Risk potency analysis and sustainability status of mud crab *scylla* sp. of Sorbay Bay, Southeast Maluku district, Indonesia.

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Abstract. Mud crab *Scylla* sp. fishery of Sorbay Bay, Southeast Maluku District has been conducted for many years by local fisher with almost no management plan. Study on risk potency and sustainability of mud crab *Scylla* sp. was conducted on June 2016. Objectives of this study were to analyze risk potency and sustainability of this fishery. Productivity susceptibility analysis (PSA) and Rapfish were used to analyze the risk and sustainability status of mud crab respectively. The result showed that risk potency for *Scylla* sp. bait fishery, and habitat was unconditionally passed with MSC score of 95. Overall sustainability status was fair sustained with sustainability scale of 55.26% of 100% sustainability score. The most sensitive attribute contribute to mud crab sustainability were governance quality, monitoring, and consumer attitude towards sustainability. The ecosystem approach to fishery management is strongly recommended for sustainable of this fishery.

1. Introduction
Sorbay Bay stretches out from north to south of the coastal waters of Small Kei Island is the largest mangrove ecosystem in Kei Islands. This area is one of the conservation regions in Maluku Province, become an important area for the local community regarding its high productivity. One of economic importance fish resources found in this area is mud crab of the genus *Scylla*. 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].

Two commonly mud crab harvested by local fisher from this area are giant mud crab *S. serrata* and orange mud crab *S. olivacea*. Interviewed with local mud crab fisher from this area revealed that this fishery has been conducted from early 1980 with almost no fishery management practices. High intensity in harvesting the mud crab due to economic
dependency and almost no fisheries management has lead to the unsustainable condition. Mud crab production has declined steadily compared to 10 to 15 years before (personal communication).

Better fisheries management needs a good quality of data [3,4,5], and in this fishery information on such data is lacking. This study, therefore, aimed to investigate risk potency and sustainability status of mud crab Scylla sp. from Sorbay Bay, Southeast Maluku Regency.

2. Materials and Methods

The study was conducted in Small Kei Island (Figure 1). Risk-based framework for risk potency of mud crab fishery, bait fish fishery and habitat was conducted using Productivity Susceptibility Analysis (PSA) according to [6,7]. The analysis was conducted using MSC Ver. 2.1. Software under Microsoft Excel [8]. Analysis of the sustainability status of mud crab fishery was conducted through Rapfish analysis [9,10], and was analyzed using MS Excel software. Sustainability status classification was based according to Pitcher et al. [11], whilst Rapfish standard variables were based according to Rapfish Group [12] and Pitcher et al. [13]. Data for sustainability status analysis was obtained through an interview with local mud crab fisher and other relevance people familiar with mud crab fishery at the study site.

![Research Location](image)

**Figure 1.** Research location: Sorbay Bay

3. Results and Discussions

3.1. Risk potency

Proper data collection for the management of mud crab at Ohoi Evu, Sorbay Bay just begun at April 2015. From data collection, it was found that mud crab production...
fluctuates from 2015 to 2017. Average mud production in 2015 (April to December) was 173 individuals, increased drastically to 674 individuals (average) in 2016, then decreased in 2017 with an average of 318 individuals. The increase in production is mainly due to more market access and high demand mainly from tourism. This data shows that mud production increase significantly, therefore proper management have to be conducted to maintain sustainability.

Mud crab is one of crustacean with economic value in Indonesia like scalloped spiny lobster [14], mole crab [15], and banana prawns [16] who have risk potency. In Marine Stewardship Council potency risk assessment, the risk assessment is divided into three groups namely risk potency towards species target, non-target species, and towards the habitat [8]. In this analysis, species target is mud crab of the genus Scylla sp., non-target species i.e. lethrinid, a bait fish, and habitats are mangrove ecosystem and lethrinid habitat. Fishing gear used for mud crab fishery are traditional mud crab pot (bubu), and iron stick (gancu), whilst gear used for baitfish are Gill net and hand line.

PSA for risk category of mud crab fishery shows low-risk category. This suggests that the risk potency from fishing gears towards mud crab fishery was considered low [8, 17]. Study on collapsible mud crab pot in Australia also shows low-risk category from mud crab trap [18, 19].

**Table 1.** Final recapitulation of PSA results on mud crab risk potency from bubu and gancu operated in mud crab fishery.

| Component                        | Mud crab species |
|----------------------------------|------------------|
|                                  | *S. serrata*     | *S. olivace* |
| MSC PSA-derived score            | 98               | 98           |
| Risk Category Name               | Low              | Low          |
| MSC scoring guidepost            | ≥80              | ≥80          |
| Consequence Score (CA)           | 80               | 80           |
| Final MSC score (per scoring element) | 89              | 89           |

**3.2. Risk potency for bait fishery**
PSA analysis for risk potency for these two baitfish species shows that risk potenti category was considered low (Table 2). Study on the same species at Philippine [20], however, shows medium risk due to high intensity in term of gear number operated.

**Table 2.** Final recapitulation of PSA results for bait fish risk potency from hand line and Gill net used in mud crab fishery.

| Component                        | Gill net | Gill net | Hand line | Hand line |
|----------------------------------|----------|----------|-----------|-----------|
|                                  | *Lethrinus* sp. | *Lutjanus* sp. | *Lethrinus* sp. | *Lutjanus* sp. |
| MSC PSA-derived score            | 86       | 90       | 86        | 90        |
| Risk Category Name               | Low      | Low      | Low       | Low       |
| MSC scoring guidepost            | ≥80      | ≥80      | ≥80       | ≥80       |

**3.3. Risk potency for habitat**
Table 3 shows CSA (Consequence Spatial Analysis) result for risk potency on mangrove habitat and the coastal bay of Sorbay Bay. This table shows that all fishing gears used in mud crab fishery have a low-risk impact both on mangrove habitat and coastal area.

In mud crab harvesting with bubu, fishermen put the pot at creek area within mangrove ecosystem and covered the pot with some mangrove leaves. This practice has a very low impact on the mangrove ecosystem and the habitat. In hand picking (iron stick),

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fishermen search for mud crab holes and pick up the crab within the whole hence this technique also has a low impact on mangrove.

The final result from Risk-Based Framework using PSA and CSA approach to evaluate Performance Indicator (PI) of species target (PI 1.1.1), species non-target, in this case, bait fish, (PI 2.2.1.) and effect of fishing gear on habitat (PI 2.4.1.) at Sorbay Bay can be seen at Table 4. This table shows that performance indicator (PI) for species target, bait fish, and impact of fishing gear on the habitat of mud crab at Sorbay Bay was unconditional pass according to MSC standard [8].

| Component | Bubu | Gancu | Gill net | Hand line |
|-----------|------|-------|----------|-----------|
|           | Mangrove | Coastal area |
| MSC CSA-derived score | 90 | 93 | 94 | 93 |
| Risk category | Low | Low | Low | Low |
| MSC scoring guidepost | 80 | 80 | 80 | 80 |

| PI | Automated MSC scores | Explanation |
|----|-----------------------|-------------|
| 1.1.1 | 95 | Unconditional Pass | Species target |
| 2.1.1 | FAIL | FAIL | Species primer ¹) |
| 2.2.1 | 95 | Unconditional Pass | Species non-target |
| 2.3.1 | FAIL | FAIL | Species ETP ²) |
| 2.4.1 | 95 | Unconditional Pass | Habitat |

¹) Retain species (Not analyzed); ²) ETP (not analyzed)

3.4. Mud crab sustainability

In the ecosystem approach to fisheries management, the management should be implemented covering six dimensions i.e. bio-ecological, social, economy, technology, ethical, and institutional [13,17,23]. Ecology sustainability analysis for mud crab fishery of Sorbay Bay shows that the sustainability status of this mud crab was at 76.79% of 100% sustainable scale (Figure 2A.), and considered sustain according to an ecosystem approach to fisheries management [11]. This result is slightly higher than a study on the same species at Western Seram which considered less sustain [24] but same as a study on mud crab from Sanleko Village of Buru District [25].

Monte Carlo scatter plot was performed to analyze stability in Rapfish ordination which will determine the validity of the analysis. Figure 2B shows the anchor and reference did not move during the ordination signifying high validly of the test [9,10]. The stress value for goodness of fit was 0.1372 which is < 0.25 indicating good result [26].

The Rapfish ordination for sustainability analysis was performed for the remaining five sustainability dimension and the results are shown in Table 5. Average sustainability was 55.26% and was considered less sustain [13].
Figure 2. Rapfish ordination showing ecology sustainability status of mud crab (A) and Monte Carlo scatter plot showing the stability of ordination (B).

Table 5. Summary result of sustainability status, Monte Carlo scatter plot, stress value and square correlation of mud crab fishery at Sorbay Bay.

| Dimension     | Sustainability level (%) | Monte Carlo | Stress  | R²    | Sustainability Category |
|---------------|--------------------------|-------------|---------|-------|-------------------------|
| Ecology       | 76.79                    | 75.28       | 0.1372  | 0.9528| Sustain                |
| Social        | 52.31                    | 52.23       | 0.1376  | 0.9514| Less sustain            |
| Economy       | 48.98                    | 48.88       | 0.1480  | 0.9482| Less sustain            |
| Technology    | 52.82                    | 52.60       | 0.1413  | 0.9504| Less sustain            |
| Ethic         | 55.15                    | 54.66       | 0.1442  | 0.9481| Less sustain            |
| Institutional | 45.53                    | 45.81       | 0.1426  | 0.9495| Less sustain            |
| Mean          | 55.26                    | 54.91       | 0.1418  | 0.9501| Less sustain            |

3.5. Attribute sustainability

From 59 attributes used in sustainability analysis, the most sensitive attribute from each dimension which affects mud crab sustainability is presented in Table 6. The sensitive attribute can inhibit or foster sustainability [18]. Before WWF involvement in the mud crab fishery in this area, local mud crab fisher never releases berried female caught. Almost no fisheries management exists and local fisher has no influence in the management of the fishery.

Table 6. Most sensitive attribute affecting sustainability of mud crab

| Dimension     | Most Sensitive Attribute       | RMS   |
|---------------|--------------------------------|-------|
| Ecology       | Catch before maturity          | 4.7826|
| Social        | Fisher influence               | 4.8384|
| Economy       | Other source of income         | 2.7808|
| Ethical       | Illegal fishing                | 4.3656|
| Technology    | Illegal fishing                | 4.3656|
| Institutional | Monitor/surveillance           | 4.6996|
4. Conclusion
From this study, it can be concluded that risk potency from fishing activity had a low impact on mud crab, bait fishery with MSC score of 95. The overall sustainability was 55.22% of 100% sustainable score which considered as less sustain. Ecological dimension having high sustainability status (79.79%) which considered as sustain, whilst the lowest sustainability status was the institutional dimension (45.53%) and considered less sustain. Most sensitive attributes towards mud crab sustainability were fisher influence, catch before maturity, monitor/surveillance, and illegal fishing. The ecosystem approach to fisheries management, therefore, is highly recommended in the management of mud crab fishery at Sorbay Bay.

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References
[1] Overton J L, Macintosh D J 2002 Journal Crustacean Biology 22 790-797
[2] Fox N Y, Mangubhai M S 2016 A preliminary assessment of mud crab stocks in mangrove forests in Bua Province Fiji Wildlife Conservation Society Suva Fiji
[3] Garcia S M, Zerbi A Aliaume C, Do Chi T, Lasserre G 2003 The ecosystem approach to fisheries Issues terminology principles intuitional foundations implementation and outlook FAO Fisheries Technical Paper No 443 Rome: FAO
[4] Mollmann C, Lindegren M, Blencotner T, Bergstrom L, Casini M, Diekmann R, Flinkman J, Muller-Karulis B, Neuenfeldt S, Schmidt J O, Tomczak M, Voss R, Gardmark A 2014 Implementing ecosystem- based fisheries management: from single-species to integrated ecosystem assessment and advice for Baltic Sea fish stocks. ICES Journal of Marine Science: Journal du Conseil 71 1187-1197
[5] Fischer J, Jorgensen J, Josupeit H, Kalikoski D, Lucas C M 2015 Fishers knowledge and the ecosystem approach to fisheries: applications experiences and lessons in Latin America FAO Fisheries and Aquaculture Technical Paper No 591 Rome: FAO
[6] COST – California Ocean Science Trust 2013 Overview: PSA test case for selected California Fisheries
[7] Micheli F, De-Leo G, Butner C, Martone R G, Shester G 2014 Biological Conservation 176: 224-235
[8] MSC 2013 Guidance to MSC certification requirements Marine Stewardship Council Guidance V13
[9] Pitcher T J, Preikshot D 2001 Fisheries Research 49 255-270
[10] Kavanagh P, Pitcher T J 2004 Implementing microsoft excel software for rapfish: A technique for the rapid appraisal of fisheries status University of British Columbia Fisheries Centre Research Report 12 (22004)
[11] Pitcher T J, Kalikoski D, Short K, Varkey D, Pramoda G 2009 Marine Policy 33 223 – 232
[12] Rapfish Group 2006 Standard attributes for Rapfish analysis Evaluation field for ecological technological economic social and ethical status Fisheries Center University of British Columbia 5
[13] Pitcher T J, Lam M E, Ainsworth C, Martindale A, Nakamura K, Perry R I, Ward T 2013 Journal of Fish Biology 83 865–889
[14] Damora A, Wardiatno Y, Adrianto L 2018 *Marine Fisheries* 9 11-24
[15] Muzammil W, Wardiatno Y, Butet N A 2015 *Jurnal Ilmu Pertanian Indonesia* 20 78-84
[16] Wagiyo K, Damora A, Pane A R P 2018 *Jurnal Penelitian Perikanan Indonesia* 24 (2) 127-136
[17] Neil M P 2009 Use of Productivity-Susceptibility Analysis (PSA) in setting annual catch limits for US fisheries: an overview Lenfest Ocean Program
[18] Grubert M A, Lee H S 2013 Improving gear selectivity in Australian mud crab fisheries Northern Territory Government Australia Fishery Report No 112
[19] Broadhurst M, Butcher P, Cullis B R 2014 PLoS One 9 (9) 1-9
[20] Banks R, Leadbetter D 2010 Sustainability audit report for groupers and snappers taken in selected municipal and city waters of Zamboanga del Norte province Republic of the Philippines Regional Fisheries Livelihoods Programme for South and Southeast Asia (GCP/RAS/237/SPA) Field Project Document 2011/PHI/1
[21] Le Vay L, Lebata M J H, Walton M E, Primavera J, Quinitio E, Lavila-Pitigogo C, Parado-Estepa F, Rodriguez E, Ut V N, Nghia T T, Sorgeloos P, Wille M 2008 *Review in Fisheries Science* 16 (1-3) 72-80
[22] Staples D, Brainard R, Capezzuoli S, Funge-Smith S, Grose C Heenan A, Hermes R, Maurin P, Moews M, O’Brien C, Pomeroy R 2014 Essential EAFM Ecosystem Approach to Fisheries Management Training Course Volume 1 – For Trainers FAO Regional Office for Asia and the Pacific Bangkok Thailand RAP Publication 2014/13
[23] Cowan Jr J H, Rice J C, Walters C J, Hilborn R, Essingto T E, Day Jr J W, Boswell K M 2012 *Science* 4 496–510
[24] Ayhuwan S M 2013 Study on some biological aspects and sustainability status of mud crab *Scylla serrata* for their management at Pelita Jaya Village Western Seram District BSc Thesis Department of Aquatic Resources Management Pattimura University Ambon
[25] Tetelepta J M S, Lopulalan Y, Pattikawa J A 2018 Status of mud crab (*Scylla* sp) fishery and mangrove ecosystem of Sanleko Village Buru District Indonesia Proceeding The 1st Maluku International Conference on Marine Science and Technology 24-26 October 2018 Ambon Indonesia IOP Conference Paper
[26] Clarke K R, Warwick R M 2001 Change in marine communities: an approach to statistical analysis and interpretation Plymouth Marine Laboratory UK Primer-E Ltd 2nd Edition