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Sustainable Fisheries Management: A Spatial Policy Assessment for Archipelagic State

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Abstract

The United Nation Convention on The Law of The Sea (UNCLOS) states the role of coastal state to manage the EEZ, as in article 61 about the conservation of the living resources and articles 62 about the utilization of the living resources. Indonesia should take the opportunity of these articles in order to manage sustainable environment of territory. Hereby, Indonesia may support the scientific evidence to determine the allowable catch of living resources by providing best scenarios of sustainable management of the living resources. Both can be analyzed using spatial ecological model of capture fisheries. Using the model, the stock and the allowable catching limit can be determined beforehand in spatial manner. An example of the local assessment of national territory may describe the important role of this model to be further implemented in the EEZ. This study is significant to manage the sustainability of EEZ waters through international cooperation.

Keywords: EEZ, allowable catch, spatial assessment, sustainable, archipelagic

INTRODUCTION

In Southeast Asia region, marine are becomes potential issue to discuss since there are lots of marine resources prospects in this area, such as fisheries, oil and gas. Besides that, disputes over marine area are not new to countries of South East Asia. Technical and legal aspect of maritime boundaries, fishing rights, the transit of refugee, problems of marine pollution are the examples of problems that exist within the region.

Relating to the living resources, United Nation Convention On The Law Of The Sea (UNCLOS)-articles 61 states the role of coastal state in determining the optimum allowable catch of living resources in the Exclusive Economic Zone (EEZ) as parts of sustainable utilization of the marine resources. Articles 62, states the role of coastal state in promoting the objective of optimum utilization of the living resources in EEZ. Indeed, articles 61 also states the role of coastal state in taking into account the best scientific evidence to ensure the proper conservation and management of the living resources in EEZ to protect it from over-exploitation. These articles clearly declare the role of archipelagic states as Indonesia, to utilize its EEZ. The state also has rights to provide such assessment and data or marine research or scientific evidence for sustainable management of EEZ. Relating to the data need for better management of marine environment, the development of the spatial ecological model for captured fisheries will contribute to the science and technology, since it provide better visualization of the nature in its miniature.

The aim of this study is to develop spatial ecological model using the sample of a national territory as an input for managing the living resources in EEZ. Therefore, the stock, the sustainable prospect and the determination of allowable catching limit will be acknowledged. This concept hopefully will help the sustainable exploitation of marine living resources especially in EEZ.

PROBLEMS IN REGIONAL MARINE MANAGEMENT

The maritime boundaries of coastal or archipelagic state can be described as (1) *territorial zone*: up to a limit not exceeding 12 nautical miles, measured from the baseline, (2) *Exclusive Economic Zone (EEZ)*, shall not extend beyond 200 nautical miles from the baseline and become the sovereign rights of coastal or archipelagic state to manage and utilize its resources.

The sovereignty of territorial waters is subject to the law of coastal or archipelagic state. Meanwhile, within its EEZ, a state has its economic rights but not political rights and sovereign rights over the waters is subject the convention and to other rules of international laws (see Figure 1).

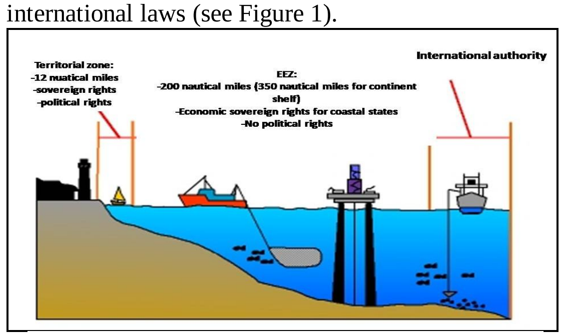

Figure 1. Illustration of maritime boundaries (Pustekkom, 2005)

Indonesia has ratified UNCLOS 1982 and has been added to the act no 17/1985) and established the law of EEZ in act no 5 /1983. Following this act, Indonesia has 2.7 km^2 of EEZ in spite of its 3.1 $km^2$of territorial waters. This may cause the rights of Indonesia to manage its 5.8 km^2 of waters' region (see Figure 2).

Dealing with the living resources, fisheries activities and preservation of the marine environment are the subjects that should be taken into account in any waters boundaries. A potential conflict on fisheries arises wherein there is the violating of the allowable catch of any living resources.

Figure 2. Illustration of Indonesian maritime boundaries (Pustekkom, 2005)

The maximum sustainability of capture fisheries in Indonesia territorial zone and EEZ is about 6.1 million ton (Nikijuluw, 2002). The utilization of these capture fisheries are about 60 % of its prospect. According to the Food and Agriculture Organization (FAO) and Code of Conduct for Responsible Fisheries (CCRF) 80 % of its prospect is the limit of allowable fishing capture (Nikijuluw, 2002). Therefore 60% of utilization seems to be an alarmed (Nikijuluw, 2002). An indication of overfishing in the EEZ for specific economic species, such as large pelagic species has been reported lately (Sutisna, 2005), even though it is not supported by reliable ata for better arguments.

To mitigate the practices of over-exploitation, the EEZ's state should determine the number of allowable catch of the living resources in *its EEZ.* This aim to maintain or restore populations` of harvested species at level which can produce the maximum sustainable yield as qualified by relevant environmental and economic factors. Therefore, the EEZs state should determine the need through scientific approach, that spatial ecological model is one of it.

SPATIAL ECOLOGICAL METHOD

The concept of spatial ecological model for captured fisheries was firstly based on the unit mapping of marine ecosystem within three dimensions object. For this need, the zone of marine species communities was based on their ability to live within such vertical and horizontal oceanographic characteristics. Bathymetry and sea temperature are the two factors that affect the life zone of these marine species that easily can be obtained using the remote sensing and geographical information system data. The research approach of the model was described in the following diagram

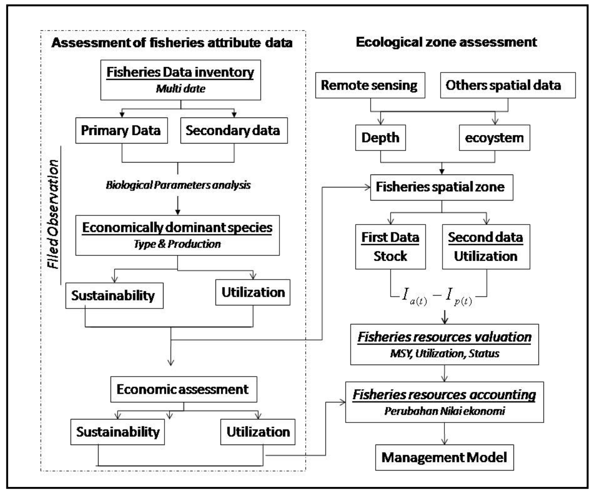

Figure 3. Flow chart of Research approach

The method of spatial ecological model for capture fisheries consist of:

a. Ecological zone assessment

The unit mapping was developed based on the assumption that the ecological zone of marine species may depend on sea temperature or depth or both of them (Nybakken 1992). Other oceanographic parameters such as primary productivity are also part of ecological zone. Using this approach, the spatial zone of marine species' habitat can be developed in vertical and horizontal approach within the surface and the water column. Remote sensing data were being employed for analysing and clasifying the sea surface temperature, waters primary productivity and its relation to eufotic zone and thermocline layers within the sea water column. The coastal ecosystem such as mangrove, coral reef and sea grass also can define using remote sensing data. Both remote sensing derived map and bathymetri map were being assessed to clasify this unit mapping (see figure 4)

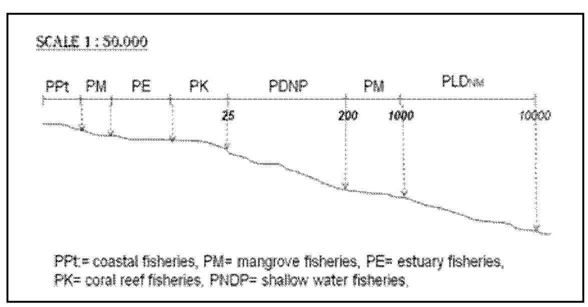

Figure 4. The concept of ecological zones

b. Assessment of Fisheries Data

The assessment of fisheries attribute data is depended on the inventory of both secondary and primary data. The secondary data is any fisheries activities derived from related institution. Meanwhile, the primary data is any *in situ* fisheries data that usually obtain from field observation. Both of these data may consist of: production, species, production/ species, fishing gears, species production/fishing gears, number of trips, market price of each species, cost per trip etc. These data are the time series data that were being employed to assess the potentiality and the sustainability of the fisheries resources. The processes of analysis are;

1. Assessment of Biological Parameters

Surplus production approach (Clark et al, 1992) was used for assessing the potentiality of fisheries resources based on fisheries production and efforts. The formula for this assessment was;

$$u = \frac{h}{E} \quad (1)$$

where *µ = CPUE (catch per unit effort), h = Production and E = effort.*

Standardization of fishing gears were also being employed for assessing the dominant fishing gears that was used for productivity of capture fisheries.

2. Assessment of Sustainable Yield

Based on related inventory of fisheries time series data, the sustainable yield were calculate using Gompert method (Fauzi 2004), i.e;

$$h = KE\left(\frac{qE}{r}\right) \quad (2)$$

where *h = sustainable yield, q = Production, E = effort (trip)*

By applying this Gompert formula, the actual production can also be analyzed.

3. Assessment of fisheries resources balance sheet

Fauzi and Anna (2005) method was used for this assessment, i.e;

$$\Delta NP_t = \left[\frac{NO_t}{x_t}\right] x \Delta\Omega \quad (3)$$

where NP_t = *Change of productivity at t*, NO_t = output value at *t*, X_t = output value at *t*, $\Delta\Omega$ = *Change of productivity*

Change of productivity can be calculated using the formula:

$$\Delta\Omega = \bar{x} - x_t \quad (4)$$

Where

$$\bar{x} = \frac{1}{n}\sum_{t=1}^{t_b} x_t \quad (5)$$

$\bar{x}$ = average of productivity from *year 1 to basic year (t_b) of productivity change. The basic year is the year of productivity change.*

The next step is calculating the monetary unit that can be describe as follow;

1. Conversion the market price to the real price using the market price and consumer index price

$$\Pr ice_{riil} = \frac{price_{\min}}{indexconsumerprice} x100\% \quad ..(5)$$

2. Calculate the average of fisheries product (= year of basic)
3. Calculate the productivity change = average production – productivity at year i
4. Calculate the depreciation value.

c. Integrating spatial and attribute data

The Attribute data (b) then integrate to the ecological spatial data (a) to derive the fisheries resources accounting maps.

ASSESSMENT OF THE CASE STUDY

Due to the problem of collecting data from EEZ area, the sample of the model has to be employed. A part of the waters of Tomini gulf – central Celebes was selected as the study area. Considering its high prospect in high economic fisheries such as Tuna and groupers, and so does the conflict in exploitation, this area may represent the EEZ.

The depth of spatial information is designed at 1: 50.000 scale, develop using fisheries statistical data of Central Celebes province (Fisheries department and center for Statistic Agency, 2002 – 2010), Landsat ETM 2010, Aster data (2005), Coastal Environmental Map(LPI), ETOPO2 Global 2-Minute Gridded Elevation Data (NGDC) and Bahtymetry map.

The result indicates that there are 5 (five) spatial ecological zones for capture fisheries, whereas its characteristics with its each marine species can be described as follow;

1. Coastal fisheries

Characterized by the coastal area that still affected by tidal wave, the marine species for this zone can be classified as small pelagic fisheries. The dominant species are: *Bombay duck, Peperek, Blotched grunt, Threadfin bream, White spotted, Scad mackerel, Yellowstrip trevally, Trevally, Hardtail scad, Slender Leatherfish, Rainbow runner, Anchovy, Sardinella, Oil Sardinella, Short bodied and Hairtail*

2. Coral reef fisheries:

The marine species for this ecosystem is classified as the demersal fisheries, with the dominant species such as *Yellow goatfish, Red snapper, Grouper, Baramundi, Yellowtail*.

3. Shallow water fisheries:

Located between the coastal area that still affected by tidal wave up to the less than 100 m continental shelf, the marine species for this zone can also be classified as pelagic fisheries, with the dominant species such as *Bigeye tuna, Skipjack, Barracuda, Spotted flyingfish, Barred garfish, Spotted spanish mackerel.*

4. Mesopelagic fisheries:
Characterized by less solar intensity, the marine species for this zone can be classified as big pelagic as well, with *tuna* as the dominant species.

5. Deep water fisheries:
Characterized by the least solar intensity and the depth of the water that more than 1000 m, the marine species for this zone can be classified as big pelagic fisheries as well, whereas the *big tuna, Skipjack* become the dominant species.

The other ecological fisheries such as mangrove and estuary cannot be found within the study area

The result of the assessment can be seen in figure 5, which indicate the ecological zone and the information of capture fisheries within the area of study, the decreasing or increasing productivity, the decreasing and the increasing species type within the ecological zone, the sustainable prospect of the fisheries, the actual productivity and the maximum allowable catch of fishing capture activities.

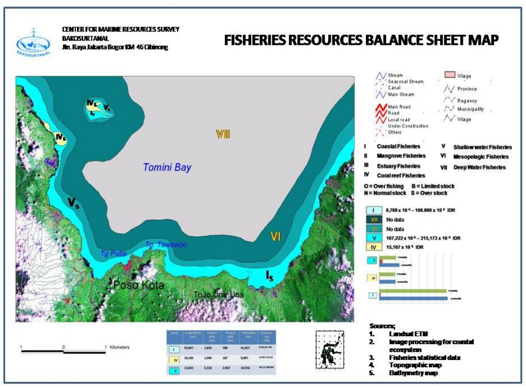

Figure 5. The example of fisheries resource assessment spatial data

The spatial data assessment as can be seen in Figure 5, indicate the unit mapping of the fisheries zone, state as the ecological zone

I	Coastal Fisheries	V	Shallow water Fisheries
II	Mangrove Fisheries	VI	Mesopelagic Fisheries
III	Estuary Fisheries	VII	Deep Water Fisheries
IV	Coral reef Fisheries		

O = Over fishing   B = Limited stock
N = Normal stock   S = Over stock

Figure 5a. Ecological zone units

The status of actual productivity based on 6 years fisheries data assessment.

O = Over fishing   B = Limited stock
N = Normal stock   S = Over stock

Figure 5b. The status of actual productivity of capture fisheries

Whereas *O = overfishing condition, B= limited stock that the exploitation of the fisheries almost reach its allowable catch, N= still possible to be utilize (still in the range of allowable catch), S = over stock means plenty of stock.*

Indeed, the existing condition of fisheries status in each ecological zone

I	Decreasing Utilization , Increasing Species
VII	No data
VI	No data
V	Decreasing Utilization , incrasing Species
IV	Decreasing Utilization, increasing Species

Figure 5c. The existing conditions of the fisheries

The spatial ecological model indicates that the coastal fisheries zone has *over stock* (I_s) status which plenty of fisheries activities still can be implemented since its allowable catch still under the sustainable limit. The similar case also occurred in coral reefs zone (IV_s) and shallow water zone (V_s). Unfortunately, no data was available from mesopelagic and depth water fisheries, so the assessment of this two zones cannot be assessed.

Information of the fisheries change trend and the type of the fisheries within two date of observation can also be assed (Figure 5d). Herein, *zones* indicate the ecological areas, *Sustainability (ton)* indicates the maximum sustainable yield of capture fisheries sector in each zone, *Product (2002 and 2010)* indicates the actual productivity, *species* indicates the type of capture fisheries species within two years of actual product, *Resources valuation* indicates the changes of capture fisheries and its species.

Zones	Sustaina-bility (ton)	2002		2010		Resources va	
		Product. (ton)	Species	Product. (ton)	Species	Prod. (ton)	Sp
I	42.847	1.820	Peperek Scad mackerel Yellow strip Trevaly Rainbow runner Anchovy Sardinella Short bodied	780	Peperek Bombay duck Blotched grunt Threadfin bream White spotted Scad mackerel Yellow strip Trevaly Rainbow runner Anchovy sardinella Oil sardinella Short bodied Hairtail	-1.030	+Bomba +Blotch +Threac bream +White +Rainbo +Oil sar +Hairtai
IV	10.184	1.040	Grouper Baramundi Yellow tail	187	Yellow goatfish Gouper Baramundi Yellow tail	-852	+Yellow
V	12.633	5.318	Big eye tuna Skipjack Baracuda Barred garfish	2.067	Big eye tuna Skipjack Baracuda Spotted flyingfish Barred garfish Spotted spanish	-2.711	+Spotte flyingfis +Spotte

Figure 5d. The capture fisheries valuation table (actual production, type of species) and sustainable product.

Based on the market price assessment, the spatial model can be illustrated in Figure 6.
The information that can be taken from the spatial data assessment is;

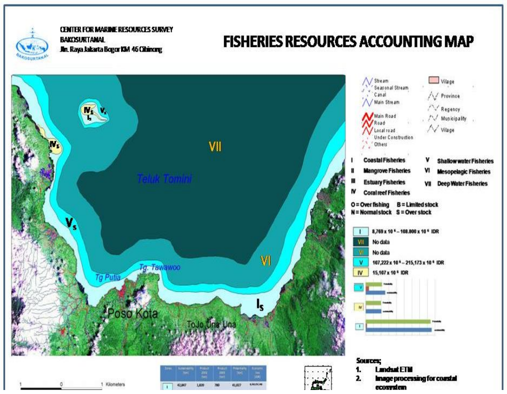

Figure 6. The example of balance sheet maps

The information that can be taken from the spatial data assessment is;

1. The status of fisheries in each zone indicates the maximum allowable catch for capture fisheries in each ecological zone), the actual productivity and the maximum sustainable yield of capture fisheries

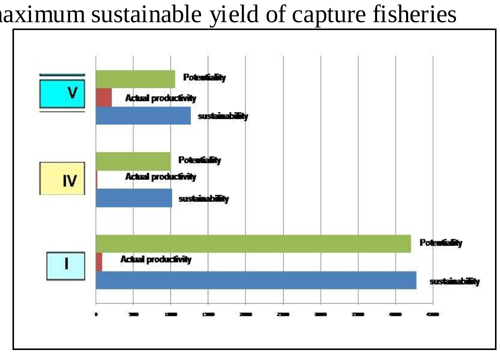

Figure 6a. The Status of the fisheries in each ecological zone

Zones	Sustainability (ton)	Product 2002 (ton)	Product 2010 (ton)	Potentiality (ton)	Economic loss (IDR)
I	42,847	1,820	780	41,027	108,769,197,748
IV	10,184	1,040	187	9,997	15,107,173,519
V	12,633	5,318	2.067	10.556	107,222,989,602

Figure 6b. The tabular data of each zone fisheries status

2. The quantitative data whereas zones Indicate the classes of ecological zone as it is mention in above figure, *Sustainability (ton)* indicates the maximum sustainable yield of capture fisheries sector in each zone, *Product* indicates the actual productivity, *potentiality* indicates the maximum allowable catch, *Economic loss (IDR)* indicates the monetary value that still can be optimally utilized, relating to the maximum allowable catch.

It is clearly seen that the spatial assessment using ecological approach will give scientific information about the allowable catch, maximum sustainable yield of capture fisheries and the existing or actual productivity. This information possibility be implemented within the EEZ waters in such management and policy to maintain the sustainability of the marine species and any disputes regarding the exploitation of the living resources on that area.

A study within the depth water fisheries zone in EEZ regarding the flying fish and Yellow fin Tuna indicate their migration pattern (Figure 7) would be meaningful if the scientific evidence as has been discussed above has also been implemented in order to decrease the destructive exploitation of those species due to the "open access" characteristics of the EEZ.

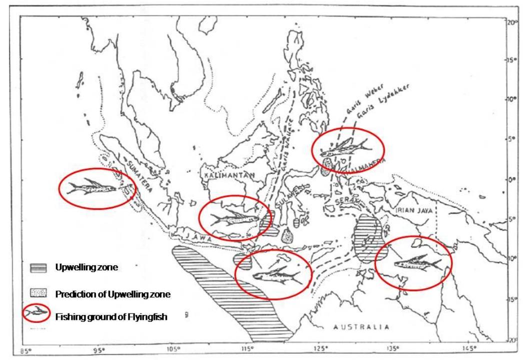

Figure 7. The fishing ground of flying fish (Hutomo and Burhanuddin, 1985).

COOPERATIVE APPROACH

The role of spatial assessment for supporting the UNCLOS articles has been clearly described in the above chapters. However, its implementation seems unlikely without further actions. The cooperation with neighboring states and the keenness to implement the treaty from the EEZ countries and all users are the key to success, such as the cooperation that has been established between Australia and Indonesia, and among the states in the South China Sea region may be raised up to the scientific programs.

UNCLOS states in its articles that; *……..states are to endeavour directly or through an appropriate regional organization to coordinate on the matters of marine living resources, marine environment, and marine scientific research, as well as to invite, as appropriate, other interested states or international organization to cooperate with … (article 123), and …the coastal states, taking into account the best scientific evidence available to it, shall ensure through proper conservation and management measure that the maintenance of the living resources in the exclusive economic zone is not endangered by over-exploitation….(*UNCLOS chapter V. Article 61)
In this case, the treaty among the regional state has to be established and obey by all the states in the region.

CONCLUSION

- Scientific evidence is definitely needed to maintain the sustainability of the EEZ, which one of it can be fulfilled by the spatial ecological model.
- The implementation of the model within a national territory waters indicate the ability of the model to give spatial information of the sustainable yield, the actual productivity and the allowable catch of marine living resources. The data those are needed for EEZ
- The completeness of the data for the sample area become the limitation for the study, and so does the data in EEZ
- The implementation of the scientific evidence of spatial ecological model won't be success without cooperation among the regional states and obedience of the treaty .
- Therefore, further joint research should be employed under the umbrella of UNCLOS

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