Study Bioecological of Banggai Cardinalfish in the Sea Waters of Banggai Laut Regency, Indonesia

ABSTRACT

Indonesia is a country with a high level of biodiversity. This is proven by the large number of fish and coral species. The large amount of biodiversity also makes it possible for Indonesia to have endemic species, one of which is the Banggai Cardinalfish. Banggai Cardinalfish (pterapogonkauderni) is an endemic species found in the Banggai Islands, Central Sulawesi, Indonesia. This research aims to look at the bio-ecological conditions of the Banggai Cardinalfish. This research was carried out in January-March 2014 indistrictBanggai Utara, Banggai Laut Regency, Central Sulawesi Province. The research was carried out using the method of observing and monitoring the number of *Pterpogonkauderni**populations* at predetermined stations and measuring the quality of sea waters at each station. Population monitoring is carried out using the *Belt transect method.* The data obtained was then analyzed using population density analysis. The water quality data obtained is then compared with sea water quality standards according to PP No. 22 of 2021 . Based on the research results, it is known that the highest population of Banggai Cardinalfish was found at station III with a total population of 15.92 individuals/m^2 . The population is dominated by juveniles 12.60 individuals/m^2, recruits 1.14 individuals/m^2 and adults 2.18 individuals/m^2. The highest population of associated biota was found at station III with a population of sea urchins of 0.91 individuals/m^2 and sea anemones of 0.08 individuals/m^2. Water quality conditions at each station are temperature 29.3-31.8 ^{o} C (optimum) , pH 8.01-8.19 (optimum), DO 7.9-11.04 ppm (optimum) , Salinity 34-41 ppt (Less optimal).

Keywords: Bioecology; Banggai cardinalfish; Banggai Laut

1. INTRODUCTION

Indonesia is part of *The Coral Triangle region* , which is a region that has a very high level of biodiversity and is the center of marine biota diversity [1]–[3] . This high level of biodiversity allows for native/endemic marine biota species that are only found in Indonesian waters. Banggai Cardinalfish (*Pterapogonkauderni*) is a species native/endemic to the Banggai Islands-Central Sulawasi, and one of Indonesia's Endemic Coral Fish Species [4], [5] . This species has a distribution area of 5,000 km^2 with a potential habitat area of 20-24 km^2, its main habitat is coastal areas containing coral reefs and seagrass beds with a depth of 0-5 m [6] .

current existence of *Pterapogonkauderni has experienced a decline in population numbers due to human activities, both due to fishing, land use and so on. Pterapogonkauderni*has

Comment [R1]: Capital letter necessary at the genus name. Italic in scientific names.

Comment [R2]: Unnecessary italic here and in other parts of the document (not highlighted). Be more care about formatting before submitting a paper. To many errors in this sense hampers the manuscript's evaluation.

Comment [R3]: It is necessary to correct verbal time throughout the document. Some situations were pointed out (not all of them).

Comment [R4]: It is necessary to correct verbal time throughout the document. Some situations were pointed out (not all of them).

Comment [R5]: "Station III" it is not a reference known by the readers. The information that four distinct sites were assessed it is fundamental to the abstract. Then, it is possible to present that there were diferences between sites, naming Bone Baru village (Station III) and the values recorded.

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Comment [R7]: Review the phrase wrinting, particularly this term. It is confusing.

Comment [R8]: Suggestion: first citation of the species name should be followed by its describing author within the zoological nomenclature code. In the papers case, it should be: *Pterapogon kauderni* Koumans 1933

Comment [R9]: It seems that there is a "The" missing at the begining of the paragraph.
Although, my sugestion is to begin the paragraph by the species name (exclude 'current existence of')

Comment [R10]: If there are other important human activities that prejudice P. kauderni' conservation they should be brougth here, accompained by the litereture references.

It is possible to say that there are several studies on P. kauderni's conservation and biology that can be used to improve the writing.

There is room to be more specific about how fishing prejudice this species. It could be useful to highlight the major problems, that will facilitate the writing of the following paragraphs, especially concerning the management policies taken by the Indonesian government.

been categorized as an endangered species in the 17th CITES CoP in 2016, Appendix I. This decision requires Indonesia to ensure the preservation of this species by carrying out conservation and sustainable management [7]–[9] .

The Indonesian government through the Decree of the Minister of Maritime Affairs and Fisheries of the Republic of Indonesia has issued decision Number: 49/KEPMEN-KP/2018 concerning Determination of the Limited Protection Status of the BanggaiCapungan Fish (*Pterapogonkauderni*). Along with the Decree of the Minister of Maritime Affairs and Fisheries Number: 53/KEPMEN-KP/2019 concerning coastal conservation and the Banggai Small Islands, Banggai Sea, Banggai Islands and the surrounding waters of Central Sulawesi Province. To maintain the preservation of *Pterapogonkauderni*in its natural habit.

Based on monitoring in 2019, the population status of *Pterapogonkauderni*at 8 monitoring locations in the Bokan Islands showed a decline in the population of *Pterapogonkauderni*and its associated biota (sea urchins and sea anemones) [10] . Judging from the results of previous population monitoring, it is necessary to re-monitor the *Pterapogonkauderni population* in other locations in the Banggai Islands. The waters of North Banggai District, Banggai Laut Regency are one of the areas where *Pterapogonkaudernilives,* and have been designated by the KKP as part of the coastal and small island conservation area in Central Sulawesi Province. This area is also a beach tourist attraction in Banggai Laut Regency.

The existence of aquatic biota populations cannot be separated from the quality conditions of the waters. Water quality can be broadly interpreted as physical and chemical factors that influence the life of fish and other aquatic organisms, either directly or indirectly [11] . Monitoring water quality aims to maintain ecosystems and aquatic habitats, because these two components are very easily affected by a decrease in water quality [12] . Therefore, this research aims to determine the population density of *Pterapogonkauderni*and water quality in BanggaiUtara District, Banggai Laut Regency.

2. MATERIALS AND METHODS

2.1 TIME AND PLACE

The research was carried out in January-March 2024 located inBanggai Utara District, Banggai Laut Regency, Central Sulawesi Province. This area is an area that is included in the conservation area that has been designated by the KKP in PERMEN KP Number: 53/KEPMEN-KP/2019. The data collection location can be seen in Figure 1.

Comment [R11]: Review text. There is no coherence.

Comment [R12]: Suggestion: after the first citation, present the species name as *P. kauderni*.

Comment [R13]: Sugestion: it is repetitive. Improve text cohesion.

Comment [R14]: Present the full name with the acronym between parenthesis in the first use.

Comment [R15]: The tourist attraction is anm issue to the species conservation, and could be brought more specifically at the second paragraph, highlighting the importance of this study.

Comment [R16]: Be more specific. To present the specific date of each sampling trip, and even the hour can be useful. Any other caracteristics are wellcome considering that you are noticing the necessity to adjust sampling design becaouse of the tidal influences.

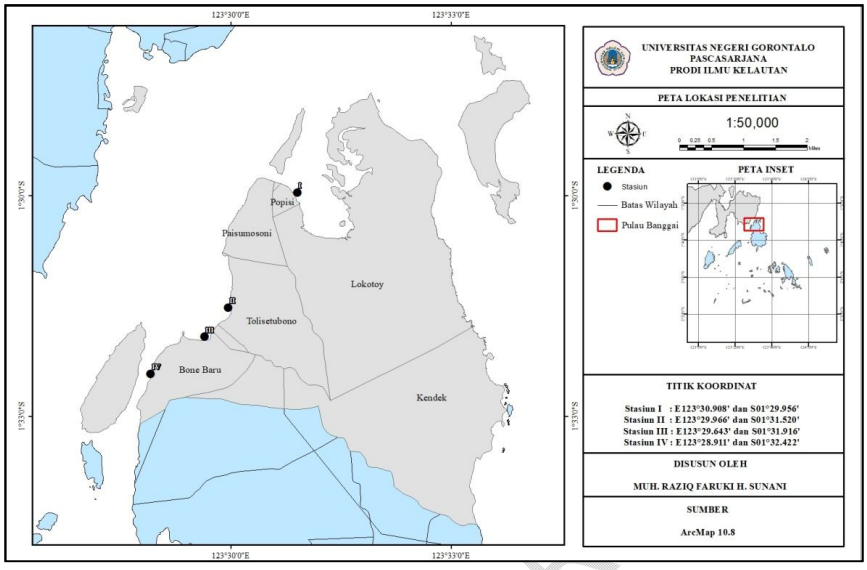

Figure 1. Research Location

Data collection on population and water quality was carried out at four location points, namely:

1. Station I Popisi Village: E123 ^{o} 30,908' and S01 ^{o} 29,956'
2. Station II Tolisetubono Village: E123 ^{o} 29,966' and S01 ^{o} 31,520'
3. Station III Bonebaru Village: E123 ^{o} 29,643' and S01 ^{o} 31,916'
4. Station IV Bonebaru/Bongo Village: E123 ^{o} 28,911' and S1 ^{o} 32,422'

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2.2 TOOLS AND MATERIALS

The tools and materials used in this research can be seen in table 1.

Table 1. Tools and materials in research

No	Tools/Materials	Works
1	ATK	Data Logging
2	Water Quality Check	Measuring Temperature, pH and DO
3	*Refracto meter*	Measuring salinity
4	*Drifter Buoy*	Measuring current speed
5	Meter Roll	Measure
6	Camera	Documentation

2.3 RESEARCH METHODS

Comment [R17]: Suggestion: Unify the sections "**2.2 Tools and Materials"** and "**2.3 Research Methods**", name it "SAMPLING", then exclude the table 1 and present its content in full sentences.

Comment [R18]: Improve caption

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The research was carried out using survey methods and direct observation at predetermined research locations. Data collection in this research was by monitoring the population number of *Pterpogonkaudernia*t predetermined stations and measuring the quality of sea waters at each station. The technique for collecting data on population numbers and water quality can be seen as follows.

a. Number of Populations of *Pterpogonkaudernir*efers to [13]
   1) Observations were carried out placing transects parallel to the coastline at a depth of 1.5-3 m where Banggai Cardinalfish are generally found. However, it will have to be adjusted to tidal conditions;
   2) Observations were made using the *belt transect method.* The size of the transect is 20 m long and 5 m wide (transect area 10 m ^{2}), namely 2.5 m wide on the right and 2.5 m on the left (figure 2);

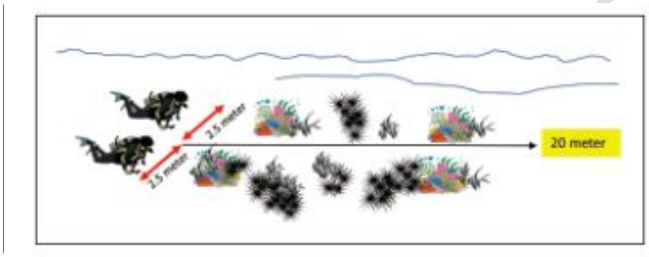

Figure 2. Population survey *of Pterapogonkaudernii*using the *belt transect method* [13]

   3) Data collection was carried out by two divers with each diver dividing the task of collecting fish data, each on the left and right of the transect;
   4) SumuaBanggai Cardinalfish found were recorded based on fish size categories.

b. Water quality
   1) Water quality measurements carried out *in-situ* in the field include temperature parameters (^{o}C), pH, DO (ppm), salinity (ppt), current speed (m/s), waste and odor.
   2) The water sampling technique is carried out in a composite manner between the bottom of the water and 30 cm from the water surface;

2.4 DATA ANALYSIS

The data analysis used is descriptive qualitative, namely describing existing conditions analytically and synthesizing them integrally. Data from *the Pterapogonkauderni population survey* and associated Biota were analyzed to determine the density of fish at each location and size category using a density formula based on the following monitoring guidelines from the Ministry of Marine Affairs and Fisheries:

$$Kepadatan\ (individu/m^2) = \frac{Jumlah\ total\ individu\ ikan}{100}$$ ---------- [13]

Comment [R20]: What do you mean by that? It is important to specify the methodological issues, affecting or not the results. They are important to sampling design assessment, as well its improvement in future works.

The location of sampling sites must be adjusted in future studies or the timming of tidal conditions better calculated?

Comment [R21]: This figure can be inserted after de item 4 to a better presentation.

Comment [R22]: How many transects per sampling site?

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Comment [R25]: These two characteristics were only mentioned here. Remove them or detail how it was done (scale used) and present the results.

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Water quality measurement data is analyzed by comparing with quality standards based on PP No. 22 of 2021 concerning Sea Water Quality Standards.

3 . RESULTS AND DISCUSSION

3.1Population Conditions of *Pterapogonkauderni*

*Pterapogonkauderni*population survey are presented in Figure 3. Based on Figure 3, the most numerous *Pterpogonkauderni*population is at station III which is dominated by the very high presence of Juveniles reaching 12.60 Individuals/m ^{2}, then Adults 2.18 Individuals/m ^{2} and Recruitment 1.14 Individuals/m^2.

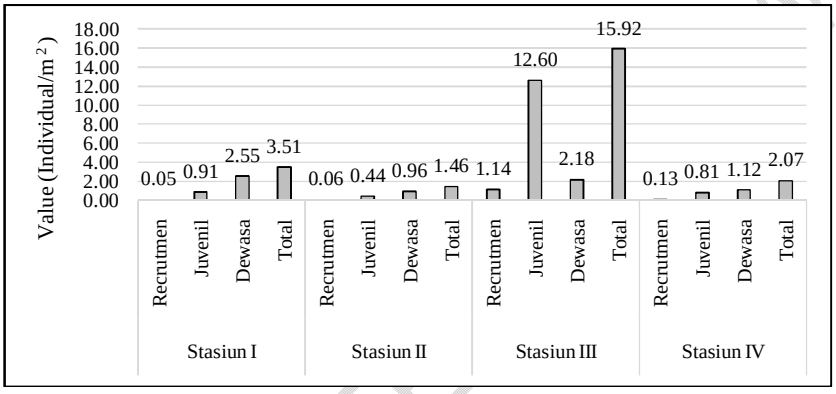

Figure 3. Population Density of *Pterpogonkauderni*

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The high population at station III is thought to be due to the large number of associated biota and coral reefs at this station. It is known that *Pterapogonkauderni*can be found in seagrass and coral reef ecosystems in the form of *fringing reefs* and *reef flats* [7] . Coral reefs are ecosystems that provide a place for fish to shelter, spawn and provide food.

The lowest population density was found at station II with the number of recruits being 0.06 individuals/m^2, juveniles 0.44 individuals/m ^{2} and adults 0.96 individuals/m ^{2} . The low population of *Pterapogonkauderdi*at station II is thought to be due to the lack of associated biota at that location. The absence of an ecosystem that supports the existence of this species and its associated biota can affect its population density. *Pterapogonkauderni*does not have a self-defense mechanism so it needs associated biota to avoid predators. It is known that for most of its life it coexists with biota, its main associations are sea urchins, soft corals and sea anemones [7], [10], [14] .

3.2 Condition of Association Biota

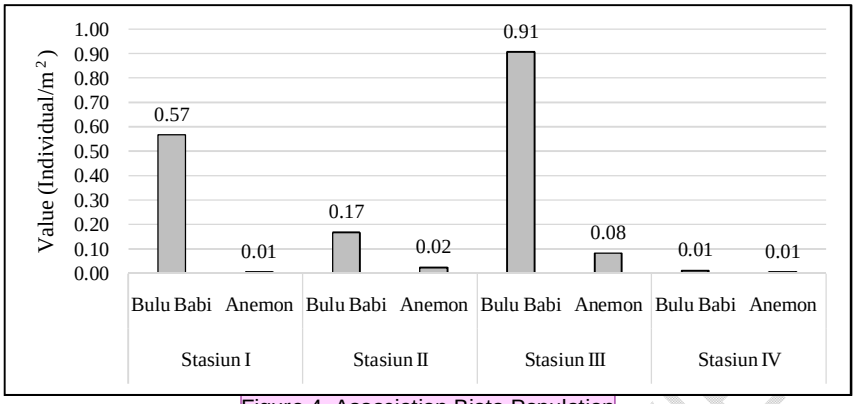

Figure 4. Association Biota Population

Based on Figure 4. The population of associated biota (sea urchins and anemones) is most abundant at station III with a density of sea urchins of 0.91 individuals/m ^{2} and anemones of 0.08 individuals/m ^{2} . Meanwhile, the lowest was at station IV with a density of both associated biota, namely 0.01 individuals/m ^{2} .

It is strongly suspected that the existence of associated biota at Station IV is because it is captured for consumption by the local community. Tourist activities can also be the cause of the reduction in sea urchins in the area. As is known, this area is a tourist spot for local people on Banggai Island. The loss of associated biota is caused by habitat degradation caused by human activities and climate change[7], [10] .

3.4 Water Quality

Water quality conditions at each research location can be seen in table 2.

Table 2. Water quality at the research location

Parameter	Location				Quality Standards (PP No. 22 of 2021)	Note.
	Station I	Station II	Station III	Station IV		
Temperature (^{o}C)	29.8	29.9	29.3	31.8	28-32 ^{o}C	Optimal
pH	8.06	8.08	8.01	8.19	7-8.5	Optimal
DO (ppm)	7.9	11.04	8.1	11.04	> 5 ppm	Optimal
Salinity (ppt)	35	34	41	36	33-34 ppm	Bad

Comment [R29]: Translate the text inside the graph. Improve the Figure caption.

Comment [R30]: The methods of assessment the biota associated was not mentioned.

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Comment [R32]: These hypotheses must be linked with references.

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Based on the research results (Table 2), it is known that the water quality conditions for temperature, pH and DO at each station are still at optimal conditions for seawater biota. The water temperature at the research location ~~ranges~~ ranged from 29.3 to ~~-~~31.8 ^{o}C. Optimal water conditions will have a good impact on marine biota, these conditions will support the metabolic processes of fish so that they can support growth, survival and reproduction.

The pH of the waters ranges between 8.01-8.19, which is still in optimal conditions. Water pH can affect the physiology of marine biota, including inhibiting growth, biota will be very sensitive to bacteria and parasites and the water will be toxic to fish. Changes in pH that are very acidic or alkaline will disrupt the survival of aquatic organisms because they disrupt the respiration process [15] .

The DO condition of the research location waters ranges from 7.9-11.04 ppm, which is very good. The DO of waters greatly determines the survival of marine biota. Water conditions that contain dissolved oxygen. Oxygen levels can affect the decomposition, reproduction and growth processes. The need for dissolved oxygen in fish is influenced by age, activity and water conditions. The oxygen content influences the oxidation and reduction processes of organic and inorganic materials [16] .

Salinity at the research location ranges from 34~~-~~ to 41 ppt, this value is quite high and can be dangerous for the existence of marine biota. Seawater salinity influences the distribution, abundance and growth of aquatic biota as well as their density in a body of water [17] . Suboptimal salinity can cause osmoregulation disorders for biota. The high salinity in the waters is thought to be due to the very high level of evaporation that occurs. The cause of the high salinity is also thought to be due to the data collection being carried out in sunny and cloudless conditions. One of the factors that influences salinity is evaporation. The greater the level of seawater evaporation in an area, the higher the salinity and vice versa in areas with low levels of seawater evaporation [18] .

4. CONCLUSION

[Based on research results, it is known that the highest population of Banggai Cardinalfish was found at station III with a total population of 15.92 individuals/m ^{2} . The population is dominated by juveniles 12.60 individuals/m ^{2} , recruits 1.14 individuals/m ^{2} and adults 2.18 individuals/m ^{2} . The highest population of associated biota was found at station III with a population of sea urchins of 0.91 individuals/m ^{2} and sea anemones of 0.08 individuals/m ^{2} . Water quality conditions at each station are temperature 29.3-31.8 ^{o}C (optimum) , pH 8.01-8.19 (optimum), DO 7.9-11.04 ppm (optimum) , Salinity 34-41 ppt (not optimal)]

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Comment [R35]: The discussion can be improved with the existing literature regarding specifically the Banggai cardinalfish. Example: Alejandro A. Vagelli and M.V. Erdmann. 2002. First Comprehensive Ecological Survey of the Banggai Cardinalfish, Pterapogon Kauderni. 2002. Environmental Biology of Fishes 63(1):1-8. DOI:10.1023/A:1013884020258

Comment [R36]: However, the higher salinity recorded in this study occured at the same sampling site which presented the largest population of Banggai Cardinalfish. What can be discussed about this?

Comment [R37]: repetitive

Comment [R38]: There were some hypotheses created along the manuscript. This is a section to point out what to to with the information obtained, which questions the study created and must be pursued…

Is there any management policy suggestion / monitoring suggestion to be made, considering the study results?

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