JURNAL PERIKANAN DAN KELAUTAN
Volume 31 No. 2, June 2026: 254-261

e-issn : 2721-8902
p-issn : 0853-7607

Technical Challenges and Prospects for the Development of *Eucheuma cottonii* Seaweed Cultivation in Indonesia: A Literature Review

Tantangan Teknis dan Prospek Pengembangan Budidaya Rumput Laut (Eucheuma cottonii) di Indonesia: Tinjauan Literatur

Ayi Yustiati[1*] and Chevrina Tri Prasetya Ningsih[1]
[1]Department of Fisheries, Faculty of Fisheries and Marine Sciences, Padjadjaran University, Sumedang 45363 Indonesia
**email: yustiati@unpad.ac.id*

Received
20 May 2026

Accepted
19 June 2026

Abstract

Eucheuma cottonii is one of Indonesia's leading seaweed commodities, possessing high economic value as a raw material for the carrageenan industry. Productivity levels in seaweed cultivation are influenced by cultivation methods, aquatic environmental conditions, and technical challenges during cultivation. This study aims to analyze the productivity of *E. cottonii* by considering various cultivation methods, assessing the impact of environmental factors and technical challenges on production yields, and linking these findings to the potential for the development of seaweed cultivation in Indonesia. The method used in this study is a literature review, analyzing various national and international scientific journals published between 2014 and 2025. The data analyzed included cultivation techniques, productivity levels, temperature, salinity, cultivation locations, and technical challenges affecting the growth of *E. cottonii*. Research findings indicate that the longline and floating raft methods generally yield higher productivity than the Off-bottom method, thanks to better water circulation, more even nutrient distribution, and higher light intensity. Environmental factors such as temperature, salinity, currents, and sedimentation influence the growth and biomass formation of seaweed. In addition, technical challenges such as ice-ice disease, changes in environmental conditions, seedling quality, and the stability of cultivation structures hinder productivity. Overall, the prospects for developing *E. cottonii* cultivation in Indonesia are quite promising. However, they require proper environmental management, the use of high-quality seedlings, the application of efficient cultivation technologies, and the strengthening of the downstream industry to sustainably improve productivity and increase the added value of seaweed products.

Keywords: *Eucheuma cottonii*, Productivity, Environmental, Seaweed.

Abstrak

Eucheuma cottonii merupakan salah satu komoditas rumput laut unggulan di Indonesia yang memiliki nilai ekonomi yang tinggi sebagai bahan dasar industri karagenan. Tingkat produktivitas dalam budidaya rumput laut dipengaruhi oleh metode budidaya, kondisi lingkungan perairan, serta berbagai tantangan teknis selama proses pemeliharaan. Penelitian ini bertujuan untuk menganalisis produktivitas *E.cottonii* dengan mempertimbangkan berbagai metode budidaya, menilai dampak faktor lingkungan dan tantangan teknis terhadap hasil produksi, serta menghubungkannya dengan potensi pengembangan budidaya rumput laut di Indonesia. Metode yang digunakan dalam penelitian ini adalah studi literatur, dengan menganalisis berbagai jurnal ilmiah nasional dan internasional yang

diterbitkan antara tahun 2014 hingga 2025. Data yang dianalisis mencangkup teknik budidaya, tingkat produktivitas, suhu, salinitas, lokasi budidaya, serta tantangan teknis yang berdampak pada pertumbuhan *E. cottonii*. Hasil penelitian menunjukkan bahwa metode *Long line* dan rakit apung umumnya menghasilkan produktivitas yang lebih tinggi dibandingkan dengan metode *Off-bottom*, berkat sirkulasi air, distribusi nutrien, dan intensitas cahaya yang lebih baik. Faktor lingkungan seperti suhu, salinitas, arus, dan sedimentasi memengaruh pertumbuhan serta pembentukan biomassa rumput laut. Di samping itu, tantangan teknis seperti penyakit *ice-ice*, perubahan kondisi lingkungan, kualitas bibit, dan kestabilan struktur budidaya menjadi hambatan bagi produktivitas. Secara keseluruhan, prospek pengembangan budidaya *E.cottonii* di Indonesia memiliki prospek yang cukup baik, namun memerlukan pengelolaan lingkungan yang tepat, penggunaan bibit yang berkualitas, penerapan teknologi budidaya yang efisien, serta penguatan industri hilir untuk memperbaiki produktivitas dan meningkatkan nilai tambah produk rumput laut secara berkelanjutan.

Kata kunci: *Eucheuma cottonii*, Produktivitas, Lingkungan, Rumput Laut.

1. Introduction

Indonesia plays a key role in the development of seaweed products, as it contributes significantly to the national economy and global trade. Seaweed is one of the main commodities in the marine and fisheries sector with high economic value, both through the export of raw materials and processed products such as carrageenan, which is used in the food, pharmaceutical, and cosmetic industries (Hurtado et al., 2019). One of the most widely cultivated seaweed species in Indonesia is *Eucheuma cottonii*, which has a high carrageenan content and a continuously growing market demand. In addition to contributing to international trade, seaweed cultivation also serves as a primary source of livelihood for coastal communities in various regions across Indonesia. Indonesia ranks among the top producers of seaweed globally, with primary products such as *E. cottonii* and Kappaphycus alvarezii serving as raw materials for the global carrageenan industry (Rimmer et al., 2021). In recent years, seaweed production in Indonesia has increased significantly. According to data from the Ministry of Marine Affairs and Fisheries, seaweed production in Indonesia rose from 9,092,029 tons in 2021 to 9,853,606 tons in 2024 on a wet weight basis (Nasution & Khalid, 2025).

Figure 1. Indonesian seaweed production per year
Source: KKP (2024)

Based on the data in Figure 1, seaweed production in Indonesia from 2020 to 2024 shows an upward trend despite fluctuations in certain years. This indicates that Indonesia has significant potential for seaweed production; however, yield consistency remains influenced by environmental factors, cultivation practices, and market conditions. Global demand for seaweed, particularly *E. cottonii*, continues to rise alongside the growth of industries focused on hydrocolloids. It is estimated that the global carrageenan market will exceed USD 1 billion by 2022 and will continue to grow through 2030 (Said et al., 2025). Meanwhile, seaweed cultivation practices still face various technical challenges that can affect yield and harvest quality. Several studies show that environmental factors, such as temperature, salinity, currents, and nutrient availability, play a crucial role in the growth and biomass production of *E. cottonii*. In addition, ice-ice disease poses a major challenge in seaweed cultivation because it can cause reduced growth and even the death of the thallus as a result of environmental stress (Fathurrahman & Hidayati, 2025).

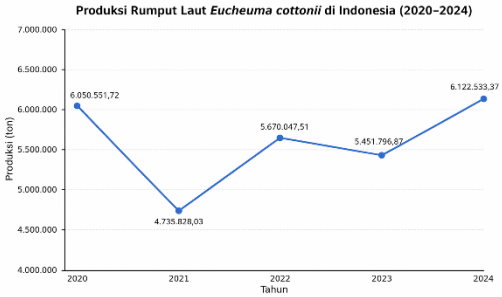

Figure 2. Production of *E. cottonii* in Indonesia per Year
Sumber: KKP (2024)

Based on the information in Figure 2, *E.cottonii* production in Indonesia has fluctuated significantly between 2020 and 2024. These fluctuations indicate that the success of *E. cottonii* cultivation is still influenced by various factors, including aquatic environmental conditions, cultivation methods, and technical management during cultivation. Cultivation methods such as Off-bottom, Long line, and floating rafts have distinct characteristics when interacting with aquatic environmental conditions. Differences in these characteristics result in variations in production yields across cultivation methods. Research by Kartini & Tantu (2021) revealed that the Long line method typically yields better growth under stable current conditions compared to methods focused on the water bottom. On the other hand, the off-bottom method is more suitable for shallow, calm waters, while the floating raft method can be applied more flexibly in deeper waters. This indicates that success in aquaculture depends not only on the method used but also on its suitability for the aquatic environmental conditions.

Several studies on *E. cottonii* cultivation have been conducted, but most still focus on environmental, biological, or cultivation techniques in isolation. Research comparing production from various cultivation methods and linking them to environmental conditions and changes in international market demand remains scarce. Additionally, review studies that present productivity comparisons using quantitative data from previous research are also rare. These limitations have led to the ineffective use of scientific information in designing cultivation strategies. Therefore, a review study is needed to synthesize various research findings on the productivity of *E. cottonii* across different cultivation methods.

Given this situation, this study aims to evaluate the productivity of *E. cottonii* using cultivation methods from previous studies and to examine the impact of environmental factors and technical challenges on harvest yields. Additionally, this study links cultivation aspects with global market demand trends to provide a more comprehensive understanding.

2. Material and Method

This study used a literature review method with a descriptive-analytical approach to examine the productivity, environmental factors, technical challenges, and development prospects of *E. cottonii* cultivation. Literature sources were obtained from national and international scientific journals, conference proceedings, and other relevant academic publications published between 2014 and 2025. The selected literature was chosen for its relevance to cultivation methods, productivity levels, environmental conditions, and technical challenges in *E. cottonii* cultivation. The collected data were then classified and analyzed descriptively, comparing findings across studies to identify differences in productivity, environmental influences, technical constraints, and their implications for the development of seaweed cultivation in Indonesia.

3. Result and Discussion

3.1. Productivity by Cultivation Method

The productivity of *E. cottonii* varies considerably depending on cultivation method and research location. These differences are influenced by cultivation techniques, aquatic environmental conditions, seedling quality, and cultivation management during the rearing period. Commonly used methods include longline, off-bottom, and floating raft systems. Table 1 presents a comparison of *Eucheuma cottonii* productivity levels obtained from various cultivation methods based on previous studies. As shown in Table 1, *E. cottonii* productivity varies across cultivation methods and research sites. These differences indicate that cultivation success is not solely determined by the method used but is also influenced by aquatic environmental conditions, seedling quality, and the cultivation management practices employed.

In the longline method, Hernanto et al. (2015) reported a daily growth rate of 2.36%/day in the waters off Jepara, while Nurqomar et al. (2022) achieved a productivity of 11.69 g/day using framed longlines on Lemukutan Island. Mau et al. (2020) also reported a productivity of 2.87 g/day in longline cultivation in Kupang Regency. The relatively high productivity of this method is thought to be related to the position of the seaweed in the water column, which allows for better water circulation, oxygen distribution, and light intensity. These conditions

support photosynthesis and nutrient uptake, both of which contribute in biomass formation. Additionally, relatively stable water movement can reduce sediment and epiphyte buildup on the rafts' surfaces, allowing for more optimal growth (Kartini & Tantu, 2021). However, this method requires more intensive management because the cultivation structures are vulnerable to damage from strong currents and waves.

Table 1. Productivity of *E. cottonii* by cultivation method

No	Method	Productivity	Duration of cultivation (days)	Temperature (ºC)	Salinity (ppt)	Location	References
1.	Long line	2,36%/day	±45	28-30	30-32	Jepara, Jawa Tengah	Hernanto et al. (2015)
2.	Framed longline	11,69 g/day	±50	29,6	32	Pulau Lemukutan, Kalimantan Barat	Nurqomar et al. (2022)
3.	Long line	2,87 g/day	±45	26-28	29-32	Kabupaten Kupang	Mau et al. (2020)
4.	Off-bottom	3,84%/day	±42	29,5	30	Perairan Kalianda, Lampung Selatan	Wijayanto (2011)
5.	Off-bottom	11,56 g/day	±45	28-30	32-34	Langgudu, Nusa Tenggara Barat	Bakhtiar (2025)
6.	Off-bottom	95,4 g/ day	±45	29-30,7	28-31,5	Kepulauan Selayar	Akib et al. (2015)
7.	Floating Raft	4,45%/ day	±42	29-30	30-32	Pulau Lemukutan, Kalimantan Barat	Maulana et al. (2023)
8.	Floating Raft	4,92%/ day	±42	28,7-31	30-32	Perairan Pantai Pandawa, Bali	Antari et al. (2021)

In the off-bottom method, productivity varies across aquaculture sites. Wijayanto (2011) reported a growth rate of 3.84% per day in the waters off Kalianda, South Lampung, while Bakhtiar (2025) recorded a productivity of 11.56 g per day in Langgudu, West Nusa Tenggara. Akib et al. (2015) also reported productivity of 95.4 g/day in the Selayar Islands. These results indicate that the off-bottom method remains capable of yielding high productivity when applied under suitable environmental conditions. However, because the seaweed is positioned close to the seabed, this method is more susceptible to sedimentation and suboptimal water circulation. Sediment accumulation on the talus surface can hinder light penetration and reduce photosynthetic efficiency. Nevertheless, the off-bottom method remains widely used because its operational costs are relatively low and it is easy to implement in sheltered, shallow waters (Bakhtiar, 2025).

The floating raft method has also demonstrated relatively high productivity at various aquaculture sites. Maulana et al. (2023) reported a daily growth rate of 4.45%/day on Lemukutan Island, while Riraid et al. (2018) recorded a growth rate of 6.51%/day in Ekas Bay, East Lombok. Antari et al. (2021) also reported a growth rate of 4.92%/day in the waters off Pandawa Beach, Bali. The high productivity of this method is believed to be related to the plants' more open position to water movement and light intensity, thereby supporting optimal nutrient uptake and biomass formation. Additionally, the floating raft method can be applied in deeper waters and is not dependent on the condition of the water's bottom substrate. However, the raft's stability poses a major challenge, particularly in locations with strong waves and currents (Fu et al., 2018).

In general, the results of various studies indicate that all cultivation methods have the potential to yield good productivity when applied under suitable environmental conditions. Although the longline and floating raft methods generally provide better conditions for water circulation and light penetration, the off-bottom method can also achieve high productivity at sites with supportive environmental conditions. Therefore, the success of *E. cottonii* cultivation is determined not only by the cultivation method but also by environmental suitability, seedling quality, and the technical management practices applied at each cultivation site.

3.2. The Effect of Environmental Factors on Productivity

The productivity of *E. cottonii* is influenced not only by cultivation methods but also by aquatic environmental conditions. The main factors involved include temperature, salinity, currents, light intensity, pH, turbidity, nutrient availability, seasonal variations, sedimentation, and other oceanographic conditions. Based on the various studies analyzed, water temperatures at the cultivation sites ranged from 26 to 30.7°C. This range is still considered optimal for Eucheuma cottonii growth. Hernanto et al. (2015) reported water temperatures of 28–30°C with a growth rate of 2.36%/day using the longline method, while Maulana et al. (2023) achieved a growth rate of 4.45%/day at temperatures of 29–30°C using the floating raft method.

Salinity at the aquaculture sites under review ranged from 28 to 34 ppt. Hernanto et al. (2015) reported salinity levels of 30–32 ppt in longline cultivation, while Antari et al. (2021) reported salinity levels of 30–32 ppt with a growth rate of 4.92%/day using the floating raft method. Stable salinity is crucial for maintaining osmotic balance and supporting nutrient uptake in seaweed tissues. Conversely, drastic changes in salinity due to heavy rainfall or the influx of freshwater can inhibit growth and reduce plant resistance to disease. Water currents also play a crucial

role in distributing oxygen and nutrients around plants. Longline and floating raft systems are typically placed in locations with better water circulation compared to off-bottom systems. Stable currents help ions of sedimentary material accumulate on the raft's surface, allowing photosynthesis to occur more effectively (Kartini & Tantu 2021). Additionally, the position of the plants in a more open water column allows for optimal light reception to support biomass growth.

In addition to temperature, salinity, currents, and light availability, other water-quality parameters, such as pH, turbidity, and nutrient concentrations, also influence the productivity of *E. cottonii*. pH levels play a role in physiological processes and the availability of dissolved inorganic carbon required for photosynthesis. Stable pH conditions support metabolic activity and nutrient uptake, while large fluctuations can reduce growth performance. Water turbidity is also an important factor because it determines the amount of light penetrating the water column. High turbidity can reduce the intensity of light reaching the thallus surface, thereby reducing photosynthetic efficiency and biomass production.

Additionally, nutrient availability, particularly nitrates and phosphates, plays a crucial role in tissue formation, protein synthesis, and biomass accumulation. Adequate nutrient concentrations support growth, whereas nutrient deficiencies can limit productivity. Therefore, appropriate pH, low turbidity, and sufficient availability of nitrate and phosphate are essential for supporting the sustainable cultivation of *E. cottonii*. In general, various studies have shown that appropriate pH levels, low turbidity, and adequate availability of nitrate and phosphate contribute to increased growth and biomass production of *E. cottonii*, whereas suboptimal water quality conditions can reduce cultivation productivity (Sirajuddin, 2009; Salihin et al., 2020; Laelaem et al., 2024).

Other environmental factors, such as sedimentation, waves, and seabed conditions, also affect aquaculture productivity. Off-bottom methods are more susceptible to sedimentation because the plants are positioned close to the seabed. In contrast, floating raft and longline methods are more susceptible to damage from strong waves and currents. Therefore, the success of aquaculture is highly influenced by the compatibility between the aquaculture method used and the environmental characteristics of the aquaculture site.

Seasonal variations also contribute to differences in the productivity of *E. cottonii* through changes in rainfall patterns, temperature, salinity, currents, nutrient availability, and water turbidity. In tropical regions, seasonal changes and monsoon periods can alter water quality, ultimately affecting the physiological performance of cultivated seaweed. Seasonal fluctuations can also affect nutrient dynamics and increase the risk of environmental stress, which impacts growth rates. Therefore, determining planting and harvesting times must account for local seasonal patterns to maximize productivity and minimize the risk of disease outbreaks and cultivation failures. Seasonal changes in environmental conditions can also increase seaweed susceptibility to ice-ice disease, thereby affecting productivity and harvest quality (Kasim & Asnani, 2012).

3.3. Technical Challenges in Cultivation

The cultivation of *Eucheuma cottonii* still faces various technical challenges that can reduce productivity and harvest quality. These challenges include disease outbreaks, changes in environmental conditions, seedling quality, sedimentation, physical damage to the thallus, and limited monitoring of cultivation environment quality. Ice-ice disease is one of the major constraints frequently reported in *E. cottonii* cultivation. This disease causes the thallus to turn white, become brittle, and break easily, thereby reducing biomass and harvest quality. The onset of ice-ice disease is generally triggered by environmental stress caused by abrupt changes in temperature, salinity, and water quality. These conditions make thallus tissue more susceptible to opportunistic bacteria, such as *Vibrio* and *Aeromonas* (Tuhumury et al., 2024; Tahiluddin & Terzi, 2024). Arisandi et al. (2013) also reported that this disease can inhibit growth and reduce cultivation productivity.

Climate change is also putting pressure on seaweed cultivation systems through rising sea surface temperatures, shifting seasonal patterns, and an increasing frequency of extreme weather events. These conditions can cause repeated physiological stress, increase disease susceptibility, and reduce cultivation productivity (Duarte et al., 2017; Kartini & Tantu, 2021). Seedling quality is also a critical factor in cultivation success. Mau et al. (2020) demonstrated that variations in seedling weight and quality result in differences in growth rates under the longline method. The continuous use of vegetative propagules without selection and renewal can degrade genetic quality and reduce the plants' ability to adapt to environmental changes.

In addition, physical damage to the thallus caused by waves, strong currents, or the activity of other organisms can serve as an entry point for pathogens and hinder photosynthesis. This risk is generally higher in longline and floating raft methods applied in open waters. Majid (2018) indicates that the stability of the raft structure is a key factor in ensuring the success of the floating raft method, particularly in locations with relatively high currents and waves. Each aquaculture method also faces distinct challenges. Off-bottom methods are more susceptible to sedimentation because the plants are positioned close to the water bottom, which can block light penetration and reduce photosynthetic efficiency. Meanwhile, the longline and floating raft methods require better structural management to withstand strong currents and waves. Additionally, limitations in environmental monitoring technology often result in changes in water quality going undetected early on, thereby increasing the risk of reduced productivity or cultivation failure.

3.4. The Relationship Between Productivity and the Potential and Prospects for Aquaculture Development

The productivity of *E. cottonii* is closely linked to the potential for seaweed cultivation in Indonesia. High productivity indicates that the environmental conditions and cultivation techniques employed are capable of supporting optimal biomass growth, thereby potentially increasing business efficiency and the income of coastal communities. Results from various studies show that the longline, floating raft, and off-bottom methods have the potential to yield good productivity when applied under suitable environmental conditions. Therefore, productivity is determined not only by the cultivation method used but also by environmental suitability, seedling quality, and the cultivation management practices implemented (Kartini & Tantu, 2021).

The prospects for the development of *E.cottonii* continue to grow in line with the increasing global demand for carrageenan raw materials in the food, pharmaceutical, and cosmetics industries, as well as for various other hydrocolloid-based products. However, increased productivity does not always correlate directly with increased economic benefits. Fluctuations in global market prices, reliance on raw material exports, and suboptimal supply chain systems mean that the economic benefits farmers receive are not yet maximized. Additionally, product quality is a critical factor, as the carrageenan industry requires specific quality standards. Zikriyani et al. (2025) state that improper post-harvest handling can degrade seaweed quality and reduce product competitiveness in international markets. Indonesia has great potential for developing *E. cottonii* cultivation, as it is supported by vast tropical waters suitable for seaweed growth, particularly in South Sulawesi, East Nusa Tenggara, West Nusa Tenggara, and various other coastal regions. The development of cultivation technology, the use of high-quality seeds, water quality monitoring, and capacity building for farmers are key factors in supporting sustainable productivity growth (Kartini & Tantu, 2021).

In addition to increasing production, strengthening the downstream sector is also necessary to enhance the value added of national seaweed products. The development of the carrageenan processing industry and various derivative products can boost competitiveness, create jobs, and reduce dependence on raw material exports. On the other hand, aquaculture development must continue to consider environmental carrying capacity to ensure the sustainability of coastal ecosystems is maintained (Hurtado et al., 2019). Overall, the productivity of *E. cottonii* is a key indicator in the development of seaweed cultivation in Indonesia. However, increasing productivity must be supported by sustainable environmental management, the use of high-quality seedlings, the application of appropriate cultivation technologies, improvements in product quality, the strengthening of downstream industries, and improvements in supply chain efficiency, so that Indonesia's seaweed economic potential can be fully realized.

4. Conclusions

Based on the review of various studies, the productivity of *Eucheuma cottonii* is influenced by a combination of cultivation methods and aquatic environmental conditions. The longline, framed longline, floating raft, and off-bottom methods all have the potential to yield good productivity when applied under suitable environmental conditions. Therefore, the success of cultivation is determined not only by the method used but also by the suitability of the cultivation site, seedling quality, and the technical management practices applied.

The productivity of *E. cottonii* is significantly influenced by various environmental factors, including temperature, salinity, current, light intensity, pH, turbidity, nutrient availability (especially nitrate and phosphate), sedimentation, and seasonal variations. Optimal environmental conditions can support photosynthesis, nutrient uptake, and biomass formation, thereby enhancing seaweed growth. Conversely, unsuitable changes in water quality or extreme environmental fluctuations can cause physiological stress, increase susceptibility to ice-ice disease, and reduce cultivation productivity.

The development of *E. cottonii* cultivation in Indonesia still faces various technical challenges, including disease outbreaks, seasonal and climatic changes, suboptimal seedling quality, sedimentation, and damage to cultivation structures from strong waves and currents. Nevertheless, the strong global demand for carrageenan-based products suggests that *E. cottonii* has excellent growth prospects. Therefore, productivity improvements must be supported through the use of high-quality seedlings, the application of appropriate cultivation technologies, continuous environmental quality monitoring, capacity building for cultivators, strengthening of the downstream industry, and sustainable environmental management to ensure productivity, product quality, and long-term economic benefits.

5. References

Akib, A., Litaay, M., Ambeng, A., & Asnady, M. (2015). Kelayakan kualitas air untuk kawasan budidaya *Eucheuma cottonii* berdasarkan aspek fisika, kimia dan biologi di Kabupaten Kepulauan Selayar. *Jurnal Pesisir dan Laut Tropis*, 1(1): 25–36.

Antari, N.P.P.S.D., Watiniasih, N.L., & Dewi, A.P.W.K. (2021). Pertumbuhan rumput laut (*Eucheuma cottonii*) dengan berat bibit awal berbeda di Pantai Pandawa, Bali. *Jurnal Biologi Udayana,* 25(2): 122.

Arisandi, A., Farid, A., Wahyuni, E.A., & Rokhmaniati, S. (2013). Dampak infeksi ice-ice dan epifit terhadap pertumbuhan *Eucheuma cottonii*. *Ilmu Kelautan: Indonesian Journal of Marine Sciences*, 18(1): 1–6.

Bakhtiar, B. (2025). Pengaruh metode lepas dasar terhadap pertumbuhan rumput laut (*Eucheuma cottonii*) di Desa Dumu Kecamatan Langgudu tahun 2025. JIMU: *Jurnal Ilmiah Multi Disiplin*, 3(4), 934-945.

Duarte, C.M., Wu, J., Xiao, X., Bruhn, A., & Krause-Jensen, D. (2017). Can seaweed farming play a role in climate change mitigation and adaptation?. *Frontiers in Marine Science*, 4: 100.

Fao, G.D., & Jiang, J.C. (2022). Theoretical investigation of CO_2 conversion on corrugated g-C_3N_4 Surface decorated by single-atom of Fe, Co, and Pd. *Molecular Catalysis*, 526: 112402.

Fathurrahman, L.A., & Hidayati, E. (2025). Physiological response of *Kappaphycus alvarezii* seaweed to ice-ice disease exposure. *Samota Journal of Biological Sciences*, *5*(1): 41-52.

Fu, F., Zhang, X., Hu, Z., Li, Y., Wang, L., & Yu, J. (2024). Research on sea trial techniques for motion responses of HDPE floating rafts used in aquaculture. *Journal of Marine Science and Engineering*, *12*(7), 1150.

Hernanto, A.D., Rejeki, S., & Ariyati, R.W. (2015). Pertumbuhan budidaya rumput laut (*Eucheuma Cottoni* dan *Gracilaria* sp.) dengan metode long line di Perairan Pantai Bulu Jepara. *Journal of Aquaculture Management and Technology*, 4(2): 60–66.

Hurtado, A.Q., Neish, I.C., & Critchley, A.T. (2019). Phyconomy: The extensive cultivation of seaweeds, their sustainability and economic value, with particular reference to important lessons to be learned and transferred from the practice of eucheumatoid farming. *Phycologia*, 58(5): 472-483.

Kartini, K., & Tantu, A.G. (2021). Analisis kesesuaian lahan untuk budidaya rumput laut *Kappaphycus Alvarezii* berdasarkan parameter fisika kimia dan oceanografi perairan Kecamatan Tanete Riattang Timur Kabupaten Bone. *Journal of Aquaculture and Environment*, 4(1): 07-12.

Kasim, M., & Asnani, A. (2012). Penentuan musim reproduksi generatif dan preferensi perekatan spora rumput laut (*Eucheuma cottonii*). *Ilmu Kelautan: Indonesian Journal of Marine Sciences, 17*(4): 209–216.

Laelaem, A., Tuhumury, S.F., & Pattiasina, B.J. (2024). Kesesuaian parameter fisiko-kimiawi bagi budidaya rumput laut *Eucheuma cottonii* di Perairan Desa Leiting Kabupaten Kepulauan Aru. *Indonesian Journal of Sustainable Aquaculture, 1*(2): 71–88.

Majid, U. (2018). Research fundamentals: Study design, population, and sample size. *Undergraduate research in natural and clinical science and technology journal*, *2*, 1-7.

Mau, M.E., Dahoklory, N., & Sunadji, S. (2020). Pengaruh berat awal rumput laut *Eucheuma cottonii* dalam kantong pelindung terhadap pertumbuhan dengan menggunakan metode long line. *Jurnal Akuatik*, 3(1): 36-41.

Maulana, F.W., Minsas, S., & Safitri, I. (2023). Laju pertumbuhan rumput laut *Eucheuma cottonii* berdasarkan perbedaan kedalaman dengan metode keramba jaring apung di Perairan Pulau Lemukutan. *Jurnal Laut Khatulistiwa*, 6(2): 58-70.

Nasution, M.A., & Khalid, K. (2025). Implementation of the regulation of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia Number 18 of 2021 Concerning marine fishing equipment in the city of Sibolga from the perspective of Siyasah Dusturiyah. *Journal Analytica Islamica*, *14*(2): 1007-1024.

Nurqomar, A., Idiawati, N., & Minsas, S. (2022). Laju pertumbuhan *Eucheuma cottonii* dengan metode long line berbingkai di Perairan Pulau Lemukutan. *Oseanologia*, 1(3), 78-83.

Rifaid, R., Cokrowati, N., & Scabra, A.R. (2023). The effect of cultivation age on the carginan content of seaweed (*Kappaphycus alvarezii*) in Beach of Ekas, Lombok Timur District. *Indonesian Journal of Aquaculture Medium*, *3*(1): 50-57.

Rimmer, M.A., Larson, S., Lapong, I., Purnomo, A.H., Pong-Masak, P.R., Swanepoel, L., & Paul, N.A. (2021). Seaweed aquaculture in Indonesia contributes to social and economic aspects of livelihoods and community well-being. *Sustainability*, 13(19): 10946.

Said, A., Saleh, S., & Khaeriyah, A. (2025). Seaweed agribusiness in a mining-influenced region: A study of *Eucheuma cottonii* quality and marketing in Kolaka, Indonesia. *Proceedings of International Seminar on Agricultural Conservation and Cultural Heritage* (1): 115-120.

Salihin, A., Muhiddin, A.H., & Yasir, I. (2019). Evaluation study of *Eucheuma cottonii* species of seaweed cultivation based on oceanographic parameters in Pasiea, Bonegunu Subdistrict, North Buton District. *Jurnal Ilmu Kelautan Spermonde*, 51-56.

Sirajuddin, M. (2009). Early information about bio-physical quality of seaweed culture (*Eucheuma cottonii*) in Waworada Bay, Bima Regency. *Jurnal Akuakultur Indonesia*, *8*(1), 1–10.

Tahiluddin, A.B., & Terzi, E. (2024). Ice-ice disease prevalence and intensity in eucheumatoid seaweed farms: Seasonal variability and relationship with the physicochemical and meteorological parameters. *Plants*, 13(15), 2157.

Tuhumury, N.C., Sahetapy, J.M., & Matakupan, J. (2024). Isolation and identification of bacterial pathogens causing ice-ice disease in *Eucheuma cottonii* seaweed at Seira Island Waters, Tanimbar Islands District, Maluku, Indonesia. *Biodiversitas: Journal of Biological Diversity*, 25(3).

Wijayanto, T., Hendri, M., & Aryawati, R. (2011). Studi pertumbuhan rumput laut *Eucheuma cottonii* dengan berbagai metode penanaman yang berbeda di Perairan Kalianda, Lampung Selatan. *Maspari Journal*, 3: 51-57.

Zikriyani, H., & Hutasoit, M.E. (2025). Eksplorasi spesies rumput laut dan pemanfaatan komoditas budidaya di Perairan Mamolo. *Jurnal Biogenerasi*, *10*(2).