ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

QUANTIFICATION THE EFFECT OF MANGROVE COVERAGE ON THE PRODUCTION OF RED SNAPPER (*Lutjanus malabaricus*) IN THE COASTAL AREA CENTRAL JAVA

Sri Puryono[1], Muhammad Zainuri[2], Suryanti Suryanti[2], Rini Budi Hastuti[3] and Sakina Rosellasari[4]
[1]Regional Secretary, Province of Central Java, Indonesia
[2]Faculty of Fisheries and Marine Science, Diponegoro University Semarang, Indonesia
[3]Faculty of Science and Mathematics, Diponegoro University Semarang, Indonesia
[4]Marine and Fisheries Service, Province of Central Java, Indonesia
E-Mail: spuryonodr@gmail.com

ABSTRACT

Mangrove is an important ecosystem which supports fish resources diversity and abundance. However, it's impact on the economically important fish such as Red Snapper is not well understood. This research aimed to study the fluctuation of Red Snapper yields, study the dynamic of mangrove coverage and its condition, and analyze the effect of mangrove dynamic to the yield of red snapper in the northern coastal area of Central Java. The research was conducted from November 2017 to February 2018, while the northern coastal area of central Java was selected as the area of interest. Data collection was conducted by literature study in the Fisheries and Marine Services of Central Java to obtain data of mangrove condition (good, moderate, poor) and coverage and catch of Red Snapper. The primary data utilized in this research were obtained from the Statistics Book of Marine, Coastal and Small Islands and the Statistic Book of Capture Fisheries between 2009 and 2016. Data analysis was conducted by regression through weighting of mangrove condition.The result showed that the yield of Red Snapper was fluctuated ranging from 508.5 tons to 4,242.9 tons. There were also fluctuations on the mangrove coverages based on its conditions ranging from 9,844.8 to 12,877.0 ha. Regression analysis showed that weighted mangrove coverage has significant negative impact on the yield of Red Snapper in the northern coastal area of Central Java. The best estimator for the relationship was power regression model, with the equation $\ln(y) = 4.08.e^{40} - 9.58.\ln(x)$ and determination coefficient of 61.3%.

Keywords: mangrove, power regression, red snapper, weighted, yield.

INTRODUCTION

Fish is one of the renewable resources. However, the renewability of fish stock is limited (Lindegren, Diekmann, & Möllmann, 2010), while the exploitation tends to increase overtimes. Fish stocks in the coastal area are dynamic resource which fluctuates among times and places (Rouyer *et al.,* 2011). However, the dynamics is strongly related to the ecological aspects. In the coastal area, there are several ecosystems which support fish resources which act as temporary habitat or permanent habitat, such as coral reefs, seagrass beds, mangrove, estuaries and sand. Some fish species are migratory, move between ecosystems to complete the life cycle (Hammerschlag-Peyer & Layman, 2010). The movements are generally driven by the availability of appropriate food. Even though a fish species inhabits certain ecosystem, but it may also dependent to another ecosystem. Thus, the condition of the ecosystem plays important role to support the sustainability of fish biodiversity and stock abundance in the coastal area.

Among the known coastal ecosystems, mangrove ecosystem has important role in supporting the biodiversity of coastal area, especially fish stocks and resources (Zakaria & Rajpar, 2015). Some fish species are dependent to mangrove ecosystem. The spawning, nursery and feeding of some fish species occurs in the mangrove ecosystem (Auliyah & Blongkod, 2018; Lapolo, Utina, & Baderan, 2018). Fish migrates from or to mangrove ecosystem to accomplish its life cycle (Nyanti, Nur Asikin, Ling, &Jongkar, 2012; Sihombing, Gunawan, & Sawitri, 2017). Thus, mangrove ecosystem plays important role in the process of fish restocking. Any disturbances on mangrove ecosystem may affect the capability of mangrove in supporting the fish resources and further impact the abundance of fish biodiversity and stock in the coastal area.

Mangrove ecosystem provides goods and services for the fish community. Known mangrove services include: the improvement of water quality, remediation of pollutant, nutrient recycling, shelter, protection, and provision of complex food webs (MacKenzie & Cormier, 2012; Mendoza-Carranza, Hoeinghaus, Garcia, & Romero-Rodriguez, 2010; Rahman *et al.*, 2013). However, the role of mangrove in nutrient recycling is the dominant process which promotes the biodiversity in the mangrove ecosystem (Lucy G. Gillis, Bouma, Cathalot, Ziegler, & Herman, 2015). Nutrient recycling involves various organisms, provides nutrient for plankton as primary producer of aquatic ecosystem (Saifullah, Kamal, Idris, Rajaee, & Bhuiyan, 2016; Shoaib, Burhan, Shafique, Jabeen, & Siddique, 2017). Thus, more organism with higher trophic level gathered in the mangrove ecosystem.

Red snapper is one of the precious fishing target in many regions (Baharudin, 2013). Thus, it is considered as an economically important fish species. Currently, the price of Red Snapper is ranging from Rp. 45,000 to Rp. 70,000 /kg (Rikza, Asriyanto, & Yulianto, 2013). Generally, Red Snapper is caught by artisanal fisheries.

Fishing activities of Red Snapper occurs in the coral ecosystem. Thus, only small boats could be used to access the fishing ground. The economic importance of Red Snapper is recently increased due to its expanded market potential (Rikza et al., 2013). The demand of fish production is increased for export activity. Unfortunately, the intensive fishing effort on Red Snapper stocks has caused overfishing in many regions / countries (Black, Allman, Schroeder, & Schirripa, 2011; Cowan *et al*., 2011; Lukman, 2012).

Red snapper (*Lutjanus* sp.) is one of fish species which inhabit coastal waters. Even though, Red Snapper is well known as coral fish (Gallaway, Szedlmayer, & Gazey, 2009), but mangrove ecosystem is an important area for the life cycle of some Red Snapper (Monteiro, Giarrizzo, & Isaac, 2009). The spawning of Red Snapper occurs in the coastal area, including inshore and estuarine area (Fry et al., 2009). Thus, the restocking of Red Snapper is dependent to the condition of mangrove ecosystem.

Snapper (*Lutjanidae*) is a group of coastal mesopredators which is susceptible to decline and threatened by over-exploitation (Hammerschlag-Peyer & Layman, 2010). Red snapper (*Lutjanus* sp.) is an important fish commodity in Central Java Province. The northern coastal area of Central Java has important value to the artisanal fisheries. The coastal waters consisted of several clusters of coral reefs. Moreover, the tidal activity is relative calm which is supportive for the fishing activity of coral fishes, including the Red Snapper.

Red Snapper is widely distributed all over the world, but genetic analysis showed there are differences among locations (Soewardi & Suwarso, 2006). Genetic analysis showed that there are several genetical differences of Red Snapper caught in Java Sea, in which the northern coastal area of Central Java has one of the specified character (Soewardi & Suwarso, 2006). The northern coastal area of Central Java is unique coastal water condition. The geographic condition forms a huge basin from Demak to Brebes, while Jepara, Pati and Rembang are located in the upper area. Thus, the oceanographic activity in the basin area is generally calm.

Mangrove ecosystem is one of the most dynamic ecosystem in the coastal area. Various factors could affect the condition of mangrove. Mangrove could naturally extend, but could also be decreased due to the environmental stress it achieves. Moreover, anthropogenic driven factors also has significant impact on mangrove ecosystem. The mangrove ecosystem in Central Java is fluctuated, both the coverage and the condition (Mondal, Trzaska, & de Sherbinin, 2017).

In order to maintain the sustainability of Red Snapper fishing, various effort has been conducted to minimize the risk of exploitation activity, such as measurement of maximum sustainable yield (MSY) (Baharudin, 2013). However, valuation of fish yields potential based on its ecological condition is still scarce. Moreover, whether the condition of an ecosystem could be utilized in the estimation of fish stock is not well understood. This research aimed to : study the fluctuation of red snapper yields, study the dynamic of mangrove coverage and its condition, and analyze the effect of mangrove dynamic to the yield of red snapper in the northern coastal area of Central Java.

METHODS

The area of interest of this research is the northern coastal area of Central Java, which consisted of thirteen Regencies/Cities. The research was conducted from November 2017 to February 2018. The primary data for this research was the yield of Red Snapper from the fishing activities and the mangrove coverage in Central Java. The yield data was achieved from the Statistics of Capture Fisheries, while mangrove coverage data was achieved from the Statistics of Marine, Coastal and Small Islands of the Fisheries and Marine Services of Central Java. Data coverage of the last ten years was selected as the sample.

Data analysis was conducted through regression analysis by curve estimation. However, before the regression analysis was conducted, the coverage of mangrove should be standardized. Mangrove ecosystem consisted of three condition levels, including good, moderate and poor. Thus, each level was considered to provide different effect on the fish stocks. In order to standardize the quality of particular level of mangrove coverage, qualification was conducted through weighting of mangrove state.

Table-1. Weighting of mangrove condition.

No.	Mangrove condition	Weighting			
		Q1	Q2	Q3	Q4
1	Good	1	1	1 (3/3)	1
2	Moderate	0	1	2/3	1/2
3	Poor	0	1	1/3	1/4

There are four weighting models utilized in this research. The first model (Q1) assumes that only mangrove with good condition would affect the yield of Red Snapper. Thus, mangrove with moderate and poor conditions are neglected. The second model (Q2) assume that each mangrove condition has the same effect on the yield of Red Snapper. Thus, total mangrove coverage is utilized in the estimation. The third (Q3) and fourth (Q4) models assume that, mangrove with moderate and poor conditions have different effect on the yield of Red Snapper. In the Q3, the weight of poor mangrove condition is considered only have 1/3 of the good mangrove condition, while the moderate mangrove condition is weighted as 2/3. While in the Q4, the moderate and poor mangrove conditions are considered to have 1/2 and 1/4 of the weight of good mangrove condition. Statistical analysis with ANOVA was conducted to compare the weighted and unweighted total coverage of mangrove from the calculation.

RESULT

The yield of Red Snapper in the Northern coastal area of Central Java was fluctuated. Data collection only obtained data from 2009 to 2016. Unfortunately, the statistics of capture fisheries of the year 2013 was not available. Detailed fluctuation of Red Snapper yields is presented in Figure-1.

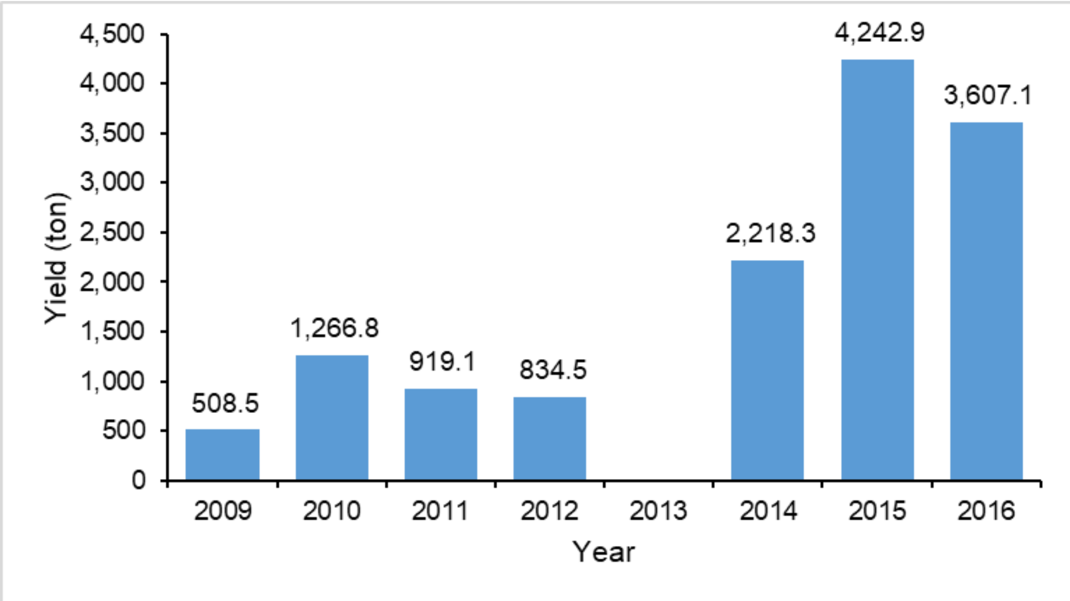

Figure-1. Fluctuation of red snapper (*Lutjanus* sp.) Catch in the Northern coastal area of central Java 2009-2016 (Source: Statistics of capture fisheries, marine and fisheries services of central Java).

Figure-1 shows that there was an increasing trend of Red Snapper yield in the northern coastal area of Central Java. According to the obtained data, the yield was lower in the early years. However, during 2014-2016 the yield was much higher than previous years. The condition of mangrove coverage in the northern coastal area of Central Java was fluctuated. The fluctuation occurred on the mangrove coverage and its condition. Generally, the total mangrove coverage was decreased. Detailed fluctuation of the mangrove coverage is presented in Table-2.

Table-2. Fluctuation of mangrove coverage in the Northern coastal area of central Java 2009-2016.

Year	Mangrove coverage (ha)					
	Good (Q1)	Moderate	Poor	Total (Q2)	Weighted total I (Q3)	Weighted total II (Q4)
2009	6,183.9	3,246.0	3,447.0	12,877.0	9,497.0	8,668.7
2010	5,648.5	4,970.7	1,736.4	12,355.6	9,541.1	8,568.0
2011	6,306.1	2,249.1	1,783.3	10,338.4	8,399.9	7,876.5
2012	7,153.2	1,981.3	2,296.1	11,430.6	9,239.4	8,717.9
2013	8,571.9	1,988.7	2,209.1	12,769.8	10,634.1	10,118.6
2014	6,034.9	2,040.4	1,769.5	9,844.8	7,985.0	7,497.5
2015	5,787.9	2,038.5	3,487.6	11,314.1	8,309.5	7,679.1
2016	5,919.1	1,819.4	3,487.6	11,226.1	8,294.5	7,700.7
Average	6,450.7	2,541.8	2,527.1	11,519.6[a]	8,987.6[b]	8,353.4[b]

Source: Statistik Kelautan, Pesisir dan Pulau-Pulau Kecil, Fisheries and Marine Services of Central Java (2009-2016)

Table-2 shows that mangrove with good condition was dominant in the observed years. The trend of mangrove with moderate condition was decreased along with the increasing coverage of mangrove with poor condition. In 2009, the total mangrove coverage was the highest, while the lowest was in 2014. However, in 2013 mangrove ecosystem in the northern coastal area of Central Java was in the greatest condition. Mangrove with good condition was at the highest coverage. Statistical analysis was conducted to compare the total and weighted total coverage of mangrove. The result shows that there was no significant difference between Q3 and Q4, but the total coverage (unweighted - Q2) was significantly different from the two.

Regression analysis was conducted to formulate appropriate relationship model of mangrove coverage and the yield of Red Snapper in the northern coastal area of Central Java. The analysis was conducted through curve estimation, including the linear, logarithmic, exponential and power models. However, of the equation was simplified through linearization. Detailed result of the regression analysis is presented in Table-3.

Table-3. Model of red snapper yield – Mangrove coverage relationship in the Northern coastal area of central Java.

No.	Curve model	Equation	F	Sig.	R^2
A.	Q1				
1.	Linear	y = 11,199.30-1.51x	1.755	0.243	0.260
2.	Logarithmic	y = 86,820.64-9,732.43ln(x)	1.803	0.237	0.265
3.	Exponential	$\ln(y) = 258,100.67 – 0.84e^{-3}.(x)$	1.892	0.227	0.275
4.	Power	$\ln(y) = 5.78e^{23} – 5.44.\ln(x)$	1.966	0.220	0.282
B.	Q2				
1.	Linear	y = 6,419.88 – 0.40x	0.436	0.538	0.080
2.	Logarithmic	y = 40,513.57 – 4,133.01.ln(x)	0.370	0.570	0.069
3.	Exponential	$\ln(y) = 54,409.89 -0.32.e^{-3}.x$	1.071	0.348	0.176
4.	Power	$\ln(y) = 1.03.e^{17} – 3.41.\ln(x)$	0.956	0.373	0.160
C.	Q3				
1.	Linear	y = 14,978.66 – 1.49x	3.844	0.107	0.435
2.	Logarithmic	y = 120,591.52 – 13,074.66.ln(x)	3.809	0.108	0.432
3.	Exponential	$\ln(y) = 3,148,749.06 – 0.87.e^{-3}.x$	5.230	0.071	0.511
4.	Power	$\ln(y) = 3.17.e^{33} – 7.70.\ln(x)$	5.231	0.071	0.511
D.	Q4				
1.	Linear	y = 18,334.34 – 2.02x	5.641	0.064	0.530
2.	Logarithmic	y = 149,971.52 – 16,451.41.ln(x)	5.634	0.064	0.530
3.	Exponential	$\ln(y) = 20,781,649.58 – 1.18.e^{-3}.x$	7.915	0.037	0.613
4.	Power	$\ln(y) = 4.08.e^{40} – 9.58.\ln(x)$	7.929	0.037	0.613

Table-3 shows that among the equation models, only the equation resulted from the Q4 with the exponential and power trends has significant relationship to the yield of Red Snapper in the northern coastal area of Central Java. The linearized equations resulted from the analysis were $\ln(y) = 20,781,649.58 - 1.18.e^{-3}.x$ and $\ln(y) = 4.08.e^{40} – 9.58.\ln(x)$ respectively for the exponential and power trends. However, both equations have similar probability and determination levels which are 0.037 and 61.3%. The relationship is presented in a graphical view as shown in Figure-2.

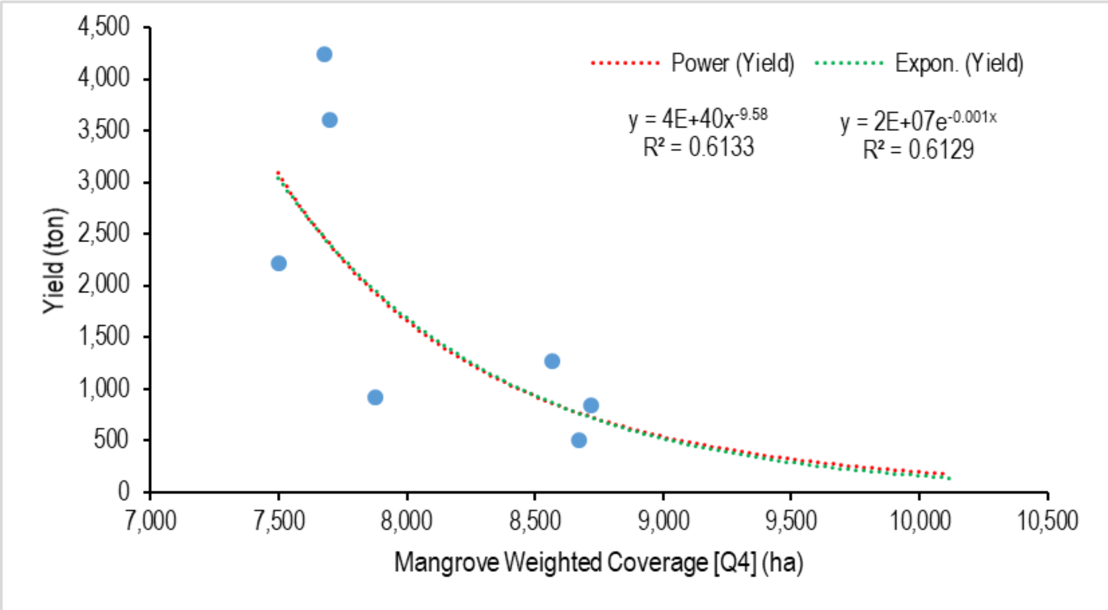

Figure-2. Trend of mangrove coverage – red snapper yield in the Northern coastal area of central Java.

Figure-2 shows that mangrove coverage tends to have negative effect on the yield of Red Snapper in the northern coastal area of Central Java. Increasing mangrove coverage significantly decreases the yield of Red Snapper. However, this result disobeys the condition of coral reefs and the fishing effort for Red Snapper.

DISCUSSIONS

Red Snapper is one of the important fish resource in the world. Red Snapper refers to many fish species, including *Centroberyx affinis, C. gerrardi, Etelis carbunculus, E. oculatus, Lutjanus argentimaculatus, L. bengalensis, L. bohar, L. compechanus, L. dodecacanthoides, L. erythropterus, L. gibbus, L. jornadi, L. lemniscatus, L. malabaricus, L. monostigma, L. sanguineus, L. sebae, L. vivanus, Rhomboplites autrorubens*, and *Sebastes ruberrimus* (www.fishbase.de). However, the Red Snapper in Indonesia refers to the fish species from the genus Lutjanidae, especially *Lutjanus malabaricus*(Soewardi & Suwarso, 2006; Wahyuningsih, Prihatiningsih, & Ernawati, 2013).

Generally, Red Snapper is fish with a long life cycle. It reaches maturity at the age of 2 years (Gallaway *et al*., 2009). The main habitat of most of the Red Snapper species are coral reefs, however sometimes older fish also found in the open sea (Gallaway *et al*., 2009). Catches of Red Snapper mostly occur in depth of 50 to 90 m where coral or coral like structure exist (Karnauskas & Walter III, 2017). Another factors affect the distribution of Red Snapper includes temperature, salinity, chlorophyll, turbidity and current speed in the bottom (Matrutty, 2016). Even though Red Snapper is distributed widely in the world, but there might be some genetic differences among location (Soewardi & Suwarso, 2006). Red snapper (*Lutjanus malabaricus*) spawns in the various habitat, including inshore and estuarine areas with silty, muddy, and coarse sand/rubble substrates at the size of 300 mm and 237 mm respectively for male and female (Fry *et al*., 2009). When the fish becomes an adult, it inhabits deeper water area.

The protein content of Red Snapper is pretty high with 15.61% (Natsir & Latifa, 2018). Red Snapper contains various essential fatty acid such as saturated fatty acid (SFA), monounsaturated fatty acid (MUFA), and polyunsaturated fatty acid (PUFA) (Jacoeb, Suptijah, & Kristantina, 2015). At least there are 12 SFAs identified in the Red Snapper's meat where palmitic acid was the most dominant concentration, while MUFA and PUFA consisted of eight types of fatty acids respectively with oleic acid and Cis-4,7,10,13,16,19-Docosahexaenoic acid as the most dominant components (Jacoeb *etal*., 2015). The economic value of Red Snapper is between Rp. 45,000 to Rp. 70,000 (Rikza *et al*., 2013). Instead of the commercial purpose, Red Snapper is also become one of the favorite target of tourism fishing (Hammerschlag-Peyer & Layman, 2010).

Fluctuation on the fishing yield generally occurs due to various factors related to fishing activity. The number of fishing effort, type of fishing gear, fishing ground, as well as the fishing power affects the exploitation rate (Caddy, 2011; Overzee & Rijnsdorp, 2015). The increasing yield of Red Snapper in the last few years could be caused by the change of some the mentioned factors.

Red Snapper is an important commodity in the capture fisheries sector in Indonesia. Red Snapper fishing is one of five fish species with the highest yield in Indonesia (Rikza *et al*., 2013). However, the stock of Red Snapper in many regions in Indonesia has been reported to be overfished (Lukman, 2012; Suryana*et al*., 2012). Catch of Red Snapper showed that most of the captured fish is under the reproductive size (Wahyuningsih *et al*., 2013). Generally, excessive fishing effort is considered as the main cause of the resource depletion (Costello *et al*., 2016). But, recent researches show that the degradation of the essential ecosystems has significant contribution to the long term resource depletion (Zhou *et al.,* 2010). However, the estimation to the contribution of ecosystem degradation on the resource dynamic is rarely conducted.

The decreased fish stocks definitely affect the yield of capture fisheries. It further impacts the fishing activity, productivity as well as the prosperity of the fishermen (Nayak, Oliveira, & Berkes, 2014). The resource overfishing along with the degraded ecosystem generates multiplied impact on the decrease of fish stocks. Degraded ecosystems would slow down the stock recovery processes (Wilson *et al.,* 2010). In the meantime, fishing activity tends to occur at the constant or even increased rate. Thus, the decrease of fish stock might be accelerated.

Another impact of fish over-exploitation is biological overfishing (Lin, Chang, Sun, & Tzeng, 2010; Thuy & Flaaten, 2013). Captured fish size is decreased due to the limited stock of adult fish. Younger fish is forced to reproduce causing decreased catchable size (Overzee & Rijnsdorp, 2015). The degraded ecosystems also decrease the availability of suitable habitat. Thus, the resource is more vulnerable to degradation. Rehabilitation of coastal ecosystems is required to improve the carrying capacity to the fish resources (Guntur, Sambah, Arisandi, Jauhari, & Jaziri, 2018).

The fluctuation of mangrove coverage and condition in the northern coastal area of Central Java was due to the intensive utilization of the coastal area (Cerlyawati, Anggoro, & Zainuri, 2017). Generally, anthropogenic activity becomes the main factor affecting the dynamic of mangrove ecosystem. Mangrove related activity such as pond, agriculture, and settlement developments cause direct impact on the reduction of mangrove coverage (Udoh, 2016). However, there are replanting activities which improve the mangrove coverage (Cerlyawati *et al.*, 2017; Hastuti & Hastuti, 2018).

The development of industries, settlements and agriculture in the upland area indirectly affect the condition of mangrove ecosystem in the coastal area. Those activities produce pollutants and increase sediment transport causing the decrease of water quality in the downstream, estuaries and coastal areas (Benitez, Ceron-Breton, Ceron-Breton, & Rendon-Von-Osten, 2014; Maiti & Chowdhury, 2013; Pawar, 2016). For mangrove ecosystem, increasing sediment loads causes disturbance on mangrove rooting and further cause stress on mangrove trees (Okello *et al.*, 2014). Thus, the mangrove ecosystem in Central Java was fluctuated, both the coverage and the condition.

Mangrove and seagrass ecosystems are the nursery ground of Lutjanidae family during juvenile and sub-adults stage (Monteiro *et al.*, 2009). However, not all of the fish species from the genus *Lutjanus* occupy mangrove as their nursery habitat. Even most of the species are dependent to coral reefs (Frédérich & Santini, 2017; Fukunaga, Kosaki, & Hauk, 2017). The result of the research showed that mangrove coverage has negative impact on the yield of Red Snapper. This indicates that the Red Snapper species existed in the northern coastal area of Central Java is not Mangrove Red Snapper (*L. argentimaculatus*). Thus, instead of having positive impact, the increasing mangrove coverage decreases the yield of Red Snapper. Unfortunately, there is no appropriate data about the condition of coral reefs in the northern coastal area of Central Java. Moreover, the coral reef ecosystem in Central Java only existed in limited area. Thus, it is considered that the catch of Red Snapper in northern coastal area of Central Java did not only occur in the coastal water, but also in the open sea.

Considering that Red Snapper has a long life cycle, there is a possibility that the negative impact of mangrove doesn't occur in a real time, but as the effect of mangrove condition several years backward (McNally, Uchida, & Gold, 2011). Another factor that should be considered is the increasing activity in the land area. Various anthropogenic activities including agriculture, aquaculture and industry lead to the increase of pollutant load to the aquatic environment, including the rivers, estuaries and coastal waters (Benitez *et al*., 2014; Pawar, 2016). Moreover, increasing anthropogenic activities leads to the increase of freshwater discharge which becomes one factor affecting the survival of Red Snapper larvae (Hernandez Jr, Filbrun, Fang, & Ransom, 2016). Generally, the pollutants could be remediated by mangrove ecosystem (Jing et al., 2015). However, the remediation capacity of mangrove is limited. Thus, excessive pollutant loads could not be treated optimally.

The impacts could be observed on the coral reef and seagrass ecosystems. Currently, the turbidity of water in most of the coral reefs and seagrass ecosystem is increased (L G Gillis *et al.,* 2014). Mangrove ecosystem is vulnerable to turbidity stress. Increased turbidity limits the light penetration so it could not reach coral reefs (Erftemeijer, Riegl, Hoeksema, & Todd, 2012), or at least decrease its intensity. Moreover, sediment particles of the turbid water could cover mangrove polyps and cause its death.

Further impact of water quality degradation in the coral reef area is the limitation of food source for Red Snapper. Coral reef provides more complex prey resources for Red Snapper (Schwartzkopf, Langland, & Cowan, 2017). There are various sources of Red Snappers food, including shrimp, fish, crab, zooplankton and zoobenthos (Chi & True, 2017). However, Red Snapper dominantly feeds on small fishes in the coral reef ecosystem, while the small sized fish feed more on zooplankton at artificial reefs placed in the mud substrate during spring (Schwartzkopf *et al*., 2017). The disturbed environment affects the community of micro-organisms which lead to the change of the structure of food webs. Thus, the diversity and abundance of the natural food of Red Snapper is as well disturbed.

Even though mangrove showed negative impact on the yield of Red Snapper, various factors seems to have more contribution on the declining fish stocks. However, mangrove management is required in order to support another coastal ecosystems, such as estuaries, seagrass and coral reefs (Campbell, Kartawijaya, & Sabarini, 2011;

Granek, Compton, & Phillips, 2009). An appropriate mangrove condition and extent could help improving the coastal water quality through the environmental services it provides.

However, the most challenging effort which should be conducted related to the recovery of Red Snapper fish stocks is the rehabilitation of coral reefs ecosystem. Compared to any other coastal ecosystem, coral reef requires a much longer time to recover (Perry & Morgan, 2017; Roff & Mumby, 2012). The growth and development of coral organism is very slow, thus rehabilitation process takes a few decades or even centuries. However, various efforts should be conducted to support the recovery process, including minimizing pollutant and sediment load to the coral ecosystem (Hairsine, 2017), improving water quality, and preserving coral area from any activities (Hsieh *et al.*, 2011), especially the destructive ones.

Mangrove ecosystem is strongly related to another coastal ecosystems and the fisheries resource within. A study showed that the decrease of mangrove coverage significantly decreases the biomass of mullet in the seagrass ecosystem (Ola, 2008). However, the role is less noticeable in the northern coastal area of Central Java, because the sediment structure is dominated by clay. Moreover, the seagrass and coral reefs ecosystems are limited to certain regencies. According to the statistics book of Marine, Coastal and Small Islands by Fisheries and Marine Services of Central Java, seagrass ecosystem is only recorded in Batang, Jepara and Pati Regencies, while coral reef is recorded in Tegal, Pemalang, Pekalongan, Batang, Kendal, Jepara, Pati and Rembang Regencies. However, proper management of mangrove ecosystem is still required in order to support coastal area as habitat of the other fish species.

Mangrove ecosystem services such as nutrient retention and recycling, pollutant and sediment trapping, controlling nutrient release is required to improve the quality of coastal waters. Without mangrove, coastal water is more vulnerable to nutrient enrichment which may cause eutrophication (L G Gillis *et al.*, 2014). Moreover, tidal dynamic may drag sediment and nutrient to the offshore area causing further ecological disturbance.

Recent effort to fulfil the market needs of Red Snapper fisheries has been conducted through aquaculture activities (Abbas, Siddiqui, & Jamil, 2011). However, the capacity to conduct artificial breeding is still limited, thus the juvenile is still dependent to the wild source which is seasonal, variable and probably unsustainable (Chi & True, 2017). The degradation of coastal ecosystem contributes to the increasing stress on fish resources due to the loss of its spawning and nursery areas.

Management of fish resource should consider the sustainability of the resource as well as the ecological, social and economics sustainability (Suryana *et al*., 2012). Various fishing aspects such as fishing ground, fishing effort, resource-friendly fishing gear, as well as human resource utilization should be regulated to maintain the sustainable rate (Failler, Pan, Thorpe, & Tokrisna, 2014). However, the ecology of fishing activities should also be considered. Fishing activities in the previous decades has considered about the resource sustainability, but the ecological sustainability is mostly neglected. This paradigm should be changed. Since fish resource is mainly related to its restocking capability, while restocking capability is mainly related to the ecosystem conditions, thus the management of ecosystem should take the first place to consider.

In order to improve of the wild stock of Red Snapper, integrated management acts should be conducted. The impact of anthropogenic activities is the main issue which should be overcome (Liu, Wang, & Chen, 2013), not just for Red Snapper but also for any other fish resources. Waste management along with optimization of mangrove ecosystem services could be emphasized to maintain the water quality of the coastal area. Protection on the spawning and nursery ground becomes the second priority to improve the restocking rate and survival of fish juveniles. Specifically related to Red Snapper, this should be supported through the rehabilitation of coral reef ecosystem. Development of artificial reefs is also required to improve the residence time for Red Snapper (Topping & Szedlmayer, 2011). Then, limitation of fishing effort, allowable catch size, as well as the yield should be determined so that biological overfishing doesn't occur. Thus, the sustainability of Red Snapper fishing business could be maintained.

CONCLUSIONS

The yield of Red Snapper in the northern coastal area of Central Java is increasing, however the coverage of mangrove tends to decrease. Mangrove coverage has significant negative effect on the yield of Red Snapper in the northern coastal area of Central Java. Each mangrove condition need to be weighted to standardize the quality of mangrove where mangrove with moderate condition has a half impact, while poor condition has a quarter impact of the good mangrove condition.

ACKNOWLEDGEMENT

The authors would like to thank the Head Office of Marine and Fisheries Service, Province of Central Java, Indonesia for data support and field assistance during the research.

REFERENCES

Abbas G., Siddiqui P. J. A. & Jamil K. 2011. The Optimal Protein Requirements of Juvenile Mangrove Red Snapper, *Lutjanus argentimaculatus* fed isoenergetic diets. Pakistan Journal of Zoology. 44(2): 469-480.

Auliyah N. & Blongkod A. 2018. Struktur Komunitas Mangrove Pesisir Pantai Desa Dalapuli Barat, Bolaang Mongondow Utara. Gorontalo Fisheries Journal. 1(1): 1-11.https://doi.org/10.32662/.v1i1.92

Baharudin L. 2013. Potensi Lestari Ikan Kakap di Perairan Kabupaten Sambas. Vokasi. 9(1): 1-

10.http://repository.polnep.ac.id/xmlui/handle/123456789/1228

Benitez J. A., Ceron-Breton R. M., Ceron-Breton J. G.& Rendon-Von-Osten J. 2014. The environmental impact of human activities on the Mexican coast of the Gulf of Mexico: review of status and trends. WIT Transactions on Ecology and the Environment. 181, 37-50. https://doi.org/10.2495/EID140041

Black B. A., Allman R. J., Schroeder I. D. & Schirripa M. J. 2011. Multidecadal otolith Growth Histories for Red and Gray Snapper (Lutjanus spp.) in the Northern Gulf of Mexico, USA. Fisheries Oceanography. 20(5): 347-356. https://doi.org/10.1111/j.1365-2419.2011.00588.x

Caddy J. F. 2011. Sustainability indicators for fisheries: their use in fisheries management. Part ii. ciencia pesquera. 19(1): 73-100.

Campbell S. J., Kartawijaya T. & Sabarini E. K. 2011. Connectivity in reef fish assemblages between seagrass and coral reef habitats. Aquatic Biology, 13, 65-77. https://doi.org/10.3354/ab00352

Cerlyawati H., Anggoro S. & Zainuri M. 2017. Mangrove Rehabilitation Program in North Coast, Central Java-Indonesia (Case Study in Regency of Brebes, Pemalang and Demak). Journal of Applied Environmental and Biological Sciences. 7(5): 131-139.

Chi V. V& True J. D. 2017. Recruitment and habitat ecology of juvenile mangrove red snapper (Lutjanus argentimaculatus Forsskal, 1775) in central Vietnam. International Journal of Fisheries and Aquatic Studies. 5(6): 103-107.

Costello C., Ovando D., Clavelle T., Strauss C. K., Hilborn R., Melnychuk M. C., … Leland A. 2016. Global fishery prospects under contrasting management regimes. PNAS. 113(18):5125-5129. https://doi.org/10.1073/pnas.

Cowan J. H., Grimes C. B., Patterson W. F., Walters C. J., Jones A. C., Lindberg W. J., … Rose K. A. 2011. Red snapper management in the Gulf of Mexico: science- or faith-based? Reviews in Fish Biology and Fisheries, 21(2): 187-204. https://doi.org/10.1007/s11160-010-9165-7

Erftemeijer P. L. A., Riegl B., Hoeksema B. W. & Todd P. A. 2012. Environmental impacts of dredging and other sediment disturbances on corals: A review. Marine Pollution Bulletin, 64(9): 1737-1765. https://doi.org/10.1016/j.marpolbul.2012.05.008

Failler P., Pan H., Thorpe A. & Tokrisna R. 2014. On macroeconomic impact of fishing effort regulation: measuring bottom-up fish harvesters economy-wide contribution. Natural Resources, 5, 269-281. https://doi.org/10.4236/nr.2014.57025

Frédérich B. & Santini F. 2017. Macroevolutionary analysis of the tempo of diversification in snappers and fusiliers (Percomorpha: Lutjanidae). Belgian Journal of Zoology. 147(1): 17-35. https://doi.org/10.26496/bjz.2017.2

Fry G., Milton D. A., Velde T. Van Der, Stobutzki I., Andamari R., Badrudin & Sumiono B. 2009. Reproductive Dynamics and Nursery Habitat Preferences of two Commercially Important Indo-Pacific Red Snappers Lutjanus erythropterus and L. malabaricus. Fisheries Science. 75, 145-158. https://doi.org/10.1007/s12562-008-0034-4

Fukunaga A., Kosaki R. K. & Hauk B. B. 2017. Distribution and abundance of the introduced snapper Lutjanus kasmira (Forsskål, 1775) on shallow and mesophotic reefs of the Northwestern Hawaiian Islands. BioInvasions Records. 6(3): 259-268. https://doi.org/10.3391/bir.2017.6.3.12

Gallaway B. J., Szedlmayer S. T. & Gazey W. J. 2009. A life history review for Red Snapper in the Gulf of Mexico With An Evaluation Of The Importance Of Offshore Petroleum Platforms and Other Artificial Reefs. Reviews in Fisheries Science, 17(1): 48-67. https://doi.org/10.1080/10641260802160717

Gillis L. G., Bouma T. J., Cathalot C., Ziegler A. D. & Herman P. M. 2015. Particulate Matter in Mangrove Forests and Seagrass Beds as a Nitrogen Source in Tropical Coastal Ecosystems. Biotropica, 47(3): 286-291. https://doi.org/10.1111/btp.12220

Gillis L. G., Bouma T. J., Jones C. G., Katwijk M. M. Van, Nagelkerken I., Jeuken C. J. L., … Ziegler A. D. 2014. Potential for Landscape-Scale Positive Interactions Among Tropical Marine Ecosystems. Marine Ecology Progress Series, 503, 289-303. https://doi.org/10.3354/meps10716

Granek E. F., Compton J. E. & Phillips D. L. 2009. Mangrove-Exported Nutrient Incorporation By Sessile Coral Reef Invertebrates. Ecosystems, 12, 462-472. https://doi.org/10.1007/s10021-009-9235-7

Guntur G., Sambah A. B., Arisandi D. M., Jauhari A. & Jaziri A. A. 2018. Study on water quality around mangrove ecosystem for coastal rehabilitation Study on water quality around mangrove ecosystem for coastal rehabilitation. IOP Conference Series: Earth and Environmental Science, 106, 12041. https://doi.org/10.1088/1755-1315/106/1/012041

Hairsine P. B. 2017. Review: Sediment-related controls on the health of the Great Barrier Reef. Vadose Zone Journal, 16(12). https://doi.org/10.2136/vzj2017.05.0115

Hammerschlag-Peyer C. M. & Layman C. A. 2010. Intrapopulation variation in habitat use by two abundant coastal fish species. Marine Ecology Progress Series. 415, 211-220. https://doi.org/10.3354/meps08714

Hastuti E. D. & Hastuti R. B. 2018. Growth characteristics of mangrove seedling in silvofishery pond – the allometric relationship of height, diameter and leaf abundance. IOP Conf. Series: Earth and Environmental Science, 130, 12015. https://doi.org/10.1088/1755-1315/130/1/012015

Hernandez Jr, F. J., Filbrun, J. E., Fang J. & Ransom J. T. 2016. Condition of Larval Red Snapper (*Lutjanus campechanus*) Relative to Environmental Variability and the Deepwater Horizon oil spill. Environmental Research Letters. 11(9): 94019. https://doi.org/10.1088/1748-9326/11/9/094019

Hsieh H. J., Chen K.-S., Lin Y. I., Huang Y. A., Baird A. H., Tsai W.-S., … Chen C. A. 2011. Establishment of a no-take area (NTA) Could Not Guarantee The Preservation of Coral Communities in Chinwan Inner Bay, Penghu, Taiwan. Zoological Studies. 50(4): 443-453.

Jacoeb A. M., Suptijah P. & Kristantina W. A. 2015. Komposisi Asam Lemak, Kolesterol, dan Deskripsi Jaringan Fillet Ikan Kakap MerahSegar & Goreng. JPHPI. 18(1): 98-107. https://doi.org/10.17844/jphpi.2015.18.1.98

Jing H., Xia X., Liu H., Zhou Z., Wu C. & Nagarajan S. 2015. Anthropogenic impact on diazotrophic diversity in the mangrove rhizosphere revealed by nifH pyrosequencing. Frontiers in Microbiology. 6, 1172. https://doi.org/10.3389/fmicb.2015.01172

Karnauskas M. & Walter III J. F. 2017. Red Snapper distribution on natural habitats and artificial structures in the Northern Gulf of Mexico. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science. 9(c): 50–67. https://doi.org/10.1080/19425120.2016.1255684

Lapolo N., Utina R., & Baderan D. W. K. 2018. Diversity and density of crabs in degraded mangrove area at Tanjung Panjang Nature Reserve in Gorontalo, Indonesia. Biodiversitas, 19(3): 1154-1159. https://doi.org/10.13057/biodiv/d190351

Lin Y.-J., Chang Y.-J., Sun C.-L. & Tzeng W.-N. 2010. Evaluation of the Japanese eel fishery in the lower reaches of the Kao-Ping River, southwestern Taiwan using a per-recruit analysis. Fisheries Research. 106(3): 329-336. https://doi.org/10.1016/j.fishres.2010.08.015

Lindegren M., Diekmann R., & Möllmann C. 2010. Regime Shifts, Resilience and Recovery of a Cod stock. Marine Ecology Progress Series. 402, 239-253. https://doi.org/10.3354/meps08454

Liu T.-K., Wang M.-W. & Chen P. 2013. Influence of waste Management Policy on the Characteristics of Beach Litter in Kaohsiung, Taiwan. Marine Pollution Bulletin. 72(1): 99-106. https://doi.org/10.1016/j.marpolbul.2013.04.015

Lukman E. 2012. Evaluasi Aspek Biologi Terhadap Kegiatan Penangkapan Ikan Kakap Merah (Lutjanus) dan Pengembangannya di Sekitar Perairan Sinjai Teluk Bone. Bimafika. 4, 417-419.

MacKenzie R. A.& Cormier N. 2012. Stand Structure Influences Nekton Community Composition And Provides Protection From Natural Disturbance in Micronesian mangroves. Hydrobiologia. 685(1): 155–171. https://doi.org/10.1007/s10750-011-0865-3

Maiti S. K. & Chowdhury A. 2013. Effects of anthropogenic pollution on mangrove biodiversity: a review. Journal of Environmental Protection. 4, 1428-1434. https://doi.org/10.4236/jep.2013.412163

Matrutty D. D. P. 2016. Pofil kondisi oseanografi daerah penangkapan ikan (pasi) ikan Kakap Merah sub famili Etelinae di Kepulauan Lease. Amanisal. 5(1): 10-17.

McNally C. G., Uchida E. & Gold A. J. 2011. The effect of a protected area on the tradeoffs between short-run and long-run benefits from mangrove ecosystems. PNAS, 108(34): 13945-13950. https://doi.org/10.1073/pnas.1101825108

Mendoza-Carranza M., Hoeinghaus D. J., Garcia A. M. & Romero-Rodriguez A. 2010. Aquatic food webs in mangrove and seagrass habitats of Centla Wetland, a Biosphere Reserve in Southeastern Mexico. Neotropical Ichthyology. 8(1): 171-178.

Mondal P., Trzaska S. & de Sherbinin A. 2017. Landsat-derived estimates of mangrove extents in the Sierra Leone coastal landscape complex during 1990–2016. Sensors. 18(2): 12. https://doi.org/10.3390/s18010012

Monteiro D. P., Giarrizzo T. & Isaac V. 2009. Feeding ecology of juvenile Dog Snapper Lutjanus jocu (Bloch and Shneider, 1801) (Lutjanidae) in intertidal mangrove creeks in Curuçá Estuary (Northern Brazil). Brazilian Archives of Biology and Technology. 52(6): 1421-1430.

Natsir N. A. & Latifa S. 2018. Analisis kandungan protein total ikan Kakap Merah dan ikan Kerapu Bebek. Jurnal Biology Science & Education. 7(1): 49-55.

Nayak P. K., Oliveira L. E. & Berkes F. 2014. Resource degradation, marginalization, and poverty in small-scale fisheries: threats to social-ecological resilience in India and Brazil. Ecology and Society. 19(2): 73. https://doi.org/10.5751/ES-06656-190273

Nyanti L., Nur Asikin R., Ling T. Y. & Jongkar G. 2012. Fish diversity and water quality during flood mitigation works at Semariang. Sains Malaysiana. 41(12): 1517-1525.

Okello J. A., Robert E. M. R., Beeckman H., Kairo J. G., Dahdouh-Guebas F. & Koedam N. 2014. Effects of Experimental Sedimentation on the Phenological Dynamics And Leaf Traits Of Replanted Mangroves at Gazi Bay, Kenya. Ecology and Evolution. 4(6): 3187-3200. https://doi.org/10.1002/ece3.1154

Ola O. La. 2008. Kajian Dampak Pemanfaatan Hutan Mangrove Terhadap Penurunan Biota Laut pada Ekosistem Lamun di Kepulauan Wakatobi. Agriplus. 19(2): 90-96.

Overzee H. M. J. van & Rijnsdorp A. D. 2015. Effects of fishing during the spawning period: implications for sustainable management. Reviews in Fish Biology and Fisheries. 25(1): 65-83. https://doi.org/10.1007/s11160-014-9370-x

Pawar P. R. 2016. Anthropogenic threats to coastal and marine biodiversity: A review. International Journal of Modern Biological Research. 4, 35-45.

Perry C. T. & Morgan K. M. 2017. Post-bleaching coral community change on southern Maldivian reefs: is there potential for rapid recovery? Coral Reefs. 36(4): 1189-1194. https://doi.org/10.1007/s00338-017-1610-9

Rahman M. M., Rahman M. T., Rahaman M. S., Rahman F., Ahmad J. U., Shakera B.& Halim M. A. 2013. Water quality of the world’s largest mangrove forest. Canadian Chemical Transactions. 1(2): 141-156. https://doi.org/10.13179/canchemtrans.2013.01.02.0018

Rikza C., Asriyanto & Yulianto T. 2013. Pengaruh perbedaan umpandan waktu pengoperasian pancing perawai (set bottom longline) terhadap hasil tangkapan ikan Kakap Merah (Lutjanus spp) di sekitar perairan Jeparan. Journal of Fisheries Resources Utilization Management and Technology. 2(3): 152-161.

Roff G. & Mumby P. J. 2012. Global disparity in the resilience of coral reefs. Trends in Ecology & Evolution. 27(7): 404-413. https://doi.org/10.1016/j.tree.2012.04.007

Rouyer T., Ottersen G., Durant J. M., Hidalgo M., Hjermann D. O., Persson J., … Stenseth N. C.2011. Shifting dynamic forces in fish stock fluctuations triggered by age truncation? Global Change Biology. 17, 3046-3057. https://doi.org/10.1111/j.1365-2486.2011.02443.x

Saifullah A. S. M., Kamal A. H. M., Idris M. H., Rajaee A. H. & Bhuiyan M. K. A. 2016. Phytoplankton in Tropical Mangrove Estuaries: Role and Interdependency. Forest Science and Technology. 12(2): 104-113. https://doi.org/10.1080/21580103.2015.1077479

Schwartzkopf B. D., Langland T. A. & Cowan J. H. 2017. Habitat Selection Important for Red Snapper Feeding Ecology in the Northwestern Gulf of Mexico. Marine and Coastal Fisheries. 9(1): 373-387. https://doi.org/10.1080/19425120.2017.1347117

Shoaib M., Burhan Z. U. N., Shafique S., Jabeen H.& Siddique P. J. A. 2017. Phytoplankton Composition in a Mangrove Ecosystem at Sandspit, Karachi, Pakistan. Pakistan Journal of Botany. 49(1): 379-387.

Sihombing V. S., Gunawan H. & Sawitri R. 2017. Diversity and community structure of fish, plankton and benthos in Karangsong Mangrove Conservation Areas, Indramayu, West Java, Indonesia. Biodiversitas. 18(2): 601-608. https://doi.org/10.13057/biodiv/d180222

Soewardi K. & Suwarso. 2006. Variasi geografik dalam struktur genetik populasi ikan Kakap Merah, Lutjanus malabaricus (Lutjanidae) dan interaksi lingkungan di Laut Jawa. Jurnal Ilmu-Ilmu Perairan Dan Perikanan Indonesia. 13(1): 69-75.

Suryana A., Wiryawan B., Monintja D. R. & Wiyono, Ek. S. 2012. Analisis keberlanjutan RAPFISH dalam pengelolaan sumber daya ikan Kakap Merah (Lutjanus sp.) di perairan Tanjungpandan. Buletin PSP. 20(1): 45-59.

Thuy P. T. T. & Flaaten O. 2013. The backward-bending supply curve in fisheries-revisited. Journal of Sustainable Development. 6(6): 15-33. https://doi.org/10.5539/jsd.v6n6p15

Topping D. T. & Szedlmayer S. T. 2011. Site fidelity, residence time and movements of red snapper Lutjanus campechanus estimated with long-term acoustic monitoring. Marine Ecology Progress Series. 437, 183-200. https://doi.org/10.3354/meps09293

Udoh J. P. 2016. Sustainable Nondestructive Mangrove-Friendly Aquaculture in Nigeria I: Ecological and Environmental Perspectives. AACL Bioflux. 9(1): 50-70.

Wahyuningsih Prihatiningsih & Ernawati T. 2013. Parameter Populasi Ikan Kakap Merah (*Lutjanus malabaricus*) di Perairan Laut Jawa Bagian Timur. BAWAL. 5(3): 175-179.

Wilson S. K., Fisher R., Pratchett M. S., Graham N. A. J., Dulvy N. K., Turner R. A., … Polunin N. V. C. 2010. Habitat degradation and fishing effects on the size structure of coral reef fish communities. Ecological Applications. 20(2): 442-451.

Zakaria M. & Rajpar M. N. 2015. Assessing the fauna diversity of Marudu Bay Mangrove Forest, Sabah, Malaysia, for future conservation. Diversity. 7(2): 137-148. https://doi.org/10.3390/d7020137