Analyzing seagrass species and distribution for sustainable management of coastal areas and small islands: a case study of Java Island, Indonesia

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Abstract. Seagrass beds are essential components of coastal communities globally, as they support productive fisheries and coastline stabilization. In view of its numerous ecosystem services, the coverage of seagrass is an important indicator of ecosystem health. However, there are conflicting data regarding Indonesia's seagrass coverage. Some research indicates that seagrass bed areas have declined, with significant damage observed on Java Island. The objective of this study are to provide an inventory of the various species of seagrass found; present their distribution on a map; and assess the extent of seagrass cover. This seagrass study was conducted from 2014 to 2021 on the java Coast. Data were collected using a systematic literature review. The distribution of seagrass species was processed using QGIS. The coverage of seagrass analysis was conducted descriptively by considering the categories listed in the Decree of the Minister of Environment of the Republic of Indonesia 200/2004. There are 11 types of seagrass found in 13 districts along the Java Coast. Seagrass coverage are varies 3% to 80%. The health status of seagrass beds on the north coast of Java is moderate to good, while the condition of seagrass beds on the south coast is poor to moderate.

1 Introduction

Seagrasses, mangroves, and coral reefs are crucial components of coastal management because of their interconnected nature and the benefits they provide to coastal ecosystems.

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The physical and biogeochemical relationships between these ecosystems are highlighted by research by [1], establishing a cohesive "seascape" in which coral reefs are essential to the creation of favorable habitats for seagrass beds and mangroves. The protective functions of mangroves, seagrass beds, and coral reefs in reducing the susceptibility of coastal areas to storms and waves have been further emphasized by [2].

Seagrass ecosystems often provide a wide range of beneficial ecological services. According to [2], these benefits include nutrient cycling, improving coral reef fish productivity, providing habitat for a variety of species, and serving as a food source for threatened marine animals, such as dugongs, manatees, and green turtles. It has been determined that seagrass meadows are effective carbon sinks, helping to sequester CO_2 and regulate the climate [3]. Seagrass beds also provide vital nursery settings for young fish. According to [4], human activities and environmental factors can have varying effects on the ecological service value of seagrasses.

Seagrass ecosystems are crucial for coastal management, and provide a variety of ecosystem services. Seagrass meadows are essential components of coastal communities globally, as they support productive fisheries, nutrient cycling, and coastline stabilization. They offer vital services such as coastal protection and erosion control [5]. Seagrass canopies are critical to the world's coastal environment and provide essential ecological services [6]. These ecosystems significantly contribute to carbon and nutrient sequestration, biodiversity, fishery enhancement, and coastal protection [7].

The management of coastal and marine areas is of utmost importance given the wide range of human activities from different sectors that take place within these areas. It is mandated by various laws, including Law No. 27 of 2007, amended by Law No. 1 of 2014 on coastal management, and further reformulated by Law No. 11 of 2011 concerning Job Creation. In addition, the utilization of coastal space by humans frequently occurs, sometimes overlapping, which in turn has an impact on management policies [8]. Coastal ecosystems play a crucial role in benefiting humans in several ways. They provide natural resources, assist in waste assimilation, support life services, and offer comfort services [5]. Coastal regions are prone to changes caused by human activities and natural factors, including abrasion, erosion, and sedimentation [1].

Seagrass coverage is a crucial indicator of ecosystem health because of its numerous ecosystem services. Globally, seagrass habitats have experienced difficulties. One worrying trend that could affect the general health of coastal ecosystems is the decrease in seagrass coverage [9]. Seagrass coverage can be greatly impacted by human activity, especially when it comes from the mainland, which emphasizes the susceptibility of these ecosystems to outside impacts [10].

However, there are conflicting data regarding Indonesia's seagrass coverage. Some research indicates that seagrass bed areas have declined by approximately 30% – 40%, with significant damage observed on Java Island [11]. However, other studies suggest that Indonesia has extensive seagrass coverage, with estimates of over 30,000 km^2, because many coastal areas remaining unsurveyed [12]. Furthermore, a study points out the current dearth of data on the state of seagrass meadows in Indonesia, pointing out incorrect hydrodynamic findings in earlier research [6]. This suggests that seagrass beds in Indonesia are at a moderate level, with a national average coverage of 34% [13]. Between 2015 and 2021, there was a decline in the area of Indonesian seagrass beds, averaging about 0.4 hectares per year [13]. This article aims to (1) provide an inventory of the various seagrass species found on Java Island, (2) present their distribution on a map, and (3) analyze the coverage of seagrass beds at research locations on the island of Java.

2 Methods

This seagrass study was conducted from 2014 to 2021 on the coast of Java. Data were collected using a systematic literature review. A systematic literature review is a methodological approach to review a large body of literature on a specific topic [14]. The methodology for conducting a review involves several key steps to ensure rigor and comprehensiveness. First, it is essential to categorize the type of literature review being conducted. Second, the search for relevant articles should be systematic, following specific criteria to identify and select articles for inclusion. Third, the review should include a critical appraisal of the selected articles to assess their quality and relevance [15].

There were 27 articles were used to collect data in this study. The distribution of seagrass species was analyzed using Rupa Bumi Indonesia (RBI), which was then processed using QGIS software [[16]]. Analysis of seagrass distribution using QGIS can benefit from various studies that provide insights into the factors that influence seagrass landscapes. The coverage of seagrass analysis was conducted descriptively by considering the categories listed in the Decree of the Minister of Environment of the Republic of Indonesia No. 200 of 2004 [17].

3 Results and discussions

3.1. Seagrass species found worldwide, in Indonesia, and in Java Island

There are 63–70 seagrass species worldwide, divided into four families: *Zosteraceae, Hydrocharotaceae, Posidoniaceae,* and *Cymodoceae* [18]. Zostera consists of two genera and 22 species found in the waters of Korea and Japan. The *Hydrocharitaceae* family comprises three genera and 22 species with a relatively wide distribution [19]. The *Posidoniaceae* family, which is primarily found in Australian waters, contains 2–9 species that are still being researched. The *Cymodoceae* family has 17 species, the majority of which are favorite diets for manatees and dugongs [20], [21], [22].

Of the 63–70 species globally, there are 16 seagrass species in Indonesia. *Enhalus acoroides, Thalassia hemprichii, Cymodocea rotundata, Oseana serrulata, Haludole pinifolia, Halodule uninervis, Halophila decipiens, Halophila ovalis, Halophila minor, Halophila spinulosa, Syringodium isoetifolium*, and *Thalassodendron ciliatum* are among the species commonly found in Indonesian waters [23], [24]. *Halophila sulawesii*, a newly discovered seagrass species, and *Halophila major* have been reported in numerous locations in Indonesia [25], [26]. *Ruppia maritima* and *Halophila becarii* were only discovered as herbarium specimens in Ancol and Pasir Putih.

Of the 16 seagrass species in Indonesia, 11 were found along the coast of Java Island: *Cymodocea rotundata, Enhalus acoroides, Halodule uninervis, Halodule pinifolia, Halophila ovalis, Halophila minor, Halophila decipiens, Oceana serrulata, Syringodium isoetifolium, Thalassia hemprichii*, and *Thalassodendron ciliatum* (**Table 1**). According to a survey, *Thalassia hemprichii* was the most frequently observed species. This species tolerates a wide range of substrate conditions, including muddy sand and rubble [27]. *Thalassodendron ciliatum* is the least common seagrass species on Java Island and is only found in Baluran National Park, Situbondo District [28]. Although this species has been reported to be widespread in Indo-Pacific waters, the Indian Ocean, and even the Maldives [29], [30], it is normally found in monospecific stands in sublittoral zones down to depths of 17m, on sandy and crushed coral substrates [31].

Table 1. Seagrass Species found in Java Island. Details: East Java (A); Central Java (B); West Java (C); DKI Jakarta (D); Banten (E); found (1); not found (0); *Cr = Cymodocea rotundata; Ea = Enhalus acoroides; Hu = Halodule uninervis; Hp = Halophila pinifolia; Ho = Halophila ovalis; Hm = Halophila minor; Hd = Halophila decipiens*; *Os = Oseana serrulate;* Si = *Syringodium isotifolium*; Th = *Thalassia hemprichii*; Tc = *Thalassodendron cilliatum.*

No	Prov	City	Cr	Os	Ea	Hu	Hp	Ho	Hm	Hd	Si	Th	Tc	Reference
1	A	Lamongan	0	0	1	0	0	0	0	0	0	1	0	[17], [32]
2	A	Gresik	1	1	1	0	1	1	0	1	0	1	0	[33], [34]
3	A	Situbondo	1	1	1	1	1	1	1	0	1	1	1	[28]
4	A	Banyuwangi	1	0	0	0	1	0	0	0	0	1	0	[35]
5	A	Malang	0	0	0	0	1	1	0	0	1	1	0	[36]
6	A	Pacitan	1	0	0	0	0	1	0	0	0	1	0	[37]
7	A	Bangkalan	0	0	0	0	0	0	0	0	0	1	0	[37]
8	A	Sumenep	1	1	1	1	1	1	0	0	1	1	0	[38], [39]
9	B	Jepara	1	1	1	1	0	1	1	1	1	1	0	[22,29, 30,31, 32,33, 34,35]
10	C	Pangandaran	1	0	0	0	1	0	0	0	0	1	0	[47]
11	D	Kep. Seribu	1	1	1	1	0	1	0	0	1	1	0	[38], [48], [49], [50]
12	E	Serang	1	1	1	0	0	1	0	0	0	1	0	[27,40.41]
13	E	Pandeglang	0	1	1	1	0	1	0	0	0	0	0	[53]

3.2. Seagrass distribution worldwide, in Indonesia, and in Java Island

Seagrass beds are found in marine seas, spanning from tropical regions to the peripheries of the Arctic (**Fig. 1**). The global spatial distribution of seagrass exhibits significant variation in estimates found in published studies, with reported values ranging from 177,000 km² to 600,000 km². However, simulations suggest the possibility of even greater levels of distribution [54]. Australia has the largest seagrass beds worldwide, spanning 83,013 km². In contrast, Cape Verde holds the record for the smallest documented area, measuring only 20 m². However, comprehensive mapping of Russia, Canada, the Philippines, and Indonesia has not been completed [54].

The Wallace Line delineates two distinct regions in Indonesia with regard to the distribution and proliferation of seagrass: western and eastern regions. This distinction is predicated on Wallace's notion of the existence of an illusory demarcation called the Wallace Line. The vertical line spans from the Makassar Strait, located between the islands of Kalimantan and Sulawesi, to the area between Bali and Lombok [8], [55]. This line exerts a significant impact on the interconnections between species, landscapes, ecology, tourism, spatial planning, conservation, and human interactions [8]. At least 12 seagrass species are present in the western region of Indonesia, whereas at least 14 species have been documented in the eastern region (**Fig. 2**). *E. acoroides* and *T. hemprichii* are the predominant seagrass species along the Indonesian coast, whereas *H. sulawesii* and *H. mayor* are exclusive to eastern Indonesia [35].

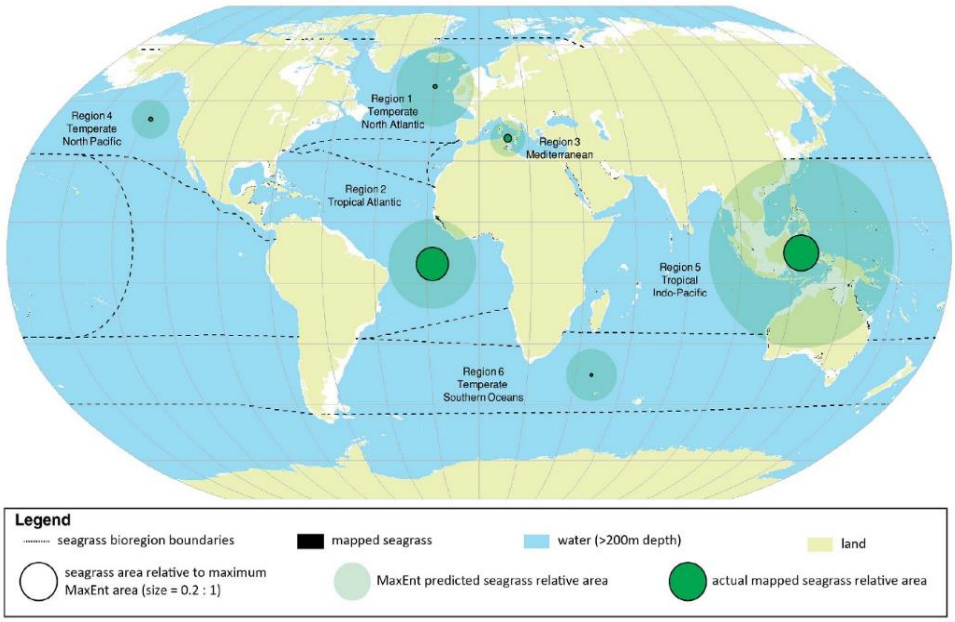

Fig. 1. The distribution of seagrass worldwide, ranging from subtropical to tropical waters. Source: [54].

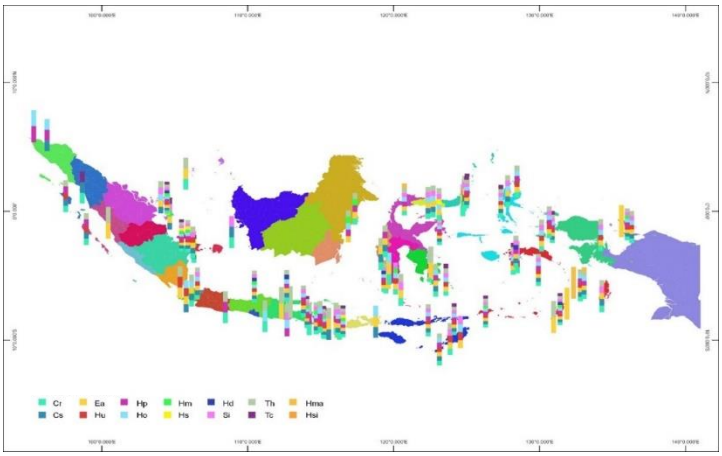

Fig. 2. Distribution of Seagrass Species in the Coastal Areas and Small Islands of Indonesia, detailed as follows: *Cr = C. rotundata; Ea = E. acoroides; Hu = H. uninervis; Hp = H. pinifolia; Ho = H. ovalis; Hm = H. minor; Hd = H. decipiens*; *Os = O. serrulate;* Si = *S. isotifolium*; Th = *T. hemprichii*; Tc = T. *cilliatum*; Hma = *Halophila mayor;* Hsi = *H. sulawesii.* Source: [35].

Seagrass species are distributed throughout Java Island, with the exception of the Special Region of Yogyakarta. The distribution of these marine plants spans eight districts in East Java, one district in Central Java, one district in West Java, one district in DKI Jakarta, and two districts in Banten (**Fig. 3**). Seagrass beds are primarily found in the northern coastal areas of Java Island rather than on the southern coastline. The southern half of Java Island is exposed to the Indian Ocean, which is renowned for its stronger currents and waves than the northern area. This disparity in oceanic conditions is believed to be the cause of the reduced number of seagrass beds in the southern area. Seagrass beds typically thrive in shallow, calm oceans that receive abundant sunlight [56].

Baluran National Park, located in the Situbondo District of East Java, is renowned for its rich variety of seagrass species, with a total of ten distinct varieties [28]. Karimun Jawa National Park, located in the Jepara District of Central Java, is home to a diverse range of seagrass species, with nine documented species. Both sites are recognized as marine-protected areas, classified as National Parks. These areas have strict regulations on human activity, ensuring that seagrass ecology remains well-preserved (https://ksdae.menlhk.go.id/kawasan-konservasi.html).

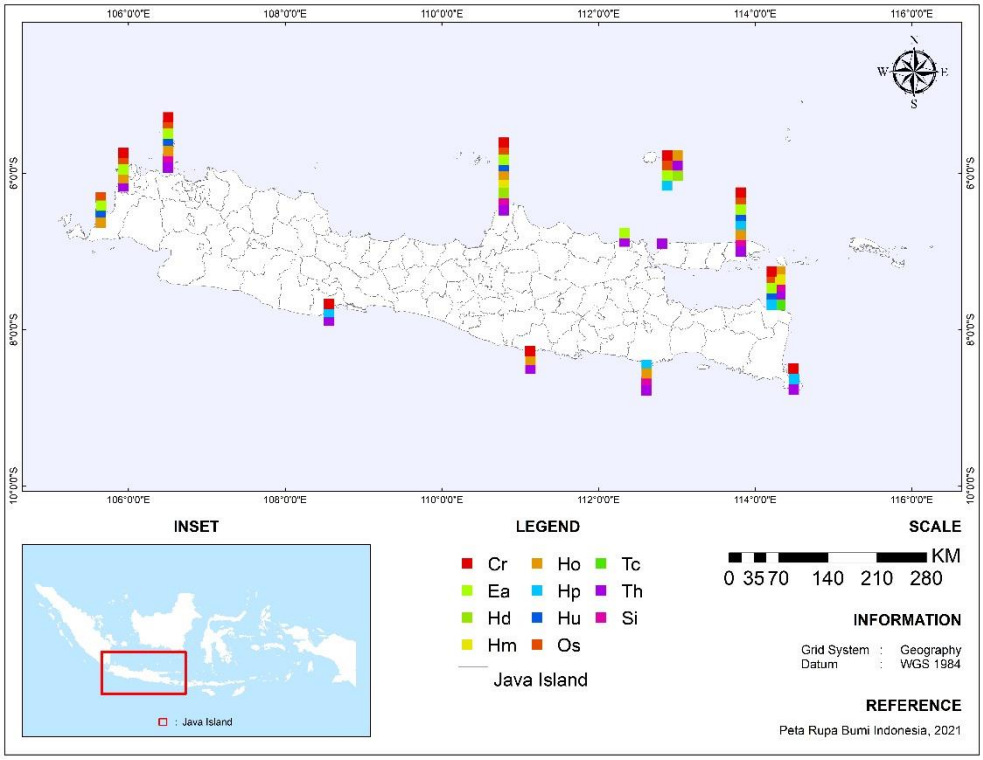

Fig. 3. Distribution of Seagrass Species in the Coastal Regions of Java Island, detailed as follows: *Cr = Cymodocea rotundata; Ea = Enhalus acoroides; Hu = Halodule uninervis; Hp = Halodule pinifolia; Ho = Halophila ovalis; Hm = Halophila minor; Hd = Halophila decipiens; Os = Oceana serrulate*. Source: Processed from **Table 1.**

3.3. Coverage of seagrass bed in Java Island

Seagrass coverage on Java Island varies between 3% to 80% (**Fig. 4**). In general, the maximum percentage of seagrass cover on the north coast of Java Island (45%-80%) was higher than that on the south side (15%-37%). This shows that the seagrass beds on the north coast of Java are in the moderate-to-health category, while those on the south coast are in the unhealth-to-moderate category [17]. The preference of seagrasses for living in areas with slow water currents, such as inshore lagoons, estuaries, and bays, is well-documented [31]. Although it is commonly understood that strong winds and wave actions contribute to the formation of currents, there is competing evidence regarding the height of waves between the southern and northern coasts of Java.

Coastal development in northern Java is indeed more intensive than that in southern Java, emphasizing the importance of various factors such as local resource utilization, infrastructure development, economic disparities, and sustainable coastal management

practices [57], [58], [59]. This affects the seagrass ecosystem. The anthropogenic threat to the seagrass ecosystem on the northern side of Java is certainly greater than that on the southern side. The threat to seagrass meadows in coastal areas is of significant concern because of their ecological importance and the potential consequences of their decline. They face numerous threats, such as nutrient abundance, sedimentation, plastic pollution, vessel traffic, and overfishing [60]. These threats can lead to the degradation of seagrass meadows, thereby impacting the biodiversity and productivity of coastal areas [60].

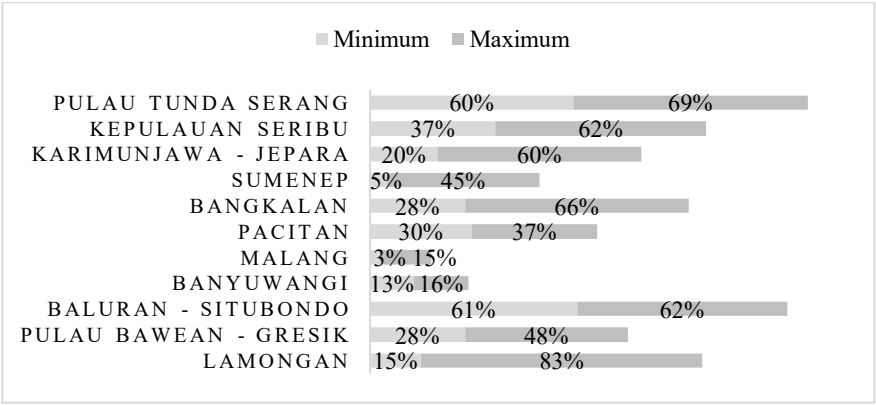

Fig. 4. Range of percent cover of seagrass beds in the Coastal Regions of Java Island. Source: Processed from **Table 1.**

4 Conclusion

There are a total of 11 seagrass species that have been identified along the coast of Java Island: *Cymodocea rotundata, Enhalus acoroides, Halodule uninervis, Halodule pinifolia, Halophila ovalis, Halophila minor, Halophila decipiens, Oceana serrulata, Syringodium isoetifolium, Thalassia hemprichii*, and *Thalassodendron ciliatum.* The seagrass beds were located in eight districts in East Java, one district in Central Java, one district in West Java, one district in DKI Jakarta, and two districts in Banten. The condition of seagrass beds on the north coast of Java is moderate to healthy, while in the south of Java, it is poor to moderate. Therefore, it is necessary to manage the coastal areas of Java, such as utilizing coastal spatial planning and small islands, so that the condition of the seagrass ecosystem can be maintained.

Data collection and the creation of the seagrass species distribution map were conducted at the Laboratory for Fisheries and Marine Resources Exploration, Faculty of Fisheries and Marine Sciences, Universitas Brawijaya (FPIK – UB). The map compilation in this study was supported by Natasha, M. Choirul Anam, Pratama Diffi Samuel, and Ir. Sukandar, MP.

References

1. D. G. Bengen, in *International Affairs*, **99**, 3 (2023)
2. G. Guannel, K. Arkema, P. Ruggiero, and G. Verutes, *PLoS One*, **11**, 7 (2016)
3. S. Febrianto, N. S. Adi, and F. Hamzah, *Diversity*, **15**, 978 (2023)
4. J. R. Peters, R. M. McCloskey, S. L. Hinder, and R. K. F. Unsworth, *Mar. Biodivers.*, **45**, 4 (2015)
5. A. W. Rudiastuti, Munawaroh, I. E. Setyawan, and G. H. Pramono, *IOP Conf. Ser. Earth Environ. Sci.*, **148**, 1 (2018)
6. J. Risandi *et al.*, *Front. Earth Sci.*, **11**, February (2023)

7. J. Yan, T. van der Heide, B. Cui, J. Bai, T. Ysebaert, and J. van de Koppel, *Limnol. Oceanogr.*, **65**, 11 (2020)
8. M. R. Fisher, B. Verheijen, and M. A. K. Sahide, *For. Soc.*, **4**, 1 (2020)
9. P. Wicaksono, W. Lazuardi, and M. Munir, *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci. - ISPRS Arch.*, **42**, 4/W19 (2019)
10. S. Wardono *et al.*, *J. Biodjati*, **7**, 2 (2022)
11. I. Riniatsih, R. Hartati, H. Endrawati, R. Mahendrajaya, S. Redjeki, and W. Widianingsih, *IOP Conf. Ser. Earth Environ. Sci.*, **116**, 1, (2018)
12. D. M. Alongi, *Carbon Manag.*, **3**, 3 (2012)
13. S. Rahmawati *et al.*, *Status Ekosistem Lamun di Indonesia Tahun 2021*. (2022)
14. Y. Xiao and M. Watson, *J. Plan. Educ. Res.*, **39**, 1 (2019)
15. R. Ganann, D. Ciliska, and H. Thomas, *Implement. Sci.*, **5**, 1 (2010)
16. Fajrillah, *J. Multimed. dan Teknol. Inf.*, **4**, 01 (2022)
17. C. S. U. Dewi *et al.*, *E3S Web Conf.*, **153**, (2020)
18. A. B. Carter, C. Collier, E. Lawrence, M. A. Rasheed, B. J. Robson, and R. Coles, *Sci. Rep.*, **11**, 1 (2021)
19. J. M. Seddon, J. R. Ovenden, H. L. Sneath, D. Broderick, C. L. Dudgeon, and J. M. Lanyon, *Conserv. Genet.*, **15**, 6 (2021)
20. G. E. Heinsohn, J. Wake, H. Marsh, and A. V. Spain, *Aquaculture*, **12**, 3 (1977)
21. H. . De Longh, W. Kiswara, and H. Bauer, Leiden University, (1997)
22. V. Edmondson and D. Kolosov, *Cougar J. Undergrad. Res. Cougar JUGR*, p. (2022)
23. S. Sukandar and C. S. U. Dewi, *Depik*, **6**, 2 (2017)
24. A. J. Wahyudi *et al.*, *Ocean Sci. J.*, [Online] (2020)
25. J. Kuo, *Aquat. Bot.*, **87**, 2 (2007)
26. F. Kurniawan *et al.*, *Aquat. Bot.*, **161**, June (2019)
27. R. Widayanti, Y. H. Fibrianto, and W. D. Wendo, *J. Vet.*, **15**, 1 (2014)
28. S. Sutadi, L. Sulistyowati, and E. Sriwiyono, *Sci. J. Reflect. Econ. Accounting, Manag. Bus.*, **4**, 2 (2021)
29. P. Roe, *Seagrass Monitoring 2020 Six Senses Laamu Six Senses Laamu Seagrass Monitoring 2020*. Maldives Underwater Initiative, (2020)
30. H. K. East *et al.*, *Commun. Earth Environ.*, **4**, 1 (2023)
31. A. W. Larkum, R. J. Orth, and C. M. Duarte, *Seagrasses: Biology, Ecology and Conservation*. Dordrecht, The Netherlands: Springer International Publishing (2006)
32. E. F. Ndaria, A. Sartimbula, and C. S. U. Dewi, *J. Fish. Mar. Res.*, **3**, 1 (2019)
33. N. E. Pradana, F. F. Wardiwira, L. Hakim, A. N. Imamah, and W. Istianisa, *SAINTEK Perikan. Indones. J. Fish. Sci. Technol.*, **13**, 2 (2018)
34. C. S. U. Dewi, S. Sukandar, and C. J. Harsindhi, *KARANG DAN IKAN TERUMBU PULAU BAWEAN*, **1**, 1 (2018)
35. C. S. U. Dewi, *JFMR-Journal Fish. Mar. Res.*, **6**, 1 (2022)
36. C. S. U. Dewi, R. D. Kasitowati, S. H. J. Sari, A. Yamindago, A. Rohenda, and R. Fatmawati, *J. Ilmu dan Teknol. Kelaut. Trop.*, **12**, 3 (2020)
37. E. D. Aulia *et al.*, *Biodiversitas*, **22**, 4 (2021)
38. C. S. U. Dewi, Sukandar, B. Subhan, and D. Arafat, *JFMR-Journal Fish. Mar. Res.*, **2**, 2 (2018)
39. C. S. U. Dewi and Sukandar, *AIP Conf. Proc.*, **1908** (2017)
40. R. Hartati *et al.*, *J. Kelaut. Trop.*, **20**, 2 (2017)
41. A. Iftinaan, D. J. Prihadi, M. U. K. Agung, and P. Wahyuniar, *J. Perikan. dan Kelaut.*, **VIII No. 2**, 2 (2017)
42. I. Riniatsih, R. Hartati, W. Widianingsih, and R. T. Mahendrajaya, *IOP Conf. Ser. Earth Environ. Sci.*, **1224**, 1 (2018)
43. R. R. Yunita, S. Suryanti, and N. Latifah, *J. Kelaut. Trop.*, **23**, 1 (2020)
44. K. P. Ningrum, H. Endrawati, and I. Riniatsih, *J. Mar. Res.*, **9**, 3 (2020)
45. F. B. Aji, S. Febrianto, and N. Afiati, *J. Ilmu dan Teknol. Kelaut. Trop.*, **12**, 3 (2020)
46. T. N. B. Baeti, R. H. Hartati, and I. R. Riniatsih, *J. Mar. Res.*, **8**, 1 (2019)

47. T. Setiawati, M. Alifah, A. Z. Mutaqin, M. Nurzaman, B. Irawan, and R. Budiono, *J. Pro-Life*, **5**, 1 (2018)
48. F. Amanda Citra, S. Suryanti, and M. R. Muskananfola, *IOP Conf. Ser. Earth Environ. Sci.*, **530**, 1 (2020)
49. J. V. Gunawan, M. Parengkuan, A. J. Wahyudi, and F. Zulpikar, *Oseanologi dan Limnol. di Indones.*, **4**, 2 (2019)
50. A. Y. Retawimbi, *Kepariwisataan J. Ilm.*, **12**, 03 (2018)
51. N. N. Aziizah, V. P. Siregar, S. B. Agus, J. L. Akedemik, K. I. P. B. Dermaga, and B. Indonesia, *J. Penginderaan Jauh dan Pengolah. Data Citra Digit.*, **13**, 2 (2016)
52. N. N. Aziizah, V. P. Siregar, and S. B. Agus, *Omni-Akuatika*, **12**, 1, p. 73–80 (2016)
53. A. J. Wahyudi *et al.*, *Mar. Pollut. Bull.*, **178**, October (2021)
54. L. J. McKenzie, L. M. Nordlund, B. L. Jones, L. C. Cullen-Unsworth, C. Roelfsema, and R. K. F. Unsworth, *Environ. Res. Lett.*, **15**, 7 (2020)
55. A. R. Wallace, *The Malay Archipelago*. Jakarta, Indonesia: Periplus.
56. C. J. Collier and M. Waycott, *Marine Pollution Bulletin*, **83**, 2 (2014)
57. A. Rizal, I. Gumilar, and L. Lestari, *J. Perikan. dan Kelaut.*, **7**, 2 (2017)
58. T. Sukwika, J. Wilayah dan Lingkungan. **6**, 2 (2018)
59. H. C. Diartho, *Ecoplan*, **3**, 2 (2020)
60. I. Riniatsih, *J. Kelaut. Trop.*, **19**, 2 (2016)