The Correlation Between Mangroves and Coastal Aquatic Biota

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Abstract. Mangrove forests are important for the productivity of estuary ecosystems, including diversity and population of coastal biota because of their contribution through the fall of litter so that mangroves as the first chain of tropical chains on the coast. Most of marine biota species are thought to be highly dependent on mangrove areas from west to east tropical region. About 70% of fish caught were only found in mangrove forests that were still good. The fish population and species in healthy mangroves were 159-234% and 116-129% greater than mangrove forests that have been degraded, respectively. The loss and degradations of mangroves also causes fishermen income to decrease. Therefore, the healthy mangrove should be maintained with properly management as well as the degraded mangrove should be restored based on scientific basis. Conserving and restoring mangroves are becoming a very productive investment, not only for the present generation, but also for future generations.

1. Introduction
About one third of the world's mangroves are found in Indonesia [1] with 44 species of true mangrove plants [2]. This makes Indonesia recorded as the country that has the widest and richest mangrove forest in the world. But at the same time, Indonesia also contributed to the loss of the world's largest mangrove forest [1, 3-5]. About 80% of 1,000,000 ha of Indonesia's mangrove loss are caused by expansion of shrimp and fishponds [6-7]. In the next two decades, it is estimated that the expansion of ponds and the expansion of oil palm plantations is still a major factor in the loss of Indonesian mangroves [7-8].

The impact of brackish pond industry on the environment is very large, including contributing to carbon emissions of about 0.19 Pg CO2 per year [9], causing loss of biodiversity and reducing the adaptation capacity of coastal areas [10]. Indonesia is recorded as the largest contributo to carbon emissions due to loss of mangrove forests including conversion to ponds [11]. Mangrove loss and degradation has also led to a decrease in the productivity of these ecosystems, including a decrease in fisheries productivity [12-20] and increased socio-economic vulnerability of coastal communities [12-
This article mainly aimed to evaluate the correlation between mangrove condition and diversity and population of coastal biota.

2. Research Method
A literature study has been carried out to assess the correlation between aquatic biota in coastal areas and mangroves based on internet search engine of publication database as well as printed document of publications. In the search activities, keywords such as mangrove and aquatic coastal biota have been used. Then, the results of literature study were analyzed and presented both descriptively and quantitatively.

3. Results and Discussions

3.1. Mangroves and estuarine fishery catch
Shrimp production is closely related to mangrove litter production [22]. Furthermore, Walters et al. [23] informed that 80% of commercial marine biota species are thought to be highly dependent on mangrove areas in the Florida region, USA, 67% of commercial fishery catch species in eastern Australia [24], and nearly 100% of shrimp caught the ASEAN region depends on the mangrove area. Macintosh [25] reports that 49% of demersal fish in the Malacca Strait are highly dependent on mangrove forests.

3.2. Aquatic biota population and diversity in various mangrove conditions
Huxham et al. [26] and Shinnaka et al. [27] conducted a study to compare the population and diversity of fish in mangrove forests that are still relatively good with mangroves that have been cleared. The results are very astonishing. The results of Huxham et al. [26] in Kenya showed that 2/3 of the 30 species of fish caught were only found in mangrove forests that were still good. In Thailand, Shinnaka et al. [27] reported that mangrove forests that were still in good condition had populations and fish species respectively 159-234% and 116-129% greater than mangrove forests that had been damaged. The results of the study in Kenya and Thailand are in line with a long field study of 50 years reported by Faunce and Serafy [28], namely mangrove forests clearly support a diversity of fish species as indicated by high fish species richness and large populations of each species.

The results of the experimental studies [29-33] also showed that young fishers preferred mangrove roots which were very complex and at the same time reduced predators. Thus, mangrove forests become an ideal place for enlargement (nursery ground) of various species of coastal fish.

Thayer et al. [34] and Morton [35] previously also reported that fish populations in mangrove forests were higher compared to habitats adjacent to mangroves. In Australia [35], the average fish density in mangrove forests reached 2 times greater than the habitat adjacent to the mangrove. Higher density comparisons reported by Thayer et al. [34] who conducted research in south Florida. Thayer et al. [34] found that the average fish density in mangroves was 8 individuals per m², whereas in habitats without mangroves it was only 0.22 individuals per m². Lugendo et al. [36] who conducted a study in Tanzania also reported that fish densities in mangrove forests were significantly higher than other coastal habitats.

Crona and Ronnback [32] reported in Kenya that mangrove forests resulting from rehabilitation are very important for the preservation of fisheries in the vicinity. They [32] also reported that of all species of fish caught, most (75%) were commercial fish species. Furthermore, Wang et al. [33] explain the importance of the existence of canals (small rivers) around mangroves and not break their connection with mangroves, for example by not making dams or dams separating mangroves from these small rivers.

In mangrove areas that are still good in Trang Province, Thailand, Tongnunui et al. [37] reported that 135 fish species belonging to 43 families used mangrove forests as their habitat. In Pagbilao, the Philippines and Queensland, Australia each reported as many as 128 species of fish making mangrove
forests their habitat, as reported by Pinto [38] for the Philippines and Robertson and Duke [39] for Australia.

Martosubroto and Naamim [40] conducted a study of the association of mangrove forests with commercial shrimp catch production in Indonesia. They found a relationship that each loss of 1,000 ha of mangrove forests would result in a reduction in the yield of commercial shrimp by 112.8 tons. Thus, we can calculate how much loss of economic value due to the loss of mangrove forests? That's just from the type of shrimp which is only a small part of the total contribution of mangrove forests.

3.3. Fishery production and fishermen income surrounding mangroves
Good mangrove forests on the southeast coast of India supporting capture fisheries yields of 11 kg per ha per day for shellfish and 4.5 kg per ha per day for finfish, thereby supporting income of US $ 17 per day (US $ 14 per day from shellfish and US $ 3 per day from finfish) [41]. Onrizal et al. [21] reported that damage to mangrove forests had caused an average decline in fishermen's income which reached 41%. The conversion of mangrove forests on the Napabalano coast, Southeast Sulawesi [42] also caused a significant reduction in the population of mangrove crabs (Scylla serrata) which led to a reduction in fishermen income.

Fishermen who catch fish in mangrove forests that have been degraded or converted to other land use areas on the east coast of North Sumatra (Figure 1, left) complain about the decrease in fishing yields and their income after mangrove forests are degraded or lost. On the other hand, in areas with relatively good mangrove forests (Figure 1, right), they are still happy with an adequate catch. The results of observations made by the author, the catch of fishermen in mangrove forest areas that have been damaged only around 10-30% compared with the results of fishermen catching in mangrove forests that are still good.

![Figure 1](image1.jpg)

*Figure 1.* Fishermen around the Besitang River (left), the east coast of North Sumatra lost their catch due to damage and loss of mangrove forests. In this area, most of the mangroves have been converted into ponds and gardens. On the other hand, fishermen who catch fish around Jaring Halus (right), east coast of North Sumatra with a healthy mangrove forest report adequate catches to support their lives.

4. Conclusion and Recommendation
Various research results described in this paper show the magnitude of the contribution of mangrove forests to coastal fisheries production, and huge losses will occur if mangrove forests are degraded or destroyed. Mangrove damage has significantly reduced the productivity of coastal ecosystems, threatened the lives of fishermen and subsequently triggered a lack of nutritional resources for the nation's children. Therefore, various efforts to conserve mangrove forests and rehabilitate degraded mangrove forests are a very productive investment, not only for the present generation, but also for future generations.
5. References

[1] Hamilton S E and Casey D 2016 Global Ecol. Biogeogr. 25 729-738
[2] Spalding M, Kainuma M and Collins L 2010 World atlas of mangroves A collaborative project of ITTO/ISME/FAO/UNEP-WCMC London UK Earthscan
[3] FAO 2007 The world’s mangroves 1980–2005 FAO Forestry Paper 153 77p
[4] Giri C, Ochieng E, Tieszen L L, Zhu Z, Singh A, Loveland T, Masek J and Duke N 2011 Global Ecol. Biogeogr. 20(1) 154-159
[5] Thomas N, Lucas R, Bunting P, Hardy A, Rosenqvist A and Simard M 2017 PloS one 126 e0179302
[6] Onrizal 2013 Wanamina 3(1) 1-9
[7] Ilman M, Dargusch P, Dart P and Onrizal 2016 Land Use Policy 54 448-459
[8] Richards D R and Friess D A 2016 Proc. of the National Academy of Sciences 1132 344-349
[9] Murdiyarso D, Purboespijo J, Kaufman J B, Warren M W, Sasmito S D, et al. 2015 Nature Climate Change DOI: 10.1038/NCLIMATE2734
[10] Duke N C, Meynecke J O, Dittmann S, Ellision A M, Anger K, Berger U, Cannicci S, Diele K, Ewel K C, Field C D, Koedam N, Lee S Y, Marchand C, Nordhaus I and Dahdouh-Guebas F 2007 Science 317 41-42
[11] Onrizal O, Thoha, A S, Ahmad A G and Mansor M 2018 Mangrove loss drives global warming ICOSTEER international conference Medan
[12] Dave R 2006 Trop. Res. Bulletin 25 7-13
[13] Primavera J H 2005 Science 310(5745) 57-58
[14] Ellison A M 2008 J. Sea Res 59 2–15
[15] Nagelkerken I, Blaber S J M, Bouillon S, Green P, Haywood M, et al. 2008 Aquat Bot 89 155-185
[16] Walters B B, Rønnback P, Kovacs J M, Crona B, Hussain S A, et al. 2008 Aquat Bot 89 220-236
[17] Cannicci S, Bartolini F, Dahdouh-Guebas F, Fratini S, Litulo C, et al. 2009 Estuar Coast Shelf Science 84 305-317
[18] Cunha-Lignon M, Coelho C Jr, Almeida R, Menghini R P, Schaeffer-Novelli Y, et al. 2011 J. Coast Res. 64 349-353
[19] Satyanarayana B, Bhandari P, Debry M, Maniatis D, Foré F, Badgie D and Dahdouh-Guebas, F. 2012 AMBIO: A J. of the Human Environment 415 513-526
[20] Atwood T B, Connolly R M, Almahasheer H, Carnell P E, Duarte C M, Lewis C J E and Serrano O 2017 Nature Climate Change 7 523-528
[21] Onrizal, Purwoko A and Mansor M 2009 Impact of mangrove forests degradation on fisherman income and fish catch diversity in eastern coastal of North Sumatra, Indonesia Int. Conf. on Natural and Environmental Sciences 2009 ICONES’09 Banda Aceh Indonesia
[22] Al-Rasyid H 1986 Buletin Penelitian Hutan 475 29-65
[23] Walters B B, Rønnbæk P, Kovacs J M, Crona B, Hussain S A, Badola R and Dahdouh-Guebas F 2008 Aquatic Botany 89(2) 220-236
[24] Hamilton and Snedaker 1984 Handbook for mangrove area management IUCN/Unesco/UNEP. East-West Centre Honolulu Hawaii
[25] Macintosh D 1982 Recent advances in aquaculture pp 4-85
[26] Huxham M, Kimani E and Augley J 2004 Estuarine, Coastal and Shelf Science 60(4) 637-647
[27] Shinnaka T, Sano M, Ikejima K, Tongnunui P, Horinouchi M and Kurokura H 2007 Fisheries Science 73(4) 862-870
[28] Faunce C H and Serafy J E 2006 Marine Ecology Progress Series 318 1-18
[29] Laegsgaard P and Johnson C 2001 J. of experimental marine biology and ecology 257(2) 229-253
[30] de la Morinierre E C, Nagelkerken I, Van Der Meij H and Van Der Velde G 2004 Marine Biology 144(1), 139-145
[30] Verweij M C, Nagelkerken I, De Graaff D, Peeters M, Bakker E J and Van der Velde G 2006 *Marine Ecology Progress Series* 306 257-268

[31] Crona B I and Rönnbäck P 2007 *Estuarine, Coastal and Shelf Science* 74(1-2) 44-52

[32] Wang M, Huang Z, Shi F and Wang W 2009 *Estuarine, Coastal and Shelf Science* 85(2) 208-216

[33] Thayer G W, Colby D R and Hettler Jr W F 1987 *Marine Ecology-Progress Series* 35 25-38

[34] Morton R M 1990 *Marine Biology* 105(3) 385-394

[35] Lugendo B R, Nagelkerken I, Jiddawi N, Mgaya Y D and Van Der Velde G 2007 *Fisheries Science* 73(6) 1213-1223

[36] Tongnunui P, Ikejima K O U, Yamane T, Horinouchi M, Medej T, Sano M and Taniuchi T 2002 *Fisheries Science* 68(1) 10-17

[37] Pinto L 1988 *J. of Fish Biology* 33 35-43

[38] Robertson A I and Duke N C 1990 *Marine Biology* 104(3) 369-379

[39] Martosubroto P and Naamim N 1977 *Marine Research in Indonesia* 18 81-86

[40] Kathiresan K and Rajendran N 2002 9(5) 277-283

[41] Amala W O L 2003 *Relationship between mangrove forest conversion and abundance of mangrove crabs (Scylla serrata) on the coast of Napabalano, Southeast Sulawesi* Master thesis (Yogyakarta: Universitas Gadjah Mada)

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