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Assessment of grouper and snapper fisheries with EAFM approach and sustainable strategy management in Sumbawa-Indonesia

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Abstract. The utilization of grouper and snapper resources in Teluk Cempi, Teluk Waworada and the waters of Sape has not been carried out in a sustainable manner, so it is feared that it will interfere with stock availability and the sustainability of grouper and snapper fishery resources. This study aims to assess the status of management and policy strategies for sustainable grouper and snapper fisheries resource management. The data was collected by using a structured interview technique using a questionnaire, Focus Group Discussion, and public consultation. Analysis of the status of grouper and snapper fisheries resources using the Ecosystem Approach to Fisheries Management (EAFM) indicator. The results showed that the condition of grouper and snapper fisheries management is classified as "Less" with an aggregate score 39.6. Sustainable grouper and snapper fisheries management strategies can be carried out through several efforts, including: regulating the allowable quota and fishing time, arrangement of fishing gear, development of artificial coral reef technology and mangrove rehabilitation controlling water quality, optimizing the use of selective fishing gear, livelihood alternatives, management working groups, development for facilities and infrastructure for fisheries supervisors and strengthen institutions (Pokmaswas), knowledge, attitude and practices assistance to fishing communities and formulation of management plan.

1. Introduction

Teluk Cempi, Teluk Waworada and the waters of Sape are part of the fisheries management area (WPP NRI 573) which is the habitat for various types of fish resources so that they have high potential fishery resources, including coral, grouper, and tuna fisheries resources [1]. Coral fisheries, especially grouper and snapper, are strategic fisheries resources, because they have high economic value.

Sustainable management of grouper and snapper fisheries is important to maintain stock availability and ensure business sustainability. The study was conducted as a consideration for sustainable grouper and snapper management and to obtain the value of the fisheries reference point in policy making related to catch restrictions. Fishery reference point is one of the tools that becomes the basis for policy making related to catch restrictions. The results of the study are expected to become a reference for the government in developing national fisheries, particularly the sustainable grouper and snapper fisheries management program in Indonesia

2. Methodology

2.1. Location dan time

Data collection was carried out in Teluk Cempi, Teluk Waworada and Sape, Sumbawa Island, NTB Province (Figure 1). This location was chosen because it is a center for grouper and snapper fishing in WPP NRI 573. The research was conducted for 30 months from June 2016 - December 2018.
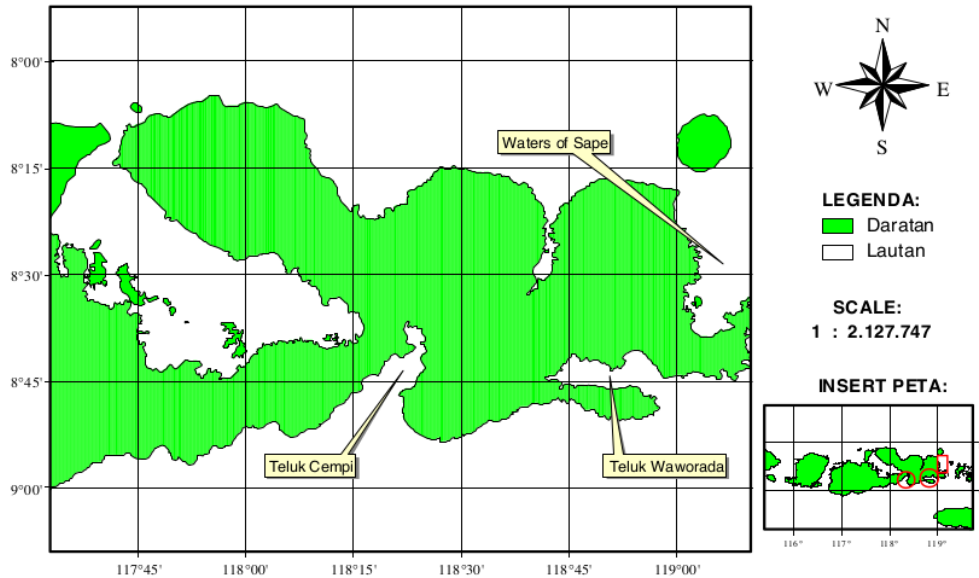
Figure 1. Location of data collection for grouper and snapper fisheries assessment on the island of Sumbawa – NTB (WPP NRI 573)

2.2. Data collection

Primary catch data collection is carried out 7-15 days every month for 18 months and sample data (non-trip/fish length) is carried out every day. Location of grouper and snapper data collection in Hu'u (Teluk Cempi), Rompo (Teluk Waworada) and Dusun Bugis, Bajo Gusung (Waters of Sape). Collecting data through structured interview techniques using a questionnaire, Focus Group Discussion (FGD), and public consultation.

2.3. Data analysis

To undertake an assessment for grouper and snapper fisheries in Sumbawa Island, EAFM approach was applied. The EAFM approach was carried out using 32 indicators represented from 6 habitat domains, there are fish resources, habitat and ecology, fishing technology, economy, social and institution. The next step, flag modeling techniques was applied using multi-criteria analysis (MCA) through the expansion of composite index [2]. Composite index calculations was result some values in each domain which are then used to determine the aggregate composite value of grouper anda snapper fisheries in Sumbawa Island.

For fish resources aspect, the analysis of the utilization of grouper and snapper fisheries uses the Length-based Spawning Potential Ratio (LBSPR) approach, with the estimation of the spawning potential ratio (SPR) with parameters of natural mortality (M), growth coefficient (K), asymptotic length (L∞), and maturity length (Lm). The analysis was carried out using the LB-SPR method requiring the distribution of fish length frequencies as input [3]. Criteria for assessment of reference points for grouper and snapper Fisheries is shown at Table 1.

Table 1. Criteria for assessment of reference points for grouper and snapper fisheries

Reference Point Utilization	Flag Model	Description
Target Reference Point SPR>30% atau >0,3	Under exploited (symbolized in green)	Safe status
Warning Reference Point SPR = 20 - 30% atau <0,2-0,3	Fully exploited (symbolized in yellow)	Less safe status
Boundry Reference Point SPR < 20% atau <0,2	Over exploited (symbolized in red)	Status threatened (unsafe)

Limitation in analyzing the assessment of grouper and snapper fisheries utilization in the study location:

1. Stock study parameters include : catch per unit effort (CPUE), growth parameters (fish age and fish body length), length of first adult fish (Lm), length of first time fish caught (Lc), mortality and exploitation rate and ratio spawning potential (spawning potential ratio/SPR).
2. Grouper and snapper fisheries in Sumbawa waters are small-scale fisheries, with a total of 22,976 fishing boats with a size of <5GT of 77%, so that several indicators related to licensing and completeness of vessel certificates have maximum scores because licensing is not a requirement for small-scale fishermen.
3. The data used in the analysis is the best available data, both from secondary data, calculation results, and from interviews.

3. Results and discussion

The number of grouper and snapper fishing boats at the study location was 22,976 units [4]. The number of individual grouper 4,148, the number of snapper 686 and the number of other fish individuals 192. The fishing gear used includes speargun 24%, troll line 13%, handline 29% and bottom longline 34%. Types of grouper caught at the study site include kerapu minyak (Epinephelus areolatus), kerapu karet (Epinephelus fasciatus), kerapu ekor bulan (Variola albimarginata), kerapu ekor bulan (Variola louti), kerapu bintik merah (Cephalopholis miniata), kerapu nurhayati (Epinephelus fasciatus), kerapu sunu halus (Plectropomus leopardus) and kerapu sunu kasar (Plectropomus maculatus), while the types of snapper that are widely exploited are kerisi bali (Etelis coruscans), kakap merah (Lutjanus boutton), kakap merah (Lutjanus gibbus), Lutjanus rivulatus and Lutjanus bohar with size when first caught an average of 25 cm (weight ± 240 gr) [5]. Dominant fishing gear are spearg, handline and bottom longline.

3.1. Status of grouper fisheries management

The calculation of the composite value of the 6 domains (Table 2) using the EAFM approach shows the lowest composite value in the domain of fish resources and fishing techniques with a "bad" status, while the habitat and aquatic ecosystems are classified as "lacking", and the Social, Economic and institutional domains are classified status "moderate".

Table 2. Composite Assessment of "Grouper Snapper Fishery Management in Teluk Cempi, Teluk Waworada and Sape"

Domain	Composite Value	Description
Grouper and Snapper Resources	30	Bad
Habitat and aquatic ecosystem	38	Less
Capture Technology	34	Bad
Social	46	Moderate
Economy	45	Moderate
Institutional	45	Moderate
Aggregate	**39.6**	**Less**

3.1.1. Grouper and snapper resources. The composite value of the fish resource domain is classified as "bad" with a score of 30, because the fishermen's catch decreased significantly from 2008 to 2018, fishermen get an average catch of 1 to 10 kg per trip, especially hand-line fishers, longline fishing line, trolling line, fish size < 300 grams, it is very difficult to find fish measuring 5 kg per fish. The fishing ground is getting further away, in 2008 it took 30 minutes to the fishing ground location, while in 2018 it took 2 hours. The types of ETP (Endangered species, Threatened species, and Protected species) caught were turtles, but in the last 2 years they were not caught. The assessment of the CPUE value indicator was obtained from the results of interviews with grouper-snapper fishermen at the study location as shown in the **Table 3 and Table 4**.

Table 3. Efforts to catch, catch, CPUE, and FPI for each fishing gear in Teluk Cempi, Teluk Waworada.

Fishing Gear	Trip	Total Catch (kg)	CPUE	FPI
Speargun	152	249.85	1.64375	0.92636
Troll line	54	133.4	2.47037037	1.392214
Handline	172	305.2	1.774418605	1
Bottom longline	171	362.4	2.119298246	1.194362

Table 4. Efforts to catch, catch, CPUE, and FPI for each fishing gear in Sape.

Fishing Gear	Trip	Total Catch (kg)	CPUE	FPI
Speargun	152	372	2.447368421	0.909174
Troll line	54	195	3.611111111	1.341493
Handline	172	463	2.691860465	1
Bottom longline	171	410.5	2.400584795	0.891794

The condition of grouper-snapper resources in the Teluk Cempi, Teluk Waworada and Sape is said to have experienced growth overfishing and recruitment overfishing [6]. Growth overfishing occurs when fish are caught before they have grown, and recruitment overfishing occurs due to a reduction in the number of young fish entering the fishing area [7]. Recruitment overfishing for snapper and grouper fisheries in Teluk Cempi, Teluk Waworada and Waters of Sape is occurs due to habitat degradation affecting the nursery area.

Table 5. Conditions of snapper grouper fisheries at study locations in 2018.

No.	Spesies	Parameter Pertumbuhan				Mortalitas			
		$L\infty$	k	t_0	A_{max}	M	Z	F	E
1.	*Cephalopholis miniata*	45.02	0.26	-0.57	12	0.35	0.68	0.33	0.48
2.	*Cephalopholis sexmaculata*	50.78	0.23	-0.61	13	0.32	1.16	0.85	0.72
3.	*Cephalopholis sonnerati*	55.69	0.21	-0.64	14	0.3	0.74	0.44	0.59
4.	*Cromileptes altivelis*	61.57	0.23	-0.60	13	0.36	0.68	0.36	0.46
5.	*Epinephelus fasciatus*	40.62	0.22	-0.70	14	0.62	1.01	0.38	0.38
6.	*Plectropomus leopardus*	79.99	0.13	-0.93	22	0.19	0.44	0.25	0.58
7.	*Plectropomus maculatus*	76.33	0.11	-1.22	28	0.15	0.32	0.18	0.54

8.	Plectropomus oligacanthus	77.58	0.10	-1.30	30	0.14	0.24	0.09	0.40
9.	Variola albimarginata	60.44	0.17	-0.80	18	0.23	1.01	0.78	0.76
10.	Variola louti	70.87	0.16	-0.79	18	0.23	0.42	0.19	0.44
11.	Lutjanus gibbus	54.38	0.23	-0.62	14	0.30	0.61	0.32	0.51

Table 6. Stock condition of snapper grouper caught in 2016-2018 at the study location.

No.	Spesies	Lmin	$L_{rata-rata}$	L_m	L_{opt}	L_c	Lc_{opt}	A_{mat}	Lifespan	SPR
1	Cephalopholis miniata	15.4	29.25	25.49	28.11	24.56	25.79	2.62	10.89	0.28
2	Cephalopholis sexmaculata	22.86	30.05	28.4	31.86	26.28	31.71	2.85	12.01	0.16
3	Cephalopholis sonnerati	21.78	34.8	30.86	35.08	34.71	33.08	3.05	13.05	0.36
4	Cromileptes altivelis	16.65	33.02	33.76	38.95	29.11	33.2	2.83	12.33	0.48
5	Epinephelus fasciatus	14.01	26.71	23.24	25.25	26.39	16.7	3.15	12.87	0.55
6	Plectropomus leopardus	21.36	43.39	42.71	51.16	31.57	47.16	4.54	20.46	0.17
7	Plectropomus maculatus	22.88	41.57	40.95	48.72	32.51	44.43	5.82	26.19	0.2
8	Plectropomus oligacanthus	24	46.89	41.55	49.55	33.4	42.76	6.20	27.95	0.38
9	Variola albimarginata	20.85	28.88	33.21	38.21	29.87	38.65	3.78	16.39	0.1
10	Variola louti	25	41.54	38.31	45.1	35.21	39.75	3.80	16.86	0.39
11	Lutjanus gibbus	16.86	12.39	30.2	34.22	23.47	27.94	2.87	12.39	0.21

3.1.2. Habitat and aquatic ecosystem. Habitat and aquatic ecosystems are classified as "less" with a score of "38", caused by mangrove degradation with a decrease in area during 2001 covering 19,280 ha and becoming 11,132 ha in 2004. The dominant bay waters are covered by 3 types of substrates, namely algae (33.10%), hard corals (29.48%), and soft corals (26.92%). Other types of substrate sand < 10%. Hard coral genera such as Acropora (27%), Porites (25%), and Montipora (13%), while other genera < 10% [8]. According to respondent information, destructive fishing activity has occurred. The results of the interviews indicated that there were unique/special habitats around coral reefs and were spawning ground locations, but they had not been managed sustainably.

3.1.3. Fishing technique. The fishing technique is classified as "bad" with a score of "30", due to the use of compressor and arrow fishing gear, which results in many small groupers being caught. The use of a compressor is a fishing technique that is prohibited under Law No. 3/2004 on Fisheries and Law No. 45/2009 on Amendments to Law No. 31/2004 on Fisheries.

   Grouper and Snapper fishermen are classified as small-scale fishers with fishing units measuring <5 GT with an LOA of 4.5-10 meters, therefore, fishermen like this are not required to have boat documents, only have a fishing card as a legal document to carry out fishing activities. In Pemen KP No.5/2019 concerning Amendments to Permen KP No. 23 concerning Registration and Marking of Fishing Vessels, it is stated that the vessels that must be registered are vessels > 10 GT, so that the grouper-snapper in Teluk Cempi, Teluk Waworada and Waters of Sape do not have crew certification as well as a certificate of expertise related to fishery activities.

3.1.4. Social. The social domain is classified as "medium" with a score of "46", because fishermen think that government involvement in the management of grouper-snapper resources is still lacking, especially in terms of supervision. Horizontal conflict occurs between fishermen with compressor, speargun and handline. The conflicts can be resolved in ways that are democratic and constructive so that parties in conflict get the opportunity to solve the problems they face or by involving neutral and fair third parties to help the parties in conflict solve the problem [9]. Fishermen have good local knowledge of grouper-snapper resources based on fishing experience, among other things, that fishermen know that grouper-snapper is spawning and foraging, but local knowledge has not been utilized in proper management of grouper-snapper resources.

3.1.5. Economy. The economic domain is classified as "medium" with a value of "45", because the ownership of assets is low and the monthly household income of fisheries is below the provincial minimum wage. The results of the interview, 37.42% of respondents have net income > Rp. 3,000,000 per month; 16.42% of respondents have a net income of 2-3 million per month; 48.32% of respondents net income of 1-2 million rupiah per month; and 11.84% of respondents with net income < 1 million rupiah per month. Based on the NTB Governor's Decree Number 561-774 of 2018, the NTB Province minimum wage is Rp. 2,012,610 per month.

Awareness of saving is still low, income is used to meet consumption needs. The results of the interview were only 23.55% of respondents saved 20-50% of their monthly income. The purpose of saving is for health insurance, children's school needs, and guarding against urgent needs, while 76.45% of respondents do not save because they do not have dependents for their children study.

3.1.6. Institutional. The institutional domain is classified as "medium" with a value of 45 ", because fishermen have not fully followed the existing rules even though they are available. Grouper fisheries are dominated by small catches below 300 grams. The level of compliance of fishermen to the principles of responsible fisheries is also low, exacerbated by the low level of policy and institutional synergy because it is not clearly programmed.

4. Conclusion
The results of the analysis of grouper and snapper fishery status based on EAFM assessment indicate that the management condition of grouper and snapper is classified as less. Based on that, the strategy that the government needs to implement in future snapper and grouper management are: regulating the allowable quota and fishing time, arrangement of fishing gear, development of artificial coral reef technology and mangrove rehabilitation controlling water quality, optimizing the use of selective fishing gear, livelihood alternatives, grouper and snapper fisheries management working groups, development for facilities and infrastructure for fisheries supervisors and strengthen institutions (Pokmaswas), knowledge, attitude and practices assistance to fishing communities and formulation of management plan.

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