Tropical marine fish from Celukan Bawang Port, Buleleng, Bali, Indonesia

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Abstract. Celukan Bawang port is located in Buleleng Regency, Bali, Indonesia. The area of Celukan Bawang Port has a coral reef ecosystem that is very rarely found in Indonesian ports. The coral reef has an important role for coral reef fish as their habitat. This study aims to conduct coral reef fish in the Celukan Bawang port area. A survey was conducted by using UVC (Underwater Visual Census) method at four (4) stations in October 2019. The coral-reef fish family identified in this research consisted of 853 individuals belonging to 14 families and 34 species. The dominant family were Pomacentridae (63.53%), Labridae (25.21%), Achanthuridae (2.70%), Chaetodontidae (1.17%), and Ptereleotrididae (1.17%). The most abundant species were *Dascyllus trimaculatus* (2270 ind/ha), *Halichoeres prosopeion* (1550 ind/ha), and *Pomacentrus coelestis* (95 ind/ha). Shannon-Wiener diversity index value was 2.414, and there were no dominant species observed.

1 Introduction

North Bali waters in Buleleng District has potential areas as water tourism with 157,05 km beach length and beautiful underwater tourism. Potential activities in the area are swimming, diving, snorkeling, fishing, enjoying sunrise and sunset, and dolphin activity. However, North Bali was called the port city by the Netherland country from the 10th century because it became a regional, national, and international trade route [1]. Nowadays, several ancient ports are non-active and replaced by more critical ports such as Celukan Bawang port.

Celukan Bawang is one of the ports in Bali that have several activities as shipping, unloading container and goods, cement Tonasa packing, and unloading bulk asphalt. This port is a collecting port [2]. The primary function is to provide domestic transportation, transfer domestic area transportation in medium quantities, origin for passengers and goods, and ferry transportation with the provincial service area [3].

Tropical marine fish related with reef fish is a fish associated with a coral reef that stays and forages there. If the coral reef is damaged, the abundance and diversity of marine fish

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would be affected [4]. Port activities have the potential to generate wastes, such as from (1) Fuel in a machine room, cooler system, pipe or tank of the ship or other effect from the ship; (2) Shipload activity that create spill and waste from loading, ballast tank cleaning and ballast system; and (3) Domestic waste in blackwater [5]. Those conditions could directly affect the water quality and, in turn, disturb the coral reef ecosystem.

There is no complete data on reef fish in Celukan Bawang. Therefore this study aims to conduct coral reef fish in this port area. This paper will be useful as a reference for environmental management in the area.

2 Materials and methods

2.1 Study site and collecting data

Field observations were conducted in October 2019 at the Celukan Bawang Port area in Penguin Village, Buleleng District, Bali, Indonesia.

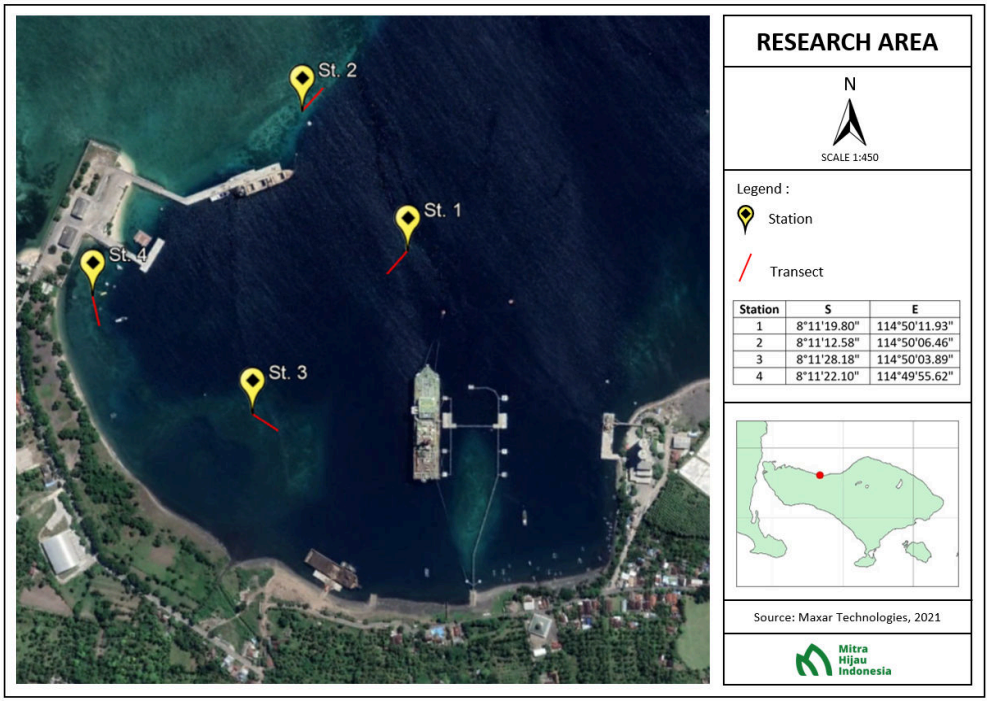

Fig. 1. Study area.

The method for collecting data was Reef Visual Census (RFVS), or familiar as Underwater Visual Census (UVC), by focusing on functional groups of fish [6]. The method focused on the fish census at sufficient resolution to analyze the individual and active group. The transect was placed in 4 locations (Figure 1). Impermanent belt transects were laid in every site (Fig. 2). The census area was 50 m x 5. Fish numbers by species were counted visually and recorded on waterproof papers. The species was validated by using Kuiter & Tonozuka (2001) and Allen (2012) [7] [8]. The conservation status of each species was checked based on IUCN Red List.

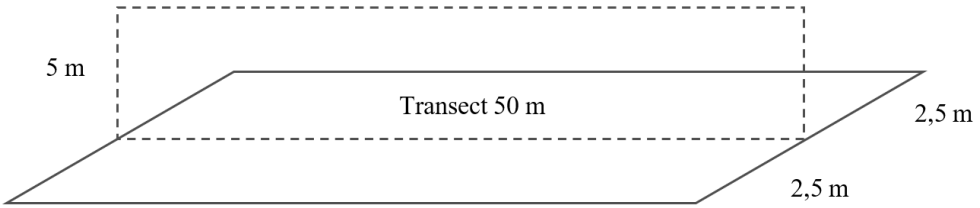

Fig. 2. Survey area dimension by UVC method.

2.2 Water quality

Seawater quality parameters were measured based on Government Regulation number 22 2021. Appendix VII concerning Sea Water Quality Standards for Aquatic Biota [9]. Samples were analyzed by KAN accredited laboratory.

2.3 Data analysis

Fish data identified then grouped as a functional group: target species, indicator species, or major species. Ecological parameters such as diversity index (H') and dominance index (C) by using:

2.3.1 Abundance and relative abundance

$$D = \frac{\Sigma\, ni}{A} \tag{1}$$

D = abundance (ind/Ha)
Ni = number of individual of species (ind)
A = area (Ha)

$$RD = \frac{ni}{N}\, x\, 100\% \tag{2}$$

RD = abundande (ind/Ha)
Ni = number of individual of species (ind)
A = area (Ha)

2.3.2 Diversity index

$$H' = -\sum_{i=1}^{s} Pi \ln Pi \tag{3}$$

H' = Shannon-Wiener index
Pi = ni/N
ni = number of individual of species -i
N = total number of individual
S = number of species

Criteria :
H' ≤ 1 = low diversity
1 < H' ≤ 3 = moderate diversity
H' ≥ 3 = high diversity

2.3.3 Dominance index

$$C = -\sum_{i=1}^{S} Pi^2 \quad (4)$$

C = Dominance index
Pi = proportion of individuals in certain species compared with a total individual of all species

Criteria :
0 < C < 0.5 = low dominance
0.5 < C ≤ 0.75 = moderate dominance
0.75 < C ≤ 1 = high dominance

3 Result and discussion

3.1 Sea water quality

The results of seawater quality are summarized in Table 1. The results show no parameters exceeding the quality standards based on Government Regulation No 22 Appendix VIII (2021) regarding seawater quality standards for aquatic biota [9].

Table 1. Water quality parameters.

No	Parameter	Unit	Quality Standards	Result
1	Clarity	meter	>5	5 - 7
2	Temperature	˚C	28 - 30	31 - 32
3	pH	-	7 - 8.5	8 - 8.7
4	Salinity	‰	33 - 34	34.4 - 34.5
5	TSS	mg/L	20	<2 - 2
6	Oil layer	-	absent	absent

All of the parameters except for clarity are above the range of quality standards for aquatic biota. The clarity is also in line with standards quality which is good. Meanwhile, other parameters exceed the quality standard so that the coral could tolerate this condition. It can be assumed that all environmental parameters in the study area are suitable for coral growth.

3.2 Coral condition

Based on Ministry of Environment of the Republic of Indonesia no 4 (2001) about Standard Criteria for Coral Reef Damage [11], the coral coverage of Celukan Bawang Port Coral was between low to middle coverage. The locations with a Coral range of 7,04% and 17,14% are categorized as low coverage. Meanwhile, The locations with coral coverage of-32,72% and 25,14% are classified as middle coverage.

Mainly at the sediments of the locations were characterized by coral rubble and sand. By interviewing local people explained that this condition was caused by fish bombing before. The port activities could be caused by sediment agitation, which floated in the water and covered coral polyps. The polyps that are covered by sediment can experience disruption of respiration, reproduction, and metabolic processes that can cause death [12].

3.3 Abundance and fish community

The result from fish data analysis is shown in Table 2. Fishes found were generally ornamental fishes. Eight hundred and fifty-three fishes were observed during this study belonging to 34 species and 14 families with a total abundance of 8530 ind/ha. Compared to research in another spot in Bali, this study has a lower number than research in Pamuteran and Sumber Kima waters. In Pamuteran, there were 3419 fishes and 4547 fishes in Sumber Kima [13]. The damaged coral condition causes this condition.

Table 2. Composition and abundance of fish

No	Family	Species	Name	ni	Abundance (ind/Ha)	Relative abundance (%)	IUCN Red List Status
1	Achanthuridae	*Acanthurus mata*	Yellowmask surgeonfish	23	230	2.696	LC
2	Apogonidae	*Apogon hartzfeldii*	Silver-lined cardinalfish	5	50	0.586	NE
3	Apogonidae	*Apogon novemfasciatus*	Sevenstriped cardinalfish	1	10	0.117	NE
4	Apogonidae	*Cheileodipterus quinquelineatus*	Three-spot cardinalfish	2	20	0.234	NE
5	Blenniidae	*Aspidontus taeniatus*	False cleanerfish	1	10	0.117	LC
6	Caesionidae	*Caesio teres*	Yellow and blueback fusilier	7	70	0.821	LC
7	Chaetodontidae	*Chaetodon adiergastos*	Eye-patch butterflyfish	3	30	0.352	LC
8	Chaetodontidae	*Chaetodon kleinii*	Sunburst butterflyfish	1	10	0.117	LC
9	Chaetodontidae	*Chaetodon lunulatus*	Redfin butterflyfish	4	40	0.469	LC
10	Chaetodontidae	*Chaetodon octofasciatus*	Eastern triangular butterflyfish	1	10	0.117	LC
11	Chaetodontidae	*Chaetodon vagabundus*	Vagabond butterflyfish	1	10	0.117	LC
12	Gobiidae	*Amblygobius noctunus*	Flase sleeper goby	2	20	0.234	LC
13	Haemulidae	*Plectorhincus polytaenia*	Yellow-ribbon sweetlip	2	20	0.234	LC
14	Labridae	*Cirrhilabrus solorensis*	Red-eyed wrasse	3	30	0.352	DD
15	Labridae	*Halichoeres prosopeion*	Half grey wrasse	155	1550	18.171	LC
16	Labridae	*Thalassoma lunare*	Moon wrasse	57	570	6.682	LC
17	Lutjanidae	*Lutjanus biguttatus*	Two-spot snapper	2	20	0.234	LC
18	Nemipteridae	*Scolopsis bilineata*	Two-lined monocle bream	3	30	0.352	LC
19	Nemipteridae	*Scolopsis margaritifer*	Perly spinecheek	5	50	0.586	LC
20	Plotosidae	*Plotosus lineatus*	Catfish	5	50	0.586	LC
21	Pomacentridae	*Abudefduf sexfasciatus*	Natal sergeant	75	750	8.792	LC
22	Pomacentridae	*Amblyglyphidodon aureus*	Golden damsel	24	240	2.814	LC
23	Pomacentridae	*Amblyglyphidodon leucogaster*	White-breasted sergeant	7	70	0.821	LC
24	Pomacentridae	*Chormis amboinensis*	Ambon puller	38	380	4.455	NE
25	Pomacentridae	*Chrysiptera rollandi*	Blue-headed damsel	13	130	1.524	NE
26	Pomacentridae	*Dascyllus melanurus*	Back-tailed humbug	1	10	0.117	NE

No	Family	Species	Name	ni	Abundance (ind/Ha)	Relative abundance (%)	IUCN Red List Status
27	Pomacentridae	*Dascyllus trimaculatus*	Three-spot humbug	227	2270	26.612	VU
28	Pomacentridae	*Dischistodus prospotaenia*	Honey-headed damsel	3	30	0.352	NE
29	Pomacentridae	*Pomacentrus chrysurus*	White-tail damsel	7	70	0.821	NE
30	Pomacentridae	*Pomacentrus coelestis*	Common blue damsel	95	950	11.137	NE
31	Pomacentridae	*Pomacentrus moluccensis*	Lemon damsel	60	600	7.034	NE
32	Pomacentridae	*Pomacentrus simsiang*	Buleback damsel	9	90	1.055	NE
33	Ptereleotrididae	*Chormis weberi*	Weber's chormis	10	100	1.172	NE
34	Scorpaenidae	*Pterois antennata*	Spotfin firefish	1	10	0.117	LC
Total				**853**	**8530**	**100**	**-**

Notes:
LC = Least Concern ; NE = Not Evaluated ; VU = Vulnerable ; DD = Data Deficient

Celukan Bawang waters are dominated by the Pomacentridae family with 63.53% relative abundance and followed by Labridae (25.21%), Achanthuridae (2.70%), Chaetodontidae (1.17%), and Ptereleotrididae (1.17%). In this study, Pomacentridae is the richest family too because it has 12 species, and the second is Chatodontidae with five species (Figure 3). Compared to other research in Bali, Pomacentridae's abundance and richest is the highest in Pamuteran waters and the second highest in Sumber Kima waters [13].

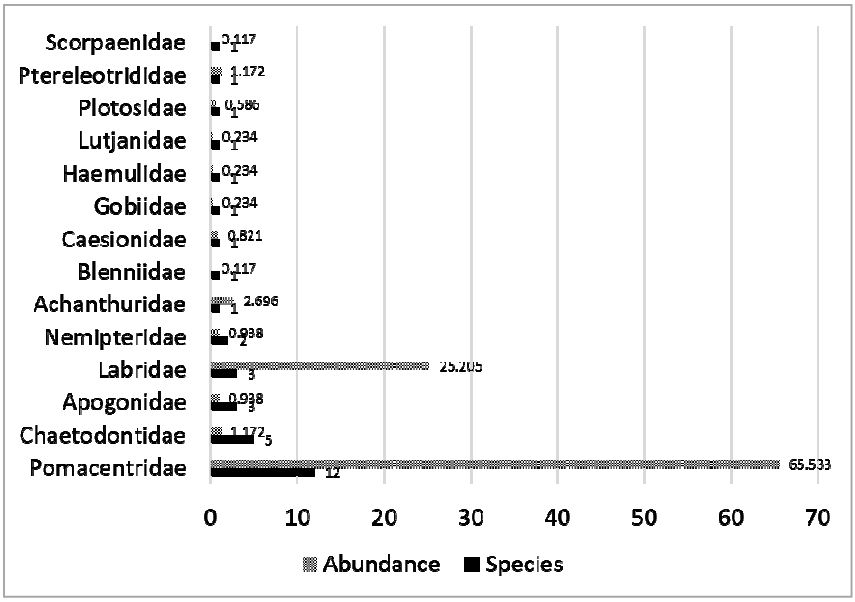

Fig. 3. Fish family comparison in Celukan Bawang area.

Pomacentridae is dominant and the richest family in Celukan Bawang port. Pomacentridae or damselfishes is a large family which has ± 348 species and 28 genera [14]. They have various individual colors. Some of them are herbivores, omnivores, or planktivores. They put their egg on the seafloor and were kept by the male [15]. Pomacentridae is diurnal fish that are active during the day and swim not far from the

bottom [16]. We found pomacentrids near the coral reef and swim 0 – 100 cm from the bottom during our survey. In this research, *Dascyllus trimaculatus, Pomacentrus coelestis,* and *Abudefduf sexfasciatus* have higher abundance in the Pomacentridae family.

Dascyllus trimaculatus known as three-spot humbug or three-spot dascyllus is the largest contributor and the most abundant (26,612%) in the Pomacentridae family. Their skin color is dark, bluish-grey, with a white spot on the upper side [17]. They swam in a group but sometimes found solitary near a coral reef, rock, and pile. *Dascyllus trimaculatus* can be found in Indo-Pacific [8]. They dwell in the coral reef, sometimes the juvenile associated with branching corals or large sea anemones. According to IUCN RedList, *Dascyllus trimaculatus is* vulnerable. This makes Celukan Bawang Port unique as this species has the highest abundance in this area.

The second position in Pomacentridae, which has high abuncande is *Pomacentrus coelestis* or common blue damsel. *Pomacentrus coelestis* has 11.137% of the total observed fish. *Pomacentrus coelestis* live around coral reefs and are frequently found around dead coral. It can be located in N.W. Australia, Great Barrier Reef, and also along with S.E. Asia and Indo-C Pacific. It is also known as neon damsel with bright blue dominant color [8]. Based on IUCN RedList, this species is not evaluated because it has not enough data or studied from a scientist.

Abudefduf sexfasciatus has 3rd place after *Pomacentrus coelestis* with abundance of 8.792%. Also known as natal sergeant or scissortail sergeant, these species live in coral and weedy reefs. The color is white with black streaks in the tail fin. This species is distributed in Indo-C Pacific [8]. According to IUCN RedList, the conservation status is the least concern.

Another family with high abundant species is *Halichoeres prosopeion* (1550 ind/ha) from Labridae. *Halichoeres prosopeion* consists 18.171% of total observed fish. *Halichoeres prosopeion* live around the coral reef and are often seen in outer slopes. It has a purplish head and anterior part and yellow color in the posterior part. During this survey, we found many juveniles of *Halichoeres prosopeion* in there. [8]. Compared with other species in the Labridae family, there are *Thalassoma lunare* or moon wrasse in the second position with 6.682% abundance and other species in the Labridae family have < 1% for its abundance.

Chaetodontidae is also known as *kepe-kepe* fish live in close association with coral reefs. They also become an indicator for coral health. They have various color patterns [18]. When surveying the area, Chaetodontidae is rarely found there. With the coral condition dominated by dead coral, it makes sense why this family was found in low abundance.

The biological index is shown in Table 3. The diversity index (H') of marine fish in Celukan Bawang Port Area is 2.414. Therefore the fish community has moderate diversity. There were no dominant species in the area which was indicated by dominance index (C) below 0.5. A high coral cover does not always follow a high diversity index. In Batbitim Misool, Papua concluded that outside marine conservation areas had higher fish diversity than inside areas. The inside area had a higher coral cover which provided protection and feeding place to certain fishes, so it might be possible that there were dominant species [19]. In this research, even though there was disturbance like port activities, it does not support the dominance of one or more species. With that condition, there might have been a dominant species because fishes have a different tolerance range. Therefore, frequent monitoring in this area is required to know the relation of port activity with the fish community.

Table 3. Biological index of fish

Biological Index	Value
Diversity index (H')	2.414
Dominance index (C)	0.138

3.4 Fish group proportion

It is well known that there are always specific interactions or responses between organisms in coral reef areas. Tropical marine fish could be differentiated into three groups: target species, indicator species, and; major species. Target species is a group of fish which are targeted by fisherman such us Acanthuridae, Haemulidae, Caesionidae, Nemipteridae, Serranidae, Scaridae, Labridae, Lethrinidae, Lutjanidae, Siganidae [19]. Indicator species are a functional group of fish that indicate coral health, like the Chaetodontidae family. Major species consist of fish groups commonly found at coral reefs, and their function in an ecosystem is unknown other than as trophic groups [20].

Fish group proportion in Celukan Bawang Port Area is shown in Fig. 4. Marine fish found are generally ornamental fish. They form fish schools-with various colors and shapes. Major fish has the highest percentage of the total fish population (58.82%), followed by target fish (26.47%) and indicator fish (14.71%). This composition is normal, especially with a high composition of indicator fish. This condition is similar to Sumbawa waters, with 50.63% major fish, 34.5% target fish, and 13% indicator fish [21]. Fish community composition will depend on substrate characteristics [22] and also human activity. In this area, there are traditional boats from local people for fishing. This area is limited for port activity, so no fishing and diving is allowed. But the composition shows that the target percentage is sufficient (26.47%).

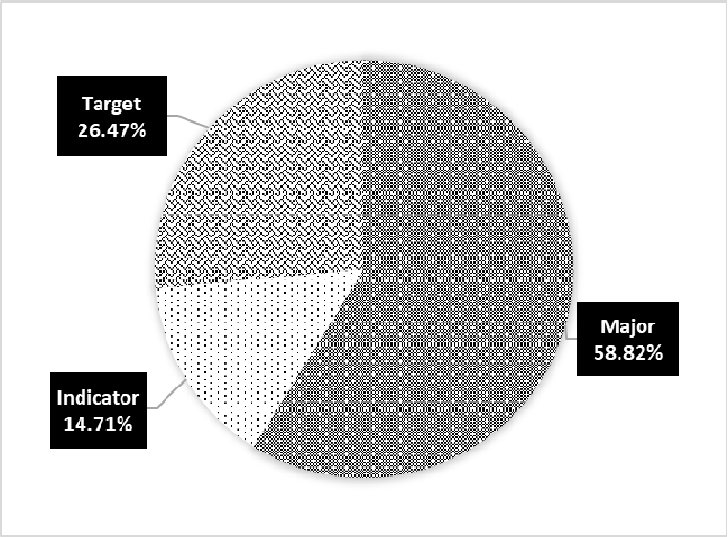

Fig. 4. Fish group composition.

4 Conclusion

Celukan Bawang port waters are suitable for coral growth. The coral-reef fish family identified in this research consisted of 853 fish in 14 families and 34 species, with most Pomacentridae, Chaetodontidae, and Labridae. These three families present 91.91% of the total fish recorded/collected. The most abundant species were *Dascyllus trimaculatus* (2270 ind/ha) from Pomacentridae, *Halichoeres prosopeion* (1550 ind/ha) from Labridae, and *Pomacentrus coelestis* (95 ind/ha) from Pomacentridae. Shannon-Wiener diversity index value is 2.414, and there were no dominant species observed.

5 Acknowledgement

This research was fully supported by PT Mitra Hijau Indonesia under developmental study project for Celukan Bawang Port area by PT Pelabuhan Indonesia Persero (Pelindo) III. The reviewer and ISFFS also corrected it.

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