Reef fishes at waters of Kei Kecil Islands, Southeast Maluku Regency, Eastern Indonesia

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Abstract. Study on reef fishes at waters of Kei Kecil Islands was conducted on October to November 2018. Eighteen stations of coral reef habitat were chosen randomly for this study and were observed by using underwater visual census method. The transect area of 250 m² (50 m length, 5 m width) was established at reef slope zone of each station and reef fish found in each transect was identified to the species level. At least 40 families of reef fish which consist of 120 genera and 381 species, and 3 of which are endemic species were found during the study. Those reef fish species found can be categorized into target species (141 species), major species (203 species) and indicator species (37 species). Coral Fish Diversity Index (CFDI) determined based on six indicator families indicate that relative diversity of reef fish in the study area can be classified into poor to good categories. Based on CFDI value, estimated number of reef fish in the coral reef of Kei Kecil Islands was 742 species.

Keywords: reef fish, species composition, coral fish diversity index, Kei Kecil Islands

1. Introduction

The position of Maluku Province is very strategic because it is influenced by the Banda Sea, Arafura Sea and Seram Sea, as well as experiencing sea water mass runoff from the Pacific and the Indian Ocean alternately. The largest proportion of Maluku Province marine waters is the deep sea with a stretch of 1,340 islands, of which 1,336 islands are small islands and its coastal area is occupied by the main ecosystem of tropical waters. Furthermore, coral reef ecosystems are very prominent in coastal area of those 1,336 small islands. As a consequence of the location of Maluku Province, it is believed to have biodiversity and high potential marine resources, especially reef fishes. This is supported by statement of Bengen (2013) [1] that coral reefs are spread on the small islands of Indonesia which play an important role as a habitat for a variety of fish species, thus giving an impact on the high productivity of fisheries (reef fish) with high economic value.

Kei Kecil Islands is situated at the east region of Banda Sea [2] and abuts with Arafura Sea [3], Southeast Maluku. Moreover, the islands are located within the world coral triangle regions [2, 4, 5], so it is believed to have a high coral reef biodiversity [4]. Kei Kecil Islands have 41 islands [6] which are classified as small islands according to island size classification [7, 8, 9, 10] with the size ranged from 0.02 to 10.15 km² [6]. Among the three main ecosystem of tropical waters that occupy in the coastal areas of Kei Kecil Islands, coral reef is the largest ecosystem (5,547 ha), followed by seagrass (1,936 ha) and 579 ha of mangrove ecosystem [6]. With the size of three most important ecosystem, Kei...
Kecil Islands waters has great marine resources potency such as fishes, molluscs, echinoderm, and crustacean of economic and non economic value [3, 11, 12, 13, 14, 15, 16, 17, 18].

Kei Kecil Islands waters has been visited by scientist through the 3rd Rumphius Expedition in 1977 to study reef fish. Reef fish in the waters Kei Kecil Islands has also been studied by Prabuning et al (2016)[16] and Wouthuyzen et al (2018)[2], however, species composition of reef fish was not found in the results of both studies. Therefore, this research was conducted with the objectives to study species composition and relative diversity of reef fish in the coral reefs habitat of Kei Kecil Islands.

2. Materials and Method

This study was conducted on October to November 2018 at 18 stations in the coral reef of Kei Kecil Islands, Southeast Maluku Regency (Figure 1). Data of reef fish were collected by using Underwater Visual Census (English et al, 1997) [19], i.e., a belt transect of 250 m² (50 m length, 5 m width) was established on reef slope zone of each station. Reef fish found inside the transect area were identified to the species level based on Allen (1991) [20], Kuiter (1992) [21], Heemstra and Randall (1993) [22], Lieske and Myers (1995) [23], Allen (2000) [24], Kuiter and Tonozuka (2001) [25], Allen et al (2003) [26] and White et al (2013) [27]. Identified species was then categorized into target species, major species and indicator species group according to English et al. (1997) [19].

Figure 1. Map showing Kei Kecil Islands dan sampling stations

Total species of reef fish in the area was estimated by using Coral Fish Diversity Index (CFDI) for restricted small areas (< 2,000 km²) as proposed by Allen (1998) [28] and Allen and Erdmann (2012) [29] using the following formula: Estimated total species (< 2,000 km²) = (3.39 x CFDI) - 20.595. CFDI values was also used to classify relative diversity of reef fish [28] in the coral reef habitat of Kei Kecil Islands, and criteria used for classification presented in Table 1.
Table 1. Relative diversity of reef fish based on CFDI

| Category  | CFDI Value | Sampling site | Local region | National region |
|-----------|------------|---------------|--------------|-----------------|
| Extraordinary | > 150 | > 330 | > 400 |
| Excellent   | 130 - 149 | 260 - 329 | 330 - 339 |
| Good        | 100 - 129 | 200 - 259 | 220 - 239 |
| Moderate    | 70 - 99 | 140 - 199 | 160 - 219 |
| Poor        | 40 - 69 | 50 - 139 | 80 - 159 |
| Very Poor   | < 40 | < 50 | < 80 |

3. Results and Discussion

3.1. Taxa Composition of Reef Fish

There are 381 species of reef fishes belonging to 120 genera and 40 families found during this study at coral reefs area of Kei Kecil Islands (Table 2). Those reef fishes can be categorized into target species (141 species), major species (203 species) and indicator species (37 species). From 40 reef fish families found, six families with the highest number of species, in decreasing order, are Pomacentridae, Labridae, Chaetodontidae, Serranidae, Acanthuridae and Scaridae, with respective number of species as follows: 73, 56, 37, 30, 24 and 23 species (Figure 2). Total number of species from those six families collectively contributes approximately 63.8% of the total reef fish found at the coral reef habitats of Kei Kecil Islands. On the other hand, 11 out of 40 families found i.e. Aulostomidae, Callyonymidae, Cirrhitidae, Dasyatidae, Gobiidae, Pempheridae, Platycephalidae, Pseudochromidae, Scombridae, Syngnathidae and Zanclidae, each has one species only.

Among families with the highest species number, Pomacentridae, Labridae and Chaetodontidae have the highest species number (Figure 2). These three reef fish families usually have the highest species number with wide habitat distribution and even can be found at areas with poor coral reef [29]. These three reef fish families were also found to have high number of species at Indonesia coral reefs [30], Banda Islands [2, 4], southern coastal waters of Ambon Island [32] and Tuhaha Bay waters [33].

At least 81% of 90 species of Chaetodontidae family on Banda Sea coral reefs [2], 59% of 123 species on Eastern Indonesia waters [30, 31] and 48% of 152 species of Pomacentridae family on Indonesia coral reefs [30] were found inhabiting the Kei Kecil Islands coral reef habitats. Evidently, two out of 73 those pomacentrid species i.e. Neoglyphidodon crossi and Pomacentrus melanochir are endemic species [30, 34]. In addition, 101.8% of the 55 species on the Banda Islands coral reefs[4],
75.6% of 75 species on the Banda Sea coral reefs[2], 31.5% of 178 reef fish species of Labridae family on Indonesia coral reefs [30] inhabit the coral reef of Kei Kecil Islands, and an endemic species was found, namely Halichoeres solorensis [30, 34]. Three species of reef fish are endemic species in the Banda Sea coral reefs [34]. This means that the three endemic species of reef fish in Banda Sea coral reefs can be found in the coral reef habitats of Kei Kecil Islands.

As much as 62.7% of 59 indicator species (family Chaetodontidae) on Indonesia coral reefs [30] inhabitant coral reef of Kei Kecil Islands, while number of species of Chaetodontidae family on Banda Islands coral reef (32 species)[4] and Banda Sea (33 species)[2] were lower than Kei Kecil Islands coral reef (37 species). In general it can be concluded that the coral reefs of Kei Kecil Islands are in a healthy condition[19, 39], although some coral reef stations can be called in an unhealthy condition.

Number of reef fish species found at each sampling station range between 76 to 217 species with the average of 127 species. Coral reef area with highest variety of reef fish species are station 15 with 217 species, station 8 with 195 species and station 1 with 187 species, as well as station 4 with 164 species and station 3 with 143 reef fish species (Table 2). This table also shows that, station with higher number of species tend to have higher number of genera and families like station 1, 8 and 15. Number of reef fish species found in this study is higher than previous study conducted in Southeast Maluku (356 species), as well as in Southwest Maluku (346 species) [36]. This difference could be due to different in station number sampled. In present study 18 stations were observed while in previous study only 11 and 10 stations were observed. Number of reef fish species found at Banda Islands [2, 4, 35, 36] is much higher than what was found in the coral reef of Kei Kecil islands. Number of reef fishes found in in Banda Islands amounted to 408, 433, 500 and 596 species. Number of sampling site of Banda Islands were 19, 20 sites. All these studies show that differences in number of species found could be affected by study sites, sampling method as well as number of sampling station.

Table 2. Taxa composition and category of reef fish in the waters of Kei Kecil Islands

| Station | TS | MS | IS | Sub-Total | Genera | Family |
|---------|----|----|----|-----------|--------|--------|
| 1       | 71 | 93 | 22 | 187       | 87     | 28     |
| 2       | 41 | 70 | 11 | 122       | 65     | 23     |
| 3       | 62 | 75 | 7  | 144       | 71     | 26     |
| 4       | 60 | 94 | 11 | 165       | 72     | 26     |
| 5       | 26 | 49 | 7  | 76        | 47     | 19     |
| 6       | 46 | 64 | 6  | 116       | 56     | 23     |
| 7       | 47 | 68 | 6  | 124       | 60     | 22     |
| 8       | 78 | 93 | 24 | 195       | 90     | 32     |
| 9       | 48 | 75 | 11 | 134       | 70     | 27     |
| 10      | 38 | 58 | 6  | 102       | 61     | 25     |
| 11      | 42 | 66 | 11 | 119       | 69     | 26     |
| 12      | 37 | 54 | 6  | 97        | 54     | 22     |
| 13      | 41 | 62 | 14 | 117       | 68     | 25     |
| 14      | 43 | 55 | 10 | 108       | 62     | 24     |
| 15      | 87 | 106| 24 | 217       | 99     | 32     |
| 16      | 37 | 51 | 6  | 94        | 54     | 23     |
| 17      | 34 | 45 | 6  | 85        | 47     | 22     |
| 18      | 32 | 54 | 6  | 92        | 54     | 22     |
| Total   | 141| 203| 37 | 381       | 120    | 40     |

Until recently, the highest number of reef fishes found in Indonesia was recorded at Bird’s Head Peninsula (Raja Ampat Island), Fak Fak-Kaimana Coast and Cendrawasih Bay, West Papua, with species number amounted for 1,511 which belong to 451 genera and 111 families [37]. Area surveyed in Allen and Erdmann (2009; 2012) [37, 29] was 50,000 km² with free scuba diving UVC method with the depth down to 60 m, and number of species found was 1,320. Other factor that can contribute to number of species differences is repeated sampling. As reported by [29], number of reef fishes found in Raja Ampat in repeated surveyed between 2001, 2002, 2009 and 2012 are 236, 1,102, 1,320 and 1,437 species respectively.
From those reef fish category, reef fishes of major species is higher than target species and indicator species, and target species is higher than indicator species (Table 2 and Figure 3). In other word majority (53.47%) of reef fish found in Kei Kei Islands belong to major species. Higher number of major species found in reef ecosystem seems to be a general pattern. In Banda Islands [2, 4], southern coast of Ambon Island [32], Tuhaha Bay, Saparua Island [33], Cendrawasih Bay, West Papua [37] and Dampier strait, Raja Ampat Islands [38], for example, number of major species found in the reef ecosystem is higher compared to two other species categories.

According to Allen and Adrim (2003) [30], Indonesia coral reefs have 102 species of Serranidae. Evidently, 30 species or 29.4% of those 102 serranid species inhabit coral reef habitats of Kei Kecil Islands. From 8 reef fish family found in this study (Figure 2), Serranidae is one of the target fish with high economy value. There are 25 species of Serranidae are commonly harvested by local fisher either for consumption and for commercial purpose. The number of species of Serranidae found at waters of Kei Kecil Islands is lower than what was found in Banda Islands (35 species) [4], also in Kotania Bay, eastern Seram Island (35 species) [40] and in Ambon Island waters (40 species) [41]. Number of species difference was attributable to number of sampling station and sampling method.

3.2. Relative diversity of reef fish
Relative diversity of reef fish based on Coral Fish Diversity Index (CFDI) at waters of Kei Kecil Islands can be seen at Table 3. This table shows that over all CFDI of reef fish found in coral reef habitat of Kei Kecil Islands is 225 which can be categorized as good (see Table 1 for criteria). CFDI value in this area ranges between 51 to 122 which means poor to good condition. Obviously, most of reef station at waters of Kei Kecil Islands have poor and moderate relative diversity (Table 3). CFDI is used to determine relative diversity of reef fish based on number of species observed that belong to 6 main or indicator families *i.e.* Chaetodontidae, Pomacanthidae, Pomacentridae, Labridae, Scaridae, and Acanthuridae [28, 29, 30].

Result presented in Table 3 showed that number of reef fish found in this study is 381 species while the number of reef fish predicted based on CFDI from six key indicator families is 742 species. This figure indicates that more species, i.e., 361 species (48.7%) of reef fish is expected to be found if repeated sampling is done in the coral reef habitat of Kei Kecil islands.

| Station | CFDI | Observed species | Estimated species | Category |
|---------|------|-----------------|-------------------|----------|
| 1       | 112  | 187             | 359               | Good     |
| 2       | 82   | 122             | 257               | Moderate |
| 3       | 82   | 144             | 257               | Moderate |
| 4       | 105  | 165             | 335               | Good     |
| 5       | 52   | 76              | 156               | Poor     |
| 6       | 74   | 116             | 230               | Moderate |
Table 4 shows CFDI value of several reef fishes in Indonesia, and it explains that there is a variation in CFDI value between sites or regions. CFDI of reef fish from Kei Kecil Islands is smaller than eight sites listed at Table 4 except from Banda Islands 2013 [36], Weh Island [29], Southern Coastal waters of Ambon Island [32], Tuhaha Bay, Saparua island [33], Southeast Maluku, Southwest Maluku, Central Maluku, Buru Island [36] and Dampier Strait, Raja Ampat Island[38].

| No. | Location                                  | CFDI | Number of species observed | Number of species estimated |
|-----|-------------------------------------------|------|-----------------------------|----------------------------|
| 1   | Weh Island, Sumatera                      | 196  | 533                         | 644                        |
| 2   | Bali and Nusa Penida                      | 377  | 977                         | 1312                       |
| 3   | Togean and Banggai Islands, Sulawesi       | 308  | 819                         | 1190                       |
| 4   | Moumure Bay, Flores                       | 333  | 1111                        | 1108                       |
| 5   | Halmahera, North Maluku                   | 327  | 974                         | 1271                       |
| 6   | Raja Ampat Islands, West Papua            | 373  | 1437                        | 1465                       |
| 7   | Fak Fak - Triton Bay, West Papua          | 322  | 1005                        | 1249                       |
| 8   | Cenderawasih Bay, West Papua              | 302  | 965                         | 1165                       |
| 9   | Dampier strait, Raja Ampat Islands        | 146  | 240                         | 474                        |
| 10  | Banda Islands, Maluku 2013                | 211  | 433                         | 695                        |
| 11  | Banda Islands, Maluku 2015                | 284  | 592                         | 942                        |
| 12  | Southeast Maluku                          | 198  | 356                         | 651                        |
| 13  | Southwest Maluku                          | 195  | 346                         | 640                        |
| 14  | Central Maluku                            | 167  | 272                         | 546                        |
| 15  | Buru Island, Maluku                       | 158  | 261                         | 515                        |
| 16  | Southern coastal waters of Ambon Island    | 165  | 293                         | 539                        |
| 17  | Tuhaha Bay, Saparua Island, Maluku        | 134  | 243                         | 434                        |
| 18  | Kei Kecil Islands, Maluku                 | 225  | 381                         | 742                        |

**Source:** No. 1-8=Allen & Erdmann (2012); No.9=Hukom et al (2018); No. 10= Muljadi & Rijoly (2013); No. 11-15 = Rijoly (2015); No. 16 = Limmon et al (2017); No.17 = Sahetapy et al (2018)

4. Conclusions

A total of 381 reef fish species which belong to 119 genera and 40 families were identified during the study in the coral reef habitat of Kei Kecil Islands, and three species of which are endemic species. Most of the reef fish are belong to major species category (139 species), while the remaining are target species (202 species) and indicator species (37 species). Generally, relative diversity of reef fish at waters of Kei Kecil Islands can be categorized as good based on reef fish diversity index, whilst at some stations they are categorized as moderate and poor. Based on reef fish diversity index of six main families of reef fish (225), then an approximately 742 species of reef fish are estimated can be found in the coral reefs habitat of Kei Kecil Islands, Southeast Maluku Regency.

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