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International

หน้า

Business Administration / Economics

Cleaner Production Opportunity Assessment for Productivity Improvement and Sustainability of SMEs 2

York Lopez, Ruby Pineda-Henson

Enterprise Resource Planning System for the Division Office of the Department of Education 12

Francisco D. Napalit

Exchange Rate Moderating Market Ratio to Stock Return Finance Sector in Indonesia 45

Etty Indriani

Could Public Transport Maintain Passenger Satisfaction 59

Faizal Haris Eko Prabowo, Nana Darna, Elin Herlina

The Impact of Islamic Religiosity on Work Spirituality and Emotional Intelligence in Individual Person : An Empirical Study 66

Achmad Choerudin, Agus Utomo

MSME's Demographic as Moderation in the Impact of Perception and Understanding of Bookkeeping Towards Quality of Financial Report 73

Cahyani Tunggal Sari, Etty Indriani, Lukman Ahmad Imron Pahlawi

The Influence of Marketing Strategies toward Consumer Experience 83

Siti Fatonah, Anggoro Panji Nugrho, Sekolah Tinggi Ilmu Ekonomi

The Expectations of Quality of Life in Higher Education : Evidence from Entrepreneurship Education 93

Panupong Pituksung, Sasirin Sayasonti, Salin Kittiamornkul, Piyaporn Prongprapa

Guidelines for Small and Medium Enterprises (SMEs) Integration in Thailand 100

Pungchompoo Jones, Naraporn Thammadee

How to Select the Suitable Mode of International Transport in International Trade and Incoterm 2010 107

Supawadee Khumrat, Unchittha Sukchokchai, Maturapoj Sripontong

International

หน้า

Economic Growth as Moderation of Financial Performance and Poverty Level 115
Benny Prawiranegara

The Effects of Banking Credit Position, Public Sector Costs, Population Growth, and Income Gap, on Poverty in West Java 126
Sukomo, Darsono, Agustinus Suryantoro

Factors Affecting of Corporate Entrepreneurship on Higher Education Institution in Thailand 136
Waraporn Kanjanaklod, Teerasak Jindaboth

Corporate Social Responsibility and Community Development on Beyond Compliance of Environmental Protection and Management 144
Anwar Hamdani, Siti Fatonah, I Gusti Putu Diva Awatara

Human Capital Discovery through Opportunity Discovery with Consumer Behaviour; The Case Study of Indigenous Vegetable Knowledge as Human Capital of Vicinity Community 153
Lanthom Jonjoubsong, Pimsiri Pootrakul, Nathaporn Thammabunwarit

Marketing Strategies for Cultural Tourism in Singburi Province Based on Local Identity 161
Sarunporn Chuankrerkul

Health Science

Effect of Hemoglobin E on Measurement of Hemoglobin A1c by Five Different Methods 170
Chompunoot Sinthupibulyakit, Tiparat Potipitak

Myosin Light Chain Kinase Inhibitor, ML-7, Suppressed Cholangiocarcinoma Cell Survival but not Cell Invasion and Matrix Metalloproteinase-2 Secretion 178
Panthip Rattanasinganchan, Rutaiwan Tohtong

Role of DMSO and Tween 20 in Acetylcholinesterase Inhibitory Activity of Donepezil Hydrochloride 184
Suthira Yanaso, Aranya Jutiviboonsuk, Noppawat Pengkumsri, Phurit Thanarangsarit

Clinical Application of Ba Duan Jin 190
Mu Ge, Zhong Qiangwei

Research on the Role of Confucius Institute in Overseas Dissemination of Chinese Medicine 202
Li Ningcen, Guo Yi, Chen Bo

International

หน้า

Science and Technology

The Antimicrobial Activity of Poly(vinylidene fluoride-chlorotrifluoroethylene) Copolymers Against Opportunistic Microorganisms 209
Wisatre Kongcharoensuntorn, Petcharat Kasa, Pornpen Atorngitjawat

Characteristics and Seasonal Abundance of Seagrass at Pidakan Coast Pacitan, East Java, Indonesia 215
Nurul Kusuma Dewi, Joko Widiyanto

Effects of Cardanol Side Chains on Thermal Properties of Polyurethanes 223
Wissawat Sakulsaknimitr, Pornpen Atorngitjawat

Indigenous Fungi Associated with Loog-pang and Their Behaviors of Broken Glutinous Rice Wine Fermentation 232
On-ong Chanprasartsuk, Supawan Chitsombat, Teerapong Nualdet

Liberal Arts /Humanities and Social Sciences

Enhancing the Communication Skills of Higher Education Students through International Student Mobility Programs 239
Natsita Chaisubanan, Jonathan Rante Carreon, Passamon Lertchalermtipakoon, Tipapan Chaiwong, Umarungsri Wongsubun

Digital Disruption : A Corpus-based Analysis of Keywords in the Bangkok Post Newspaper (January 2017–February 2018) 249
Jonathan Rante Carreon, Banjob Piyamat

A Genre-Based Approach to Enhancing Research Articles Writing 258
Lulus Irawati

A Phenomenological Study of the Intercultural Experiences of Indonesian International Mobility Students 272
Jonathan Rante Carreon, Andi Rustandi, Iskhak

Corpus Analysis of the Police Language in the American TV Series *CSI : NY* 287
Anchan Premjai, Jonathan Rante Carreon, Areeluck Harnmontree

International

หน้า

Enhancing Writing Ability Using Graphic Organizer Concepts 301

Sri Lestari

Keyword Analysis : A Case Study of Research Trends in the *English for Specific Purposes Journal* Abstracts 309

Yu Yuan Yang, Jonathan Rante Carreon

Whose Story is It in the End : Narrative Techniques in Some Contemporary Thai and Western Short Stories 320

Sean Ford

Improving Students' Vocabulary Mastery through Bingo Games 326

Brigitta Septarini Rahmasari

Absentee Land Ownership Prohibition : Indonesian Legal Perspectives 332

Ida Farida

Quality of Instructor Service : A Management Survey at a Private College in Indonesia 339

Elly Resli, Iskhak, Andi Rustandi

Empowering Human Culture through the Diversity of Education 343

Fitra Pinandhita, Irma Febriyanti

Somebody Blew Up America : A Portrayal of Moral and Social Corruption in the Globalization Era 349

Irma Febriyanti

Involving Local Wisdom in Teaching English Speaking Skill : New Model of Developing Students Character and Nation Identity 362

Dwi Rosita Sari

The Use of *Dakon* as Teaching Media to Identify the Intrinsic Element of Drama Text by Seventh Grade Students 370

Asri Musandi Waraulia

Determinant Factors on Lecturer's Performance in Improving the Quality of Higher Education Academic Services 377

Ade Suherman

Strategies in Teaching Chinese as a Foreign Language 390

Yuanling Mo, Noparat Tananuraksakul

International

หน้า

Visual Thinking of Female Prospective Mathematics Teachers in Proving a Real Function Integral 398

Darmadi

Politics Guided By Ethics : Rethinking Levinas' Liberal State 406

Alma S. Espartinez

Morale and Empowerment in Working of Government Officers at Rusamilae Subdistrict Municipalities Pattani Province, Thailand 412

Rosidah Pohsa, Sumaiyah Tayeh, Rosidah Pohsa, Nuriyah Nuteh, Suppamas Rattapipat, Yarona Sriaremhad

An Analysis of Chinese-Thai Translation in Game Online Business : a Case Study of I2I Company 418

Ratpimon Boonruangprapha

The Case Study of Mandarin Usage in Tourist Business in Thailand 432

Paveekorn Isaranontakul

A Study of Chinese Business in Promoting Thai Rubber Export Trade : Taking Thai Asia Rubber Company as an Case Study 440

Visanee Rongkitchareon

A Study of Chinese Service of Business in Pratunum Clothing Market of Bangkok 451

Naratcha Suppasit

Using Chinese to Promote Travel in Ancient City Samutprakan 460

Wannaphattharisa Yokluan

The Study of Chinese Language Using in Spa Business in Thailand : a Case Study of Health Land Spa and Massage 472

Pailin Charatwatanawan, Fan Jun

Interesting and Enlightening : American Modern Cultures in *The West Wind Monthly* 486

Yin Yushan

A Study on Chinese Business Langguage Services in Sukhothai Historycal Park 497

Pitawan Dechasiri

A Study on Name Culture of Thai Women in Thailand 506

Zeng Guoxin

Research on Ancient Chinese Teaching from the Perspective of Teaching Chinese as a Foreign Language 523

Mao Mingxue

Characteristics and Seasonal Abundance of Seagrass at Pidakan Coast Pacitan, East Java, Indonesia

Nurul Kusuma Dewi[1]* and Joko Widiyanto[2]
[1, 2]Biology Education Study Program, Faculty of Teacher Training and Education, Universitas PGRI Madiun
*Corresponding E-mail: nurulkd@unipma.ac.id

Abstract
This research was conducted to study the condition of seagrass at Pidakan Coast Pacitan, East Java, Indonesia during rainy and dry season using a percentage of the covered area and physico chemical factors. The method used was transect-plot. The physical and chemical factors measured included: light penetration, high water level, current velocity, salinity, temperature, wave height, DO, pH, sediment texture, and nutrients of NH_4, NO_3, P_2O_5, C-organic. The result showed that seagrass bed in Pidakan Coast was formed by only single species, *Thalassia hemprichii*. The average percentage of seagrass cover was 30.89% in the rainy season and 15.05% in the dry season. According to decree of the Minister of Environment No. 200 in 2004, the seagrass bed conditions in Pidakan Coast in the rainy season was categorized into less rich/less healthy, whereas in the dry season was categorized into poor. The factors that influence the distribution and abundance of seagrass in the Pidakan Coast were substrate, depth, and the waves. The decline in the seagrass covering percentage in the dry season was caused by light and temperature factors. High light and temperatures caused dieback of seagrass. Seagrasses in Pidakan Coast were associated with different types of organisms.

Keywords*: *Dieback; Light; Seagrass; Season; Temperature

1. Introduction

Seagrass, the marine flowering plants capable of completing its lifecycle fully submerged underwater, represents a dominant biological community along the shallow coastal areas of the world. Seagrass is one of the most important components of tropical coastal ecosystems, besides mangroves and coral reefs (de la Torre-Castro, 2006), and has wide global distribution (Hartog, 1970). Compared with mangroves and coral reefs, the seagrass ecosystem has perhaps received less scholarly attention, yet this ecosystem has much potential benefit and provides crucial services (de la Torre Castro et al., 2014).

Seagrasses provide a wide range of ecosystem services (Campagner et al., 2015; Cullen-Unsworth et al., 2014; Nordlund et al., 2016) here defined as natural processes and components that directly or indirectly benefit human needs (de Groot et al., 2002). Seagrass meadows are highly productive ecosystems that offer several ecosystem goods and services such as food, recreation, natural shelter, conservation, among others (Tuya et al., 2014). This habitat is used for shelter, foraging, spawning, and rearing place for marine organisms (Hemminga and Duarte, 2003). Seagrass beds are also positioned very close to the mainland, thereby, is influenced by anthropogenic effect (Ambo-Rappe, 2014).

Seagrasses are generally assigned to two families, Potamogetonaceae and Hydrocharitaceae, encompassing 12 genera of angiosperms containing about 50 species. Seagrasses occur in all coastal areas of the world, except along Antarctic shores. Seagrass beds are common in shallow waters of the tropics, subtropics, and temperate regions (Green and Short, 2003). Seagrass species are often separated into tropical and temperate genera. The former are considered to comprise seven of the genera, while the latter comprise the remaining five genera (Hemminga and Duarte, 2003).

Most seagrass meadows are monospecific, particularly those in the temperate zone, but this holds also for tropical and subtropical areas with multispecific floras. Although seagrass species richness, the number of species present in any one meadow, can be significant, seagrass species diversity, i.e. the evenness of their contribution to the community, is typically low, as even in tropical multispecific meadows the distribution of biomass is generally skewed, with one or a few species comprising most of the biomass of the community (Terrados and Ros, 1991). The major part of the biological diversity of seagrass meadows, however, is contributed by the rich associated fauna and algal floras, and not by the seagrasses themselves. The meadows with the richest species diversity are found in the Indo-Pacific area and the Red Sea, where mixed meadows are abundant, containing up to 12 co-occurring species (Duarte, 2000).

The distribution and stability of seagrass communities is determined by factors such as: nutrients, light, sediment, salinity, and temperature (Udy and Dennison 1997, Ralph et al., 2007; Hemminga and Duarte 2000; Kahn and Durako, 2006; Masini et al., 1995; Campbell et al., 2006). The influential nutrients are nitrogen (N) and phosphorus (P). The growth of *H. uninervis* is limited by N, *Zostera capricorni* Aschers is limited by N and P; otherwise *C. serrulates* are not affected by the addition of any nutrients (Udy and Dennison, 1997).

The enrichment of nutrients (eutrophication) can trigger the growth of epiphytic algae on the leaves of seagrass and algae in the water column. Both types of blooming algae reduce the amount of light reaching the seagrass. This reduces the effectiveness of photosynthesis so as to reduce the productivity of seagrasses and leads to the decline of seagrass communities worldwide (Hays, 2005; Waycott et al., 2009). Certain light intensity is important for seagrasses for photosynthesis (Ralph et al., 2007). Masini et al. (1995) reported that the distribution of seagrass species is related to the need for light. Reduced light penetration into seagrass waters other than caused by eutrophication can also be caused by increased sediment load (Ralph et al. 2007).

Seagrasses can grow in various habitat types, but most species of seagrass grow on sand and silt substrate. This is because the habitat is more easily penetrated by the roots of seagrass. The seagrass species have different salinity tolerances, but most have a wide range of tolerances to salinity between 10-440/00 (Hemminga and Duarte, 2000). Low or high temperature pressures cause disturbances to photosynthesis and the decline of seagrass biomass (Masini et al., 1995; Campbell et al., 2006). Some species of tropical seagrass, *C. rotundata*, *C. serrulata*, *H. uninervis* and *T. hemprichii* are more tolerant of high temperature pressures than *H. ovalis*, *Z. capricorni* and *S. isoetifolium* (Campbell et al., 2006).

In the Philippines, daytime temperature and length are the most influential factors in density, biomass and seagrass production. Maximum daylight poses a negative effect on seagrass. While Erftemeijer and Herman (1994) report, in the tropical region of Gusung Tallang, South Sulawesi, the biomass, production, and nutrient content of the *E. acoroides* seawater network do not respond to rainfall, salinity, tidal, nutrient availability, and water movement or turbidity. This shows that the watershed forest in the area is still healthy so it can be assumed that the nutrient input is the same between the dry and rainy seasons.

Indonesia has two seasons throughout the year, namely dry season (dry) and rain (wet). The two seasons did not take place simultaneously in the Indonesian archipelago. Generally, the dry season occurs in April continuing until about September-October, and the wet season occurring in October-November continues March-May. The islands of Java and Nusa Tenggara experienced a dry season in April-October.

Indonesia is a home to exceptional seagrass diversity and there is evidence that seagrass there is experiencing some decline due to a quick economical development with unavoidable increase of pollution (Kuriandewa et al., 2003), although relatively little is known about the ecology of its seagrass compared to other regions of the world (Waycott et al., 2009; Short et al., 2011). Tropical seagrasses, however, can show large temporal changes. For example, the biomass and growth of intertidal and upper subtidal seagass meadows in Southeast (SE) Asia can vary by up to a factor of four during the year (Brouns, 1985; Estacion and Fortes, 1988; Erftemeijer and Herman, 1994; Lanyon and Marsh, 1995; Ethirmannasingam et al., 1996). Tidal exposure and water motion are considered the main environmental factors driving the temporal variation of biomass and growth of tropical seagrasses (Erftemeijer and Herman, 1994), which may lead to more complex temporal patterns than those encountered in temperate seagrasses, where light and temperature are the main environmental factors driving temporal change (Terrados and Ros, 1991; Perez and Romero, 1992). Changes in sea level, salinity, temperature, atmospheric CO_2, and UV radiation can alter seagrass distribution, productivity, and community composition. In turn, potential changes in distribution and structure of seagrass communities may have profound implications for local and regional biota, nearshore geomorphology, and biogeochemical cycles. Few investigations to date have focused specifically on potential responses of seagrasses to the changing global environment (Short and Neckles, 1999). Our goals were to describe the temporal changes in the abundance of *Thalassia hemprichii* (Ehrenb.) Aschers in a shallow intertidal Indonesia seagrass meadow. We characterized the seagrass in the Pidakan Coast, which is located in Pacitan, East Java. At Pidakan Coast, seagrass growing on the dead coral habitat. Information about seagrass in Pacitan is limited. The objective of this research was to study on the condition of seagrass at Pidakan Coast Pacitan, East Java, Indonesia during rainy and dry season using a percentage of the covered area and physico chemical factors.

2. Materials and methods

The method used was transect-plot. We used 5 transect (each transect 50 m) perpendicular to the shoreline. The distance between transect 25 m. At each transect, data was collected using the quadrate plot, 0.5 m x 0.5 m, the distance between plot 5 m. The total number of plots is 55. On each plot, we identified the species, noted percentage of the covered area, and noted other organisms found. The determination of a percentage of the covered area follows percent cover standards from seagrasswatch.org. The physical and chemical factors measured included: light penetration, high water level, current velocity, salinity, temperature, wave height, DO, pH, sediment texture, and nutrients of NH_4, NO_3, P_2O_5, C-organic. Identification of seagrass based on Waycott et al. (2009). There is no statistical analysis was used in this study.

3. Results

Seagrass meadow in Pidakan Coast was formed by only single species, *Thalassia hemprichii*. The average percentage of seagrass cover as below:

Table 1. The average percentage of seagrass cover

Transect	C (percentage of the covered area) in rainy season	C (percentage of the covered area) in dry season
I	22,14 %	14,63 %
III	39,14 %	7,72 %
IV	15 %	3,45 %
V	25,33 %	20,45 %
Average	**30,89 %**	**15,05 %**

From the table above, we can see that the average percentage of seagrass cover varies between transects. This is because dispersion and condition of physico-chemical factors also

differ between transects. The average percentage of seagrass cover in the rainy season is higher than in the dry season.
Physico-chemical factors at Pidakan Coast as follows:

Table 2. Physico-chemical factors at Pidakan Coast

No.	Parameter	Satuan	Rainy	Dry
1	Light penetration	m	2,5	3
2	Air temperature	^{o}C	21	31
3	Water temperature	^{o}C	22	33
4	Salinity	$^{0}/_{00}$	39.56	40.05
5	DO		6.4	7.5
6	pH	-	7.795	8.210
7	Current velocity	m/s	0,125	0.1
8	NH_4	me/l	0.075	0.125
9	NO_3	me/l	0.04285	0.03345
10	PO_4	ppm	0.135	0.250
11	Organic C	%	0.40	0.55
12	Organic matter	%	0.69	0.75

The table above shows that physico-chemical factors in the rainy and dry seasons show no significant difference. All the chemical physics and nutrient factors measured are still within the tolerance range of the seagrass.

4. Discussion

Seagrass meadow in Pidakan Coast was formed by only single species, *Thalassia hemprichii*, a dominant meadow-forming species on sediments associated with coral reefs. Although *Thalassia hemprichii* dominates more reefal habitats, it is found on a diversity of substrata, although is limited in areas with any freshwater runoff. *Thalassia hemprichii* (turtlegrass) occurs throughout the Indo-West Pacific although not as far east as the Hawaiian Islands and Fiji. *Thalassia hemprichii* is an important food resource for green turtles in the tropics. This species often dominates the landward edge of islands and cays where it plays a major role in stabilizing sediments with its intertwining rhizome mat (Waycott et al., 2009)

Thalassia hemprichii found from the shallow subtidal to deeper than 10 m, this species does not tolerate long periods of exposure. But, in many places of Indonesia includes Pidakan coast, *T. hemprichii* a seagrass species that is most resistant to environmental stress conditions. *Thalassia hemprichii* also forms dense meadows and has a high productivity. Numerous grazers and other fauna inhabit these meadows. Macroinvertebrates found are 15 species namely *Nerita chamaeleon*, *Trochus niloticus*, *Thais aculeate, Cypraea eglantina, Portunus pelagicus, Tripneustes gratilla, Echinometra mathaei, Diadema setosum, Holothuria atra, Ophiomasti xannulosa, Ophiomastix variabilis, Archaster typicus, Ophiarachna affinis, Turbo argyrostomus* and *Tetraclita* sp. Most of the macroinvertebrate come from Mollusca Phylum. There are also 16 species of macroalgae found on Pidakan Coast namely: *Ulva lactuca, Enteromorpha intestinalis, Valoni aegagropila, Padina australis, Dictyopteris undulata, Sargassum binderi, Hormophysa triquetra, Turbinaria ornata, Eucheuma edule, Eucheuma cottonii, Eucheuma spinosum, Amphiroa rigida, Jania* *rubens, Galaxaura rugosa, Gelidium amansii* and *Actinotrichia fragilis*. The species found are dominated by Rhodophyta Division.

Thalassia hemprichii is the Indo-West Pacific representative of a genus with only two species, the other, *Thalassia testudinum* occurs in the Caribbean. *Thalassia hemprichii* is recognized by having curved leaves often with tannin cells which look red, purple or dark brown. These cells give the leaf a slightly speckled appearance. This species also has characteristic rhizomes, thick (usually white or pale pink) with triangular shaped scars, and fine membranous fibres at each node. *Thalassia hemprichii* has key characteristics as follows: strap-like leaves arise from an upright stem with a fully enclosing leaf sheat. Leaf tip blunt with minute serrations. Rhizome thick with obvious node scars usually triangular in shape and with persistent leaf sheaths. Found throughout the tropical Indo-West Pacific. About reproduction, *Thalassia hemprichii* has separate male and female plants. The flowers form in the regions at the base of the shoot and are obscured by the sheath until they emerge. The male flower elongates on a long stalk (pedicel), the flower when mature separates into six or more parts. The female flower appears similar although has a finer texture, the ovary being at the base of the shoot. Fruits have an almost prickly appearance and may contain up to nine seeds (around 0.6 mm diameter) (Waycott et al., 2009). The appearance of *Thalassia hemprichii* leaves differs between the rainy season and the dry season. In the rainy season, these leaves look fresh green, while in the dry season the leaves of *Thalassia hemprichii* appear burnt and blackened. This is the effect of high radiation of sunlight and temperature.

According to decree of the Minister of Environment No. 200 in 2004, the seagrass bed conditions in Pidakan Coast in the rainy season was categorized into less rich/less healthy, whereas in the dry season was categorized into poor. The factors that influence the distribution and abundance of seagrass in the Pidakan Coast were substrate, depth, and the waves. Substrate in Pidakan Coast is dominated by dead coral, only certain species and sturdy stems that can grow in these habitats. Sediment composition or substrate can also affect the availability of phosphate. In the carbonate sediments (sedimentary minerals derived from coral reefs), phosphate interact with carbonates and less available as a free phosphate. But it is still helped by excess seagrass that can take nutrients such as ammonia and phosphate through the leaves.

Depth is also one factor that influences the distribution and abundance of seagrass in the Pidakan Coast. In Pidakan Coast, seagrass grows only in shallow areas such as reef (dead coral debris). Distribution of seagrass on the beach is limited to a distance of ± 50 m from the shoreline. After that distance, depth immediately increased dramatically. This is why seagrasses are no longer found because sunlight cannot reach up to the base thus blocking seagrass make the process of photosynthesis.

The waves at Pidakan Coast are strong. Strong tidal currents cause difficult seagrass taken root at the bottom of the water so that less breed well. Strong waves also make seagrass vegetation can be ripped from the substrate. Seagrass leaves clean of algae epiphytic showed relatively strong local currents.

The decline in the seagrass covering percentage in the dry season was caused by light and temperature factors. High light and temperature caused dieback of seagrass. Thermal optima associated with high rates of photosynthesis and growth ranges from approximately 15 to 33°C, with the species-specific optimums generally reflecting their geographic distribution (Berry and Bjorkman, 1980; Bulthus, 1987; Coles and Jokiel, 1977; Collier et al., 2011; Masini and Manning, 1997; Perez and Romero, 1992). During low tide, these thermal optima are likely exceeded for shallow water habitats. Extreme events occurring during low tide have been linked to seagrass loss (Massa et al., 2009; Rasheed and Unsworth, 2011). Although coastal water temperatures are still within the range of seagrass tolerance, but seagrass has been shown to change their characteristic (morphological appearance) and percent of the covered area.

Seagrasses are affected by thermal stress in a number of ways. Water temperature affects the balance between carbon uptake (photosynthesis) and carbon consumption (respiration) (Bulthus, 1987; Perez and Romero, 1992). The photosynthetic apparatus is highly sensitive to temperature, with temperature sensitive processes occurring throughout the photosynthetic pathways (Buxton et al., 2012; Jones et al., 1998). Increases in photosynthesis occur within their physiological optimum, but this is followed by sharp reductions in photosynthetic efficiency after temperatures exceed optimum thresholds (Bulthuis, 1983; Campbell et al., 2006; Perez and Romero, 1992; Ralph et al., 1998). Sensitivity to elevated temperature is variable among species, with tropical species tolerating higher temperatures than subtropical and temperate species (Campbell et al., 2006; Collier et al., 2011). Following extreme or prolonged thermal stress, seagrass mortality results: however, *in situ* observations of seagrass mortality typically occur after the thermal event, making it difficult to directly link changes in physiological processes to mortality (Marbá and Duarte, 2010; Massa et al., 2009; Rasheed and Unsworth, 2011).

5. Conclusion

Seagrass meadow in Pidakan Coast was formed by only single species, *Thalassia hemprichii*, a seagrass species that is most resistant to environmental stress conditions. The appearance of *Thalassia hemprichii* leaves differs between the rainy season and the dry season. In the rainy season, these leaves look fresh green, while in the dry season the leaves of *Thalassia hemprichii* appear burnt and blackened. This is the effect of high radiation of sunlight and temperature. The average percentage of seagrass cover was 30.89% in the rainy season and 15.05% in the dry season. The decline in the seagrass covering percentage in the dry season was caused by light and temperature factors. High light and temperatures caused dieback of seagrass. Seagrasses in Pidakan Coast were associated with different types of organisms.

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at Pidakan Coast Pacitan, East Java, Indonesia

Given this 22nd day of June in the year two thousand and eighteen.

U. Jamvanichyanont.

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