The Seagrasses of the Southern Islands, Singapore

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ABSTRACT. Seagrass meadows provide essential ecosystem services such as carbon sequestration and coastal protection, and serve as nurseries for many marine species, some which are commercially significant. Up to 13 of the world's 72 seagrass species have been recorded in Singapore. The Southern Islands Biodiversity Survey assessed the distribution of seagrasses through a comprehensive review of published and unpublished sources together with information from intertidal field surveys. Nine seagrass species were found in the Southern Islands, highlighting the area's importance in maintaining the seagrass meadow ecosystem and the species associated with it.

Keywords. Seagrass, Singapore marine flora, flowering plants

Introduction

Covering 0.1–0.2% of the marine environment, seagrass meadows together with mangroves and coral reefs form the most biodiverse and productive marine systems in the world (Duarte, 2002). Swathes of seagrasses in the temperate zones often consist of a single species, but in the tropics they are more often a mix of seagrass species (Reynolds, 2018). They grow in sheltered coastal waters, typically no deeper than 30m, where light is available for photosynthesis and environmental conditions such as pH, salinity and temperature are favourable for growth (Tan, 2019; Seagrass Watch, 2022). In Singapore, seagrasses are found at depths no deeper than 9m (Hartog, 1970).

Seagrasses are flowering plants with vascular leaves which grow from rhizomes embedded in sand or mud (Hemminga & Duarte, 2000). The plants either reproduce asexually through branching rhizomes or sexually through producing male and female flowers (Castro & Huber, 2008). These plants provide key ecosystem services such as coastal protection against erosion (Christianen et al., 2013), provision of habitats and nurseries for other commercially important marine species such as fishes and crustaceans (Waycott et al, 2011), nourishment for large marine fauna such as the green turtle and dugong (Marsh et al., 2011), as well as carbon sequestration to mitigate climate change (Miyajima & Hamaguchi, 2019).

Plants are thought to have evolved from marine algae and transitioned to terrestrial habitats in the deep past, but seagrasses, like mangrove trees, have returned to life in water (Orth et al., 2006). Most seagrasses need to be submerged underwater to survive and grow, due to a lack of a waxy cuticle, which covers terrestrial plants to prevent desiccation (Chen et al., 2011; Tan, 2019). Most seagrass species in Singapore are intertidal and tolerate exposure for short periods (Tan, 2019) but some occur in both intertidal and subtidal waters (McKenzie et al., 2016; Seagrass Watch, 2022). Due to their shallow coastal range, these plants are at risk of being lost to anthropogenic effects such as pollution, habitat encroachment from land reclamation, and destructive practices like dredging and trawl netting, as well as natural processes such as typhoons and tidal waves (Waycott et al., 2009; Yaakub et al., 2014b).

In Singapore, around 45% of seagrass meadows have been lost to coastal modification and land reclamation (Yaakub et al., 2014b). Ten seagrass species have been confirmed in

Singapore, and another two species are under taxonomic review (McKenzie et al., 2016). In the Southern Islands, the seagrass meadows are more commonly reef associated, in contrast to the more mangrove-associated seagrasses off the north-eastern coast of Singapore (Yaakub et al., 2013).

Seagrass meadows in Singapore have been studied periodically (Yaakub et al., 2014b; McKenzie et al., 2016; Kwan et al., 2023). They can act as indicators of the marine environment, if their distribution and species composition is monitored. Therefore, they were included as an important component of intertidal surveys during the Southern Islands Biodiversity Survey (SIBS) from 2020 to 2022.

Materials and Methods

Intertidal surveys were conducted at 16 sites at Pulau Biola, Pulau Berkas, Sentosa (formerly Pulau Blakang Mati), Pulau Hantu, Pulau Jong, Pulau Salu, Pulau Satumu (Raffles Lighthouse), Pulau Sakijang Bendera (Saint John's Island), Pulau Sakijang Pelepah (Lazarus Island), Pulau Semakau, Pulau Seringat (now merged with Lazarus Island), Pulau Subar Darat (Small Sister's Island), Pulau Tembakul (Kusu Island), Pulau Tekukor, and Terumbu Pandan (Cyrene Reef). The surveys were conducted between August 2020 and March 2022 during low spring tides, typically during early morning hours (6:00am to 10:00am) or during the evening (4:00pm to 8:00pm). Intertidal surveys were not conducted at Keppel Island and Pulau Subar Laut (Big Sister's Island), although other aspects of biodiversity at those islands were included in the SIBS study (Tan et al., 2025).

A reconnaissance trip was organised for each site to identify suitable areas for laying out transects that would encompass a wide diversity of intertidal habitat types and maximise species encounters. During the actual survey, a 30m line perpendicular to the shoreline was laid across the intertidal zone, and three sets of 25 m line transects were placed parallel to the shore. There was one set each within the zones 0–10m, 10–20m and 20–30m from the shoreline, so as to ensure sampling covered the upper, middle, and lower shore. Each transect set/shore level was surveyed by a team of 3-5 surveyors, and for each transect five quadrats (50cm by 50cm) were placed along either side of the transect tape at intervals determined via a random number generator. Tan et al. (2025) provides an illustration of the layout of transects and quadrats. All living species in the quadrat were photographed for record keeping and species identification. Another team of 5-10 surveyors separately patrolled the intertidal zone beyond the vicinity of the transects to take photographs of as many species as possible for later identification.

Seagrass records for islands not covered by the above surveys were compiled from published literature as well as NParks' internal records. The earliest literature on seagrasses in the Southern Islands was published in 1996 and the most recent in 2023 (Loo et al., 1996; Kwan et al., 2023). Scientific names were standardised to those used by Lindsay et al. (2022) and WoRMS (2023).

Results

Nine species of seagrass were reported in the Southern Islands, out of a total of 12 or 13 species recorded for Singapore (Yaakub et al., 2013; Kwan et al., 2023). *Enhalus acoroides* and *Halophila ovalis* were found across the most sites, respectively from ten and 11 intertidal

surveys plus an additional five and four sites from the literature, thus both totalling 15 out of the 16 localities for which data were compiled (Table 1). *Halophila beccarii* and *Halophila spinulosa* were not observed during the SIBS survey; both species are associated with the northern shores of Singapore rather than the southern shores (McKenzie et al., 2016), and no records of them in the Southern Islands were found in the literature.

The sites with the highest number of seagrass species were Terumbu Pandan (Cyrene Reef) with eight species of which six were recorded during SIBS, and Pulau Semakau with eight species of which two were recorded during SIBS. The sites with the fewest seagrass species was Keppel Island, with only two species reported from an earlier subtidal survey.. New records of seagrasses were made for Pulau Berkas and Pulau Salu; there had been no previous published records of any seagrasses for them, likely due to lack of surveys.

Table 1. Locations of seagrass taxa found in Southern Island waters from published, un-published literature and Southern Islands Biodiversity Survey (SIBS) data. SIBS indicates taxa was observed during Southern Islands Biodiversity Survey 2019-2022. Year corresponds to most recent literature or NParks internal record with taxa observation. RDB3 = Singapore Red Data Book 3 Status, IUCN = International Union for Conservation of Nature Status, BIO = Pulau Biola, BRK = Pulau Berkas, CYR = Cyrene Reef, HNT = Pulau Hantu, JNG = Pulau Jong, KEP = Keppel Island, KUS = Kusu Island, LAZ = Lazarus Island and Pulau Seringat, RAL = Raffles Lighthouse, SAL = Pulau Salu, SIS = Sisters' Islands, SJI = St John's Island, SMK = Pulau Semakau and neighbouring patch reefs, SNT = Sentosa Island, TKR = Pulau Tekukor, TPS = Terumbu Pempangs. Acronyms for RDB3/IUCN: EX = Globally Extinct, NE = Presumed Nationally Extinct, CR = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern, DD = Data Deficient, NE = Not Evaluated, NA = Not Assessed.

Species	RDB3	IUCN	BIO	BRK	CYR	HNT	JNG	KEP*	KUS	LAZ	RAL	SAL	SIS	SJI	SMK	SNT	TKR	TPS*
Family Cymodoceaceae																		
Cymodocea rotundata	CR	LC	SIBS		SIBS; 2020		SIBS			2020; (1)			1996†					
Cymodocea serrulata	EN	LC			2020		SIBS			SIBS; 2020					SIBS; 2020			2014
Cymodocea sp	-	-													2005			
Halodule sp	-	-		SIBS	SIBS; 2020				2020	2020	SIBS				2020	SIBS; 2020	2020	
Halodule uninervis	VU	LC	2014		SIBS; 2014				SIBS						SMK; 2014			
Syringodium isoetifolium	EN	LC			SIBS; 2020					2020					2020			
Family Hydrocharitaceae																		
Enhalus acoroides	CR	NE	SIBS; 2014	SIBS	SIBS; 2020	SIBS; 2020		2020	SIBS; 2020	2020; (1)	SIBS; 2020	SIBS	SIBS; 2020	SIBS; 2020	SIBS; 2020	SIBS; 2020	2020	2020
Halophila decipiens	CR	LC			2014			2020							2020			
*Halophila minor***	CR	LC												2012		2014		
Halophila ovalis	LC	NE	SIBS; 2014	SIBS	SIBS; 2020	SIBS; 2020	1996†		SIBS; 2020	2020; (1)	2014	SIBS	SIBS; 2020	SIBS; 2020	SIBS; 2020	SIBS; 2020	SIBS; 2020	2020
Thalassia hemprichii	EN	NE	SIBS; 2014		SIBS; 2020		2020			2020		SIBS	2015	2020	2020	2020	SIBS; 2020	2020

*: Not visited for intertidal survey during SIBS **: Under review for synonymy. (1): Pers. obs. during the SIBS survey period (2019-2022) †: possibly extinct from the site



Figure 1. Female flowers of *Enhalus acoroides* photographed at Serapong, Sentosa Island. Photo courtesy of Vincent Choo.

During SIBS, *Enhalus acoroides* was observed flowering only at Tanjong Rimau and Serapong, Sentosa (Fig. 1) and not at any of the other sites; this was despite its usual habit of flowering year-round (Rollon, 1998). At other islands where it was observed, it was found only in single clumps, often cropped short, and not flowering. In particular, the formerly lush and extensive meadow of *E. acoroides* at Pulau Semakau had largely disappeared, leaving only scattered clumps with leaves cropped short. This start of this decline was documented in 2012 by citizen science group Wild Singapore (Tan, 2012), and is also reflected in the data collected by citizen science group Team Seagrass (Yaakub et al., 2014a)

Discussion

Ten seagrass species have been confirmed for Singapore, with a further two species under review for synonymy (McKenzie et al., 2016). An additional species, *Halophila major*, was reported by Kwan et al. (2023) after SIBS survey work had been completed. These bring the notional total for Singapore waters to 13 species, of which the majority (nine) have been recorded from the islands covered by SIBS - though it should be noted that McKenzie et al. (2016) reported herbarium records for a tenth (*Halodule pinifolia*) from the islands of Pulau Pawai and Pulau Senang (which lie within the Singapore Strait but are outside the scope of SIBS). The SIBS field data alone confirmed the continued presence of seven seagrass species

(Table 1), and it is likely that the remaining two (*Halophila decipiens* and *Halophila minor*) were not recorded even if present due to the difficulty in distinguishing them in the field from the more common *Halophila ovalis*. Despite the proximity of the Southern Islands to shipping, oil refineries and the city, species diversity seem to be holding up well. Dugong feeding trails are also spotted regularly amongst the seagrass meadows of the Southern Islands (Li et al., 2025), and a dead individual was sighted as recently as 2021 off Pulau Hantu (Soh, 2021), suggesting that the meadows remain substantial enough to serve as feeding sites. These points all signal the importance of the Southern Islands, especially Cyrene Reef for seagrass conservation.

The present intertidal surveys were not specifically targeted at seagrass meadows, but at areas of overall intertidal richness. Survey methods used also vary between these and previously published surveys. Site distribution data do not seem to suggest any decline in seagrass presence and abundance for the various species. However, the wide distribution of *Enhalus acoroides* masks the poor physical condition and sparse growth of this species at almost all the sites, and the apparent restriction of flowering are further causes for concern. *Enhalus acoroides* is typically considered a climax species; with its tall canopy height (up to 1.5 m) and thick rhizomes, meadows dominated by *Enhalus* (as were formerly present on Pulau Semakau) form structurally complex habitats and hold soft sediments together. This gives them high potential to act as nurseries for fish and attenuate erosion-causing waves, and their decline may have knock-on effects on the wider marine ecosystem. Today, Sentosa (especially Tanjong Rimau) and the nearby Labrador Nature Reserve on the mainland are the strongholds for this formerly abundant but now critically endangered species, and managing them sensitively could ensure a source of seeds/fragments for future seagrass restoration efforts.

As evidenced by the example above, other data in addition to presence–absence, such as population size, condition, and reproductive state, all need to be taken into account when assessing the conservation status of seagrasses and their ability to support other species associated with them. Pollen dispersal and seed dispersal are not well understood in Singapore, although recent studies based on agent-based modelling have suggested that the meadows are well-connected (Lai et al, 2024). In consequence, it is not known how sub-populations of seagrasses near the different islands interact, nor how they might be dependent on populations of the same species in neighbouring waters. The seagrass ecosystem is thought to be declining more rapidly in Southeast Asia than in other parts of the tropics (Fortes et al., 2018; Sudo et al., 2021), and the example of *E. acoroides* demonstrates how even a species that is widely distributed can in fact be doing poorly. Nevertheless, Yaakub et al. (2014b) attributed seagrass persistence in highly urbanised Singapore to the measures put in place to control pollution and other environmental impacts, and it is heartening to see that seagrass diversity in the Southern Islands remains high.

A better understanding of the distribution of seagrass around the Southern Islands in space and time could help guide policy on how, where and when these marine areas should be protected or managed to better conserve seagrasses, and inform strategic locations for upcoming seagrass restoration efforts. Seagrasses provide substantial economic and environmental benefits (de Groot, 2012; Dewsbury et al., 2016), but neither benefits nor seagrasses have been properly mapped in many regions of the world (Cullen-Unsworth et al., 2014; Unsworth et al., 2018). While efforts have been made to map out our urban meadows through remote sensing (Yaakub et al., 2013; Tan et al., 2023), regular updating of these maps will be essential to monitor their extent. Continued efforts to monitor their diversity

and health through citizen science field surveys, such as the citizen science efforts of Team Seagrass, WildSingapore, and Intertidal Watch, as well as academic studies like that by Kwan et al. (2023), will help complement such maps.

References

Castro, P. & Huber, M. (2008). *Marine Biology*. New York: McGraw-Hill.

Chen, G., Komatsuda, T., Ma, J.F., Li, C., Yamaji, N. & Nevo, E. (2011). A functional cutin matrix is required for plant protection against water loss. *Plant Signaling & Behavior* 6: 1297–1299.

Christianen, M.J., Van Belzen, J., Herman, P.M., Van Katwijk, M.M., Lamers, L.P., Van Leent, P. J., & Bouma, T. J. (2013). Low-canopy seagrass beds still provide important coastal protection services. *PLoS ONE 8*(5), e62413.

Cullen-Unsworth, L.C., Nordlund, L.M., Paddock, J., Baker, S., McKenzie, L.J. & Unsworth, R.K. (2014). Seagrass meadows globally as a coupled social–ecological system: Implications for human wellbeing. *Marine Pollution Bulletin* 83: 387–397.

de Groot, R., Brander, L., Van der Ploeg, S., Costanza, R., Bernard, F., Braat, L., Christie, M., Crossman, N., Ghermandi, A., Hein, L., Hussain, S., Kumar, P., McVittie, A., Portela, R., Rodriguez, L.C., Ten Brink, P. & Van Beukering, P. (2012). Global estimates of the value of ecosystems and their services in monetary units. *Ecosystem Services* 1: 50–61.

Dewsbury, B.M., Bhat, M. & Fourqurean, J.W. (2016). A review of seagrass economic valuations: Gaps and progress in valuation approaches. *Ecosystem Services* 18: 68–77.

Duarte, C.M. (2002). The future of seagrass meadows. *Environmental Conservation*, 29: 192–206.

Fortes, M.D., Ooi, J.L., Tan, Y.M., Prathep, A., Bujang, J S. & Yaakub, S.M. (2018). Seagrass in Southeast Asia: A review of status and knowledge gaps, and a road map for conservation. *Botanica Marina* 61*:* 269–288.

Hartog, C.D. (1970). *The seagrasses of the world*. North-Holland Publishing Company.

Hemminga, M.A. & Duarte, C.M. (2000). *Seagrass Ecology*. Cambridge UK: Cambridge University Press.

Kwan, V., Shantti, P., Yan, E., Yan, X.O. & Huang, D. (2023). Diversity and phylogeny of seagrasses in Singapore. *Aquatic Botany* 187*:* 1–10.

Li, T., Davison, G.W.H., Leong, B.P.I., Seng, R.Y.N. & Tan, Y.H.J. (2025). The Mammals of the Southern Islands of Singapore. In Davison, G.W.H., Leong, B.P.I., Tan, Y.H.J., Seng, R.Y.N. & Mark, R.Y.Y, *The Southern Islands Biodiversity Survey, Singapore*. National Parks Board, Singapore. https://go.gov.sg/sibs-mammals.

Lim, J.W.L., Loh, J.B.Y., Lim, A.J.S., Tan, B.Y.X., Ip, Y.C.A., Neo, M.L., Tan, R. & Huang, D. (2020). Diversity and distribution of intertidal marine species in Singapore. *Raffles Bulletin of Zoology* 68: 396–408.

Lindsay, S., Middleton, D.J., Ho, B.C., Chong, K.Y., Turner, I.M., Ali Ibrahim, Alonso-García, M., Ang, W.F., Ashton, P.S., Athen, P., Atkins, S., Bazilah Ibrahim, Beentje, H.J., Boo, C.M., Boyce, P.C., Bramley, G.L.C., Buerki, S., Callmander, M.W., Chantanaorrapint, S., Cheek, M., Chen, C.-W., Chen, J., Chen, L.M.J., Chew, P.T., Chong, R., Choo, L.M., Chung, R.C.K., Coode, M.J.E., Chua, S.C., Cicuzza, D., de Kok, R.P.J., Davison, G.W.H., de Wilde, W.J.J.O., Duistermaat, H., Dubéarnès, A., Duyfjes, B.E.E., Ellis, L.T., Esser, H.-J., Gajurel, P.R., Gale, S.W., Ganesan, S.K., Gardner, E.M., Geiger, D.L., Harwood, R.K., Hassan Ibrahim, He, S., Henderson, A., Hovenkamp, P.H., Hughes, M., Zaki Jamil, Jebb, M.H.P., Johnson, D.M., Kartonegoro, A., Kiew, R., Knapp, S., Koh, S.L., Kurzweil, H., Lee, S., Leong, P.K.F., Leong-Škorničková, J., Levin, G.A., Liew, D.C.H., Lim, R.C.J., Lim, W.H., Loo, A.H.B., Low, Y.W., Lua, H.K., Lum, S., Mabberley, D.J., Mahyuni, R., Maslin, B., Murray, N.A., Neo, L., Ng, X.Y., Ngo, K.M., Niissalo, M.A., Ong, P.T., Pannell, C.M., Phang, A., Prance, G.T., Promma, C., Puglisi, C., Rodda, M.L., Rubasinghe, S.C.K., Saunders, R.M.K., Savinov, I.A., Saw, L.G., Schuiteman, A., Seah, W.W., Simpson, D.A., Strijk, J.S., Sukkharak, P., Sugumaran, M., Syahida-Emiza, S., Tan, J.P.C., Taylor, N.P., Teo, Y.K.L., Thomas, D.C., Trias-Blasi, A., Utteridge, T., van Welzen, P.C., Veldkamp, J.F., Vermeulen, J., Wang, R., Wilkie, P., Wei, Y.-M., Wong, S.Y., Wong, K.M., Yaakub, S., Yam, T.W., Yang, S., Yao, T.L., Ye, W., Yee, A.T.K., Yeo, C.K., Yeoh, Y.S., Yong, C., Yong, K.T., Zerega, N.J.C., Zhu, R.-L., Er, K.B.H. (2022). Flora of Singapore: Checklist and bibliography. Gardens' Bulletin Singapore 74(Suppl.1): 3–860. https://doi.org/10.26492/gbs74(suppl.1).2022-01

Loo, M.G.K., Tun, K.P.P. & Chou, L.M. (1996). Environmental status of seagrass communities in Singapore. *Journal of the Singapore National Academy of Science* 22-24: 97–102.

Marsh, H., O'Shea, T.J. & III, J. E. (2011). *Ecology and conservation of the Sirenia: Dugongs and manatees*. Cambridge UK: Cambridge University Press.

McKenzie, L.J., Yaakub, S.M., Tan, R., Seymour, J. & Yoshida, R.L. (2016). Seagrass habitats of Singapore: Environmental drivers and key processes. *Raffles Bulletin of Zoology* 34: 60–77.

Miyajima, T. & Hamaguchi, M. (2019). Carbon sequestration in sediment as an ecosystem function of seagrass meadows. *Blue Carbon in Shallow Coastal Ecosystems*, 33–71.

NParks (2019). *Nature Areas and Nature Reserves*. National Parks Board. https://www.nparks.gov.sg/biodiversity/our-ecosystems/nature-areas-and-nature-reserves

Orth, R.J., Carruthers, T.J., Dennison, W.C., Duarte, C.M., Fourqurean, J.W., Heck, K.L., Hughes, A.R., Kendrick, G.A., Kenworthy, W.J., Olyarnik, S., Short, F.T., Waycott, M. & Williams, S.L. (2006). A global crisis for seagrass ecosystems. *BioScience* 56: 987.

Reynolds, P.L. (2018). *Seagrass and seagrass beds*. Smithsonian Ocean. https://ocean.si.edu/ocean-life/plants-algae/seagrass-and-seagrass-beds

Rollon, R.N. (1998). *Spatial variation and seasonality in growth and reproduction of Enhalus acoroides (L.f.) Royle populations in the coastal waters off Cape Bolinao, NW Philippines* [Unpublished doctoral dissertation]. Netherlands: Wageningen Agricultural University.

Seagrass Watch. (2022). *Singapore*. Seagrass-Watch. https://www.seagrasswatch.org/singapore/

Soh, G. (2021) *Critically endangered dugong found dead off Pulau Hantu.* The Straits Times, 9 Oct 2021.

Sudo, K., Quiros, T.E., Prathep, A., Luong, C.V., Lin, H., Bujang, J.S., Ooi, J.L., Fortes, M.D., Zakaria, M.H., Yaakub, S.M., Tan, Y.M., Huang, X. & Nakaoka, M. (2021). Distribution, temporal change, and conservation status of tropical seagrass beds in Southeast Asia: 2000–2020. *Frontiers in Marine Science* 8, 637722.

Tan, R. (2012) *Semakau with TeamSeagrass*. Wild Shores of Singapore. https://wildshores.blogspot.com/2012/06/semakau-with-teamseagrass.html

Tan, R. (2019). *Seagrasses on the shores of Singapore*. wildsingapore. https://www.wildsingapore.com/wildfacts/plants/seagrass/seagrass.htm

Tan, Y.H.J., Tham, J.K.Q., Paul, A., Rana, U., Ang, H.P., Nguyen, N.T.H., Yee, A.T.K., Leong, B.P.I., Drummond, S. & Tun, K.P.P. (2023) Remote sensing mapping of the regeneration of coastal natural habitats in Singapore: Implications for marine conservation in tropical cities. S*ingapore Journal of Tropical Geography* 44(1): 130–148.

Unsworth, R.K., McKenzie, L.J., Collier, C.J., Cullen-Unsworth, L.C., Duarte, C.M., Eklöf, J.S., Jarvis, J.C., Jones, B.L. & Nordlund, L.M. (2018). Global challenges for seagrass conservation. *Ambio* 48: 801–815.

Waycott, M., Duarte, C.M., Carruthers, T.J., Orth, R.J., Dennison, W.C., Olyarnik, S., Calladine, A., Fourqurean, J.W., Heck, K.L., Hughes, A.R., Kendrick, G.A., Kenworthy, W.J., Short, F.T. & Williams, S.L. (2009). Accelerating loss of seagrasses across the globe threatens coastal ecosystems. *Proceedings of the National Academy of Sciences* 106: 12377–12381.

Waycott, M., McKenzie, L.J., Mellors, J.E., Ellison, J.C., Sheaves, M.T., Collier, C., Schwarz, A., Webb, A., Johnson, J.E. & Payri, C.E. (2011). Vulnerability of mangroves, seagrasses and intertidal flats in the tropical Pacific to climate change. In *Vulnerability of tropical Pacific fisheries and aquaculture to climate change*. Pacific Community.

WoRMS Editorial Board (2023). *World Register of Marine Species*. https://www.marinespecies.org/

Yaakub, S.M., Lim, R.L., Lim, W.L. & Todd, P.A. (2013). The diversity and distribution of seagrass in Singapore. *Nature in Singapore* 6: 105–111.

Yaakub, S.M., Lai S., Rashid, N.A.M., Lim, R., Lim, W.L., Neo, M.L. & McKenzie, L. (2014) Monitoring Singapore's seagrass meadows: Trends and highlights of the first long-term seagrass monitoring initiative. In *Biodiversity Research Symposium 2014*. DOI:10.13140/RG.2.2.35625.90727

Yaakub, S.M., McKenzie, L.J., Erftemeijer, P.L., Bouma, T. & Todd, P.A. (2014). Courage under fire: Seagrass persistence adjacent to a highly urbanised city-state. *Marine Pollution Bulletin*, 83: 417–424.