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CORAL REEF HEALTH ASSESSMENT ON THE EAST COAST OF KEI BESAR ISLAND, SOUTHEAST MALUKU

PENILAIAN KESEHATAN TERUMBU KARANG DI PESISIR TIMUR PULAU KEI BESAR, MALUKU TENGGARA

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ABSTRACT

Kei Besar Island in Southeast Maluku has significant ecological coral reef potential, making it a regionally important area with great development opportunities. Like other coastal coral ecosystems, the reefs around Kei Besar Island are highly vulnerable to substantial threats from human activities and environmental pressures. A crucial initial step is to understand the ecosystem's condition through a coral reef health analysis. The purpose of this study was to analyze the reef health index in the coastal waters east of Kei Besar Island. Field data were collected from November 3-18, 2018, across six locations on the east coast of Kei Besar Island. These specific locations were chosen due to their dense populations along the eastern coast. The findings showed that coral reef ecosystems in eastern Kei Besar generally fall into the moderate to high health categories. Hard coral cover ranged from a low of 27% in Hollat to a high of 78.67% in Fako. Target fish biomass varied from 32.92 kg/ha in Kilwait (the lowest) to 311.41 kg/ha in Weduar (the highest). The coral reef health index on the east coast of Kei Beasr Island generally has a score of 6 out of a total of 10, and only Hollat has a score of 5.

Keywords: coral reef, coral reef health index, Kei Besar, point intercept transect, underwater visual census

ABSTRAK

Pulau Kei Besar di Maluku Tenggara memiliki potensi terumbu karang yang signifikan, menjadikannya daerah yang penting secara ekologis dan memiliki peluang pengembangan yang besar. Seperti terumbu karang pesisir lainnya, terumbu karang di sekitar Pulau Kei Besar sangat rentan terhadap bahaya signifikan yang ditimbulkan oleh aktivitas manusia dan tekanan lingkungan. Salah satu langkah awal yang perlu dilakukan adalah dengan mengetahui kondisi ekosistem dengan melakukan analisis kesehatan terumbu karang. Tujuan penelitian ini adalah untuk menganalisis indeks kesehatan terumbu di perairan pesisir timur Pulau Kei Besar. Penelitian lapang dilaksanakan pada 3-18 November 2018 di enam lokasi di wilayah pesisir timur Pulau Kei Besar. Lokasi-lokasi ini dipilih karena merupakan area padat penduduk di pesisir timur. Hasilnya menunjukkan bahwa ekosistem terumbu karang di pesisir timur Kei Besar tergolong pada kategori sedang hingga tinggi. Tutupan karang keras (*hard coral*) berkisar antara 27% (terendah di Hollat) hingga 78.67% (tertinggi di Fako). Biomassa ikan target bervariasi dari 32.92 kg/ha (terendah di Kilwait) hingga 311.41 kg/ha (tertinggi di Weduar). Indeks kesehatan terumbu karang di pantai timur Pulau Kei Besar secara umum memiliki skor 6 dari total 10 dan hanya Hollat yang memiliki skor 5.

Kata kunci: indeks kesehatan terumbu karang, Kei Besar, *point intercept transect*, terumbu karang, *underwater visual census*

INTRODUCTION

Coral reefs are incredibly diverse ecosystems, serving vital ecological roles. They offer physical protection, act as feeding grounds, and provide spawning and nursery areas for various marine life. A highly productive coral reef ecosystem is a clear sign of its health. Effectively managing coral reef ecosystems hinges on a thorough understanding of their health. By assessing the condition of coral reefs, we can implement strategies that promote their well-being and resilience. In essence, good management stems directly from knowing how healthy our coral reefs are (Ramadhani *et al.* 2015).

The condition of coral reefs is increasingly declining, and most of them are under serious threat. As many as 64% of the 56 islands in the Seribu Islands are classified as very vulnerable due to anthropogenic threats and natural conditions (Yonvitner *et al.* 2022). The main factor in the decline of coral reefs is influenced by increasing sea surface temperatures, which cause coral bleaching (Subhan *et al.* 2011). Other factors that cause coral reef damage are influenced by natural factors and human activity factors, such as increasing temperatures, tsunamis, bombing, dropping ship anchors, and the use of potassium (Anastion *et al.* 2018). Damaged coral reef ecosystems take a long time to recover naturally (Damhudy *et al.* 2011).

Coral reef health can not only be detected from the percentage of live coral cover but also from populated areas and the level of resilience and biomass of reef fish (Giyanto *et al.* 2017). The higher the live coral cover indicates the better the health of the coral reef. Several observation locations have high live coral cover conditions but have few reef fish resources, and vice versa. The coral reef health index is determined by benthic (hard coral cover and flashy seaweed) and the coral reef fish component. Coral reef resilience refers to the reef's capacity to bounce back to a stable condition after experiencing disturbances or changes (Giyanto *et al.* 2017). The coral reef fish component variables used were coral reef fish biomass from target fish groups, including seven fish families, namely the Acanthuridae, Haemulidae, Lethrinidae, Lutjanidae, Scaridae, Siganidae, Serranidae, and families (Giyanto *et al.* 2017).

The Kei Islands are a group of islands located in Southeast Maluku Regency, Maluku Province, with an area of 1,438 km^2. This archipelago has many islands, with two main islands, namely Kei Besar Island and Kei Kecil Island. The waters of the Kei Islands are part of the Coral Triangle, making this archipelago have a lot of potential in the marine sector and high marine ecosystem biodiversity. Kei Besar Island is part of the Maluku Islands group with an area of 550 km^2 (Rahmani *et al.* 2020).

Like other coastal coral reef ecosystems, the coral reefs in the coastal areas of Kei Besar Island are currently facing serious threats from various anthropogenic activities and environmental pressures. Rapid human population growth in coastal areas is often directly proportional to an increase in activities such as infrastructure development, domestic and industrial waste, unsustainable fishing practices, and the use of hazardous chemicals. The accumulation of these pressures has led to significant coral reef degradation, reducing their ecological function and threatening the survival of species that depend on them. Therefore, periodic monitoring and evaluation of coral reef health are crucial. One effective method for assessing this condition is by using a coral reef health index. This study aims to analyze the condition of the coral reefs on the east coast of Kei Besar Island by measuring the coral reef health index at several dive sites on the east coast of the island. Research on coral reef health indices is necessary to provide a clear and measurable picture of the impact of various existing pressures. This research can then serve as a basis for formulating more appropriate and sustainable management and conservation strategies.

METHODS

Time and Location

Data collection was carried out at six data collection points representing three large sub-districts, namely Kei Besar Sub-district: Ohoi Ngufit Bawah and Fako, North East Kei Besar Sub-district: Ohoifau and Hollat, and South East Kei Besar Sub-district: Ohoi Kilwat and Weduar, which are located on the east coast of Kei Besar Island, 3-18 November 2018. The depth of the observation location was in shallow waters (±3 m). These locations were chosen because they are areas that are widely inhabited by the community, so that the data obtained

later can provide a picture of the health conditions of coral reefs in densely populated areas that are under pressure from local fishing activities. The location of the coral reef health index study on the east coast of Kei Besar Island, Southeast Maluku, can be seen in Figure 1.

Data collection

Coral reef data collection was using the Point Intercept Transect (PIT) method, along 50 m line transect stretched parallel to the coastline, with three repetitions (Hill and Wilkinson 2004), starting from the coral reef slope. Data collection using the PIT method was taken every 50 cm on the transect, as seen in Figure 2.

Coral reef fish biomass was measured on the same line transect as coral reef data collection. The fish data was collected with a sweep of the observation area of 2.5 m to the right and 2.5 m to the left (English *et al.* 1997). An illustration of data collection using the UVC method can be seen in Figure 3.

Data analysis

Healthy coral reefs will have high live coral cover, high resilience levels, and high fish biomass (Giyanto *et al.* 2017). The hard coral cover is calculated based on the formula (English *et al.* 1997):

$$\%\ Cover = \frac{A}{B} \times 100\%$$

Description:
% Cover = Percentage of benthic cover (%)
A = Total number of points/points of basic substrate category on the transect
B = Total number of points/points on transect

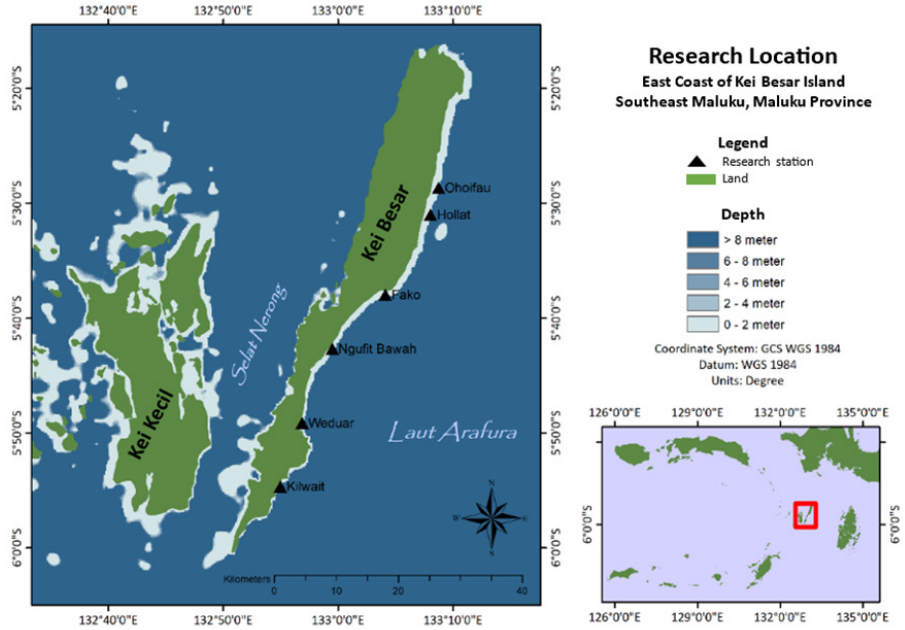

Figure 1. Research location in the east coast of Kei Besar Island, South East Maluku, Maluku Province.

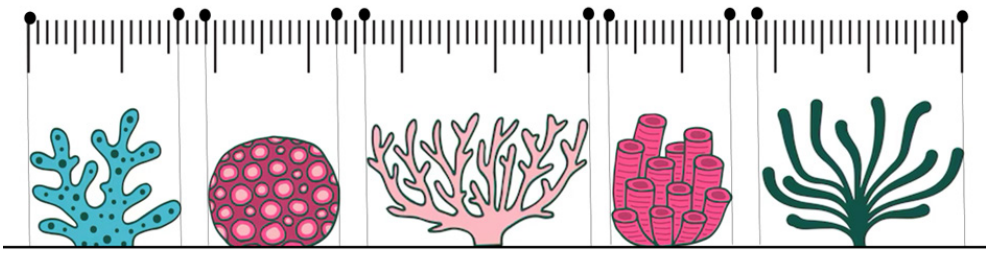

Figure 2. Data collection of coral reef and algae benthic cover on line transects using the Point Intercept Transect (PIT) method.

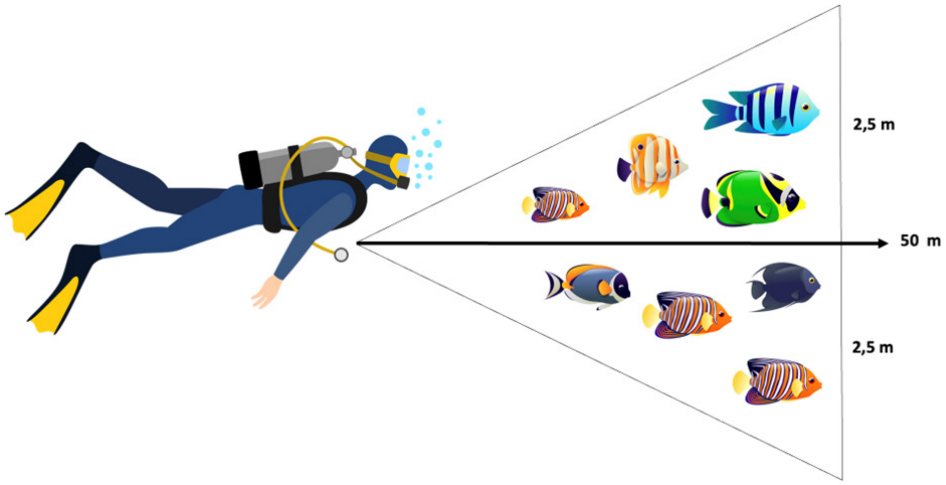

Figure 3. Data collection of coral fish biomass using Underwater Visual Census (UVC).

The percentage of benthic component cover is divided into live hard coral cover and the algae cover and/or rubble (Giyanto *et al.* 2017). The category of live hard coral cover can be seen in Table 1.

Resilience is the ability of organisms to adapt and survive when under pressure or disturbance. The level of coral reef resilience is the potential for a coral reef to recover from disturbance or pressure to return to its original condition (Giyanto *et al.* 2017). The potential for coral reef recovery categories are expressed by fleshy seaweed and rubble cover that can be seen in Table 2.

Coral reef fish biomass was calculated from the mean value of fish length (cm) estimated and recorded during diving, which was then converted to weight (g) using the length-weight index of individual coral reef fish following Froese and Pauly (2014). Coral reef fish biomass was calculated using formula:

$$W = aL^b$$

Description:
W = Fish weight (g)
L = Length of fish (cm)
a and b = Length-weight constant

The coral reef fish component used to determine the health condition of coral reefs is the total biomass of coral reef fish (Giyanto *et al.* 2017). The coral reef fish groups used are target fish or economically important fish, which can be seen in Table 3.

Table 1. Categories of live coral cover based on hard coral cover (Giyanto *et al.* 2017).

Category	Criteria
Low	Live coral cover < 19%
Medium	19% ≤ live coral cover ≤ 35%
High	Live coral cover > 35%

Table 2. Categories of resilience levels or potential for coral reef recovery (Giyanto *et al.* 2017).

Category	Criteria
Low	(fleshy seaweed cover > 3%) or (rubble > 60% and live coral cover < 5%)
High	(fleshy seaweed cover < 3%) or (rubble < 60% and live coral cover > 5%)

Table 3. Total categories of coral reef fish biomass (Giyanto *et al.* 2017).

Category	Criteria
Low	Total reef fish biomass < 970 kg/ha
Medium	970 kg/ha ≤ Total reef fish biomass ≤ 1,940 kg/ha
High	Total reef fish biomass > 1,940 kg/ha

The coral reef health index is a combination of benthic components and reef fish, whose values range from 1 to 10 (Table 4). The highest value of 10 is the healthiest coral reef and is the most ideal condition, referring to high coral cover, supported by a high level of resilience. In addition, the coral reef ecosystem is also a gathering place for economically important coral reef fish. The opposite occurs at an index value of 1, which is the lowest value, depicted by the low coral cover, and it will be difficult for coral to recover. As a result, the ecosystem is not a gathering place for economically valuable coral reef fish (Giyanto *et al.* 2017). The coral reef health index value is in the range of 1-10 shown in Table 4.

RESULTS AND DISCUSSION

The east coast of Kei Besar Island faces the Arafura Sea, which is the path of the Indonesian Throughflow (Arlindo) that connects the Pacific Ocean and the Indian Ocean (Ramadyan and Radjawane 2013). This makes the coral reef ecosystem in this area have characteristics that are current and wavy. The results of observations in the field show that each village has a dike that functions to protect residents' settlements from waves and prevent abrasion. There are rivers near the coast at the Hollat, Kilwait, and Ohoifau locations. Six observation locations do not have docks because the long coastline structure on the east coast of Kei Besar Island does not allow for the construction of docks. According to direct observations, fishing boats anchor in areas around the coral reef ecosystem because there are no docks at the six observation locations. This causes damage to the coral reef due to dredging by fishing boat anchors.

Percentage of base substrate coverage

Observation results from six locations show that hard coral, soft coral, and algae cover are the most commonly found substrate cover categories. The other category consists of macrobiota and has the lowest percentage of bottom substrate cover. Figure 4 is a graph of the percentage of bottom substrate cover at six observation locations in the coastal waters of Kei Besar Island. The average percentage of hard coral cover from the six observation locations is 52.28% with the highest percentage in Fako with a value of 78.67%, and the lowest in Hollat with a value of 27%. According to the criteria of Giyanto *et al.* (2017), the condition of coral reefs at the Ohoifau, Fako, Ngufit Bawah, Weduar, and Kilwait locations were classified as high, while at the Hollat location, commonly found was the Pomacentridae, it was classified as moderate.

The average percentage of algae cover from six observation locations was 24.61%, with the highest percentage in Ngufit Bawah with a value of 39% and the lowest in Fako with a value of 2.67%. The low algae cover reduces competition between algae and coral reefs so that coral reefs grow well at that location. Competition between coral biota and algae occurs in the acquisition of nutrients in the same growing space (Nybakken 1992; McCook *et al.* 2001; Rölfer *et al.* 2021).

The average abiotic percentage of the six observation locations was 13.28, with the highest percentage in Weduar with a value of 14.67%, and the lowest in Ohoifau with a value of 7%. The high dominance of abiotic cover in waters, especially rubble cover, indicates the pressure on the coral reef ecosystem, which was initially in the form of living coral, then died and became rubble. This pressure can be in the form of human activities such as the use of poisons and bombs (Ghiffar *et al.* 2017). Examples of other human activities, such as the random lowering of ship anchors and the use of environmentally unfriendly fishing gear by fishermen, can break coral and increase rubble.

Distribution of hard coral genera based on percentage

The graph of the percentage of hard coral genera in six observation locations in the coastal waters of Kei Besar Island is presented in Figure 5. There were 36 hard coral genera found in the six observation locations. The highest percentage of coral genera was the *Porites* genus found at the Hollat location and the *Acropora* found at the Ohoifau location. The *Porites* genus was most commonly found in Ngufit Bawah, Weduar, and Hollat because, in general, these coral genera were able to survive various disturbances such as the effects of temperature, competition, and sedimentation (Yusri *et al.* 2019). The *Porites* genus can also live on various habitat substrates such as areas with sandy,

rocky, and coral rubble substrates (Sakai and Yamazato 1986). *Porites* corals have broad habitat characteristics, able to live on various types of coral reefs such as reef flats, reef crests, and reef slopes (Lee *et al.* 2021). The *Acropora* genus is most commonly found in Kilwait, Ohoifau, and Fako locations because its ability to lives in shallow waters with high brightness (Barus *et al.* 2018). Kei waters are classified as waters that have high brightness, so the *Acropora* genus is often found in these waters.

Table 4. Coral reef health index (Giyanto *et al.* 2017).

Benthic Components		Fish Components	Coral Reef Health Index Value
Live Coral Cover	**Resilience Level**	**Coral Reef Fish Biomass**	
High	High	High	10
Medium	High	High	9
High	High	Medium	8
High	Low	High	8
Medium	High	Medium	7
Low	High	High	7
High	High	Low	6
High	Low	Medium	6
Medium	Low	High	6
Medium	High	Low	5
Low	High	Medium	5
Low	Low	High	5
High	Low	Low	4
Medium	Low	Medium	4
Low	High	Low	3
Low	Low	Medium	3
Medium	Low	Low	2
Low	Low	Low	1

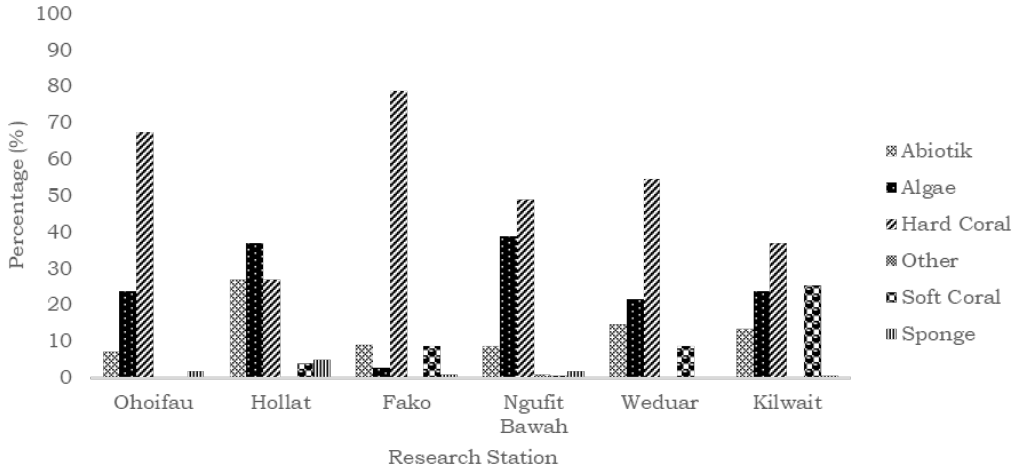

Figure 4. Percentage composition of bottom substrate cover in the coastal waters of eastern Kei Besar Island.

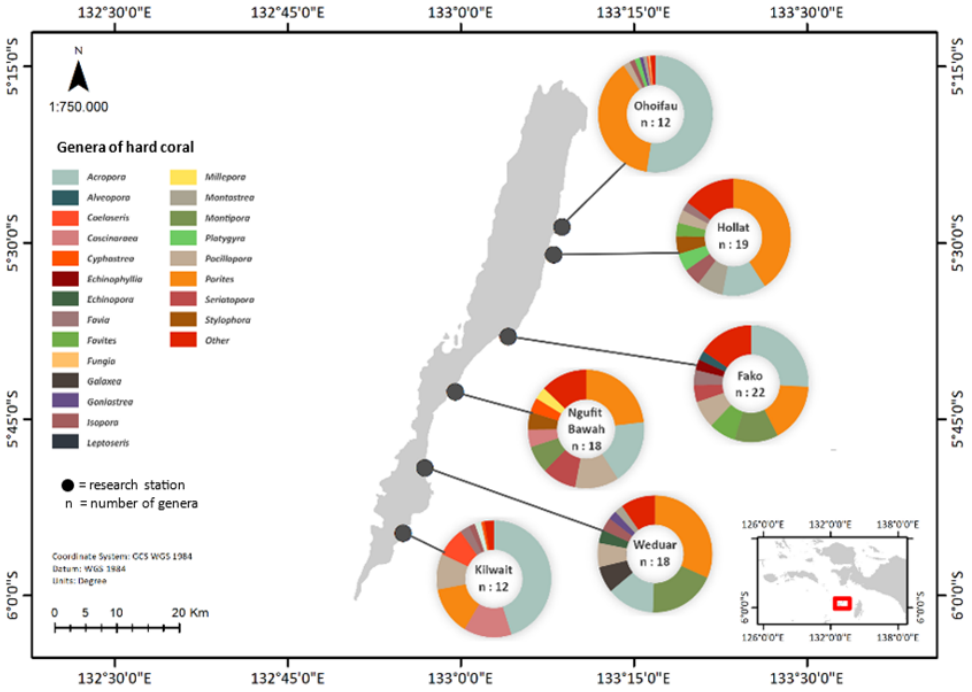

Figure 5. Distribution of hard coral genera in the east coast of Kei Besar Island, South East Maluku, Maluku Province.

Distribution of reef fish families based on a percentage

Reef fish found from six observation were 22 families, 61 genera, 148 species, and 1,532 individuals. Figure 6 shows a map of the distribution of reef fish families found at each observation location. The percentage of coral reef fish families that were most commonly found was the Pomacentridae, Acanthuridae, and Caesionidae families. Fish from the Pomacentridae family are classified as territorial fish that eat algae that form expanses in their habitat (Nybakken 1992). The Acanthuridae family is a group of fish that live in groups and are classified as herbivorous fish (Amrullah and Putrananda 2018). Fish from the Pomacentridae and Acanthuridae families were found in abundance at observation locations due to the high percentage of algae, which is the main food source for the two fish families. The Caesionidae family of fish is most commonly found because coral reefs provide zooplankton, which are used by Caesionidae fish as a food source (Koeda and Ho 2018).

Coral reef health index

The coral reef health index is used to determine the health level of coral reefs in the area. The state of the benthic community depends on the coral reef's current health and its resilience, which is its capacity to bounce back to a stable condition after disturbances. The resilience index is used to measure the vulnerability of coral reef resources so that they do not reach their critical point due to disturbances (Kusumo *et al.* 2019). The coral reef fish component variable used is the biomass of coral reef fish from the target fish group (Giyanto *et al.* 2017).

Table 5 shows the percentage of rubble, algae, hard coral, and target fish biomass to determine the coral reef health index value. Analysis of the resilience level at six observation locations showed that all six observation locations had a high level of resilience. Analysis of the target fish biomass estimates found at six observation locations showed that the highest target fish biomass was at the Weduar location with a value of 311.41 kg/ha, while the lowest target fish biomass was at the Kilwait location with a value of 32.92 kg/ha. The target fish biomass was relatively low at all stations due to data collection being carried out at shallow depths and target fish being caught by fishermen.

Coral communities show wide variations in their makeup, influenced by both their environmental conditions and the history of disturbances they've experienced. Despite this, the degree to which these differences in coral types impact the fish

assemblages associated with them remains largely unexplored. The Weduar and Ngufit Bawah locations had target fish biomass of 311.41 kg/ha and 162.70 kg/ha, respectively, which could be attributed to the dominant coral species found at both locations. The genus *Porites* tends to be a more functional fish habitat than other genera, such as *Pocillopora*. The different structural complexities found in coral communities might function as natural filters. These filters can influence not only where certain species traits are distributed, but also how many of them are present, particularly impacting the characteristics of small, schooling fish (Richardson *et al.* 2017).

Figure 7 shows the coral reef health index ranges between 5-6. A value of 5 on the coral health index is indicated by a moderate percentage of live coral cover, a high level of resilience, and low target fish biomass. The value of 6 on the coral health index is indicated by a high percentage of live coral cover, a high level of resilience, and low target fish biomass. This index value indicates that the coastal waters of Kei Besar Island are classified as moderate. The Hollat location has a lower health index value compared to other observation locations because this location has many environmental pressures that affect the level of coral cover. Environmental pressures at this location include the large amount of rubble cover caused by the lowering of ship anchors and the high level of algae cover. Based on the level of resilience, all stations have high resilience and recovery due to the still high level of live hard coral cover. However, in general, all locations also have high algae cover, which is more than 3%, so it is necessary to pay attention and provide recommendations in the future to identify the factors that cause high algae. Several factors that can increase algae competition with coral reefs are the influence of increasing nutrient levels and also the combined effects of increasing sea temperatures and ocean acidification (McCook *et al.* 2001; Swierts and Vermeij 2016; Rolfer *et al.* 2021).

This study can be used as baseline data on coral reef and fish conditions for the eastern coastal area of Kei Besar Island, considering the lack of information and publications in this area. Recording of the Coral Reef Health Index has been conducted by Giyanto *et al.* (2017) at 32 coral reef monitoring locations located at the COREMAP site, non-COREMAP, and the National Marine Conservation Area (KKPN), showing varying values. The closest monitoring location to Kei Besar Island is the Aru Islands KKPN, with a Coral Reef Health Index in 2016 ranging from 1 to 9.

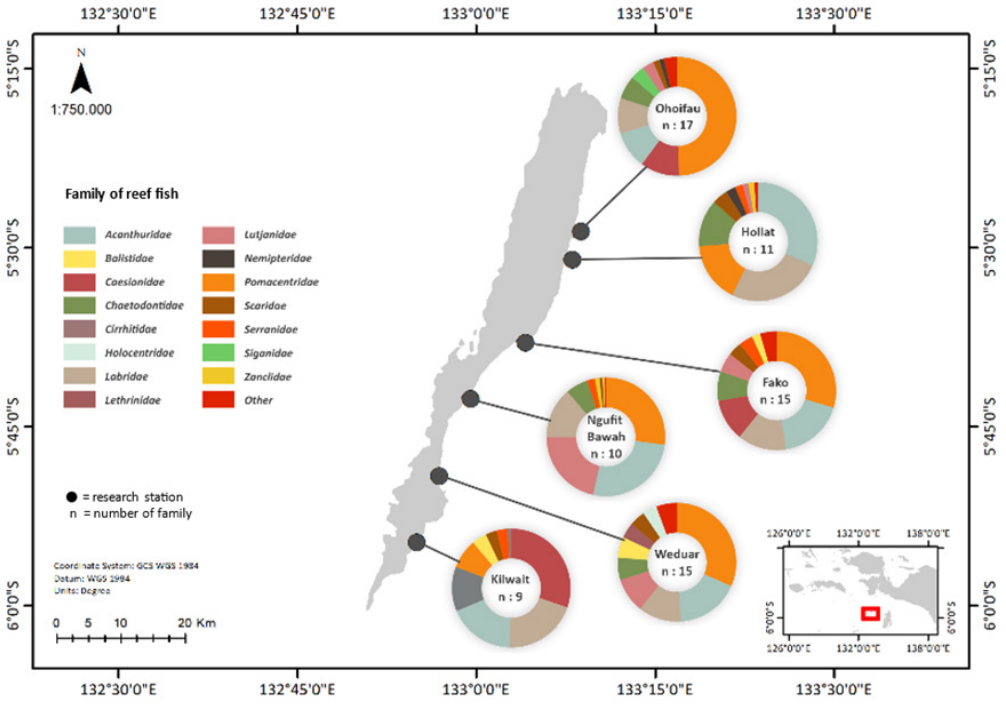

Figure 6. Composition of reef fish family in the east coast of Kei Besar Island, South East Maluku, Maluku Province.

Table 5. Coral reef health index in the east coast of Kei Besar Island.

Observation Location	Rubble	Algae	Hard Coral	Target Fish Biomass (kg/ha)	Coral Reef Health Index
Ohoifau	0.00%	23.67%	67.33%	172.92	6
Hollat	0.33%	37.00%	27.00%	41.39	5
Fako	1.00%	2.67%	78.67%	139.23	6
Ngufit Bawah	1.67%	39.00%	49.00%	162.70	6
Weduar	5.67%	21.67%	54.67%	311.41	6
Kilwait	1.00%	23.67%	37.00%	32.92	6

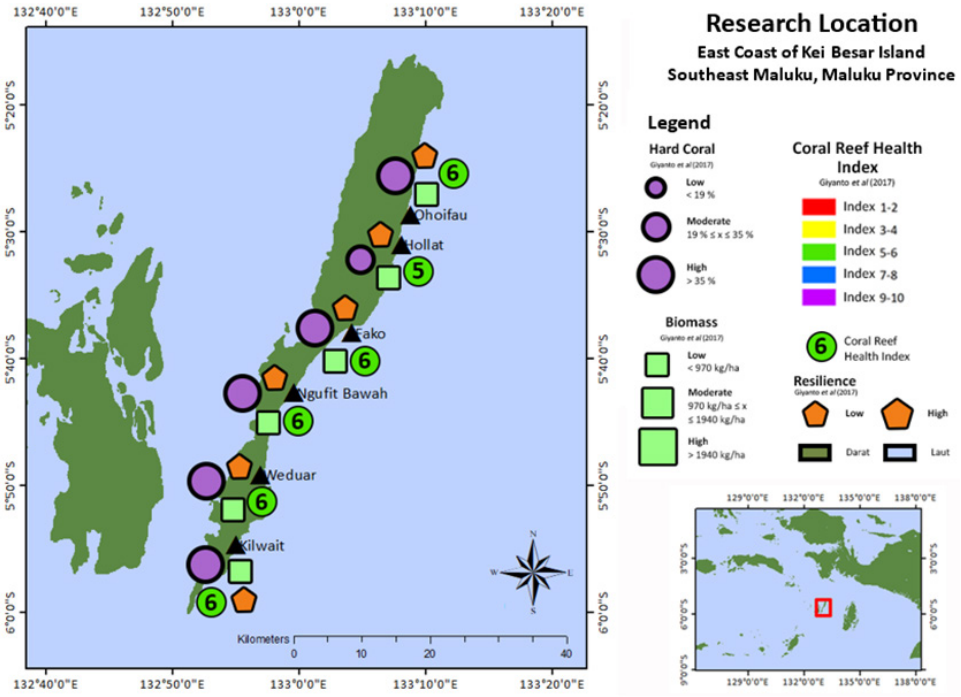

Figure 7. Coral reef health index in the east coast of Kei Besar Island, South East Maluku, Maluku Province.

Coral reef health indices can indicate a problem (e.g., "damaged" or "unhealthy"), but they do not always directly identify the root cause of the problem. To determine why a coral reef is damaged (e.g., due to destructive fishing, pollution, or bleaching), further analysis is required. Nevertheless, coral reef health indices remain invaluable tools for initial monitoring and evaluation. It is important to use these indices as one component of a more holistic approach, combined with other data such as environmental factors, anthropogenic pressures, and specific research on the ecosystem's biota. By understanding the CRI value in an area, coastal managers can identify areas that are degraded and require restoration and establish appropriate conservation zones. In addition, CRI data also helps monitor the effectiveness of marine management policies that have been implemented and provides a scientific basis for marine spatial planning. Thus, the sustainable use of CRI data not only supports the conservation of marine biodiversity but also ensures the availability of ecosystem services for coastal communities in the future.

CONCLUSION

The coral reef ecosystem along the east coast of Kei Besar is in good condition, marked by a healthy hard coral cover, primarily featuring Porites and Acropora species. While the area boasts a wide variety of fish, their overall biomass is low.

The most prevalent fish families observed were Pomacentridae, Acanthuridae, and Caesionidae. The coral reef health index for East Kei Besar's coastal waters is considered moderate, scoring between 5 and 6. Specifically, the Hollatsite exhibited the poorest coral health, likely due to damage from ship anchors and a high presence of algae. A low fish biomass could suggest either significant pressure on fish resources or an unsuitable habitat.

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REFERENCES

Amrullah MY, Putrananda H. 2018. Kelimpahan Ikan Karang pada Terumbu Karang Buatan di Lokasi yang Berbeda Perairan Kota Padang. *UNES Journal of Scientech Research*. 3(1): 001-008.

Anastion, Nur AI, Kasim M. 2018. Struktur Komunitas Ikan pada Terumbu Karang Alami dan Terumbu Buatan dari Sampah Plastik di Perairan Tanjung Tiram Kecamatan Moramo Utara. *Jurnal Manajemen Sumber Daya Perairan*. 3(3): 179-187.

Barus BS, Prartono T, Soedarma D. 2018. Keterkaitan Sedimentasi dengan Persen Tutupan Terumbu Karang di Perairan Teluk Lampung. *Jurnal Ilmu dan Teknologi Kelautan Tropis*. 10(1): 49-57. DOI: http://dx.doi.org/10.29244/jitkt.v10i1.18719.

Damhudy D, Kamal MM, Ernawati Y. 2011. Kondisi Kesehatan Terumbu Karang Berdasarkan Kelimpahan Ikan Herbivora di Kecamatan Pulau Tiga Kabupaten Natuna. *Jurnal Ilmu-ilmu Perairan dan Perikanan Indonesia*. 17(1): 215-225.

English S, Wilkinson C, Bakef V. 1997. *Survey Manual for Tropical Marine Resources*. Townsville (AU): Australian of Marine Science.

Froese R, Pauly D. 2014. Fishbase. World Wide Web Electronic Publication. www.fishbase.org. [October 1, 2024]

Ghiffar MA, Irham A, Harahap SA, Kurniawaty N, Astuty S. 2017. Hubungan Kondisi Terumbu Karang dengan Kelimpahan Ikan Target di Perairan Pulau Tinabo, Taman Nasional Takabonerate, Sulawesi Selatan. *SPERMONDE*. 2(3): 17-24. DOI: https://doi.org/10.20956/jiks.v3i2.3002.

Giyanto, Mumby P, Dhewani N, Abrar M, Iswari MY. 2017. *Indeks Kesehatan Terumbu Karang Indonesia*. Jakarta (ID): Pusat Penelitian Oseanografi Lembaga Ilmu Pengetahuan Indonesia.

Hill J, Wilkinson C. 2004. *Methods for Ecological Monitoring of Coral Reefs*. Townville (US): Australian Institute of Marine Science.

Koeda K, Ho H. 2018. The Northernmost Record of The Banana Fusilier *Pterocaesio pisang* (Perciformes: Caesionidae). *Platax*. 15(1): 37-43.

Kusumo S, Adrianto L, Boer M, Suharsono M. 2019. Indeks Resiliensi Terumbu Karang dengan Pendekatan Sistem Sosial-Ekologi: Studi Kasus KKPD Pulo Pasi Gusung, Selayar. *JFMR (Journal of Fisheries and Marine Research)*. 3(2): 227-235. DOI: https://doi.org/10.21776/ub.jfmr.2019.003.02.13.

Lee Y, Lam SQY, Tay T S, Kikuzawa YP, Tan KS. 2021. Composition and Structure of Tropical Intertidal Hard Coral Communities on Natural and Man-Made Habitats. *Coral Reefs*. 40(3): 685-700. DOI: https://doi.org/10.1007/S00338-021-02059-0.

McCook L, Jompa J, Diaz-Pulido G. 2001. Competition between Corals and Algae on Coral Reefs: A Review of Evidence and Mechanisms. *Coral Reefs*. 19: 400-417. DOI: https://doi.org/10.1007/s003380000129.

Nybakken JW. 1992. *Biologi Laut: Suatu Pendekatan Ekologis*. Eidman M, Koesoebiono, Bengen DG, Hutomo M, translator. Jakarta (ID): PT Gramedia Pustaka.

Rahmani FR, Khodijah S, Askaria P, Anisa S, Akbar I, Ardiansah I, Hidayat T, Bintang, Dzikra, Jeny N, Fuadi IN. 2020. *Kekayaan Tersembunyi Bahari Kei*. Jakarta (ID): PT Dakara Consulting LCA Indonesia.

Ramadhani RA, Damar A, Madduppa HH.

2015. Management on Coral Reef Ecosystem in the Siantan Tengah District, Anambas Islands. *Jurnal Ilmu dan Teknologi Kelautan Tropis*. 7(1): 173-189. DOI: https://doi.org/10.29244/jitkt.v7i1.9804.

Ramadyan F, Radjawane IM. 2013. Arus Geostropik Permukaan Musiman di Perairan Arafura-Timor. *Jurnal Ilmu dan Teknologi Kelautan Tropis*. 5(2): 261-271.

Richardson LE, Graham NAJ, Pratchett MS, Hoey AS. 2017. Structural Complexity Mediates Functional Structure of Reef Fish Assemblages among Coral Habitats. *Environmental Biology of Fishes*. 100(3): 193–207. DOI: https://doi.org/10.1007/S10641-016-0571-0.

Rölfer L, Reuter H, Ferse SCA, Kubicek A, Dove S, Hoegh-Guldberg O, Bender-Champ D. 2021. Coral-macroalgal Competition Under Ocean Warming and Acidification. *Journal of Experimental Marine Biology and Ecology*. 534: 151477. DOI: https://doi.org/10.1016/j.jembe.2020.151477.

Sakai, Yamazato K. 1986. Distribution and Community Structure of Hematypiccorals in the Sinchang Island, Inner Part of Gulf of Thailand. *Galaxea*. 5: 27-74.

Subhan B, Rahmawati F, Arafat D, Bayu NA. 2011. Kondisi Kesehatan Karang Fungiidae di Perairan Pulau Pramuka Kepulauan Seribu. *Jurnal Teknologi Perikanan dan Kelautan*. 2(1): 41-50. DOI: https://doi.org/10.24319/jtpk.2.41-50.

Swierts T, Vermeij MJ. 2016. Competitive Interactions between Corals and Turf Algae depend on Coral Colony Form. *PeerJ*. 10(4): e1984. DOI: https://doi.org/10.7717/peerj.1984.

Yonvitner, Agus SB, Lestari DF, Pasaribu R, Supriyanto E, Widodo C, Sugara A, Patoka J, Akmal SG 2022. Vulnerability Status of The Coral Ecosystem in Kepulauan Seribu Marine National Park, Indonesia. *Coastal Management*. DOI: https://doi.org/10.1080/08920753.2022.2037388.

Yusri S, Siregar VP, Suharsono. 2019. Distribution Modelling of Porites (Poritidae) in Indonesia. *LoCARNet: The 7th Annual Meeting - Challenges for Asia to Meet 1.5°C Target 21–22 November 2018, Jakarta, Indonesia*. IOP Conference Series: Earth and Environmental Science.