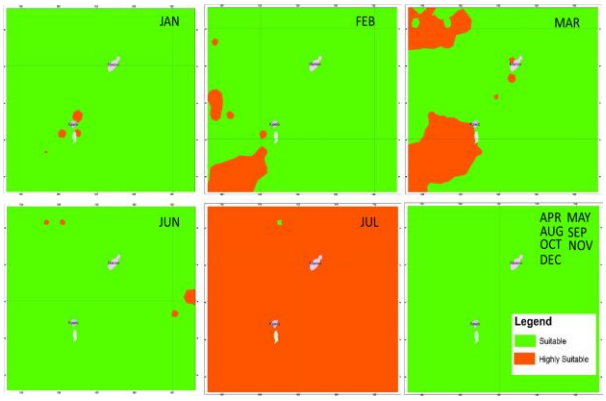

Figure 1. Potential Fishing Zone of Skipjack Tuna

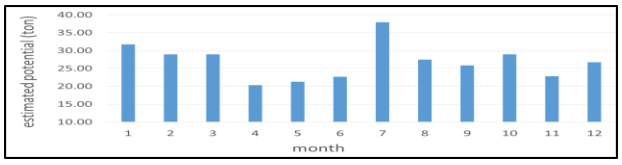

Figure 2. Estimated Potential of Skipjack Tuna Production based on Net Primary Production.

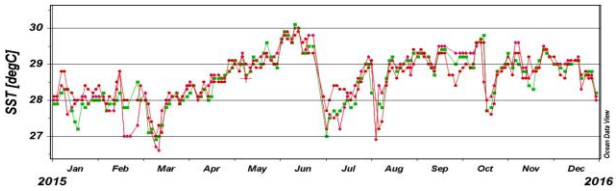

Figure 3. Sea Surface Temperature of year 2015

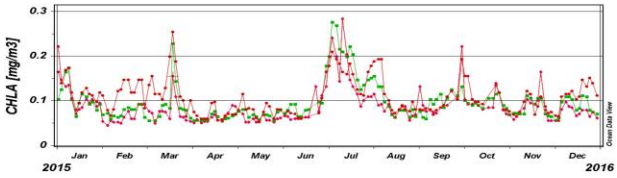

Figure 4. Chlorophyll-a concentration of year 2015

Figure 2 represents that the surrounding waters of Marore and Kawio islands is estimated has potency to produce 323.42 ton/year of Skipjack Tuna in which July is the highest period of it while April is the lowest period of it by only generating 37.95 ton and 20.31 ton, respectively. The highest potential of skipjack tuna production in July is estimated due to upwelling phenomenon which leads to high productivity.

The high potential of Skipjack Tuna in July corresponded with extreme chlorophyll-a in this month. The high density of chlorophyll-a of July which was coincided with significant decrease of SST, as illustrated by Figure 3 and Figure 4, reflected influence of upwelling phenomenon towards potential of skipjack tuna in this area. This phenomenon resulting high fisheries potency by generating significant rise of phytoplankton on this waters which then attract pelagic fishes such as skipjack tuna (Hendiarti et. al, 2004).

3.2 Feasibility of Skipjack Tuna development

In order to achieve sustainable development, by applying policy of total allowed catch only 80% of potencies (Ministry of Marine Affairs and Fisheries, 2011), fishermen in these islands can produce minimum 98.47 kg of skipjack tuna and maximum 460 kg. It is expected that each fishermen can retrieve minimum 117.95 USD/month, average 205.91 USD/ month and even can attain 325.89 USD/month from this skipjack tuna development as revealed on Table 1.

Table 1. Feasibility analysis of skipjack tuna fishing

Revenue (USD)	min	average	max
Production (kg/men)	98.47	130.67	184.00
Price (USD/kg)	2.25	2.25	2.25
Revenue before expanditure	221.56	294.02	414.00
Cost (USD)			
Total fixed cost	42.81	42.81	42.81
Fishing operational	45.29	45.29	45.29
Retribution (7%)	15.51	20.58	28.98
Total Cost	103.61	88.11	88.11
profit	117.95	205.91	325.89
Net BCR	2.14	3.34	4.70

In addition, the construction of a fishing port by government to improve the infrastructure and to support skipjack tuna development is feasible if the payback period is 10 year with interest and inflation rate are 10% and 7%, respectively which is indicated by NPV > 0 and Net BCR > 1 while this project is not feasible for 12 % of interest rate and 7% of inflation rate due to NPV < 0 and Net BCR < 1 (see Table 2).

Table 2. Feasibility analysis of fishing port construction

Cost	(USD)	FV (10 year, interest 10%, inflation 7%)	FV (10 year, interest 12%, inflation 7%)
Investment	233,333.33	550,187.79	647,051.71
Operational	13,333.33	245,117.89	245,117.89
Total Cost		795,305.69	892,169.61
Benefit			
Retribution	40,750.92	801,622.28	801,622.28
Total Benefit		801,622.28	801,622.28
NPV		6,316.59	(90,547.33)
Net BCR		1.0079	0.8985

4. Conclusions

The sea around Marore and Kawio islands has a potential fishing zone of skipjack tuna for sustainable development. Especially, July is the most expected season for producing skipjack tuna due to upwelling phenomenon. This study also estimated the contribution of this potential to the increase of fishermen's income, meanwhile construction of a fishing port can be proposed to support the sustainable development of these small islands.

Acknowledgement

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