Status of mud crab (Scylla sp.) fishery and mangrove ecosystem of Sanleko Village, Buru District, Indonesia

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Abstract. Until recently live crab business has been proven as a promising fisheries practice in many parts in Indonesia. Mud crab capture based fishery at Sanleko Village has been going for more than 20 years of time. The present study was aimed to examine the status of mangrove ecosystem as main mud crab habitat and mud crab fishery at Sanleko Village of Buru District. Mud crab fishery status was considered less sustain with an average sustainable scale of 47.36% whilst mangrove ecosystem sustainability status was considered sustain (60.29) according to the ecosystem approach to fisheries management. The economic analysis shows the NPV of 17.05 with average B/R of 2.47. The IRR of this fishery was 23.2% which is bigger than the interest rate of 15% and the payback period of 0.6. In general, the fishery of mud crab at Sanleko Village is still feasible with steadily decreasing economic sustainability.

1. Introduction

For many tropical and sub-tropic countries in Asia, the mud crabs, Scylla spp., represent a valuable component of small-scale coastal fisheries [1, 2, 3, 4]. In the global scale, it has been reported there is an increasing tendency in mud crab production as a result of the development of hatchery. In 2008, the total amount of mud crab aquaculture production from Asia and Africa amounted for 18,000 t and has been predicted to remain increase [5]. Apart from the attempt to maintain the sustainability of this resource, in some parts reported have shown an indication of over-exploitation towards mud crab resources [6, 7].

A sign in mud crab production decline was also reported from some parts of Indonesia like in North Coast of Java [8], Western Seram District [9, 10], and OhoiEvu, Southeast Maluku [11]. For the local fisher from Sanleko Village, mud crab fishery is their only source of income from fishery sector [12, 13], hence the sustainability of this resources is very important.

This mud crab is sometimes also called as mangrove crab since mainly associated with mangrove ecosystem of an intertidal and subtidal area with the predominantly muddy substrate ([1, 7, 14]. The mangrove ecosystem in Sanleko which is part of Kayeli Bay is one of the dense mangrove ecosystems in Maluku Province [12, 15] however, some of the local people use mangrove wood for burning fuel, building materials, fence, and converting the area for settlement.
2. Material and Methods

2.1. Objectives and study site
The study was conducted between August to November 2017 at Sanleko Village of Buru District (Figure 1). The objective of this study was to analyze the status of mud crab Scylla sp. fisheries, mangrove ecosystem as mud crab main habitat, and social-economy analysis of this fishery and proposes a sustainable management plan for this fishery.

Figure 1. Map of study site (Sanleko Village)

2.2. Data collection and analysis
Mud crab samples were collected from local fisher of Sanleko Village on a monthly interval. Mud crab sex determination was based on the abdominal flap morphologic structure [16]. The external carapace width was measured using the vernier caliper to the nearest mm, whilst weight was weighted using 5.0 kg. blue LCD blacklight portable digital balance to the nearest g.

Length size distribution of mud crab caught during the study period was analyzed using descriptive statistic [17], whilst carapace width-weight relationship was analyzed according to the formula proposed by [18]:

\[ W = aL^b \]

where:  
\[ \begin{align*} 
L & = \text{carapace width (cm)} \\
\alpha & = \text{intercept} \\
b & = \text{slope} 
\end{align*} \]

The b value is then used to determine growth pattern i.e. isometric growth \((b = 3)\) or allometric growth \((b \neq 3)\) by using t-Student test [18].

The sustainability status of mud crab and mangrove ecosystem was analyzed using rapid appraisal for fisheries method (Rapfish) according to [19, 20], and its sustainability standard attributes were based on attribute proposed by [21, 22] with some modifications. Data for Rapfish analysis was collected through a questionnaire distributed to local mud crab fisher of Sanleko Village. The sustainable management plan for this fishery was based on sensitivity attribute analysis (Leverage
analysis) which was derived from the Rapfish analysis [19, 20]. The sustainable level of mud crab was classified according to the ecosystem approach to fisheries management standard [23].

Economic feasibility analysis for this fisheries was analyzed covering the variables of net present value (NPV), cost-benefit ratio analysis (C/B), internal rate of return (IRR), and payback period [24, 25].

3. Results and Discussion

A total number of mud crab collected during the study was 424 individuals comprising of 218 males and 206 females. The size distribution of male mud crab range from 7.40 to 24.50 cm carapace width with average size of being 13.68 (±2.60) cm, whilst for female range from 7.60 to 21.40 cm. The size distribution for both sexes however, was no different (t\(^{(α2)}\)0.05; P=0.0002), and size most frequently caught was 11.50 cm. The smallest mud crab caught was 7.40 cm indicating first recruitment to the trap fishing started at this size.

The size composition from this study was larger than some of mud crab species found in Indonesia. Size range of mud crab from Central Tapanuli District range from 4.5 to 18.45 cm [26], Bintan Bay of Riau Province with size range from 6.7 to 16.2 cm [27], Kahyapu Village of Enggano Island, Bengkulu Province with size range from 7.0 to 19.3 cm [28], and from Kutai National Park form 4.5 to 15.5 cm [37]. Study on the same species in Western Seram [29, 30] shows a similar result with this study.

![Figure 2](image)

**Figure 2.** The percentage of size frequency of mud crab *Scylla* sp. harvested over study period

There was a strong correlation between male and female mud crab with correlation coefficient \((r)\) of 0.9059 and 0.9186 for male and female mud crab respectively (Figure 3). Strong correlation was also found in some other studies [26, 27, 29, 30] with correlation coefficient \((r)\) between 0.877 to 0.9866 for both sexes. Figure 3 shows that mud crab of both sexes at carapace width below ± 18 cm have the same weight at the same as carapace width size.
Figure 3. Carapace width-weight relationship between male and female Scylla sp.

Table 1. shows carapace width-weight relationship in mud crab Scylla sp. for each study period which shows a high correlation throughout the study period. The b value varies over time. Test of b coefficient for growth pattern of shows an isometric growth pattern (t_calc < t_α(2)0.05) throughout the study period. The same result was also found at Western Seram waters except for September and November [29]. A variation on the growth pattern of the mud crab Scylla sp. has been reported in some studies. An isometric growth for male and negative allometric for female mangrove crabs was reported from Khulna, Bangladesh [32], on the contrary, a negative allometric was reported for both male and female mud crab from Mayangan, Subang, West Java [33], and at Bintan Bay [27]. Variation in b value may arise from food availability, condition factor, and a molting [33].

| Period    | $W = aL^b$ | $r$   | $t_{calc}$ | $t_{α(2)0.05}$ | Growth pattern |
|-----------|------------|-------|------------|----------------|----------------|
| August    | $y = 0.3070x^{2.3382}$ | 0.9958 | 0.0016     | 1.990          | Isometric      |
| September | $y = 0.2139x^{2.3469}$ | 0.9667 | 0.0166     | 1.984          | Isometric      |
| October   | $y = 0.1346x^{3.0978}$ | 0.9719 | 0.0324     | 1.982          | Isometric      |
| November  | $y = 0.1542x^{2.9895}$ | 0.9142 | 0.0034     | 1.979          | Isometric      |

The Rapfish analysis for ecology sustainability status of mud crab and mangrove ecosystem (Figure 4A) shows sustainability for mud crab and mangrove was 63.01% and 79.28% respectively. In the ecosystem approach to fisheries management, mud crab sustainability was considered fair sustain whilst mangrove ecosystem was considered sustain [23]. Test for Goodness of fit shows the stress value was < 0.25 explain the high validity of the test [34]. This was also shown by Monte Carlo scatter plot (Figure 4B) where anchor and reference did not move during Rapfish ordination.
Figure 4. Rapfish ordination for sustainability analysis (A) and Monte Carlo scatter plot ordination stability (B) for ecology dimension.

Complete sustainability status of mud crab *Scylla* sp. and mangrove ecosystem are presented in Table 2. This table shows that overall sustainability for mud crab and mangrove ecosystem was 46.32% and 60.29% consecutively, whilst the lowest sustainable dimension was institutional both for mud crab and mangrove. Mud crab was considered less sustain whilst mangrove was considered sustain. Analysis of mud crab sustainability in Western Seram [35, 36], whilst the same study in Pangkajene and Kepulaun [37] shows sustainable condition. Differences in sustainability level could be due to some factors such as fishing intensity, management plan and strategy, regulation, and government quality. Study and mangrove sustainability in Western Seram also shows the overall sustainability of less sustain [38], whilst in Ambon [39] shows fair sustain.

Table 2. Sustainability level (%), stress value and square correlation in the Rapfish ordination of mud crab *Scylla* sp.

| Sustainability Dimension | Sustainability level | Stress | $R^2$ | Sustainability classification |
|--------------------------|----------------------|--------|-------|------------------------------|
| Mud crab                 |                      |        |       |                              |
| Ecology                  | 63.01                | 0.1434 | 0.9498| Fair Sustain, Sustain        |
| Social                   | 48.74                | 0.1390 | 0.9341| Less sustain, Less sustain   |
| Economy                  | 42.38                | 0.1390 | 0.9532| Less sustain, Less sustain   |
| Technology               | 58.11                | 0.1683 | 0.9068| Less sustain, Sustain        |
| Institutional            | 24.57                | 0.1436 | 0.9523| Not sustain, Not sustain      |
| Average                  | 47.36                | 0.1467 | 0.9392| Less sustain, Fair sustain    |
| Mangrove                 | 79.28                |        |       |                              |
| Ecology                  |                      |        |       |                              |
| Social                   | 59.97                | 0.1390 | 0.9341| Less sustain, Less sustain   |
| Economy                  | 57.32                | 0.1390 | 0.9532| Less sustain, Less sustain   |
| Technology               | 76.73                | 0.1683 | 0.9068| Less sustain, Sustain        |
| Institutional            | 28.16                | 0.1436 | 0.9523| Not sustain, Not sustain      |
| Average                  | 60.29                | 0.1467 | 0.9392| Less sustain, Fair sustain    |

From 40 attributes used in sustainability status of mud crab and mangrove ecosystem, attribute with the highest sensitivity towards the sustainability were bycatch, consumer attitude towards sustainability, subsidies, quota, gear capacity, change in catching power, regulation, and legality. In the Rapfish analysis, attribute uses can inhibit or foster the sustainability. Bycatch in this analysis, for example, contributes positively towards sustainability since almost no bycatch comes from mud crab and mangrove utilization. Consumer attitude towards sustainability, on the other hand, contribute
negatively towards sustainable management, for mud crab in particular. Even small size mud crab and berried female mud crab were sold and no complaint from the consumer.

Reporting and monitoring, as well as government quality, have low sensitivity in this analysis, however, it should be considered in the management since it has an important role in maintaining sustainability in term of the ecosystem approach to fisheries management [40, 41]. Table 3 summarized management plan and strategy for sustainable mud crab and mangrove ecosystem management.

**Table 3.** Proposed management strategy summary for sustainable mud crab *Scylla* sp. fishery

| No. | Sensitive attribute         | Management strategy                                                                                                                                 |
|-----|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.  | Bycatch                     | Maintaining this condition since no bycatch comes from this fisheries                                                                               |
| 2.  | Harvest before maturity     | Education and training on sustainable fisheries management for the fisher and law enforcement if insectary.                                        |
| 3.  | Consumer attitude           | Education and campaign for public awareness in sustainable fisheries management.                                                                     |
| 4.  | Subsidy                     | If necessary do not support the fisher with subsidy since it inhibits sustainable fisheries management.                                              |
| 5.  | Quota                       | Apply total allowable catch through harvest control rules approach                                                                                  |
| 6.  | Gear side effect            | Deploy mud crab pot equipped with escape gap                                                                                                        |
| 7.  | Regulation                  | Use good quality research data in implementing fisheries management.                                                                                |
| 8.  | Legacy                      | Implementing regulation available and enact law enforcement                                                                                         |
| 9.  | Report and monitoring       | Conduct regular and measurable data collection and monitoring as a basis for controlling and propose a sustainable management approach.            |

Studies have shown that mud crab contributes significantly towards income source for many local fishers in the tropic and sub-tropic countries [3, 4, 41, 42, 43]. Some studies on economic analysis of mud crab have revealed that this fishery has a potential as one of the highest economic fish resources. Table 4 shows variables used in the economic analysis for this mud crab. With the assumption of 15% interest rate, all these values stated that the mud crab fishery in Sanleko Village is feasible. Study on the same species in Western Seram [36] also shows a similar result to this present study. Study on mud crab grow out in Gresik District, East Java [44], mud crab pond culture in Belawan, North Sumatra [45], marketing mud crab in the Philippines [46] shows economy feasible for this mud crab.

The economy analysis shows that this fishery is still feasible to be conducted, but economy sustainability analysis shows less sustains in this fishery. Interviewed with local mud crab fishery and mud crab merchant collector shows that economy benefit from this fishery in decreasing compared to 15 20 years before. Fishing intensity and no fisheries management has cause the decrease of this product.

**Table 4.** The result on economic analysis of mud crab fishery from Sanleko Village

| No. | Variable                     | Result |
|-----|------------------------------|--------|
| 1.  | Net present value (NPV)      | 17.05  |
| 2.  | Benefit cost ratio (B/C)     | 2.37   |
| 3.  | Internal rate of return (IRR)| 23.2   |
| 4.  | Payback period (PP)          | 6.00   |
4. Conclusion.
The total number of mud crab collected in this study were 424 individuals with a size range of 7.40 to 24.50 cm carapace width with an average carapace width size of 13.24 cm (±2.54). Carapace width-weight relationship shows a high correlation with the r value of 0.9151 and with an isometric growth pattern. Sustainability analysis shows that overall mud crab fishery sustainability was considered less sustain whilst mangrove ecosystem was considered fair sustain. Analysis of NPV, B/C, IRR, and Payback period shows that the fishery of mud crab is still feasible apart from low in economic sustainability. An ecosystem approach to fisheries management should be implemented in order to the sustainable management of mud crab fishery.

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