Studies on seagrasses of North Sulawesi, Indonesia and adjacent waters: A critical review

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Abstract

The importance of seagrasses in terms of ecological and economic benefits are well-known. This paper describes the status of research on seagrasses conducted so far, with relevance to the North Sulawesi region. Most of the studies done in Indonesia, especially in North Sulawesi, have focused on species richness and biodiversity as well as basic biological questions such as biomass and morphometric differences of certain seagrass species between sampling localities. While several studies have been conducted, there is a general need for Indonesian marine scientists to expand research areas related to food-web dynamics and inter-connectivity of major fishery and nursery habitats (mangroves-seagrass-coral reefs) with the aid of modern tools (e.g. molecular approach).

Keywords: benefits, biology, ecology, economic, seagrass

INTRODUCTION

Seagrasses are submerged flowering plants that played major economic and ecological roles to humans (Spalding *et al.,* 2003). The importance of seagrasses, especially in regions in South-East Asia where local economy is highly dependent on coastal fisheries, is well-known (Fortes, 1990). Incidentally, the marine environment encompassing the Coral Triangle (countries of the Philippines, Indonesia, Malaysia, Brunei, Papua New Guinea, Solomon Islands), is also dependent in terms of food supply on seagrass meadows (Unsworth *et al.,* 2014). The Coral Triangle has been known for having the world's richest in terms of biodiversity (e.g. Fortes, 2013 identified 18 seagrass species in the Philippines) but is highly threatened due to overfishing, pollution (including plastics), and other coastal development (Lasut *et al.,* 2018) The importance of seagrasses and associated organisms such as commercially important species of macroinvertebrates to the fisherfolks has been discussed by (Assa *et al.,* 2015; Wagey and Bucol, 2016; Wagey *et al.,* 2017).

Considering numerous papers that have been published in the scientific literature, it is timely that this paper assessed the status of researches and their trajectories. This study focused the north Sulawesi area, which is just a small portion of the Indonesian archipelago comprises more than 17,000 islands - 6000 of which are inhabited - and shares borders with Malaysia and Papua New Guinea. The international organization Seagrass-Watch (http://www.seagrasswatch.org/indonesia.html) established five monitoring sites in Indonesia, of which

one station was monitored in 2008 in North Sulawesi. While Indonesian authors contributed substantially in terms of the number of publications, only a few (and only just recently) have focused on the seagrasses found in North Sulawesi (Wagey *et al.,* 2017).

RESEARCH METHOD

The published articles and reports (mainly available online) as well as books were reviewed. Online sources were accessed mainly using the Google Scholar with the following keywords 'seagrass+Indonesia+Sulawesi'. In addition, unpublished reports, when relevant, were also examined and included in the review. In certain topics, however, we considered any information from neighboring waters just outside of North Sulawesi, when necessary to mention.

RESULTS AND DISCUSSION

At present, there are 13 species of seagrasses known in Indonesia, with 8 species of which occur in North Sulawesi area (Hutomo and Moosa, 2005). Wahab *et al.* (2017) identified only six species of seagrasses in Panggang Island, Jakarta. Kawaroe *et al.* (2016) listed 10 species of seagrass in three marine ecoregions of Indonesia: namely Sunda Shelf/SHS (Bintan Island/SHS-B and the Seribu Islands/SHS-S), Sulawesi Sea/SS (Talaud Island), and Banda Sea/BS (Tanimbar Islands), each eco-region ranging only from 5-7 species.

A stark contrast to the extent of seagrass meadows in Indonesia (>30,000 km^2 based on Spalding *et al.* 2003), the number of seagrass species known to date in Indonesia are comparably lower compared to other reviews in neighboring countries like the Philippines (18 species) (Fortes, 2013).

Research trends and Challenges

In the 1990s, Erftemeijer and Herman (1994) have also compared seagrass biomass variation between localities in South Sulawesi, in relation to nutrient availability. It can be noticed that subsequent publications related to seagrasses, conducted in areas near Sulawesi and adjacent waters have focused on either diversity and species richness assessment (Tomascik *et al.,* 1997) or basic biology such as morphometric variations often comparing samples between localities (Sakey *et al.,* 2015; Sauyai *et al.,* 2015; Rosang and Wagey, 2016; Wagey 2017; Wangkanusa *et al.,* 2017; Menayang *et al*, 2017; Katuuk *et al.,* 2018). Most of these studies were patterned after the author's extensive experience working on seagrass biology in central Philippines (Wagey, 2013a; Wagey, 2013b; Wagey, 2015; Wagey and Calumpong, 2013; Wagey *et al.* 2017). Other ecological studies included nutrient uptake of the seagrass *T. hemprechii* in Spermonde Archipelago by Stapel *et al.* (1996), which was later followed by a more advanced study (Stapel *et al.,* 2001). A series of papers by Erftemeijer *et al.* (1993) and Erftemeijer *et al.* (1994) quantified the primary productivity and seasonal variability of biomass of seagrass species in South Sulawesi.

Lasut *et al.* (2010) determined the distribution and accumulation of mercury derived from gold mining in marine environment and its impact on residents of Buyat Bay, North Sulawesi, Indonesia. This type of study should be conducted in areas affected or may be affected in the near future. Recently, Ponti *et al.* (2016)

provided a baseline survey data on the coral reef health Bangka Island in North Sulawesi, which has been subjected to mining controversies.

While a number of studies have started using advanced approaches such as determining carbon stocks of seagrasses (Rustam *et al.*, 2017; Kondoy, 2017), there are still more challenges ahead. The use of molecular markers have been done in some studies such as those by Udhi *et al.* (2017) in Eastern Indonesia.

One aspect of seagrass as an ecosystem is their role in terms of fish nursery habitats. Igulu *et al.* (2014) highlighted that in the Indo-Pacific region where there is high tidal fluctuation, seagrass beds must perform a primary nursery function, a role played by mangroves in other areas like the Caribbean. Recently, Syahailatua (2015) described the fish species composition in seagrass beds of Tanjung Merah (North Sulawesi). This study should be followed by a more comprehensive approach such as the use of stable isotope techniques to better understand the nursery function of seagrass ecosystems and how they are interconnected to other ecosystems such as mangroves and coral reefs (Kimirie *et al.*, 2013).

CONCLUSION

Studies on Indonesian seagrasses are at present scanty and mostly basic in terms of approaches and questions being raised. This suggests that current and future investigators should expand their coverage and research interests as well as in formulating questions. While this does not necessarily mean abandoning approaches such as basic surveys for baseline studies, other ecological aspects, for example ecosystem connectivity (i.e. how seagrass beds interact with coral reefs and mangroves in terms of nutrient and larval connections) would need more studies to subsequently benefit fishery managers and policy makers. In addition, seagrass research should be focused on areas such as remote sensing, genomic tools, microsensors, computer modeling, statistical analysis, chemical compound and valuation economic. A more interdisciplinary approach would be needed to facilitate a greater understanding of the complex interactions between seagrass and its environment.

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