Diversity of coral reef fish in the coastal water of Spelman Straits, Southeast Sulawesi

Muis$^{1,3,*}$, R Kurnia$^2$, Sulistiono$^2$ and Taryono$^2$

$^1$Graduated Student Coastal and Marine Resources Management, Department of Aquatic Resources Management, Faculty of Fisheries and Marine Science, IPB University, Bogor 16680, ID
$^2$Department of Aquatic Resources Management, Faculty of Fisheries and Marine Science, IPB University, Bogor 16680, ID
$^3$Fisheries Agribusiness Department, Faculty of Fisheries and Marine Sciences, Halu Oleo University, Kendari, ID

*Corresponding author: muisfpikuho@gmail.com

Abstract. Spelman Strait is one of the potential reef fisheries. This study aims to examine the potential of reef fisheries in the Spelman Strait. The data used in this study are primary data to determine the abundance of reef fish and the use of PaST (Paleontological Statistics) tools to assess diversity, Evenness, wealth, and dominance indices. The results showed that live coral cover from all observation stations was 37.71%. The abundance of reef fish has been under pressure, the diversity index still has good but some families experience threats, the Evenness index value also still shows an even distribution but there are several families threatened, the wealth index still describes good species wealth, but the distribution is uneven, while the dominance index value illustrates that the condition of the coral reef ecosystem is under pressure. This condition is caused by destructive fishing so that the existence of some economically important targeted fish is threatened.

1. Introduction

Spelman Strait waters have a big fishery and other oceanic potencies such as the ecosystem and coral reef. The local fishermen and the Bugise have been utilizing these resources for a long period through a process the local society calls the white ship, which can be interpreted as social knowledge. However, the continuous utilization of the fishery resources degrades the condition of the Spelman Strait waters, for the coral as well as other fisheries such as handlines, lift net (kelong), rumpon, and purse seine (landa) due to the unfriendly environmental haul such as the persistent use of trawl and explosive fishing. This led to a situation worse than the pre-empted result by having only the coral and anchovy surviving up to the present moment.

Spelman is one of the Indonesia straits located in Center Buton Regency, Southeast Sulawesi Province with big potency for coral reef ecosystem. This potential is utilized by small fishermen with canoe and three gross ton outboard motor capacities.
However, the coral fish redundancy depends on the reef and the habitat complexity in the ecosystem. Fish existence in the coral reef area is influenced by several physical variables such as the coral reef condition and the environment [1]. The Spelman Strait waters are a strain with the semi-open sea directly facing Flores Sea and Bone Cove and coral fish is one of the important biota components of the ecosystem due to its ability to maintain balance and provide fishery resources for the society. Therefore, there is a need to study the fish’s redundancy based on the coral reef condition.

There are some research on coral fish diversity conducted in several places using different approaches as observed in Belitung West Island waters of Bangka Belitung [2], in Manado City Siladen Island, North Sulawesi [3], in Pemuteran waters, Bali [4], in Palu Cove waters [5], in Waters Tourism Park of Anambas Archipelago [6], and in Makian Island waters, North Maluku Province [7, 8]. This is, however, the first coral fish diversity research conducted in Spelman Strait coast waters. Therefore, this study is very important to obtain the necessary basic line data needed for the continuous management of fish in the area, because if the management is not good then the fishing obtained will decrease [9]. This study aims to determine the live coral cover, diversity, variety, domination, and fishery types at each station.

2. Methods
The study was conducted between September and May 2019 in Spelman Strait coast waters of Center Buton Regency, Southeast Sulawesi Province (Figure 1). There were five stations with coral reef ecosystem conditions used for observation in the research area.

Figure 1. Study site diversity of coral reef fish in the coastal water of Spelman Straits.

The data for coral reef condition was obtained using Underwater Photo Transect (UPT) method while coral fish observation was conducted by underwater visual census (UVC) method [10, 11]. The UPT method made used a line transect equal to the coral fish observation transect and it was
implemented by a diver using a digital camera and underwater case at 1:1 ratio frame with a large JPEG format. The photography was taken at a distance interval of 1 meter and the observation by writing a transect line alongside about 70 meters [12-14].

The results showed the redundancy, Shannon-Wiener diversity index, variety index/Evenness average, Simpson Dominancy index, and Margalev Wealth Index were analyzed through the use of PaST (Paleontological Statistic) tools [15].

3. Result

3.1. Coral reef life form

The coral reef condition in a certain area can be determined ecologically-based on the live coral covering percentage as the standard criteria for destruction. The results of coral reef measurements on 5 observation stations showed live coral cover in moderate condition [16], as shown in Table 1.

| No. | Category | % Life Coral Closure |
|-----|----------|----------------------|
| 1   | Bad      | 0 – 24.9 %           |
| 2   | Fair     | 25 – 49.9 %          |
| 3   | Good     | 50 – 74.9 %          |
| 4   | Excellent| 75 – 100 %           |

Furthermore, the percentage observation of coral reef condition in the coastal waters of Spelman Strait for the observed stations are as shown in Table 2 as follows:

| Station | Location | Cover Percentage (%) |
|---------|----------|-----------------------|
|         |          | K. Life | K. Death | Others | Abiotic | Total |
| 1       | Fringing Reef | 42.86   | 38.57    | 18.57  | 0.00    | 100   |
| 2       | Patch Reef | 39.29   | 36.43    | 6.43   | 17.86   | 100   |
| 3       | Patch Reef | 43.57   | 40.71    | 7.14   | 8.57    | 100   |
| 4       | Patch Reef | 36.43   | 42.14    | 3.57   | 17.86   | 100   |
| 5       | Patch Reef | 26.43   | 10.71    | 16.43  | 46.43   | 100   |

Source: Primary data 2019.

The coral reef condition in the five stations or the whole of the coastal waters was found to be in the fair category (Figure 2).

![Figure 2](image_url)
Table 3. The score of diversity, variety, domination, and fishery types at each station.

| Component               | ST1 | ST2 | ST3 | ST4 | ST5 |
|-------------------------|-----|-----|-----|-----|-----|
| Individuals             | 101 | 65  | 113 | 172 | 93  |
| Simpson_1-D (dominance) | 0.95| 0.93| 0.95| 0.96| 0.93|
| Shannon_H (diversity)   | 3.21| 2.73| 3.18| 3.38| 2.77|
| Evenness e^H/S          | 0.85| 0.87| 0.86| 0.84| 0.84|
| Margalef (wealthy)      | 6.07| 4.07| 5.71| 6.61| 3.97|

3.2. Coral fish composition

Based on Table 4, there were 7 families, 44 genera, and about 544 pieces of coral fishes in all the stations. The largest quantity was found at Station 4 with approximately 172 and the lowest at Station 2 with about 65. There were 101 at Station 1, 113 in Station 3, and 93 in Station 5 as shown in Table 4.

The dominance family was Acanthuridae 181 individuals and the lowest one was Haemulidae (7 individuals). Besides, there were 138 of Scaridae, 96 of Lutjanidae, 71 of Chaetodontidae, 26 of Siganidae, and 25 of Serranidae.

Table 4. Coral fish composition based on the size at the Spelman Strait coastal waters.

| Size of fish (cm) | Station 1 | Station 2 | Station 3 | Station 4 | Station 5 |
|-------------------|-----------|-----------|-----------|-----------|-----------|
| 6-10              | 6 (Chaet) | 6 (Chaet) | 14 (Chaet)| -         | -         |
| 11-15             | 21 (Acanth)| 19 (Acanth)| 7 (Chaet),| 10 (Chaet),| 4 (Chaet), |
|                   | 6 (Siga)  | 6 (Siga)  | 27 (Acanth)| 38 (Acanth),| 35 (Acanth),|
| 16-20             | 4 (Acanth),| 10 (Scari),| 6 (Chaet),| 9 (Chaet),| 2 (Chaet), |
|                   | 18 (Scari),| 1 (Haemu),| 9 (Acanth),| 6 (Acanth),| 12 (Scari),|
|                   | 15 (Lutja)| 5 (Lutja) | 9 (Scari),| 14 (Scari),| 17 (Lutja) |
|                   | 2 (Leth)  | 2 (Siga), | 16 (Lutja)| 16 (Lutja)| -         |
| 21-25             | 2 (Siga), | 6 (Scari) | 5 (Chaet),| 2 (Chaet),| -         |
|                   | 6 (Lutja),| 5 (Scari),| 2 (Siga), | 8 (Scari),| -         |
|                   | 2 (Serra) | 2 (Siga), | 2 (Siga),| 2 (Siga),| -         |
| 26-30             | 4 (Scari),| 3 (Lutja),| 5 (Acanth),| 15 (Acanth),| 8 (Scari), |
|                   | 2 (Lutja),| 2 (Serra) | 6 (Scari),| 16 (Scari),| 3 (Serra) |
|                   | 6 (Serra) | 2 (Lutja) | 2 (Lutja) | 2 (Siga), | -         |
| 31-35             | 3 (Scari),| 3 (Scari),| -         | 2 (Acanth),| 6 (Scari), |
|                   | 2 (Haemus)| 4 (Lutja) | -         | 4 (Scari), | 2 (Lutja), |
|                   | 4 (Serra) | -         | -         | 2 (Haemus),| 4 (Serra) |
| 36-40             | -         | -         | 2 (Serra),| 120       | 52        |
| 41-45             | -         | -         | -         | 6 (Scari), | -         |
| Total size 20 s/d More | 68 | 34 | 65 | 120 | 52 |
| Size (Ind/350 m²)  | 103 | 65 | 113| 172 | 93 |

Source: Primary Data 2019.
4. Discussion

4.1. Coral fish redundancy

Based on the COREMAP [17] criteria, Station 4 with 120 tails was in the “more” category of redundancy while Station 2 with 34, Station 5 with 52, Station 3 with 65, and Station 1 with 68 tails were categorized as “little” category as shown in Table 5.

The abundance of reef fish in the Spelman Strait coastal waters based on observations, some reef fish families have experienced more capture such as the families were Serranidae, Haemulidae, and Lethrinidae. This is very closely related to the condition of live coral cover. Coral cover lives in the coastal waters of the Spelman Strait at all observation stations in moderately damaged conditions (Table 2). This is caused by anthropogenic influences, such as the still widespread fishing of reef fish using bombs (destructive fishing). Low abundance of reef fish is caused by fishing that is not environmentally friendly and there is no knowledge of fish spawning season and is not selective in fishing [18].

The redundancy is closely related to the coral reef condition and surface complexity (rugosities). Besides, the fish has a narrow ecological niche, hence, more species populated (accommodated) the reef. Consequently, a certain fish is limited and localized only in a certain area of the reef [12].

Table 5. Coral fish family in the Spelman Strait coastal waters.

| Family            | Station 1 | Station 2 | Station 3 | Station 4 | Station 5 |
|-------------------|-----------|-----------|-----------|-----------|-----------|
| Chaetodontidae    | 6         | 6         | 32        | 21        | 6         |
| Acanthuridae      | 25        | 19        | 41        | 61        | 35        |
| Siganidae         | 8         | 6         | 2         | 8         | 2         |
| Scaridae          | 25        | 19        | 20        | 48        | 26        |
| Lutjanidae        | 23        | 12        | 18        | 24        | 19        |
| Serranidae        | 12        | 2         | 6         | 5         |
| Haemulidae        | 2         | 1         | -         | 4         | -         |
| Lethrinidae       | 2         | -         | -         | -         | -         |
| Total             | 103       | 65        | 113       | 172       | 93        |

4.2. The Diversity Indexes (H')

A sequential high diversity index was observed from the stations e.g 3.376 at Station 4, 3.211 at Station 1, and 3.177 at Station 3. These show the environment is good for some families and species of the fish. Furthermore, high diversity may cause interactions involving energy transfer, predation, competition, and more complex niche among the species [19]. On the contrary, another opinion was provided by an expert that diversity is not only stable. These two different opinions are, however, sustained by the logic of ecological arguments, in which it is right and wrong (the weakness) [20].

The 2.765 and 2.749 diversity index obtained at Stations 5 and 2 respectively were found to be in the fair condition, but there are some threatened families as observed in Station 4 including Lethrinidae, Haemulidae, and Serranidae as shown in Table 5. However, based on the intense destructive fishing condition of trapping pattern field, the coral reef ecosystem experienced heavy stress which influences the fish diversity. In contrast to what was found in West Wawonii, Southeast Sulawesi, the diversity of reef fishes showed more diversity compared to locations on Labengki Island, Southeast Sulawesi [21]. Diversity reef fish species in Palu Bay is in moderate condition, which illustrates that diversity is still evenly distributed [5]

4.3. Index Evenness (E)

The evenness index score is used to describe community stability. Therefore, the result showed an evenness index score of 0.8686 at Station 2, 0.8564 at Station 3, 0.8554 at Station 1, and 0.8361 at Station 4 and 5. Based on the criteria used in determining the index, the stations were found to have prevalent organism distribution and a stable community. However, some threatened families including...
Lethrinidae and Haemulidae were found in stations 1, 2, 3, and 5, Serranidae in Stations 2 and 3, Siganidae in Station 5. This is caused by the environmentally unfriendly target fishery trap. Unlike what is found in West Wawonii, the evenness index is classified as moderate, the evenness index and the dominance index are relatively low, and this indicates the concentration of certain individuals [21]. Index of coral fish species uniformity is in a stable condition, which shows that the reef fish community in the waters of Labuan District is not easy to experience ecological disturbance naturally [5].

4.4. The Wealthy Index
The results showed the best species wealthy scores to be 6.605 at Station 4, 6.067 at Station 1, 5.711 at Station 3, 4.072 at Station 2, and 3.971 at Station 5. The wealthy index from all stations shows a good species-rich for some families and only moderate for station 5 which is also categorized as a good condition [22]. Larger station leads to higher Margaley index score and higher diversity [23-24]. However, area and different habitat conditions may cause variations in the wealthy score. The level of fish species richness in shallow and deep waters is different [25].

4.5. Dominancy Index
The dominancy score obtained is 0.9293 at Station 1, 0.9223 at Station 4, 0.9159 at Station 3, 0.865 at Station 2, and 0.8625 at Station 5. Therefore, based on the dominancy criteria, the coral reef ecosystem condition in all the stations are stressed because some families are dominating the community. The biggest dominancy for station 1 is the Acanthuridae, Scaridae, and Lutjanidae; In Station 2, Acanthuridae, Scaridae, and Lutjanidae; Station 3 are Acanthuridae, Chaetodontidae, Scaridae, and Lutjanidae family; Station 4 are Acanthuridae, Scaridae, Lutjanidae, and Chaetodontidae family; and Station 5 includes Acanthuridae, Scaridae, and Lutjanidae family.

This shows all the station suffers from certain coral fish dominancy. A high dominancy shows uneven species distribution and its existence indicates variations in the powers of the fish to live and adapt in a certain place. It also means that the coral fish in the observed location does not utilize the resources available prevalently. A high dominancy index score means there is an individual dominating a particular location [26]. But the dominance index of the reef fish community in Tikus Island, Bengkulu City and the waters of the Karimunjawa National Park is in good condition and there is no pressure in the ecosystem (nothing dominates) [27, 28].

5. Conclusion and Recommendation

5.1. Conclusion
In general, the condition of coral reefs in the Spelman Strait waters is in the medium category with an average percentage of live coral cover of 37.71%. This condition is caused by reef fishing not being environmentally friendly (destructive fishing). The high fishing activities that are not environmentally friendly (destructive fishing) will accelerate the process of damage to coral reefs and coral fish abundance.

5.2. Recommendation
This is the first research to be conducted in Spelman Strait of coastal waters, therefore, field data was primarily obtained and used. It is expected that further research is conducted using this information obtained as a foundation to preserve the strait. The regional and central government are also advised to take steps towards organizing the strait waters.

Acknowledgments
Alhamdulillahirrabbil’alamin. All praise is to Allah SWT for his blessings and guidance to the writer in completing this paper. Greeting is conveyed to the great Prophet Muhammad SAW who has brought us in this brighter era. This paper is one of the requirements for completing a doctoral program in the
Coastal and Ocean Resources Study Program, Department of Water Resources Management at the Faculty of Fisheries and Marine Sciences of Bogor Agricultural University. Thanks also go to the writer’s classmate who has shared ideas and supported the writer during his studies. Special remarks are to my parents, my parents-in-law, my foster parents, my brothers and sisters as well as my beloved wife for their prayers and support. Nevertheless, the author realized that there are many shortcomings in this paper. Therefore, all constructive suggestions will be well received.

References
[1] Allen G and Adrim M 2003 Coral reef fishes of Indonesia Zoological studies 42(1) 1-72
[2] Sumadhiharca O K, Askin D M and Badrudin 2006 Keanekaran Jenis Ikan Karang di Perairan Belitung Barat, Pulau Bangka Belitung Pusat Penelitian Oseanografi LIPI Balai Riset Perikanan Laut PRPT, DKP Jurnal Ilmu Kelatuan 11(4) 201-209
[3] Patty W, Gaspar M, Emil R and Lit N D 2015 Komunitas Ikan Karang pada Terumbu Buatan Biorock di Perairan Pulau Siladen Kota Manado, Sulawesi Utara (Coral Fish Communities on the Biorock Artificial Reef in Coastal Waters of Siladen Island, Manado, North Sulawesi). Jurnal Perikanan XVII(2) 73-78
[4] Twinandia D A, Shofy M and Akhmad T M 2011 Pengaruh Luas Penutupan Terumbu Karang pada Lokasi Biorock dan Reef Seen terhadap Keragaman Spesies Ikan di Wilayah Pemuteran, Bali (Closure Area Effect on Reefs Rehabilitation in Biorock and Reef Seen Habitat Against Species Diversity in Regional Aquatic Pemuteran, Bali). Fakultas Perikanan dan Ilmu Kelautan Universitas Airlangga Jurnal Ilmiah Perikanan dan Kelautan 3 No 2, November 2011
[5] Putra A E and Mohammad A 2017 Komposisi dan Keanekaragan Jenis Ikan Karang di Perairan Teluk Palu. Program Studi Akuakultur Universitas Tadulako, Palu J. Agribisis 18(2) 77-83
[6] Ilyas I S, Sri A, Syawaludin A H and Noir P P 2017 Keanekaragaman Ikan Target Kaitannya dengan Keanekaragaman bentuk Pertumbuhan Karang pada Zona Inti di Taman Wisata Perairan Kepulauan Anambas Universitas Padjadjaran Jurnal Perikanan dan Kelautan VIII (2) 103-111
[7] Najamuddin, Samar I and Adityawan A 2012 Keragaman Ikan Karang di Perairan Makian Provinsi Maluku Utara (Diversity of Reef Fish at Waters of Makian Island in North Maluku) Fakultas Perikanan dan Ilmu Kelautan Universitas Khairun, Tertane Lembaga Ilmu Pengetahuan Indonesia, Stasiun Penelitian Lapangan, Ternate Depik 1(2) 114-120
[8] Rundonuwu A B 2014 Ikan Karang di Wilayah Terumbu Karang Kecamatan Maba Kabupaten Malahera Timur Provinsi Maluku Utara Jurnal Ilmiah Platax 2(1) 1-7
[9] Hafsidariwi R, Sulistiono, Fahrudin A, Sutrisno D and Koeshendrajana S 2018 Resource management in the Karimunjawa Islands, Central Java of Indonesia, through DPSIR approach. AES Bioflux 10(1)
[10] Hutomo M 1986 Methods of Samplings Coral Reef Fish Training Course in Coral Reef Research Methods and Management No. 2 (Bogor: SEAMEO – BIOTROP) pp 37-53
[11] Hutomo M 1986 Komunitas Ikan Karang dan Metode Sensus Visual (Jakarta: LON-LIPI) p 21
[12] Giyanto, Anna E W M, Muhammad A, Rikoh M S, Sasanti R S, Kunto W, Isa N E, Ucu Y A, Hendrik A W C, Hendra F S Y T and Dewirina Z 2014 Panduan monitoring kesehatan terumbu karang coremap-CTI (Jakarta: Pusat Penelitian Oseanografi Lembaga Ilmu Pengetahuan Indonesia)
[13] Giyanto, Peter M, Nurul D, Muhammad A and Marindah Y I 2017 Indeks kesehatan terumbu karang Indonesia COREMAP-CTI (Jakarta: Pusat Penelitian Oseanografi Lembaga Ilmu Pengetahuan Indonesia)
[14] Titaheluw S S 2017 Status Terumbu Karang dan Ikan Karang di Perairan Sidodadi dan Pulau Tegal Provinsi Lampung Jurnal Ilmiah Agribisis dan Perikanan 10(1)
[15] Hammer Ø 1999-2018 Paleontological Statistics Version 3.20 Reference Manual Natural History Museum (Norway: University of Oslo)
[16] [MENLH] Menteri Negara Lingkungan Hidup 2001 Keputusan Menteri Negara Lingkungan Hidup No. 4 Tahun 2001 Tentang: Kriteria Baku Kerusakan Terumbu Karang
[17] Suraji 2009 Penentuan Kriteria Kelimpahan Ikan Terumbu Karang, http://coremap.or.id/berita/article.php?id=683
[18] Aswani S, Albert S, Sabetian A, and Furusawa T 2007 Customary management as precautionary and adaptive principles for protecting coral reefs in Oceania Coral Reefs 26 1009-1021
[19] Resosodarmo S 1990 Pengantar Ekologi (Jakarta: PT Remaja Rosdakarya)
[20] Adrim M, Harahap S A, and Wibowo K 2012 Struktur komunitas ikan karang di perairan Kendari Jurnal ilmu kelautan 17(3) 154-163. ISSN 0853-7291
[21] Boontawee B, Plengklai C, and Kao-sa-ard A 1995 Monitoring and measuring forest biodiversity in Thailand Boontawee measuring and monitoring biodiversity in tropical and temperate forest ed Boyle T J B and B Proc. of a IUFRO Symp. held at Chiang Mai, Thailand August 27th-September 2nd, 1994 CIFOR
[22] Jorgensen S E, Costanza R and Fu-Liu Xu 2005 Handbook of Ecological Indicators for Assessment of Ecosystem Health (CRC Press)
[23] Nahlunnisa H, Ervizal A M Z and Yanto S 2016 Keanebaragaman Spesies Tumbuhan di Areal Nilai Konservasi Tinggi (NKT) Perkebunan Kelapa
[24] Angin R P, Sulistiono, Kurnia R, Fahrudin A, and Suman A 2017 Struktur komunitas sumberdaya ikan demersal berdasarkan kedalaman perairan di Laut Cina Selatan (WPP-NRI 711) [Community structure of demersal fish resources based on the depth of the waters in the South China Sea (Indonesia Management Zone 711)] Jurnal Iktiologi Indonesia 17(1) 67-82
[25] Purba H E, Djuwito and Haeruddin 2015 Distribusi dan keanekaragaman makrozoobentos pada lahan pengembangan konservasi mangrove di desa Timbul Sloko Kecamatan Sayung Kabupaten Demak, Diponegoro Journal of Maquares management of Aquatic Resources Volume 4(4) 57-65
[26] Bakhtiar D, Djamali A, Arifin Z and Sarwono T 2012 Struktur komunitas ikan karang di perairan Pulau Bengkulu Kota Bengkulu (coral fishes community structure in Tikus Island water Kota Bengkulu) Prosiding seminar nasional dan rapat tahunan bidang-bidang ilmu pertanian BKS-PTN wilayah barat 2
[27] Sugianti Y and Mujiyanto 2009 Biodiversitas ikan karang di perairan Taman Nasional Karimunjawa, Jepara Bawal 5(1) 23-31