Original Research Article

The management of seagrass ecosystem as an attractive object of ecotourism in the coastal areas of Yensawai and Arefi, in Dampier Strait marine protected area, Raja Ampat

ABSTRACT

The seagrass ecosystem and ecological interaction between the components of ecosystem and dugongs (*Dugong dugon*) have potentials to be utilized for marine ecotourism objects in the coastal of Yensawai and Arefi in Dampier Strait marine protected area of Raja Ampat. This objective of the research was to identify the characteristics and ecology interaction in the seagrass ecosystem with the emergence and presence of dugongs that can be developed as the potential ecosystem for the attractive object of marine ecotourism in a specific ecotourism destination. The data were collected and consisted of the bioecology of the seagrass ecosystem as a result of dugongs' monitoring from their emergence and presence in the seagrass ecosystem and feeding grazing. The research results showed that seagrass biodiversity consists of 4 species: *Enhalus acroides*, *Halophila ovalis*, *Syringodium isoetifolium*, and *Thalassia hemprichii*.The condition of seagrass ecosystem in Yensaway showed that *Thalassia hemprichii* had the highest frequency of presence in this area, and *Syringodium isoetifolium* was most frequently found in the coastal area of Arefi. The width of the utilization areas recommended for seagrass ecotourism based on the ecosystem preservation and migration of biota is 103,575.00 m^2. The strategy for the effectiveness of seagrass ecotourism management is to allocate the area as much as 25%, the carrying capacity as many as 104 people/day (9,581 people/year), and in 50% of the area, the carrying capacity is 207 people/day (7,665 people/year). The development of seagrass ecotourism must be managed, synergized, harmonized with the management of the conservation area, and it should guarantee and maintain the sustainability of ecological process that supports the system of life, conserve the biodiversity, and ensure the sustainable use of species and ecosystem contributing to the welfare of the community.

Key words: seagrass ecosystem, attractive object of ecotourism, marine protected area, coastal areas of Yensawai and Arefi, Dampier Strait, Raja Ampat

Introduction

Seagrass is one of the higher plants (Antophyta) that live abundantly in a marine environment and has vascular plants with leaf and rhizome, roots and reproductive systems of generative (seeds) and vegetative (budding). They live in substrates with mud, muddy sand, and fraction of death corals (Hernawan *et al.* 2017). These plants are developed in shallow water and estuaries. Around the Indonesian waters, seagrass beds generally grow in the tidal areas (coastal areas) and the coral islands (Nienhuis *et al.* 1989). Based on the research reports, there are approximately 60 species of seagrass, consisting of 2 families and 12 genera (Den Hartog 1970; Phillips & Menez 1988; Kuo & McComb 1989). Hernawan *et al.* (2017) reported that there are also 12 species consisting of 2 families and 7 genera with the wide areas of seagrass of 150,693.16 hectares in this Indonesian waters. There are also seagrass species of *Enhalus acoroides, Cymodocea rotundata, C. serrulata, Halophila decipiens, H. ovalis, H. minor, H. spinulosa, Haludole pinifolia, Halodule uninervis, Syringodium isoetifolium, Thalassia hemprichii,* and *Thalassodendron ciliatum*. The newest species was found by Kuo

(2007) *Halophila sulawesii*. The ecosystem of seagrass is very important and has ecological and economic values as a marine ecosystem. It is economically capable of producing the ecosystem services and the values are predicted as much as US$ 19,000/hectare/year (Costanza *et al.* 1997; Costanza *et al.* 2014). Wahyudin *et al.* (2014) had studied the ecosystem services of seagrass to human life, and their study concluded that the seagrass ecosystem is very useful for human welfare in which the ecosystem services can be used for human beings and are very important for the ecology, social and economy. Seagrass ecosystem has very important functions: a filter in shallow waters and an important habitat for biota with economic values: *Siganus* fish (*Siganus* spp.), crabs (Crustacea), shellfish (Mollusca) and sea cucumbers (Hollutoruidea), and a nursery and feeding ground for marine biota (dugongs and turtles). Also, the seagrass ecosystem has the physical functions to reduce wave energy and as a stabilizer sediment on the beach that can prevent erosion in coastal areas. Other important roles of the seagrass ecosystem are for climate change adaptation and mitigation (Kennedy dan Bjork 2009, McKenzie 2008, Dorenbosch *et al.* 2005, Green & Short 2003, Nagelkerken *et al.* 2002, and Rahmawati 2011). Agustin (2014) suggest that when the west season occurs, the ecosystem of seagrass has the ability to absorb carbon from the atmosphere approximately as much as ± 0.502 to 5.971 mmol $C/m^2/day$. The absorption of carbon occurs in proportion to its breadth areas of seagrass beds. Duarte (2017) studied and predicted that carbon absorbed in seagrass ecosystem is 394-449 $gr/CO_2/ m^2/year$.

Dugongs are marine mammals that have interactions with seagrass beds and regularly conducts migration to the islands and the coastal areas of Yensawai and Arefi, in Dampier straits marine protected areas for grazing in seagrass beds. In the coastal areas of Yensawai and Arefi may dugongs be seen in seagrass beds based on the information from the local community. The data on the dugong population is still limited, and the number of the population is not known. In general, it is very hard to identify by the percentage of the population of dugongs in an uncertain manner. This is because of the movement of dugongs which perform migration periodically from one area to another. Dugong migration usually occurs in the event of searching for food, taking a nap and reproducing in seagrass beds. Not all types of seagrass species can be consumed by dugongs, and there are only a few kinds of seagrass species which are short, small, and condensed such as *Halodule* sp., *Halophila* sp., *Syringodium* sp. and *Thallasia* sp., and dugongs enjoy these kind of seagrass species for food. One aspect of the research conducted to support the protection of dugongs is the ecological study of dugongs (*Dugong dugon*) and interaction with the seagrass ecosystem in the coastal areas of Yensawai and Arefi, Dampier straits marine protected areas in Raja Ampat, West Papua Province.

The development of marine tourism in the region of West Papua Province for the last few decades has progressed very fast, especially in Bird Head's Sea Scape of Papua. In 2018, the development of tourist visits to Raja Ampat was quite significant by the total number of visitors of 28,682 people. Based on the data from the Departement of Tourism of Raja Ampat Regency, at the time, as many as 5,811 domestic visitors and 22, 871 foreign visitors were recorded visiting the area. In 2018, there was a record on the amount of the tourism sector income of Raja Ampat government regency from the sale of KJL cards (entrance fee cards for environmental services). As much as Rp 22, 871, 000, 000 came from the foreign tourists and Rp 2.905,500,000 from the domestic tourists. The management of marine ecotourism can be designed by the management concept

prioritizing the preservation and sustainable uses of natural resources and environmental services synergized with the local culture for the prosperity of the community.

The development of ecotourism activities does not involve natural resource exploitation but only use the nature and culture of the local society to satisfy the physical needs, knowledge and psychology of visitors. The development of tourism market is conducted with the concept of the basic principle of management that ecotourism activities are carried out using the approach of product-driven, which is adapted to the potential of the nature, the behavior of objects and tourist attraction available, and local culture.The study was conducted by collecting data and scientific information from various sources (research reports, scientific journals, and literature study) and by studying comprehensive studies on the field using the explorative and descriptive methodology, and comparative studies. Based on the results of this analysis, issues on the priority risk management and the impact of marine ecotourism development could be identified. This study attempted to analyse the potential ecosystem services in seagrass ecosystem and the pattern of uses of resources of the seagrass ecosystem as the object attraction of ecotourism, to formulate strategies and management, and to develop marine ecotourism and support adapted strategy for the limited factors in environment, and to protect resources and sustainability of seagrass ecosystem in Arefi and Yensawai coasts, Dampier Straits marine protected area of Raja Ampat.

MATERIAL AND METHOD

Location

This research was conducted in Dampier strait marine protected area in Batanta Island, Raja Ampat Regency of West Papua Province from November 2016 to November 2017. The research stations and data collection were selected based on Bengen (2000):

1 Selected location to explore data can be a representative areas of study and indicate a description of every zonation in these study areas.

2 A conceptual assessment can be done based on a representative of areas study.

The data were collected in the seagrass ecosystem in 2 stations of research: in coastal areas of Yensawai (station 1) and Arefi (station 2). The locations were selected based on the information from the local community stating that they saw dugongs (*Dugong dugon*).

Procedures

The collected data of the seagrass ecosystem were used to assess the potential of seagrass biodiversity in marine and coastal areas. The seagrass sampling was conducted by quadrant transect of 50 x 50 cm and inline transect of 50-100 meters throughout coastal areas. The sampling stations and line transect placed in areas that nearest from coast, and the point of the first sampling was noted by the position of GPS (*Global Positioning System*). The determination of the next station was based on the same distance and the parallel location following the direction of line transect perpendicularly to the sea. The distance between the stations was adjusted to the type of seagrass ecosystem in which it has a variety of types was narrowed down into 5 m, homogeneous, and the distance often used is 15-20 meters. The data series collected in 5 times in each station, which was located perpendicular to the coastline (Setyobudiandi *et al.* 2009). The identification of seagrass species was conducted using book *Guidelines for the rapid assessment of seagrass habitats in the western Pacific* (McKenzie 2003).

Yulianda *et.al* (2010); Yulianda (2019) stated that the concept of carrying capacity considers two things: (1) the natural ability to tolerate disturbance or disaster from human, and (2) the standard of the authenticity of natural resources. The analysis of carrying capacity was proposed in the development of marine tourism with the use of the potentials

of coastal resources, beaches and small islands in the preservation and sustainable management. The areas carrying capacity assessment (DDK) is the maximum number of visitors that can be physically accommodated in the areas provided at any given time without causing interferences with nature and humans. The formulation of calculating carrying capacity can be used in diving ecotourism, *snorkelling*, mangrove, and seagrass ecotourism. The assessment of carrying capacity can be formulated as follows:

$$DDK = K \times {Lp}/{Lt} \times {Wt}/{Wp}$$

where:
DDK = Carrying capacity of the areas (DDK)
K = Potential of visitors in unit areas
Lp = Areas or width of areas that could be used
Lt = Unit area for specific categories
Wt = Given time from areas to tourism activities in a day
Wp = Spent time by visitors to carry out specific tourism activities

The calculating formulation that could be used to assess diving carrying capacity had been done, and formulated standardization was based on Papilaya *et al.* (2018). The formulation in assessing physical carrying capacity for diving ecotourism in a marine protected area in Raja Ampat is as follows:

$$PCC = A \times \frac{v}{a} \times Rf$$

where:
PCC = *Physical Carrying Capacity*
A = Areas that can be used by visitors are divided into tourism activities of beach, diving, and fishing
$\frac{v}{a}$ = Areas that may be needed by visitors (tourists) for adventure traveling that implied adjustment
Rf coefficient to the type of tourism (beach tourism, *snorkeling*, diving, and fishing)

a visitor for adventure traveling

$$RCC = PCC \times Cf$$

where:
RCC = maximum numbers of visitors that can be tolerated in using the areas of marine tourism
Cf = correction factor

$$Cf = 1 - ({M1}/{Mt})$$

where:
M1 = time (month) when visitors do not visit Raja Ampat
Mt = total time (month) in 1 year (12 months)

According to Yulianda (2019) and Yulianda *et al.* (2010), the ecological potential of visitors is adjusted to the potential resources and types of activities that can be developed (Table 12). The ecological potential of the carrying capacity must be adjusted to the coastal ecotourism resources which are very fragile to destructions and areas that visitors can visit are very limited.

Table 1. The ecological potential of visitors (K) and the area width for tourism activities (Lt)

Types of	∑ visitors	Unit of	Remarks

activities	(people)	areas (Lt)	
Seagrass ecotourism	1	250 m^2	every 1 visitor in an area of 50 m x 5 m

Source: Yulianda (2019)

The ecological and physical potentials of the carrying capacity in marine protected areas of Raja Ampat that could be used in this research were developed by Cifuentes formulation (1992) and corrected by the researchers: Amador *et al.* (1996); Ceballos-Lascurain (1996); Cifuentes *et al.* (1999); Segrado *et al.* (2008), Zacharias *et al.* (2011) and Papilaya *et al.* (2018). Some modifications are needed in the real carrying capacity and can be corrected by adjustment factors in the following formulation form:

$$DDK\ Real = DDK \times (FA_1 \times FA_2 \times \ldots FAn)$$

Where:
DDK Real = the real of carrying capacity
DDK = the areas of carrying capacity
FA1….FKn = *the adjustment factor*
The correction factors were calculated based on the following equity:

$$FAx = \frac{MPx}{MTx}$$

where:
FAx = the *adjustment factor* of variable x
MPx = the limited magnitude of variable x
MTx = the total magnitude of variable x

Zacharias (2011) states that any environmental factor can be used as a limited factor. The limited factors include rainfall, wind velocity, sunlight intensity, and *closure* (no *diving* temporarily).

Table 2. The profile of specific *adjustment factors* in marine protected area of Raja Ampat in 2016

Ecosystem	Probability of bad weather condition (the east and west seasons)	Probability of destruction of ecosystem (per year)	Probability of migratory and endemic biota (year)
Seagrass	0.5	0.1-0.2	0.1 - 0.2

RESULTS AND DISCUSSIONS

The profile of seagrass resources

The existence of seagrass beds in Sayang, Kawe, Waigeo, Batanta dan Salawati islands in marine protected area of Raja Ampat as well as in small islands have long been known and recorded. There may be an important habitat of green turtles and *baronang* fish *(Siganidae)* to feed, spawn and use the nursery ground. On the other hand, these areas are important for fishermen especially the traditional and commercial fisheries in the local communities (Firman and Azhar 2006; McKenzie *et al.* 2007). The biodiversity assessment of seagrass species in Raja Ampat has not been well described so far; however, Short *et al.* (2007) found and documented approximately 12-15 seagrass species.

The biodiversity of seagrass found in the coastal areas of Yensawai and Arefi includes 4 species (Table 3) and consisting of 2 families. There were *Enhalus acroides*, *Halophila ovalis*, *Syringodium isoetifolium*, and *Thalassia hemprichii*.

Table 3. The seagrass species found in the coastal areas of Yensawai and Arefi, in Dampie strait marine protected area of Raja Ampat in 2016

Family	**Species**
Hydrocharitaceae	*Enhalus acroides*
Hydrocharitaceae	*Halophila ovalis*
Cymodoceaceae	*Syringodium isoetifolium*
Hydrocharitaceae	*Thalassia hemprichii*

The condition of the seagrass ecosystem is described in the percentages of seagrass covers in 4 species in the coastal areas of Yensawai and Arefi. There are a variety of seagrass covers from the lowest to highest (Tables 4, 5, 6 and 7).

Table 4. The data of seagrass condition in the coastal area of Yensawai, Dampier strait marine protected area of Raja Ampat in 2016

Transect	Plot	Seagrass species				Percentage (%) seagrass covered	Average (%) seagrass covered
		Ec	Th	Hp	Si		
1	1		+	-	-	25	25.83
	2	+	-	-	-	25	
	3	-	+	-	-	25	
	4	-	-	-	-	-	
	5	-	-	-	-	-	
	6	+	+	+	-	80	
2	1	+	-	-	+	55	38.33
	2	+	+	-	-	80	
	3	+	+	-	-	80	
	4	-	-	-	-	-	
	5	-	-	-	-	-	
	6	-	+	+	-	15	
3	1	-	-	+	-	15	27.5
	2	-	+	-	-	95	
	3	-	+	-	-	15	
	4	-	+	-	-	25	
	5	-	-	-	-	-	
	6	-	+	-	-	15	
4	1	-	-	-	+	15	40.83
	2	+	+	-	-	80	
	3	-	+	-	-	15	
	4	-	+	+		65	
	5	-	+	-	-	65	

	6	-	+	-	-	5	
5	1	-	-	-	+	5	59.17
	2	+	+	-	-	95	
	3		+	-	-	95	
	4	+	+	-	-	80	
	5		+	-	-	15	
	6	+	+	+	-	65	
6	1	+	-	-	-	65	60.83
	2	-	+	-	-	95	
	3	-	+	-	-	80	
	4	-	+	-	-	65	
	5	-	+	-	-	55	
	6	-	+	-	-	5	

Table 5. The data frequency of seagrass in every transect in the coastal areaof Yensawai, Dampier Strait marine protected area of Raja Ampat in 2016

Seagrass species	Transect						Average of Relative Frequency (%)
	1	2	3	4	5	6	
Enhalus acroides	33,33	50,00		16,67	50,00	16,67	27,78
Halophila ovalis	16,67	16,67		16,67	16,67		11,11
Syringodium isoetifolium		16.67	16,67	16,67	16.67		11,11
Thalassia hemprichii	50,00	50,00	66,67	83,33	83,33	83,33	69,44

Table 6. The data condition of seagrass ecosystem in the coastal area of Arefi, Dampier strait marine protected area of Raja Ampat in 2016

Transec	Plot	Seagrass species				Percentage (%) Seagrass covered	Average (%) Seagrass covered
		Ec	Th	Hp	Si		
1	1	-	-	-	+	5	54.17
	2	-	-	-	+	5	
	3	-	-	-	+	70	
	4	-	-	-	+	75	
	5	-	-	+	+	75	
	6	+	+	+	+	95	
2	1	-	-		+	80	53.33
	2	-	-	+	+	10	
	3	-	-	-	+	5	
	4	-	-	-	+	70	
	5	-	-	-	+	75	

	6	+	+	+	+	80	
3	1	-	-	-	+	25	34.17
	2	-	-	-	-	-	
	3	-	-	-	-	-	
	4	-	-	-	+	10	
	5	+	-	+	+	75	
	6	+	+	+	+	95	
4	1	+	+	-	+	15	35.83
	2	-	-	-	+	5	
	3	-	-	-	-	-	
	4	+	-	-	+	5	
	5	+	+	-	+	95	
	6	+	+	-	+	95	
5	1	+	+	-	+	80	75.83
	2	+	+	+	+	70	
	3	+	+	-	+	85	
	4	+	+	+	+	75	
	5	+	+	-	-	70	
	6	+	+	+	+	75	
6	1	+	+		+	5	66.67
	2	+	+	+	-	80	
	3	+	+	-	-	95	
	4	+	+		+	80	
	5	+	+	+	+	85	
	6	-	+	-	+	55	

Table 7. The data frequency of seagrass in every transect in the coastal areas of Arefi, Dampier Strait marine protected area of Raja Ampat in 2016

Seagrass species	Transect						Average of Relative Frequency (%)
	1	2	3	4	5	6	
Enhalus acroides	16,67	16,67	33,33	50,00	100,00	83,33	50,00
Halophila ovalis	33,33	33,33	33,33		50,00	50,00	33,33
Syringodium isoetifolium	100,00	100,00	66,67	83,33	83,33	66,67	83,33
Thalassia hemprichii	16,67	16,67	16,67	50,00	100,00	83,33	47,22

The existence and preservation of the seagrass ecosystem are highly essential in the ecosystem around this area. Seagrass ecosystem has been an important role in supplying the flow of energy, elements of nutrients and feeding, nursery, and spawning resources for

marine biota which will support mangrove ecosystem and coral reefs. It is also important for the mechanisms used in the carbon reserves in the islands and coastal areas. The condition of the seagrass ecosystem has been good, beneficial, and highly supportive to the complexity of the food chain and the life cycle of marine biota associated with the ecosystem. The marine biota associated with the seagrass ecosystem include Mollusca (*Pinna bicolor*), snails, oysters, echinoderm, sea birds and others. The seagrass ecosystem is vulnerable from the pressure of the environment especially due to the high impact in the development of the areas in upland and sedimentation. It can be said that the management plan of the seagrass ecosystem must become a part of the integrated management in the ecosystem and resources of marine and coastal regions and other areas in Raja Ampat marine protected area.

Dugongs as a potential attraction for ecotourism and specific destination

Based on the interviews with the local people who live near coastal areas of Yensawai and Arefi, it can be said that they have seen dugong simultaneously with the tidal waves. Monitoring and observations of dugong have been undertaken directly in the field station. The presence of dugongs was witnessed by the researchers directly in Arefi coast in the early morning of the day when the tidal waves were rising. Dugong presence was seen unexpectedly in just a few minutes, and it was quickly back swimming into the sea; as a result, no photographs were taken for the documentation.

Dugongs are shy fast swimmers and do not enjoy the crowd interferences and noises, and they usually looks for foraging and sometimes consumes seagrass beds in the coastal areas where they are found abundantly. The activity of a meal usually stops in unison with seawater, began to ebb and flow, and dugongs go back to sea to continue their life activity. Generally, the local community does not consume dugongs, and almost all the people in Yensawai and Arefi have a very well understanding and concern to protect marine mammals categorized as endangered species. The support of protecting animals in the commitment of the local community due to coastal areas in Yensawai and Arefi still found dugong emerging at certain times.

Dugongs (*Dugong dugon*) are seagrass herbivores and they consume many kinds of seagrass such as *Halodule uninervsis, H. pinifolia, Syringodium isoetifolium. Halophila ovalis. H. spinulosa, Cymodocea rotundata, C. serrulata, Thalassia hemprichii* and *Zostera capricorni* (Pren 1993; Lanyon *et al.* 1989; de Longh *et al.* 1995). The results of a number of researches showed that dugongs consumed seagrass beds in different species from one place to another. In Australia, dugongs generally consume seagrass species i.e. *H. ovalis, Z. capricorni*, while in the Red Sea, they only consume *H. uninervis*. Dugong is one animal of the 35 (thirty-five) marine mammals that are found scattered around the Indonesian waters, especially in the seagrass beds. This mammal has a large body weighing up to 600 kg and has a friendly and lively behaviour associated with the particular ecosystem that feeds off as the habitat seagrass beds. Dugongs have differences with other animal herbivores which prefer fibrous plants. They prefer root of seagrass which are soft and easily digestible but have high nutritional values. Turtles consume the leaves of seagrass, but dugong explore seagrass beds and consume the roots (Nontji 2012).

Dugongs are marine mammals that can still be found in the tropical seas, subtropical seas and Indo Pacific Ocean (Nishiwaki dan Marsh 1985), and they are distributed and spread in 48 countries from the east coast of Africa to Vanuatu in the Southeast Papua New Guinea (Marsh et al. 2002). It is hard to identify the existence of dugongs in Indonesia. Marsh *et al.* (2002) stated that in the years of 1970s, it was estimated that the

number of dugongs in Indonesia was approximately 10,000 dugongs while in 1994, the number was estimated to reach 1,000 dugongs. The latest report on the distribution and the status of dugongs in Indonesia is based on the reports from de Lóngh *et al.* (2009a) and Kiswara *et al.* (2011). In nature, dugongs have slow reproduction, so they need 10 years to get mature and 14 months to give birth to one new individual with an interval of 2.5 - 5 years (Juraij *et al.* 2017). In Indonesia, dugongs are protected species as stated in the government policy of Republic of Indonesia in PP No 7/1999 regarding the preservations of plant and animal species. They are also included in the red list (susceptible and vulnerable animals) by IUCN listed in CITES Appendix I, indicating all forms of international trades in this kind of wildlife are prohibited.

Table 8 The potentials of utilization areas for seagrass ecotourism in Yensawai and Arefi, in Dampier Strait marine protected areas, Raja Ampat, 2016

Location	The width of utilization areas in seagrass ecotourism (m2)
Coastal areas of Yensawai	24,300
Coastal areas of Arefi	113, 800

The coastal area of Arefi has wider seagrass beds than those of Yensaway (113,800 m^2 or 11.38 ha). The characteristic of seagrass ecosystem that supports dugong habitats is seagrass beds with very fine sand white grains. This condition of habitat is found in the coastal area of Arefi located along the areas of the inhabitants of the local community. Very fine sand white grains are found and spread in the seagrass ecosystem. Ecologically, it is predicted that the condition supports dugongs and their activities where they can have a good place for playing and feeding grazing.

The study on the dugong interaction with the seagrass ecosystem had also been carried out outside Australia (Aragones dan Marsh 2000). Previous studies were conducted outside Indonesia, and they evaluated dugongs' eating behavior, specifically those feeding on roots and rhizomes seagrass beds; however, their diet strategy is still not well known (Johmstone and Hudson 1981). Juraij *et al.* (2014) conducted the research on seagrass biodiversity as a resource of feeding grazing of dugongs (*Dugong dugon)* in Busung Bintan village in North of Riau islands. The result of research showed the seagrass species found including *Cymodoceae serrulata, Halophila minor, Syringodium isoetifolium, H. spinosa and Halodule uninervis* that can be consumed by the dugongs and function as feeding grazing. Seagrass species of *H. uninervis* was found and distributed in the highest value of abundance and percentage of seagrass covered. The research result conducted in the coastal areas of Yensawai and Arefi showed 4 species of seagrass found in these areas including *Enhalus acroides, Halophila ovalis, Syringodium isoetifolium,* and *Thalassia hemprichii.* The condition of the seagrass ecosystem in the coastal area of Yensawai showed that *Thalassia hemprichii* was found with the highest frequency of presence; in contrast, in the coastal area of Arefi was found *Syringodium isoetifolium*.

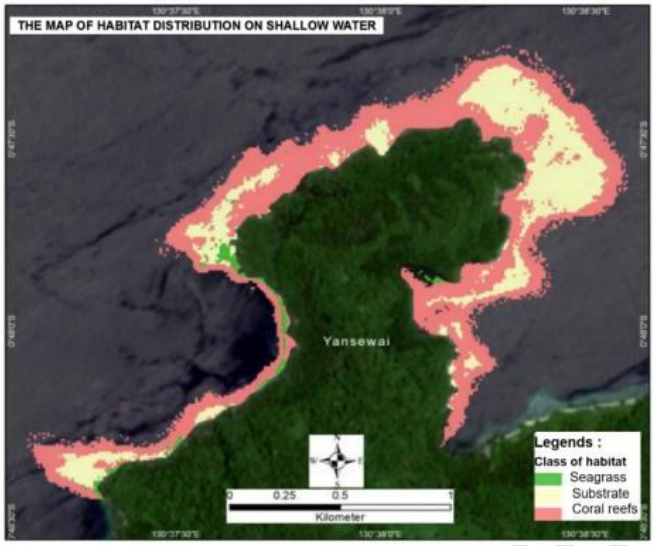

Figure 1 The map of suitability areas of seagrass ecotourism in the coastal area of Yensawai, Damper strait marine protected area, Raja Ampat, 2016

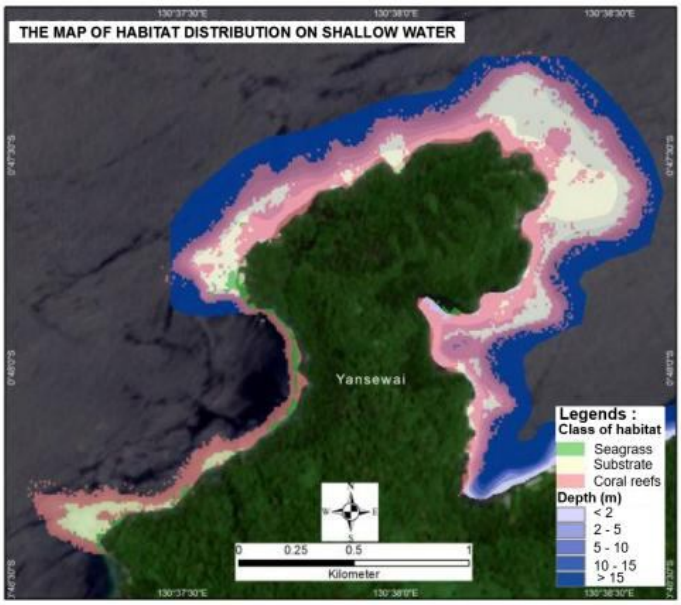

Figure 2 The map of water depth in the coastal area of Yensawai, Dampier strait marine protected area, Raja Ampat, 2016

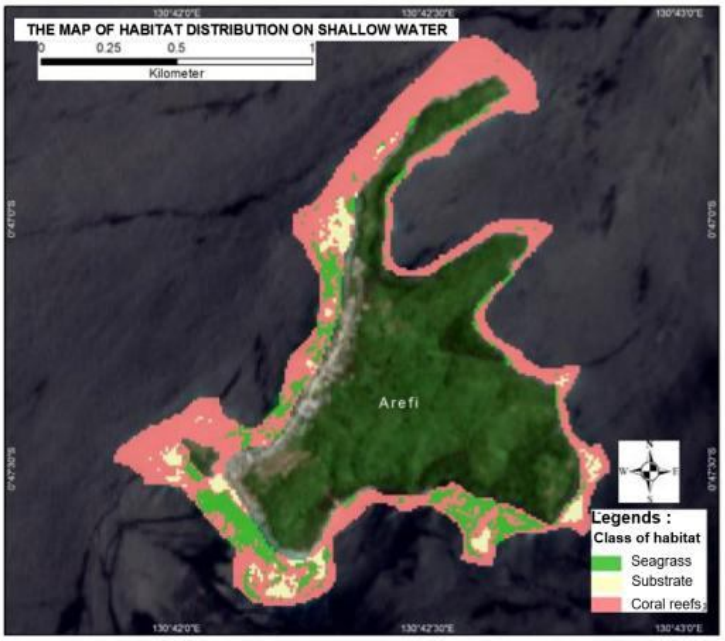

Figure 3 The map of suitability areas of seagrass ecotourism in the coastal area of Arefi, Damper strait marine protected area, Raja Ampat, 2016

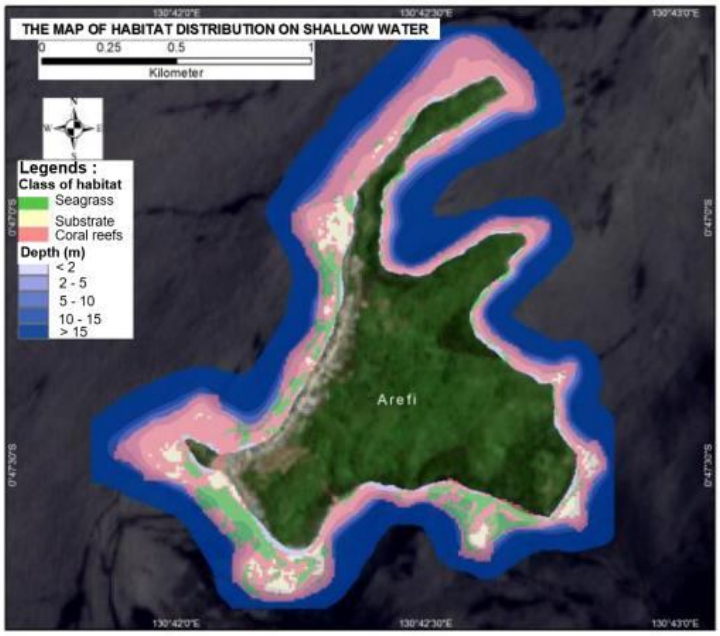

Figure 4 The map of water depth in the coastal area of Arefi, Dampier strait marine protected area, Raja Ampat, 2016

The areas of carrying capacity

The potential of the wide areas of seagrass ecosystem found in 2 locations of ODTE (the object attractiveness of ecotourism) of seagrass ecosystem in Dampier strait marine

protected areas is 138,000 m2. If the wide area of seagrass ecotourism is assumed for 1 person to explore the beauty of the seagrass ecosystem (seagrass ecotourism), the area width should be 50 m (Yulianda 2007; Yulianda 2010), indicating that the potential of carrying capacity in seagrass ecotourism is 1,105 people/day. The activity of seagrass ecotourism is influenced by the conditions of wind, wave, and rainfall (the weather conditions in the east and west seasons). The condition of the water environment can be *an adjustment factor* due to influences of the changes, distributions, and fluctuations of tourists visiting Dampier strait marine protected area Raja Ampat. Based on the computation of *Real Carrying Capacity* (RCC), the number of tourists is 545 (people/day). If the coefficient of rotation is doubled, and the conditions of wind, wave and rainfall (the weather conditions in east and west seasons) are regarded as *an adjustment factor,* with the tourist visits in 180 days, the number of tourist visitors becomes 24,518 people/year (Table 9).

Table 9 DDK seagrass ecotourism in Dampier strait marine protected area in Raja Ampat, 2016

ODTE Seagrass location	Width of area (m2)	Coefficient rotation	DDK (people/day/ ODTE)	RCC seagrass ecotourism (people/day/m2)	Number of visitor (people/trip/day)	Adjustment factor in season (day/year)	Number of visitors (people/ year)
Coastal area of Yensawai	24,300	4	194	96	24	180	4,314
Coastal area of Arefi	113,800	4	910	449	112	180	20,203
Number	138,100		1,105	545			24,518

The effectivity of the strategy of seagrass ecotourism management

The assessment of ecological carrying capacity in ODTE of seagrass ecosystem in Dampier strait marine protected area, Raja Ampat, had been conducted and worthy based on the ecological assessment in the coastal areas of Yensawai and Arefi. The concept of seagrass ecotourism has been developed in harmony and synergy with the conservation management: maintaining the ecological process supporting the system of life, preserving the biological diversity, conserving and utilizing species and their ecosystem in a sustainable manner that contribute to the welfare of the community. Based on the results of the explorative and descriptive research and comparative assessments, the followings are the designs of the effectivity of integrated marine ecotourism management in the marine protected area in Raja Ampat:

1 The management of seagrass ecotourism is based on the carrying capacity with the priority of specific adjustment factors in management areas.

Based on the result of the assessment, the specific *adjustment factor* in marine protected area Raja Ampat was formulated:

1.1 Probability of east season (Juni-Agustus) and west season (December-February)

1.2 Probability of annual marine resource degradation caused by marine tourism activity

1.3 Probability of charismatic and endemic marine biota migratory (every year)

The recommendation for the width of the areas allocated for seagrass ecotourism based on ecosystem preservation and migratory of biota is 103,575.00 m2. Table 10 shows the analysis result of the area carrying capacity based on the ecosystem preservation and migratory of biota.

Table 10 The analysis result of area carrying capacity based on the ecosystem preservation and migratory of biota

Ecotourism	The potentials of tourism *spots*	Real DDK (people/day)	Rotation (day)	Number of visitors/trip/day	Number of visitors (people/year)
Seagrass	2 areas	414	2	207	38,323

The seagrass ecotourism carrying capacity is 414 people/day. Based on the visitor distribution management and visitor rotation in 1 day, the number of visitors that can be allocated for seagrass ecotourism is 207 people/day/trip. The management of visitors for annual seagrass ecotourism is 38,323 people/year. The management of marine ecotourism is based on carrying capacity with the priority management scenarios of 25% and 50% through ecosystem preservation and migratory of charismatic and endemic biota. The effectivity of the strategy for the ecotourism management can be carried out by allocating the distribution of visitors in the scenarios of 25% and 50% through ecosystem preservation and migratory of charismatic and endemic biota (see Table 11 and Table 12).

Table 11 The analysis result of computation in DDK ecotourism area by scenario of tourism area management of 25%

Ecotourism	Width of area (m2)	Potentials of tourism spot	Management in 25 % of tourism areas	Real DDK (day)	Rotation (day)	Number of visitors (people/year)
Seagrass	103,575.00	2 areas	25,893.75	104	2	9,581

Table 12 The analysis result of computation in DDK ecotourism area by scenario of tourism area management of 50 %

Ecotourism	Width of area (m2)	Potentials of tourism spot	Management in 50 % of tourism areas	Real DDK (day)	Rotation (day)	Number of visitors (people/year)
Sea grass	103,575	2 areas	51,787.50	207	2	7,665

In Table 11, DDK ecotourism area is presented by a scenario of tourism area management of 25% for seagrass ecotourism (104 people/day). If the distribution of visitors has been managed by visitor rotation in 1 day, the number of visitors in a year that can be allocated to seagrass ecotourism is 9,581 people/year. In table 12, DDK ecotourism area is presented by a scenario of tourism area management of 50% for seagrass ecotourism (207 people/day). If the distribution of visitors has been managed every year, the number of visitors for seagrass ecotourism is 7,665 people/year).

2 The management of marine ecotourism is based on DDK through ODTE management, accessibility, and affordability to tourism destination areas.

The strategy of the effectivity of ecotourism management can be carried out by allocating the tourism visitors through ODTE management by the scenarios for the allocation of utility areas with ecosystem preservation and migratory of charismatic and endemic biota.

Table 13 shows the performance of carrying capacity and scenario management based on ODTE management, accessibility, and affordability to tourism destination areas.

Table 13 The justification of management recommendation based on ODTE management, accessibility, and affordability to tourism destination areas

Ecotourism activity	Management Areas	The justification of management recommendation
	Batanta	
Seagrass		
The potentials of wide areas seagrass ecotourism	138 100	1 Seagrass ecotourism activity and dugong watching have become the focuses in the priority and strategic locations in the area management of Batanta (in north and south areas). 2 Dugong watching has required the Dugong Watching Specific Protocol, limited tourism visitors, and specific tourism attractions and must be supported by dugong conservation (*Red List IUCN : vulnerable*)
The width of areas (recommendation) (m2)	103 575	
The number of seagrass ecotourism areas	2	
ODTE of seagrass ecotourism	The coastal areas of Yensawasi and Arefi	
Real DDK (day)	414	
The number of visitors (people/day/trip)	207	
The number of visitors (people/year)	38 323	

Conclusions:

1 There are 4 species of seagrasses consumed by dugongs (*Dugong dugon*): *Enhalus acroides, Halophila ovalis, Syringodium isoetifolium*, and *Thalassia hemprichii*. The conditon of the seagrass ecosystem in the coastal area of Yensawai showing that Thalassia hemprichii is found in the highest frequency, but in the coastal area of Arefi, only Syringodium isoetifolium exists.

2 The width of area of utility that can be recommended for seagrass ecotourism through ecosystem preservation and biota migratory reaches103, 575.00 m2.

3 The effective strategy of seagrass ecotourism management can be carried out in allocated areas of 25%, so The areas carrying capacity assessment (DDK) is 104 people/day (9,581 people/year), and in area of 50%, DDK is 207 people/day (7.665 people/year).

4 Development of seagrass ecotourism can be improved in harmony and synergy with conservation management i.e. maintaining the ecological process that supports the system of life, conducting preservation in biological diversity, conserving and utilizing species and their ecosystem in a sustainable manner contributing to the welfare of the community.

Recommendation:

1 Seagrass ecotourism activity and dugong watching must become the priority and strategic location in area management of Batanta (in north and south areas).

2 Dugong watching requires the Dugong Watching Specific Protocol, limited tourism visitors, and specific tourism attractions which can support dugong conservation (*Red List IUCN: vulnerable*)

REFERENCES

Agustin R. 2014. The contribution of seagrass beds in regulatory of carbon and stabilization of the ecosystem. [Disertation]. Bogor (ID): Bogor Agricultural University. 116 pp.

Aragones L, Marsh H. 2000. Impact of dugong grazing and turtle cropping on tropical seagrass communities. *Pac Conserv Biol*. 5:277–288.

Costanza R, dArge R, deGroot R, Farber S, Gasso M, Hannon. 1997. The value of the world's ecosystem services and natural capital. *Nature*. 387: 253-260.

Costanza R, de Groot R, Sutton P, van der Ploeg S, Anderson SJ, Kubiszewski I, Farber S, Turner RK. 2014. Changes in the global value of ecosystem services. *Global Environmental Change*. 26: 152–158.

De Iongh HH, Hutomo M, Mooral M., Kiswara W. 2009a. *National conservation strategy and action plan for the dugong in Indonesia*. Part II. Strategy report Institute of Enviromental Sciences Leiden and Research Centre for Oceanography, Jakarta (ID): 31p.

De Iongh HH, Hutomo M, Moraal M, dan Kiswara W. 2009. Scientific Report Part I. National Strategy and Action Plan for the Dugong in Indonesia. Institute of Environmental Sciences, Leiden.

De Longh HH, Wenno BJ, Meelis E. 1995. Sea grass distribution and seasonal biomass chanes in relation to dugong grazing in the Moluccas, East Indonesia. Aguat. Bot. (50) : 1 - 19.

Den Hartog C. 1970. The seagrass of the world. Amsterdam (NL): North-Holand Publ. Co.

Dorenbosch M, Grol MGG, Christianen MJA, Nagelkerken I, Van der Velde G. 2005. Indo-Pacifi c seagrass beds and mangroves contribute to fish density and diversity on adjacent coral reefs. Marine Ecology Progress Series, 302; 63-76

Duarte C. 2017. Reviews and syntheses: Hidden forests, the role of vegetated coastal habitats in the ocean carbon budget. Biogeosciences, 14, 301–310.www.biogeosciences.net/14/301/2017/doi:10.5194/ bg-14-301-2017

Duarte CM, Gattuso JP. 2008. *Seagrass meadows*. In: Cleveland CJ (ed.) Encyclopedia of Earth. Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment. [First published in the Encyclopedia of Earth December 11, 2006; Last revised April 18, 2008; Retrieved May 28, 2008]. http://www.eoearth.org/ article/Sea grass_meadows.

Firman A, Azhar I. 2006. The atlas of coastal resources in Raja Ampat, West Irian Jaya Province. The regency government of Raja Ampat.

Green EP, Short FT. 2003. World atlas of seagrasses. Amerika (USA): University of California Press.

Hernawan UE, Sjafrie NDM, Supriyadi IH, Suyarso, Marindah YI, Anggraini K, Rahmat. 2017. The status of seagrass beds on Indonesia 2017. Jakarta (ID): Center research of Oceanography-The Sciences Institute of Indonesia.

Johnstone IM, Hudson BET. 1981. *The dugong diet: mouth sample analysis*. Bull.31 :681 – 690

Juraij, Bengen DG, Kawaroe M. 2014. *The species diversity of seagrass as a source of feed for Dugong dugon in Busung village, North Bintan, Riau islands.* Omni-Akuatika 13(19):71 – 76.

Juraij, Suprapti D, Tania C, Wijanarko, Khaifin, Santiadji V, Atapada Z, Hadinata SY, Jamal MJ, Mahfud *et al*. 2017. *Survey report of dugong and the habitat of seagrass*. WWF-Indonesia:1-47

Kennedy H, Björk M. 2009. *Seagrass Meadows*. In: Laffoley, D.D'A. & GRIMSDITCH, G. Editor. The management of natural costal carbon sinks. IUCN, Gland, Switzerland. 53p.

Kiswara W, Rahmawati S, Novianty H, Dzumalex AR. 2014. Guide Book of Training Course in Seagrass Transplantation Methods. 24 Maret 2014, Pulau Pari, Jakarta (ID): P2O-LIPI

Kuo J, McComb AJ. 1989. Seagrass taxonomy, structure and development. In : Biology of seagrasses : a treatise on the biology of seagrasses with special reference to Australian region (Larkum AWD, Comb AJ & Shephered SA, eds.). Amstredam (NL): Elsier.

Lanyon JM, Limpus CJ, Marsh H. 1989. *Dugong and turtles : grazers in the sea grass system*. In : Biology of sea grass : a treatise on the biology of sea grass with special responses to the Australian region (Larkum AWD, McComb A J, .Shepeedek SA). Elsevier Science Pulb. Amsterdam : 610 - 634.

Marsh H. 1986b. Development of aerial survey methodology and results of aerial surveys for dugongs conducted in the northern and central section of the Great Barrier reef Marine Park. Unpublished report to GBRMPA, June 1986. 52p.

Marsh H, Channells PW, Heinshon GE, Morrissey I. 1992. Analysis of stomach contents of dugongs from Queensland. Aus. Wildl. Res. 9 : 55 -67.

Marsh H, Eros C, Penrose H, dan Hugues J. 2002. The Dugong (*Dugong dugon*) Status Reports and Action Plans for Countries and Territories in its Range. IUCN, Gland.

Marsh H. 1986a. The status of the dugong in Torres Strait. In : Tones Strait Fisheries Seminar, Port Moresby, 1 1 - 1 4 February 1985 (Heines AK, Williams CG, Cortes D. eds.) AGPS, Canberra: 53-76.

Marsh H. 1993. The Status of the dugong (Abstract). Sirenews 20 : 13 - 14. Marsh H, Span AV, . Heinshon GE.1978. Mini review physiology of dugong. Comp. Biochm. Physiol. 61 : 159 - 168.

McKenzie CR, Coles R, dan Erftemeijer P. 2007. Seagrass ecosystems of Papua. In: The Ecology of Papua Part 2. Periplus, Singapore, pp. 800–823.

McKenzie LJ, Yoshida RL. 2009. Seagrass-watch: Proceedings of a workshop for monitoring seagrass habitats in Cape York Peninsula, Queensland, 9-10 March 2009. (Seagrass-Watch HQ, Cairns). 54pp.

McKenzie LJ. 2003. *Guidelines for the rapid assessment of seagress habitats in the Western Pacific*. Townsville

McKenzie LJ. 2008. Seagrass Educator Handbook. Seagrass-Watch, Queensland, Australia.

Nagelkerken I, Roberts CM, Van der Velde G, Dorenbosch M, Van Riel MC, Cocheret de la Moriniere E, Nienhuis PH. 2002. How important are mangroves and seagrass beds for coral-reef fish? The nursery hypothesis tested on an island scale. Marine Ecology Progress Series, 244; 299-305.

Nienhuis PH, Coosen J dan Kiswara W. 1989. Community structure and biomass distribution of seagrass and macrofauna in the Flores Sea, Indonesia. Net.J.Sci.Res. 23 (2): 192-214.

Nishiwaki M, Marsh H. 1985. *The dugong*. *Dugong dugon (Muller, 1776)*. Ridgway SH, Harrison RJ. Editor. Handbook of Marine Mammals. London (UK): Academic Press.

Nontji A. 2012. Dugong is not the mermaid. The foundation seagrass Indonesia. Jakarta.
Phillips RC, Menez EG. 1988. Seagrasses. Washington D.C (USA): Smithsonion Institution Press.
The Indonesian government regulation Number 7/1999 about Preservation in Flora and Fauna.
Preen A. 1993. *Dugong : cultivation grazers of sea grass (Abstract)*. Sirenews 20: 14-15.
Preen A. 1995. Impacts of dugong foraging on seagrass habitats: observational and experimental evidence for cultivation grazing. J Mrine Ecology Progress Series (124): 201-213
Preen AR, Lee Long WJ, Coles RG (In press) Flood and cyclone related loss, and partial recovery, of more than 1,000 km2 of seagrass in Hervey Bay, Queensland, Australia. Aquat Bot
Preen AR. 1993. Interactions between dugongs and seagrasses in a subtropical environment. PhD thesis, James Cook University of North Queensland.
Preen AR. 1995. Diet of dugongs: are they omnivores? J Mammal 76:163-171
Rahmawati S. 2011. The Estimation carbon reserve on a community seagrass beds in Pari islands, Tousand Islands National Park, Jakarta. J. Segara 7 (1): 1-12.
Short FT, Carruthers TJ, Dennison WC, dan Waycott M. 2007. Global seagrass distribution and diversity: a bioregional model. Journal of Experimental Marine Biology and Ecology 350, 3–20.
Wahyudin Y, Kusumastanto T, Adrianto L, Wardiatno Y. 2014. Sea grass ecosystem inJasa ekosistem lamun bagi kesejahteraan manusia. Omni-Akuatika 12 (3): 29-46