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Susceptibility analysis of cuttlefish (*Sepia recurvirostra*) to blue swimming crab fisheries in Keboromo village, Pati

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Susceptibility analysis of cuttlefish (*Sepia recurvirostra*) to blue swimming crab fisheries in Keboromo village, Pati

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Abstract. The coast of Pati Regency and its surroundings are one of the crab sanctuaries on the north coast of Java that have tended to increase in the last decade. The purpose of this study was to analyze the level of vulnerability of cuttlefish (*Sepia recurvirostra*) to crab fisheries in Keboromo Village, Pati. The sample used was the catch of cuttlefish by blue-swimming crab fishermen in Keboromo Village during the research period of June 2023. The productivity value was obtained from the literature, while the parameters of vulnerability were obtained from interviews with local fishermen, which were analyzed using productivity and susceptibility analysis (PSA). The average length of the cuttlefish was 80–125 mm, with a weight of 25–61.6 grams. While having a PSA score of 1.71 with an MSC score of 84.7 (limit > 80). The smaller PSA value indicates the level of vulnerability is still relatively low, so fishing activity pressure has not had a serious impact on the potential sustainability of cuttlefish.

Keywords: blue swimming crab; cuttlefish; PSA; vulnerability

1. Introduction

Pati Regency is one of the areas in Central Java Province that has large-scale fishing operations and the potential for fish stocks to increase significantly, one of which is blue swimming crab [1]. Specifically, Keboromo is one of the crab fishing areas in Pati, where there are at least 100 fishermen and 8 active crab collectors in Keboromo Village. Fishermen make catching crabs in the waters of Keboromo Village, which are 1–15 miles from the seafront. The high selling value found in foreign and domestic markets has led to an increase in the number of crabs caught.

In catching small crabs in Keboromo Village, the majority of fishermen use folding traps. Folding traps are fishing gear that is currently popularly used by fishermen to catch crabs. This fishing gear was first used by fishermen to catch small crabs in early 2000. Folding traps use a net cover made of polyethylene with a mesh size of 25 x 50 mm attached to the trap frame. Because the size of the mesh in the trap is relatively small, small fish have a great chance of being caught in the trap and cannot escape [2].

Besides getting crabs, fishermen also get bycatch such as demersal fish, shrimp, and squid by using folding traps. The bycatch obtained by fishermen is dominated by blekutak (local name) or cuttlefish with the scientific name *Sepia recurvirostra*. The selling price for blekutak in Keboromo Village ranges from Rp. 20,000–25,000 per kg. The market for this blekutak is also very easy to obtain, so many

fishermen catch it as an additional source of income besides small crab [16].

Central Java is one of the provinces that has contributed to national marine fisheries production. Central Java's marine fisheries production in 2021 was 302.40 thousand tons (Central Java Statistics Agency, 2023). One of the contributions of Central Java itself is supported by the marine fishery products of Pati Regency, which amounted to 70,978 tons or 76.59% (BPS Kab. Pati, 2023). Squid is one of the largest capture fisheries products in 2021, amounting to 50,021 kg (BPS Kab. Pati, 2023).

Under these conditions, proper management is needed by reducing the intensity of overfishing, especially for fish species that are vulnerable to being caught. Fish species vulnerability determinations can be made if sufficient data on stock status and fishing impacts are available, however, the vulnerability will be difficult to determine if the availability of data is limited, such as for fish species that are not the target of fishing. To manage blekutak fishing, it is necessary to study the vulnerability of blekutak in these waters. Vulnerability studies can be carried out using the Productivity and Susceptibility Analysis (PSA) method. The method is carried out by assigning a value to each attribute, and this value is used as a reference for entering a species into the category of low, medium, or high vulnerability. The higher the susceptibility value of the species, in this case, the blekutak, indicates that the condition of the stock in the waters has decreased and can be threatened with extinction [3]. This study aims to analyze the level of vulnerability and potential sustainability of the blue swimming crab fishery bycatch.

2. Methods

2.1. Study area

Data collection and interviews were conducted from June 1–30, 2023. The data collection location in Keboromo Village, Tayu District, Pati Regency, as shown in the red mark in Figure 1. During data collection, the tools used included a ruler with an accuracy of 0.5 mm, scales with an accuracy of 0.5 grams. The materials used in this study were samples of fish from the research location.

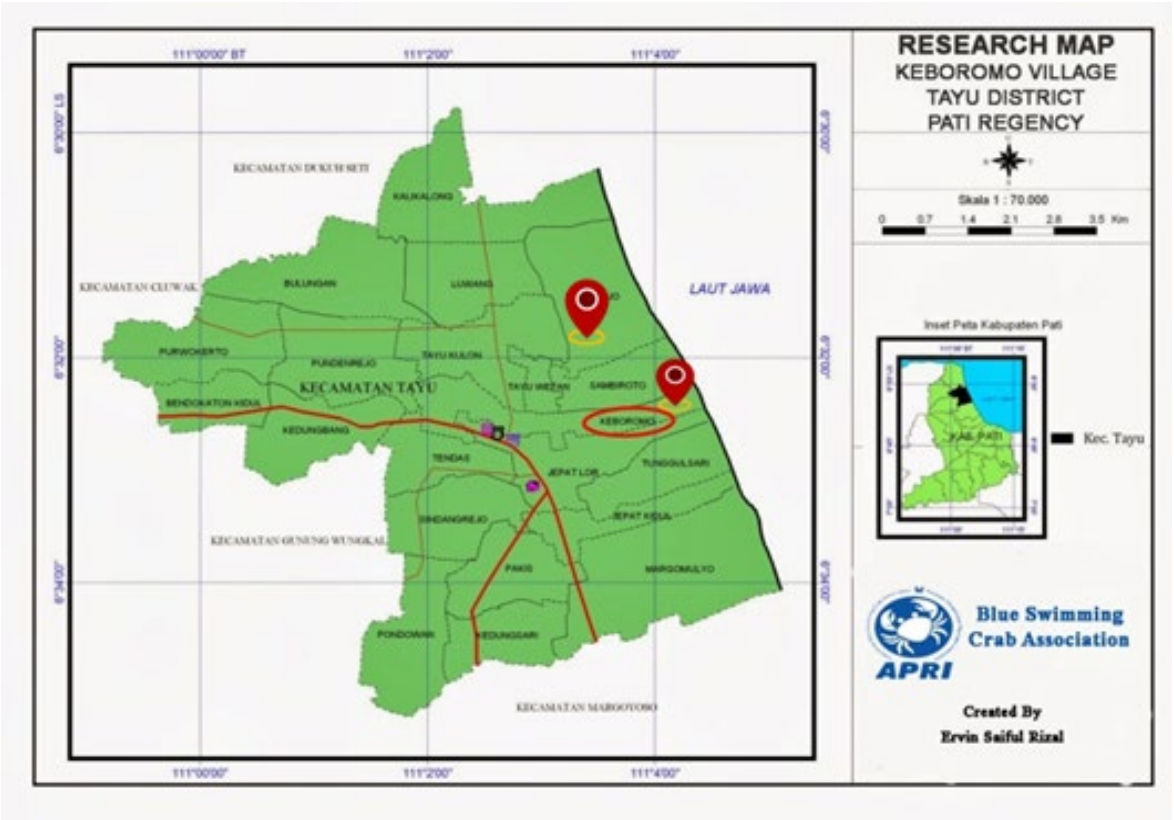

Figure 1. Location of bycatch data collection from collapsible trap of blue swimming crab.

2.2. Data collection

Data collection at the research site was carried out in stages. Data collection was carried out during the morning landings of several crab fishermen. Bycatch was identified as being measured for length and weight, which were selected purposefully and represented all sizes. These data are then used for the process of analyzing susceptibility [4].

Fish resources with high susceptibility and low productivity can lead to a decline in fish stocks in the waters. Decreased productivity of fish stocks in waters due to fishing activities can lead to vulnerability of fish stocks. Therefore, the Productivity and Susceptibility Analysis (PSA) method is needed to analyze the level of vulnerability of fish resources as information for sustainable fish resource management [17].

2.3. Vulnerability analysis

Vulnerability analysis begins with an assessment of the attributes of susceptibility and productivity using scoring techniques. The scoring results obtained are then plotted as data for vulnerability index analysis.

2.4. Data analysis

The analytical method used in this study is the determining parameter of productivity and susceptibility. The productivity and susceptibility parameters, along with their analysis and data collection mechanisms, are presented in Table 1.

Table 1. Productivity and Susceptibility Parameters.

Productivity Parameter	**Database source**	**Analysis**	**Reference**
R (*Intrinsic growth*)	*length frequency*	*growth analysis*	This paper results
Maximum age	*length frequency*	*Reference*	[5]
Max size	*length frequency*	*Reference*	[5]
K *(Growth Coefficient)*	*length frequency*	*Bartalannfy*	[5]
M *(Natural Mortality)*	*length frequency*	*Pauly's empirical equation*	[5]
Fecundity	*Caviare*	*Reference*	[5]
Breeding strategy	*Caviar diameter*	*Cohort analysis*	[5]
Recruitment pattern	*length frequency*	*Normsep and Gausian distribution*	[5]
Age at Maturity	*Length diameter*	*Reference*	[5]
Mean Tropic level	*Food habit*	*Reference*	[5]
Management strategy	Data of catches	PSA	[6]
Overlapping Area	Distibution	Distibution	[5]
Geographic concentration	Distribution	Distibution	[5]
F/M	Length data	Pauly and Evanof formulation	This paper results
Seasonal migration	Data migration	Distribution Pattern	[5]
Schooling aggregation	Schooling	Distribution Pattern	[5]
Morfology affecting	Morfology	Morfology	[5]
Survival after capture	Morfology	Morfology	[5]
Value of the fishery	The economic value of fish	Production value	[7]
Fishery impact to essential fish habitat	Habitat	Distribution and habitat	This paper results

Sepia recurvirostra growth rate was analyzed using the Von Bertalanffy (Sparre and Venema1999) equation with the following formula,

$$\text{Growth rate (daily length)} = \frac{\ln L_t - \ln L_0}{t} \text{x} 100\% \ln(W_t/W_0) \quad (1)$$

Information :
L_t = average total length on day-t
L_0 = average total length on day-0
t = observation day

The growth coefficient was analyzed with the following formula,

$$G_t = \ln(W_t/W_0) \quad (2)$$

Information :
G_t = Growth coefficient
W_t = Weigth at time-t
W_0 = Weigth at time-0

Natural mortality (M) was estimated by the empirical equation method of Pauly (1983)[8] as the following formula,

$$\text{Ln } M = -0{,}152 - 0{,}279 \times \text{Ln } L_\infty + 0{,}6543 \times \text{Ln } K + 0{,}463 \times \text{Ln } T \quad (3)$$

Information :
M = Natural mortality per year
L_∞ = maximum length of fish
K = growth coefficient
T = annual average temperature (^{0}C)

Fecundity refers to Bagenal 1978 [9], which is often associated with length and weight, by depicting it using the following equation,

$$F = a \times L^b \quad (4)$$

$$F = a \times W^b \quad (5)$$

Information :
F = fecundity
a = regression axis
b = regression exponential

To determine the value of vulnerability, an analysis of all productivity and vulnerability attributes is carried out. Each productivity and vulnerability attribute whose characteristics are known is given a score on three risk scales: low (3), medium (2), or high (1) [10]. The attribute scores of each species can then be displayed in an x-y scatter plot. The overall susceptibility score (v) of the stock is calculated using the Euclidean distance equation with the following formula [6].

$$\text{Vulnerability index} = \sqrt{(P-3)^2 + (S-1)^2} \quad (6)$$

Information :
V = vulnerability index
P = productivity score index
S = susceptability score index

The threshold value for the vulnerability analysis is set at 1.8 [11]. If the index value is large (> 1.8), then it is explained that the stock is under pressure and the vulnerability to resources is high, which potentially leads to overfishing conditions. If the vulnerability index value is less than 1.8, it could be caused by high productivity or low susceptibility. This condition is described as having low overfishing potential and a sustainable potential stock.

3. Results and discussion

3.1. Results

The main catch from trap fishing gear is the blue swimming crab (*Portunus pelagicus*). While the type of bycatch is blekutak (*Sepia recurvirostra*), Based on information from several fishermen, the current condition has indicated a decrease in crab catches. This condition indicates that there is a possibility that the population population in the area has declined due to caused by overfishing pressure, so it is feared that it will threaten the sustainability and sustainability of its utilization. To earn additional income, fishermen sell the bycatch of cuttlefish . PSA analysis was carried out by catch at the time of observation at the study site. The results of the recapitulation of productivity values are shown in Table 2. For the analysis of susceptibility data, the *Sepia recurvirostra* obtained was also evaluated with the recapitulation results of the susceptibility parameters presented in Table 3.

Table 2. Productivity values of *Sepia recurvirostra* from collapsible trap of blue swimming crab.

Intrinsic growth (R)	0.6 per year
Maximum age	2 years
Maximum size	17 centimeters
Growth coefficient (K)	0.64
Natural mortality (M)	7.6
Fecundity (F)	30000-40000
Breeding strategy	Spatial spawner
Recruitment pattern	20%
Age at maturity	0.6 per year
Mean tropic level	3.7

Table 3. The Value of Susceptibility *Sepia recurvirostra* from collapsible trap of blue swimming crab.

Susceptability parameter	Results
Management strategy	has no catch limits as it is a by-product of crab fishing, and there are no proactive accountability measures.
Overlapping Area	Overlapping capture areas are 10–35% in the fishing area.
Geographic concentration	>70% spread throughout the fishing grounds
F / M	0,01
Seasonal migration	Not all species make seasonal migrations, but many species do in reaction to changes in temperature, especially in the subtropics.
Schooling aggregation	Group
Morphological factors	Folding traps are environmentally friendly fishing gear, so they do not affect the morphology of the fish caught
Survival after capture	The majority died after being caught.
Value of the fisheries	The selling price is quite high, Rp. 20,000 per kg.
Fisheries impact to essential fish habitat	Bubu is an environmentally friendly fishing gear, so there is no adverse impact on the environment or other fish resources.

Growth rate (R) was 0.6 per year, maximum age was 2 years, and maximum length was 17 cm. The result for the growth coefficient (K) value was 0.64. The natural mortality (M) value obtained for each fish was 7.6. The recruitment pattern yielded 20%, and the broodstock used was spatial spawning. Data on age at first gonad maturity and average tropic level were obtained from fish-based media. The result of age at first gonadal maturity for each fish was 0.6 years, and the average tropic level was 3.7. High vulnerability potential is usually seen in the high number of immature fish caught [12], such as in the northern Java Sea waters. Vulnerability parameters show that the area overlap rate is above 30%, and the maturation of fishing gear by depth is also high. [13] stated that vertical overlap affects vulnerability due to feeding patterns, latitude, and changes in water temperature. The size at the time of gonad maturity is larger than the mesh size of the folding traps.

3.2. Vulnerability

The total productivity score for cuttlefish averaged 1.33, with a total vulnerability of 1.05 obtained. Cuttlefish shows a slightly higher than average threat value. The pattern explains that the cuttlefish has a fairly good level of resilience, but needs to be aware of the potential for overexploitation. The results of the calculation of vulnerability of cuttlefish caught as bycatch in Table 4 show that cuttlefish has a high productivity value and a low threat, so its vulnerability is low, and it can be concluded that the potential for capture is lower. In fisheries management based on limited data, the PSA analysis technique actually takes into account biological and ecosystem conditions [14]. In the productivity parameter, some data sets related to life history have also considered sustainable fisheries management development strategies [15] after knowing the vulnerability status.

Table 4. *Sepia recurvirostra* productivity, susceptibility, and susceptibility scores from collapsible trap of blue swimming crab.

	Parameter Attributes	Result
Produktivity score (1-3)	Average age at maturity	1
	Avarage max age	1
	Fecuncity	1
	Average max size	1
	Average size at maturity	1
	Reproductive strategy	1
	Tropic level (fishbase)	3
	Total Productivity (average)	1.33
Susceptability score (1-3)	Availability	1
	Encounterability	1
	Selectivity	1
	Post-capture mortality	3
	Total (multiplicative)	1.05
	Score PSA	1.71
	Score MSC	84.7
	Risk Category	Low
	Score limit MSC	>80

4. Conclusion

Continuous crab fishing using folding traps not only risks vulnerability of the target species, but also of bycatch and discard species. Research on crab fisheries in Keboromo Village shows a low level of vulnerability and potential for sustainability. This condition is also influenced by the high level of productivity and low vulnerability of the object under study.

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Author Contribution

Ervin Saiful Rizal : conceptualization, methodology, writing-original draft.

Kamal Mustabiq : review the original draft based on previous research, editing, investigation.

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