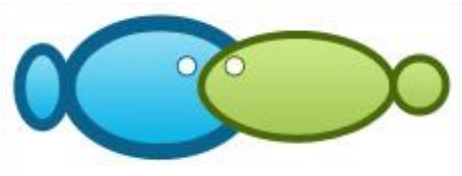

Current status of the coral reef ecosystem in Gresik Regency, East Java

[1,2]Sukandar, [3,4]Pratama D. Samuel, [5,6]Citra S. U. Dewi, [7]Imas D. Pratiwi, [8]Muhamad C. Anam, [5]Jessica E. Beno, [9]Riska Fatmawati

[1] Utilization of Fisheries Resources, University of Brawijaya, Malang, East Java, Indonesia; [2] Research Group Indonesian Marine Fisheries (IM-FISHER), University of Brawijaya Malang, East Java, Indonesia; [3] Aquatic Resources Management, University of Brawijaya, Malang, East Java, Indonesia; [4] Research Group Aquatic Biofloc, University of Brawijaya, Malang, East Java, Indonesia; [5] Marine Science, University of Brawijaya, Malang, East Java, Indonesia; [6] Coastal Resilience and Climate Change Adaptation Research Group, University of Brawijaya, Malang, East Java, Indonesia; [7] Dive Wonderfull Indonesia, SSI, Indonesia; [8] Fisheries Diving School, University of Brawijaya, Malang, East Java, Indonesia; [9] Fisheries Resources Utilization, Riau University, Pekanbaru, Riau, Indonesia. Corresponding author: Sukandar, kdr_1212@ub.ac.id

Abstract. Coral reefs are a unique ecosystem in the oceans and are found mainly in tropical Indo-Pacific regions. This ecosystem has many benefits that can increase its economic value. The economic value of the ecosystem will be high if its ecological value is also good. In simple terms, it can be said that a good and healthy coral reef will have a higher economic value. A coral reef ecosystem is found in Gresik, East Java, being included in the Kertosusilo National Strategic Area. The existence of coral reef ecosystems and their conditions unquestionably becomes of interest. This research was conducted in the waters of the Gresik Regency from March to November 2020. The Reef Check Monitoring method was used in this study. The substrate and fish species were also analyzed in four research locations. The results showed that the coral reef ecosystems were only found in two of the four research locations recommended by local communities, namely Station 1 (5°52'22.78" S 112°37'21.65" E) and Station 2 (5°52'3.35" S 112°37'34.74" E). The two stations are administratively located in Bawean waters, Lebak Village, Sangkapura District, Gresik Regency. The percentage of hard coral cover at Station 1 was 44.97% (moderate condition), while at Station 2, it was 51.914% (good condition). The families of reef fish that have economic value found at Station 1 consisted of Achanturidae (6 individuals), Scaridae (9), Siganidae (4), Lethrinidae (2), Haemulidae (3), Serranidae (3), Lutjanidae (7), and Chaetodontidae (9). Station 2 had the families Achanturidae (5 individuals), Scaridae (7), Siganidae (3), Lethrinidae (1), Haemulidae (4), Serranidae (5), Lutjanidae (9), and Chaetodontidae (16). This indicated that the research location was in good condition.
Key Words: Bawean Island, coral reef, Gresik, reef fish.

Introduction. Coral reefs are a unique ecosystem in the oceans and are found mainly in tropical Indo-Pacific areas. The main component of this ecosystem is hard coral (Luthfi & Anugrah 2017). More than 29% of the world's coral reefs are concentrated in six tropical countries, creating a hot spot formation known as the World Coral Triangle (Veron et al 2009). Suharsono (2008) stated that there are 80 genera of hard corals found in Indonesian waters.

This ecosystem has an ecological function and also economic benefits. The ecological role of coral reefs, among others, functions as a place of refuge and a place to find food and lay eggs (Oceana 2006). This condition indirectly produces economic benefits, especially in the form of tourism for snorkeling, diving, and fishing (Pustikawati et al 2016). Another environmental service provided by this ecosystem is as a wave breaker and wave absorber (Totoda 2018). This is due to the very stable physical condition of the reef.

The ecological function and economic benefits of coral reefs result in financial value. Furthermore, the financial value of this ecosystem will be high if the ecological value of the ecosystem is also good. In simple terms, it can be said that a good and healthy coral reef will have a higher economic value. Therefore, the current status of the coral reef ecosystem is essential to study to determine its economic potential (Maulana et al 2016).

A potential distribution area of this ecosystem in East Java is in Gresik Regency, a district that is also the constituent of the Kertosusilo National Strategic Area (Sukandar et al 2017). The existence of coral reef ecosystems and their conditions unquestionably becomes essential to be studied. The objectives of this study were to determine the substrate cover of coral reefs and the diversity of reef fish in the waters of the Gresik Regency.

Material and Method. This research was conducted from March to November 2020. Dive data collection was carried out in the waters of Gresik Regency. Meanwhile, data processing, data analysis, and writing reports were performed at the Faculty of Fisheries and Marine Science, University of Brawijaya. The tools used in this study were the SCUBA set, roll meter, slate, pencils, and underwater camera. Subsequently, the materials needed in this study included waterproof paper and plastic containers for sampling.

The stages of this research included preparation and determination of stations, data collection, data processing, data analysis, and writing reports. The research stations were determined by interviewing the community (community group supervisors) and the government (marine and fisheries services), so that four stations were assigned. Two stations were located in the mainland waters of Gresik Regency, while the other two were in Bawean Island waters.

The locations for collecting data on coral reef ecosystems and fish were carried out in three locations, namely: 1) Bawean waters, Lebak Village, Sangkapura District, Gresik Regency (2 Stations); 2) Dalegan waters, Panceng District, Gresik Regency (1 Station); and 3) Campurejo waters, Panceng District, Gresik Regency (1 Station). The coordinate points of each data collection station can be seen in Table 1. The description and the map of the data collection station can be seen in Figure 1.

Table 1

Survey locations and coordinates of data collection stations

No	*Village/District*	*Station*	*Coordinates*
1	Bawean Waters, Lebak Village, Sangkapura District, Gresik Regency (Tanjung Lebak Selatan and Tanjung Lebak Utara)	Station 1	5°52'22.78" S 112°37'21.65" E
		Station 2	5°52'3.35" S 112°37'34.74" E
2	Dalegan Waters, Panceng District, Gresik Regency	Station 3	6°53'11.95" S 112°27'59.74" E
3	Campurejo Waters, Panceng District, Gresik Regency	Station 4	6°52'51.28" S 112°27'54.77" E

Data collection included substrate cover and reef fish using the Reef Check Eco-Diver method (Done et al 2017). Diving to obtain substrate data was carried out using the Line Intercept Transect method. The LIT method determines the percentage of benthic communities in coral reefs based on growth and records the number of benthic biotas present along the transect line. Communities are characterized through the life form category, which describes the coral community's morphology. LIT also monitors coral reef health in detail by creating permanent transect lines. The procedure for LIT is presented next. Firstly, there need to be minimum two observers; one person is responsible for creating transects, while the other is responsible for recording the categories of coral life encountered. Secondly, transects are carried out at two depths (3 and 10 m). The cross-section length is 100 m. The transect line is established by spreading a tape meter with a centimeter (cm) scale. Then, observers must master and recognize the types of coral

growth forms, both live coral and other biota. Observers swim from point zero to point 100 m along the established transect line and record all coral life forms in the area crossed by the transect line. Each life form must be recorded in breadth (up to a centimeter-scale). The life form category can refer to either aim (English et al 1994) or COREMAP. If possible, observers should also assign the coral species observed to at least the genus level taxa.

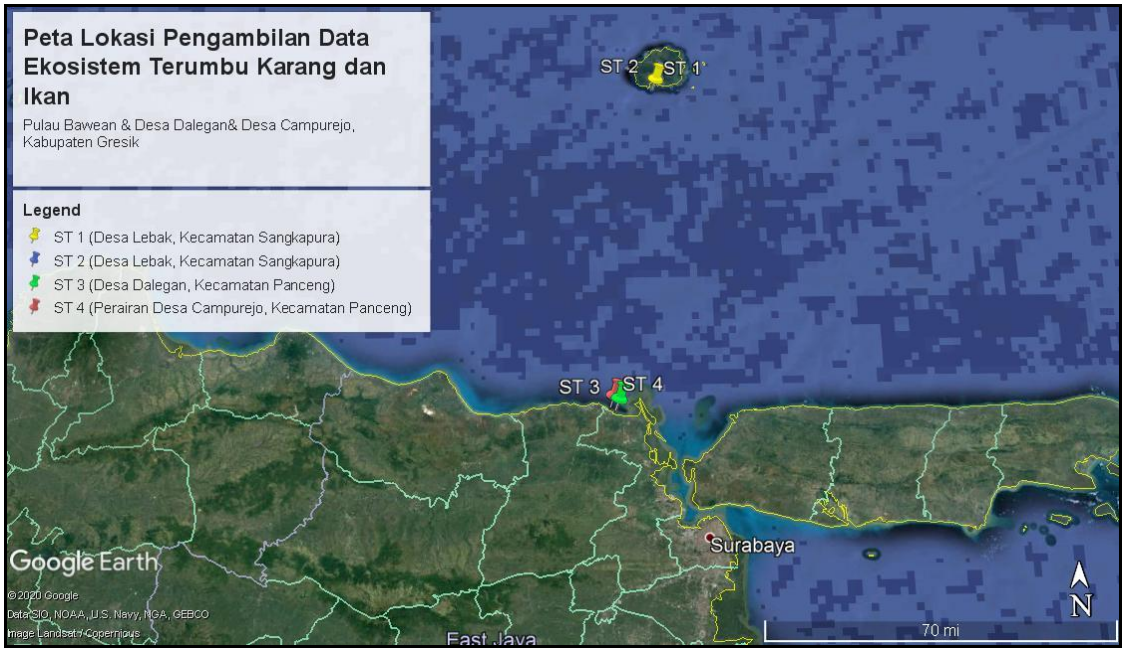

Figure 1. Map of the stations in Gresik Regency.

English et al (1997) developed an underwater visual counting method that is fast, accurate, effective, and environmentally friendly. The resulting data is relevant to the goals of coral fisheries management and the general management of coral reef ecosystems. Reef fish are primarily diurnal (daytime) and few nocturnal, so the ideal visual count time is from morning to late afternoon (between 09:00-16:00). The time approach takes into account tidal conditions. Low tide often results in strong currents and high turbidity. The ideal time is when the water starts to rise, when the fish come out to forage. The procedure for LIT starts before diving, with writing the information on the reef fish observation data sheet: transect number, location, date, time, collector, coordinates, depth, tides, weather (sunny, cloudy, rainy), and location description. Afterwards, there is a dive to spread the meter tape on the coral reef area with a stretching pattern parallel to the shoreline with the island's position to the left of the meter tape, starting at the zero-meter point. The meter tape is stretched to 70 m. The laying depth of the meter tape is between 7 and 10 m or by the design of the transect location specified in the research goals and must be carried out at a constant depth. After the transect line is installed, the census dive needs to wait about 5-15 min for the fish that left to return. Recording takes place of each species and abundance of reef fish (coralivorous, herbivorous, and target fish) found along the 70 m transect line with the right and left boundaries spaced 2.5 m apart, so that the observation area covers an area of 350 m^2 (cross-sectional areas do not have to be considered). In addition, the estimated total length of the herbivores and target fish were recorded and the number of individual fish in the length range (e.g., 6 fish 20 cm long). In the case of coral fish, the size is not required; only the number of individuals corresponding to their respective species is recorded. After that, we took underwater photos and videos of fish that are

difficult to identify in person. At last, identification of specific fish species was carried out through photos or videos based on specific literature.

The data obtained were then calculated in Microsoft Excel, so that the percentage value of substrate cover and ecosystem status could be known from the families of reef fish, because these have associations with coral habitats. The data was also analyzed descriptively using figures and tables.

The percentage of coral coverage less than 25% was categorized as bad coral cover condition, coral coverage between 25-50% was in the moderate condition, coral coverage between 50 and 75% is in the good condition, and coral coverage higher than 75% is in the excellent condition (Hill & Wilkinson 2004).

Results and Discussion

General condition. Underwater conditions at Station 1 can be seen in Figure 2. The coral reef observation transect at Station 1 was at an average depth of 5 meters, at the end of Tanjung Lebak. Based on processed data, the percentage of live coral cover was 44.97%. It implied that the coral cover at Station 1 was in a moderate condition (25-49.9%). Dead coral percentage was 15.81%. Threats to the coral reef ecosystem in this area were the activities of boats, particularly tourism boats and fishing boats. This can be seen from the damage to coral reefs that could be identified, especially due to fishing anchors. Moreover, sedimentation and overfishing cause a poor balance of the aquatic environment around the site. However, in general, the coral reef ecosystem in Bawean Island, as in other small islands, was very good. It was evidenced by the discovery of several keystone species from coral reef ecosystems, namely sea turtles and Napoleon wrasse (*Cheilinus undulatus*) (Figure 3).

Figure 2. Data collection process at Station 1, Bawean Island waters.

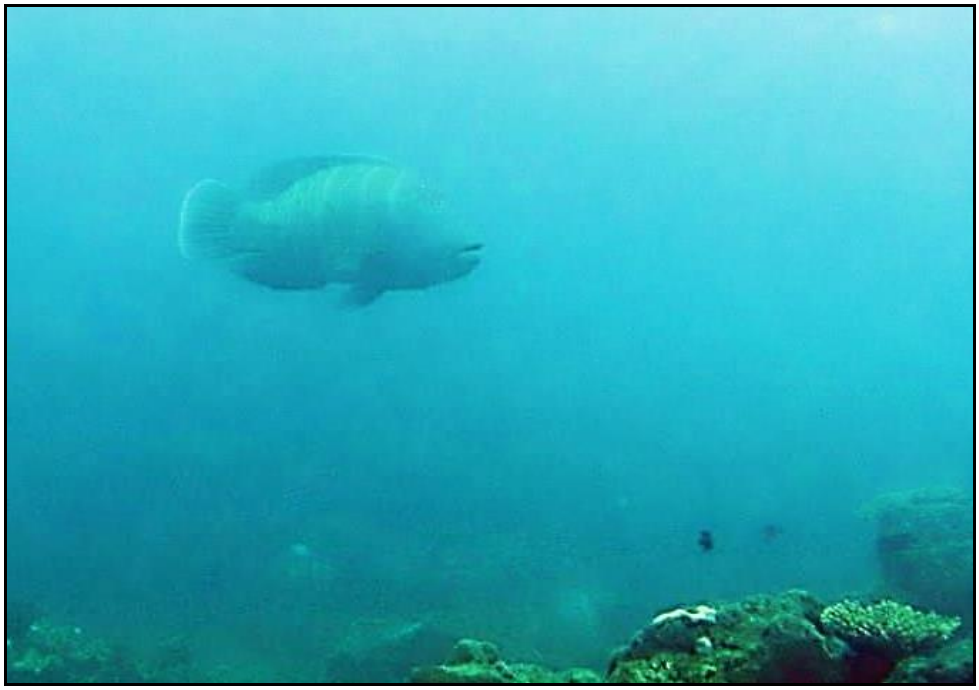

Figure 3. One of the keystone species found at the survey site, Napoleon wrasse (*Cheilinus undulatus*).

The coral reef observation transect at Station 2 was at an average depth of 8 meters, on the central side of Tanjung Lebak. Underwater conditions at Station 2 can be seen in Figure 4. Based on the data that had been processed, the percentage of live coral cover (hard coral) was 51.914%. It suggested that the coral cover at Station 2 was in good condition (50-74.9%). Dead coral percentage was 10.17%. Threats to the coral reef ecosystem in this area are the activities of boats, both tourism and fishing boats. Similarly with Station 1, boat anchors damage the reef. Moreover, sedimentation causes turbidity. However, in general, the coral reef ecosystem in Bawean Island, as in other small islands, is very good. It was evidenced by the discovery of several keystone species from coral reef ecosystems, namely sea turtles (Figure 5).

Figure 4. Underwater conditions at Station 2.

Figure 5. One of the keystone species found at the survey site.

Administratively, Station 3 is located in the waters of Dalegan Village, Panceng District, Gresik Regency. However, due to the turbid state of the waters, the activity conducted was only to observe the substrate condition. Based on the turbidity, it can be ascertained that there was little underwater life, specifically, there were no coral reefs living in the area. The situation of the underwater at Station 3 can be seen in Figure 6.

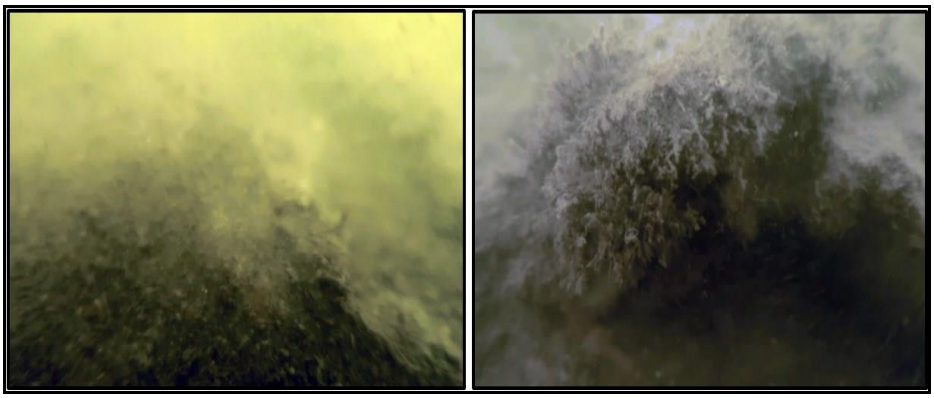

Figure 6. Mud substrate at Station 3.

The water conditions in Campurejo Village were not much different from those in Dalegan Village, because they were located on the same coastline. Furthermore, the distance between Campurejo Village and Dalegan Village is relatively small. Therefore, the activities carried out were limited to checking the primary conditions of the substrate at Station 4. The condition of the turbid waters (zero visibility) made it impossible for further observations to be made regarding coral reef growth or coral reef ecosystem, since it was closely related to the safety factor of divers. However, from observations, some coral colonies in poor condition could still be seen (Figure 7).

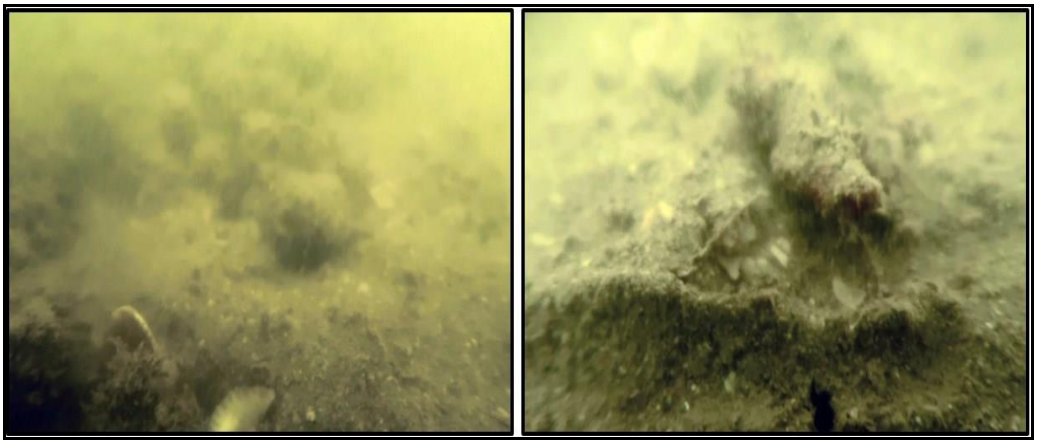

Figure 7. Mud substrate at Station 4.

Substrate coverage. The substrate coverage at Station 1 shows that the percentage of live coral cover was 44.97%, the coral cover at Station 1 being in moderate condition (25-49.9%). Furthermore, dead coral reefs percentage was 15.81%, algae had 16.21%, and other biota had 6.09% (Figure 8).

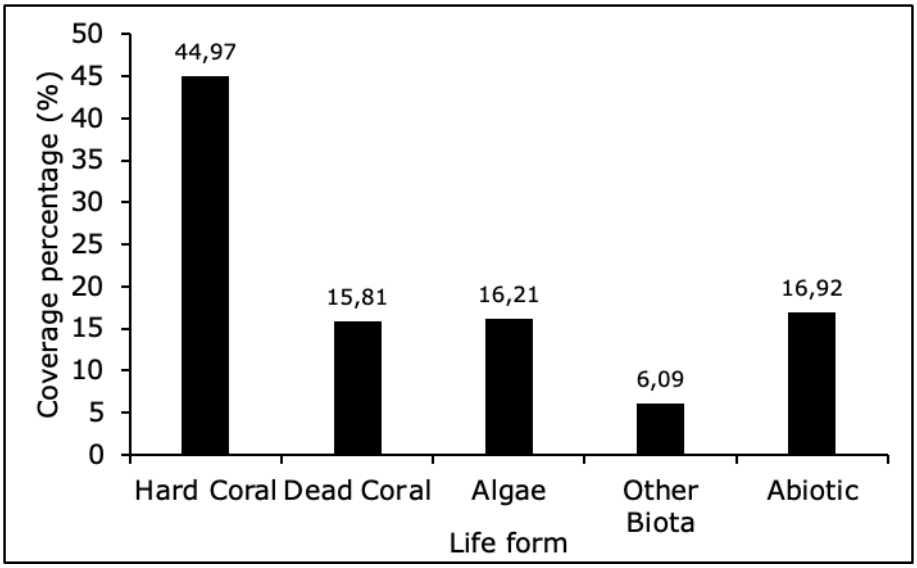

Figure 8. Coral reef ecosystem substrate conditions at Station 1.

The results show that the percentage of live coral cover (hard coral) was 51.914%, the coral cover at Station 2 being in good condition (50–74.9%). Moreover, dead coral reefs had a percentage of 10.17%, algae had 12.50%, and other biota had 9.98% (Figure 9).

Reef fish. The results of reef fish observations at Station 1 found 19 herbivorous fish from the family Achanturidae (6 individuals), family Scaridae (9 individuals), and family Siganidae (4 individuals). The number of individuals belonging to the carnivore group was 15, namely 2 individuals from the family Lethrinidae, 3 individuals from the family Haemulidae, 3 individuals from the family Serranidae, and 7 individuals from the family Lutjanidae (Figure 10).

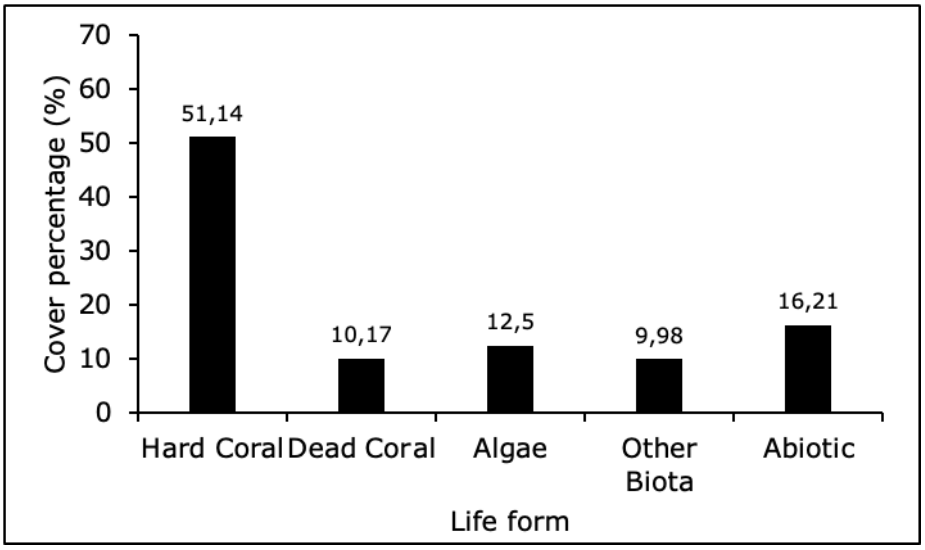

Figure 9. Coral reef ecosystem substrate conditions at Station 2.

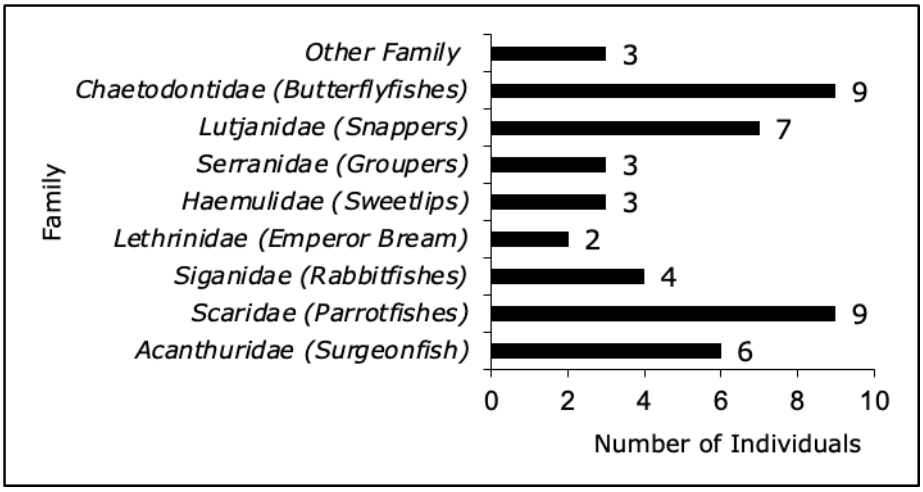

Figure 10. Reef fish at Station 1.

The results of reef fish observations at Station 2 found 15 herbivorous fish from the family Achanturidae (5 individuals), family Scaridae (7 individuals), and family Siganidae (3 individuals). The number of individuals belonging to the carnivore group was 19 individuals, namely 1 individual from the family Lethrinidae, 4 individuals from the family Haemulidae, 5 individuals from the family Serranidae, and 9 individuals from the family Lutjanidae (Figure 11).

The percentage of hard corals in Station 1 is lower when compared to Station 2. It is presumably due to boat activities for tourism and fishing. The anchors of the boats cause damage to coral reefs. Apart from boat activities, the high number of tourist visitors and high sedimentation rates were also thought to cause the low percentage of hard corals in Station 1. The average percentage of hard corals in Bawean Island waters was 48.442%. This value was classified in moderate condition (25-49.9%). This situation showed a decrease in the state of hard coral cover in general on Bawean Island in 2014-2017 (Dewi et al 2018). The rate of hard coral cover on Bawean Island was also classified as better than the conditions in the waters of Ujung Kulon National Park, Banten (Fahlevy et al 2019), and Pahat Island waters (Arafat et al 2020). However, it was worse compared to conditions in Paiton waters, Probolinggo (Maziyyah 2019), Gili Noko Island waters (Jasmine 2019), and Gili Ketapang waters (Krisnawati & Hidayah 2020).

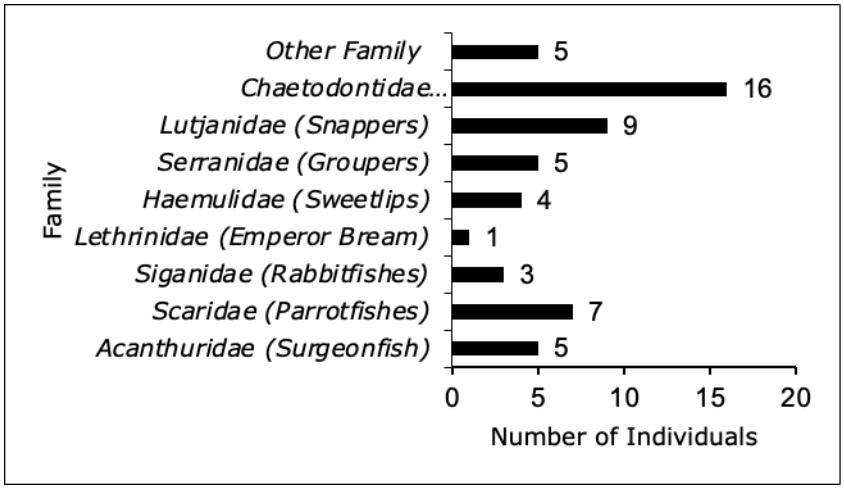

Figure 11. Reef fish at Station 2.

The number of individual reef fish that are indicators of the current status of the coral reef and have economic value at Station 1 was also lower when compared to Station 2. At Stations 1 and 2, only eight reef fish families were found. This number indicated a decrease in the number of reef fish families found on Bawean Island from 2014-2017 (Dewi et al 2018), totaling 14 families. This condition place the waters of Bawean Island in a worse state when compared to the number of reef fish families found in the Northern Seribu Islands waters (Prabowo et al 2019) and Kendari waters (Adrim et al 2012).

Conclusions. In conclusion, the percentage of hard coral cover at Station 1 was 44.97% (moderate condition), while at Station 2, it was 51.914% (good condition). The reef fish that are indicators of the current status of the coral reef and have economic value found at Station 1 consisted of the families Achanturidae (6 individuals), Scaridae (9), Siganidae (4), Lethrinidae (2), Haemulidae (3), Serranidae (3), Lutjanidae (7), and Chaetodontidae (9). Station 2 presented the families Achanturidae (5 individuals), Scaridae (7), Siganidae (3), Lethrinidae (1), Haemulidae (4), Serranidae (5), Lutjanidae (9), and Chaetodontidae (16). Ultimately, the research location was in good condition for hard coral cover.

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Conflict of Interest. The authors declare that there is no conflict of interest.

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Authors:
Sukandar, Utilization of Fisheries Resources, University of Brawijaya, 65145 Malang, East Java, Indonesia, e-mail: kdr_1212@ub.ac.id
Pratama Diffi Samuel, Aquatic Resources Management, University of Brawijaya, 65145 Malang, East Java, Indonesia, e-mail: diffisamuel@gmail.com
Citra Satrya Utama Dewi, Marine Science, University of Brawijaya, 65145 Malang, East Java, Indonesia, e-mail: satryacitra@ub.ac.id
Imas Duwi Pratiwi, Dive Wonderfull Indonesia, SSI, 60187 Surabaya, East Java, Indonesia, e-mail: imasduwipratiwi@student.ub.ac.id
Muhamad Choirul Anam, Fisheries Diving School, University of Brawijaya, 65145 Malang, East Java, Indonesia, e-mail: anam.imp76@gmail.com
Jessica Elona Beno, Marine Science, University of Brawijaya, 65145 Malang, East Java, Indonesia, e-mail: jessicaelona@student.ub.ac.id
Riska Fatmawati, Fisheries Resources Utilization, Riau University, 28293 Pekanbaru, Riau, Indonesia, e-mail: riskafatmawati@lecturer.unri.ac.id

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