GENERAL INTRODUCTION

Seagrass Taxonomy

Seagrasses have similar organs and tissues as the other flowering plants, but because they have to live in marine environment, this has strongly influenced their morphology and anatomy. So that, morphologically, seagrasses are closely similar to terrestrial grasses, but botanically, they are more closely related to lilies than grasses. Seagrasses have a horizontal rhizome linking clusters of leaves referred to as shoots, and roots are usually found at each shoot (Figure 1). Seagrasses as other flowering plants, also have flowers and seeds. The flowers of some species (e.g., Halodule wrightii, Thalassia testudinum) are found near the sediment surface while other seagrass species (e.g., Zostera marina, Ruppia maritima), when reproductive, form long vertical stems that can occupy most of or the entire water column. The above-ground vegetation that occupies the water column is referred to as seagrass canopy (Figure 1, Koch et al. 2006).

Figure 1 Nomenclature commonly used to describe parts of seagrasses and attributes of the canopy they form (adopted from Koch et al. 2006)
Seagrasses can be grouped into three main morphological categories with some taxonomic implications (Kuo and den Hartog 2006):

a. Plants without strap-shaped leaves but with either a pair of petiolate leaves at the rhizome node or two or more leaflets on each of the distal nodes of the erect stem. This category is restricted to Halophila, which has the smallest shoots among seagrasses. Shoots can be less than 1 cm in length, as for *H. beccarii* and *H. minor* (Figure 2B and 2C), and up to 20 cm long as for *H. australis*.

b. Shoots with a distinct erect stem and strap-shaped leaves borne at the top of an erect stem. This group includes Thalassia of the Hydrocharitaceae and all genera of the Cymodoceaceae (Figure 2F and 2I).

c. Plants without visible erect stems, but with strap-shaped leaves derived from the rhizome nodes. *Enhalus* of the Hydrocharitaceae, the Posidoniaceae and all members of the Zosteraceae belong to this group (Figure 2A, 2D and 2E). The leaves of some members of *Zostera* subgenus *Zosterella* can be as small as 10 cm; while for *Enhalus, Posidonia, Zostera* subgenus *Zosterella* and *Phyllospadix*, it is not uncommon for them to reach 1 m or more.

**Seagrass Distribution**

Seagrasses have been found in almost all part of the world, with the exception of Antarctic (Hemminga and Duarte 2000; Short and Cole 2001), and globally they consist of two families, Potamogetonaceae and Hydrocharitaceae, and they are grouped into 12 genera containing about 50-60 species (Hemminga and Duarte, 2000). The most diverse of this flora is found in the Tropical Indo-Pacific (Figure 3, UNEP-WCMC 2001; Short et al. 2007) of which 12 seagrass species (UNEP 2004) occur in the Indonesian coastal waters, and one new recently found species, *Halophila sulawesii*, grows in deep water around reef island of the Spermonde Archipelago Kuo (2007). Table 1 provide list of seagrass species that grow in Indonesian coastal waters.
Figure 2 General morphology of seagrasses. A. Enhalus acoroides. Scale = 3 cm. B. Halophila engelmanni. Scale = 3 mm. C. Halophila minor. Scale = 2 cm. D. Zostera asiatica. Scale = 15 cm. E. Posidonia sinuosa. Scale = 3.5 cm. F. Halodule uninervis. Scale = 2.5 cm. G. Cymodocea serrulata. Scale = 5 cm. H. Syringodium isoetifolium. Scale = 4.5 cm. I. Thalassodendron pachyrhizum. Scale = 4 cm. (Pictures adopted from Kuo and den Hartog 2006).

Figure 3 Seagrass distribution in the world (source: UNEP-WCMC 2001)
<table>
<thead>
<tr>
<th>Family/Genus</th>
<th>Species</th>
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<tbody>
<tr>
<td>Enhallus</td>
<td>1. E. acoroides*</td>
</tr>
<tr>
<td>Halophila</td>
<td>2. H. decipiens*</td>
</tr>
<tr>
<td></td>
<td>3. H. minor*</td>
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<td></td>
<td>4. H. ovalis*</td>
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<td></td>
<td>5. H. spinulosa*</td>
</tr>
<tr>
<td></td>
<td>6. H. sulawesii*</td>
</tr>
<tr>
<td>Thalassia</td>
<td>7. T. hemprochii*</td>
</tr>
<tr>
<td>Cymodoceaceae</td>
<td>8. C. rotundata*</td>
</tr>
<tr>
<td>Cymodocea</td>
<td>9. C. serrulata*</td>
</tr>
<tr>
<td>Halodule</td>
<td>10. H. pinifolia</td>
</tr>
<tr>
<td></td>
<td>11. H. unineris*</td>
</tr>
<tr>
<td>Syringodium</td>
<td>12. S. isotifolium*</td>
</tr>
<tr>
<td>Thalassodendron</td>
<td>13. T. ciliatum*</td>
</tr>
</tbody>
</table>

*Source: Tomascik et al. (1997), ♦Source: Kuo (2007)

### Importance of Seagrass Ecosystems in Supporting Fisheries

Seagrasses consist of less 0.02% of the angiosperm flora in the world (Hemminga and Duarte 2000). Even though the contribution is small, the seagrasses are of great ecological importance and have a high conservational value. There are various functions of seagrass beds in marine coastal ecosystems. Seagrasses absorb carbon dioxide from marine water and then they provide oxygen to the water and sediments through photosynthesis process. Their roots have important role in stabilizing sediments and their leaves are playing role in preventing eutrophication in the seawater by trapping suspended solids and absorbing inorganic salts, so that contributing to water quality improvement in coastal waters (Hemminga and Duarte 2000).

The seagrass meadows, moreover, have been known as one of the most productive marine ecosystems following the mangrove and coral reefs (Rasheed et al. 2006; Blankenhorn 2007). The total economic value of seagrass systems services is at least US$ 3.8 trillion per year globally, and is likely to increase (Costanza et al. 1997).

The primary productivity of seagrasses is highest in the Indo-Pacific (Hemminga and Duarte 2000) where Indonesian waters are included. The high primary production of the seagrasses provide valuable contribution to marine
productivity. The primary production is derived not only from tissue of seagrasses themselves but also from epiphytes that grow and attach to the leaves surface of the seagrasses. So, seagrasses provide service as one of nutrient sources in the coastal ecosystems, including as a source of food for associated organism directly and indirectly via detritus and epiphytes. Several authors have proved this argument (MacArthur and Hyndes 2007; Unsworth et al. 2007b; Kneer et al. 2008b; Lepoint et al. 2006; Kaiser 2008). Consequently, high abundance of fauna species can be found in the seagrass beds as showed by Unsworth et al. (2007c); Manik (2007) and Sabarini and Kartawijaya (2006) in their study results. The productive seagrass communities contribute also the diets of consumers (including transient predators) that spend a portion of their time foraging in seagrass habitat (Ganter 2000; Valentine et al. 2002). Decomposition of seagrass litters supporting also a microbial marine food web (Peduzzi 1991). This is making the seagrass ecosystems play an important role to the marine food webs. It is because seagrass together with mangrove and coral species create a series of connected habitats and ecosystems that supporting a variety of complex trophic-interaction (Figure 4).

Figure 4 Illustration of marine food web in seagrass ecosystems (Fortes 1990 In: Unsworth 2007).

In addition to provide living space, shelter, and protection for fauna, seagrasses are also vitally important for fisheries productivity as they form habitat
for many species especially for spawning ground and nursery habitat (Dorenbosch et al. 2006; Polte and Asmus 2006; Kaiser 2008; Nakamura et al. 2009a,b).

**Seagrass Degradation and Loss**

Although seagrass ecosystems are commonly well-known as important features of coastal zones, unfortunately, they are seldom given the attention or protection they deserve. In last decade, seagrass beds have drastically declined in tropical and temperate zone worldwide (Robblee et al. 1991; Hall et al. 1999; Westphalen et al. 2004; Orth et al. 2006; Murdoch et al. 2007; Waycott et al. 2009; Hughes et al. 2009). New research showed that 58% of world’s seagrass meadows are currently declining (UMCES 2009), including Indonesia lost about 30-40% of its seagrass beds (UNEP 2004).

The assessment result of the research of UMCES (2009) showed that seagrasses are disappearing at rates similar to coral reefs and tropical rainforests. The decline results from direct, indirect human impacts, and from natural causes. Direct human impacts including mechanical damage (by dredging, fishing, and anchoring) (Hasting et al. 1995; Francour et al. 1999; Creed and Amado 1999; Badalamenti et. al. 2006), eutrophication (van Katwijk et al. 1997; Burkholder et al. 2007), aquaculture and siltation (Alexandre et al. 2005; Frederiksen et al. 2007; Marianne et al. 2008), effects of coastal constructions (Cambridge et al. 1984; Freeman et al. 2008), food web alterations (Douglas et al. 2007) and declining water quality (Jacobs 1980; Macinnis-Ng and Ralph 2002; Hughes et al. 2009); and from indirect human impacts, including negative effects of climate change (erosion by rising sea level, increased storms, increased sea surface temperature, increased ultraviolet irradiance) (Robblee et al. 1991), as well as from natural causes, such as cyclones and floods (Short et al. 2006).

**Consequences of Seagrass Declining and Loss**

The loss of each seagrass meadow will result in declining of fisheries productivity because the loss of the ecosystem services they provide to the fishes, crustaceans and bivalves relying on these areas for spawning ground and nursery
habitat. The impact of the continuing losses of the ecosystems will also expand far beyond the areas where seagrasses grow. Including to both shallow waters and the deep sea, as the export detached seagrass leaves, by currents and waves, has been correlated with high densities of invertebrates and fishes in these areas (Valentine et al. 2002). The impact will also definitely spread out to the neighbouring ecosystems of seagrass, the mangrove forest and coral reefs. It is because as an ecotone between coral reefs and mangrove forests in tropical coasts, the seagrass ecosystems are important in their interaction, including structural and dynamic components of the adjacent ecosystems (Dorenbosch et al. 2005; Nakamura et al. 2009a; Unsworth et al. 2009).

Seagrass Study in Indonesia

Now the time to acknowledge the opinion on the status of seagrass ecosystems that there is a global decline of seagrass ecosystems and the ecosystems are increasingly threatened. This opinion is required in order to achieve the visibility and recognition necessary to protect and manage this valuable global resource. This is especially important in tropical developing countries with high coastal population densities, such as Indonesia.

Despite their ecological importance and serious threatened condition, studies on seagrass have been scarce in the Indonesian coastal area. The first investigation on seagrass beds was ecological study on fish community in Banten Bay (Hutomo 1985). Furthermore, some detailed description of community structure and distribution of either the seagrasses theirselves or their associated organisms were completed, e.g. for fish and shrimp post larvae in Jepara (Merryanto 2000; Rinatsih 2000), macrozoobenthos in Bontang Kuala Estuary, East Kalimantan (Irawan 2003), seagrass bed fish assemblages in the Wakatobi Marine National Park (Unsworth et al. 2007c), sea urchin in Hatta Island, Maluku (Dobo 2009), periphyton in Pandan and Banten Bays (Zulkifli 2000; Erina 2006), grazing in Bone-Bone Waters and Bontang Kuala Coastal Waters (Kasim 1999; Sari 2003), seagrass detection by acoustic method (Deswati 2009), nutrient dynamic in Banten Bay and Derawan Island (Evrard et al. 2005; Sutiknowati
2008), and seagrass community in Manokwari Coastal Waters (Lefaan 2008). Study on the role of seagrass ecosystems in supporting the faunal productivity of Indo-Pacific coastal marine systems was carried out on the Wakatobi Marine National Park (Unsworth 2007b; Unsworth et al. 2007a, 2007b, 2007c; Unsworth 2008; Unsworth et al. 2009). Benthic microbial metabolism was investigated by Alongi et al. (2008) in Awerange Bay, Barru, South Sulawesi.

Spermonde Archipelago, a shelf region located at the west coast of South Sulawesi, Indonesia, with about 120 islands, represents a favorable area to study seagrass ecosystems, as it is a hotspot of coral and seagrass diversity (Hemminga and Duarte 2000). Seagrass beds in the archipelago were first described by Erftemeijer and Middelburg (1993) who studied sediment-nutrient interaction in the seagrass beds located in two different sites, Barrang Lompo and Gusung Tallang, although at the moment, the seagrass beds in the later site cannot be confirmed anymore. Further studies about nutrient were investigated by Erftemeijer et al. (1994); Erftemeijer and Middelburg (1995); Stapel et al. (1996); Stapel et al. (1997); Stapel and Hemminga (1997); and Stapel et al. (2001); Vonk et al. (2008a,c); Vonk and Stapel (2008).

Another seagrass investigation in the Spermonde Archipelago included primary production (Erftemeijer et al. 1993; Erftemeijer and Stapel. 1999; Supriadi 2003), food source (Erftemeijer et al. 1993; Kneer et al. 2008a), effect of grazing (Kaiser 2008; Liu et al. 2008; Vonk et al. 2008d), seasonal dynamic of biological and environment variables (Erftemeijer and Herman 1994), burrower organisms (Kneer et al. 2008b; Vonk et al. 2008b), distribution of foraminifera and gastropods (Troelstra et al. 1996; Hadijah 2000). However, little is known about the sustainability of seagrass ecosystems in the Spermonde Archipelago, especially in Barrang Lompo Island and Kapoposang Island.

**Strategy Design for Sustainable Management of Seagrass Ecosystems**

Dense population in the south east of the archipelago implements an increased pressure to the seagrass ecosystems, as most of the population depends on subsistence and small scale fisheries (Pet-Soede et al. 2001). This leads to the
high stress of seagrass ecosystems as Priosambodo et al. (2006) found in the small islands (Pulau Barang Lompo and Pulau Sarapokeke) with very high density of population.

Seagrass ecosystems management is an important part of managing the marine fisheries as the reasons previously described, although this concept has not been understood by most Indonesian people, including local community in the Spermonde Archipelago. As a result there has been little inclination to protect seagrass meadow ecosystems and they rarely incorporated specifically into coastal management plans, so that are vulnerable to degradation.

In order to effectively manage the seagrass ecosystems, strategies of seagrass ecosystems management for supporting fisheries should be designed in advance. This is important in order to provide biodiversity protection and sustainable use of the seagrass ecosystems. As a multidimensional human effort, seagrass use as a part of fisheries sector relates to multidimensional aspects (ecological, economical, social, technological and institutional dimension). Therefore, there is a requirement of better understanding about seagrass habitat provide for fauna including fish and about multidimensional human effort related to seagrass use that affect the sustainability of the seagrass ecosystems. These understanding is important in designing the responsible management of seagrass ecosystems (as a part of fisheries resource) for supporting long-term sustainable use of fisheries resources as suggested within the Code of Conduct for Responsible Fisheries (FAO 1995).

**Research Objectives**

The main goal of the research is to design the sustainable management of seagrass ecosystems for supporting fisheries in the Spermonde Archipelago. In order to achieve the main goal, the following specific objectives will be performed:

1. To characterize fish community structure in the seagrass beds
2. To examine the fishing status in the seagrass ecosystems
3. To determine the sustainability status of the seagrass ecosystems
Research Benefit

The resulted strategies of seagrass ecosystems management will make an important contribution to:

- The science development, mainly on coastal management science development.
- The government, particularly on policy making for coastal management plans.
- The community, especially on awareness improvement for the importance of seagrass ecosystems management.
- Seagrass-related human activities including fishing practices on the seagrass ecosystems.

Scope of Research

Scope of the research include 1) fish community structure (including the difference over diel cycle, life stage and size class distribution) in two seagrass beds dominated by different species, 2) fishing activities in the seagrass ecosystems and their status in Barrang Lompo Island and Kapoposang Island, 3) sustainability status of seagrass ecosystems for supporting fisheries in Barrang Lompo Island and Kapopoang Island.