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Sargassum in Singapore: What, Where and When?

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Abstract: A total of 42 *Sargassum* species with valid names have been documented to occur in Singapore. This tally takes into account recent revelations on synonymies and misidentifications in this taxonomically complex group. The species list is derived from collections residing offshore and locally, and from field observations. Voucher specimens for only 11 species exist in local herbaria, of which only four have been observed in the islands south of Singapore. Of these four species, *S. siliquosum* was the dominant species, followed by *S. aquifolium*, *S. granuliferum* and finally, *S. polycystum*. Three other species from the local herbaria have not been reported before, even though they were collected in the early 1900s. It is unclear at this point how many of the other species documented from Singapore are still extant. Field surveys show that the reef flats of the islands south of Singapore are typically dominated by *Sargassum* (26.5 to 54.2% cover) up to the reef crest (6.4 to 31.6% cover), but no further (slope = 0.2-0.8% cover). Why this is so is not known, but it is likely that sediment load in the water limits the light penetrating to the reef slope, in addition to causing smothering of juveniles. Historically, *Sargassum* is known to "bloom" seasonally in Singapore, forming an almost impenetrable wall around the reefs, corresponding to the North East Monsoon. Preliminary results of a growth study of *S. siliquosum* showed that the growth cycle began in August, with very rapid extensions between September and October, extending from 24.3 ± 6.6 cm and 23.3 ± 6.0 cm to a maximum in November at 227.8 ± 43.0 cm to 247.2 ± 43.0 cm before tapering off in December.

Introduction

The genus *Sargassum* is one of the most diverse and taxonomically complex algae. Worldwide, over 1000 holotypes, syntypes, variants and forma exist, while regionally, over 200 species have been reported (Ang, 2006) encompassing tropical and temperate waters in the Indian and Pacific Oceans. However, many of the species are heavily synonymized, and recent work have greatly clarified and simplified the classification, with less than 40% now recognised as current (Mattio & Payri, 2009, 2010; Mattio *et al*., 2009, 2010). Many inconsistencies in the morphological characters selected to classify *Sargassum* (Mattio & Payri, 2010), suggest that much of the older descriptions did not take into account the wide variation in growth characters exhibited by the species (Mattio *et al*., 2010).

In Singapore, over 50 species (before taking into account synonymies) have been documented (Teo & Wee, 1984; Silva *et al.*, 1996, Phang *et al*., 2007; Lee *et al.*, 2009), several of which have Singapore as the type locality (Silva *et al.*, 1996). Earlier works (such as Teo & Wee, 1983), although with line drawings, had vague descriptions, and since physical evidence for their description has not been found, positive identification is impossible. Recent reviews (e.g. by Lee *et al*., 2009) did not consider new material for this group of Phaeophyta when reporting new algal records for Singapore.

Chuang (1977) classified Singapore's reefs as "*Sargassum*" reefs, based on the gradient of the slope and the predominance of *Sargassum* species on the reef flat and upper reef slope, but the lack of studies on *Sargassum* locally is surprising. While most of the marine biodiversity work has focused on hard corals, it is known that *Sargassum* occurs commonly in the southern coast of the main island, and in the reefs of the islands south of Singapore, where they form

dense thickets that roughly coincide with the Northeast Monsoon (Chuang, 1977). During the Southwest Monsoon (between February and July), their abundance is "low". Other than these anecdotal observations, only one study has focused on its distribution and seasonality, classifying *Sargassum* to genus (Chou & Wong, 1984). They reported the dominance of *Sargassum* from the reef flat to the upper reef slope, followed by other Phaeophyta like *Padina taenius* and *Turbinaria ornata*, along with five other chlorophytes (green algae). Other reef surveys provide further evidence of the occurrence of algae on Singapore's reefs, but since they lump *Sargassum* with other "macroalgae" (or MA, as outlined in English *et al*., 1997), it was not possible to determine if they were *Sargassum*.

Other studies on *Sargassum* include *in-situ* measurements of its productivity (although the species was not indicated) using an automated respirometer (Tun *et al.*, 1994a and 1994b). This was carried out as part of a preliminary study of reef productivity. No further work was done, as the emphasis shifted to underwater photoflourometry using DIVING PAM on scleractinian corals (Tun *et al.*, 1994b). Finally, an undated report (Ang *et al.*, undated) looked at *Sargassum* as a possible bio-indicator of sedimentation, but results of the study were inconclusive.

This paper reviews the status of Singapore's *Sargassum* species, and provides preliminary observations on *Sargassum* distribution and growth in the islands south of Singapore.

Materials and Methods

Examination of herbarium records

Herbarium records from the Singapore Botanic Gardens Herbarium (SBG Herbarium) and from the National University of Singapore Herbarium (SINU Herbarium) were examined. Location of the collection and habitat descriptions were noted. Online information was also extracted from AlgaeBase (http://www.algaebase.org) and the online version of Silva *et al*. (1996). The latter listed Singapore as the eastern most of their catalogue of algae of Indian Ocean (at http://ucjeps.berkeley.edu/rlmoe/tioc/ioctoc.html) (see Tables 1 through 3).

Distribution surveys

Field observations and collections were carried out at various sites of the islands south of Singapore (Fig. 1). These included rapid surveys, and a more detailed distribution survey at selected sites. The rapid surveys were carried out by swimming along the reef in zig-zag pattern (Table 4).

Line-intercept transect surveys were carried out to determine the distribution of *Sargassum* at the reefs (see Fig. 1) of Pulau Hantu west (site H2s) and Pulau Semaku (sites S1, S2, PS5 and PS6) between August and December 2010. These surveys comprised two sets of transects along two axes: perpendicular-to-shore and along the reef crest. The perpendicular-to-shore transects resembled the method described by Chou & Teo (1983) and Chou & Wong (1984), but differed in the way the data were recorded. Transects were laid out from the reef crest, one towards the shore, and the other towards the seabed. Since the emphasis was on sub-tidal distribution, the survey was limited to no more than 30m in length in either direction. In the case of the crest -to-shore transect, it terminated when either the end of the reef flat was reached, or when the tape ran out, and for the crest-to-seabed transect, it terminated at the seabed or at the 15m-depth mark. A similar 30m transect was laid parallel-to-shore following the contour of the reef crest based on the methodology described by English *et al*. (1997).

In all transects, benthic cover of each transect was estimated in the manner described by English *et al.* (1997) where the transitions of the benthos under the measuring tape were recorded, their respective lengths calculated and the percent cover of each determined (Table 5). *Sargassum* was recorded to species level, but if the identity of the species was in doubt, a sample was collected for later identification.

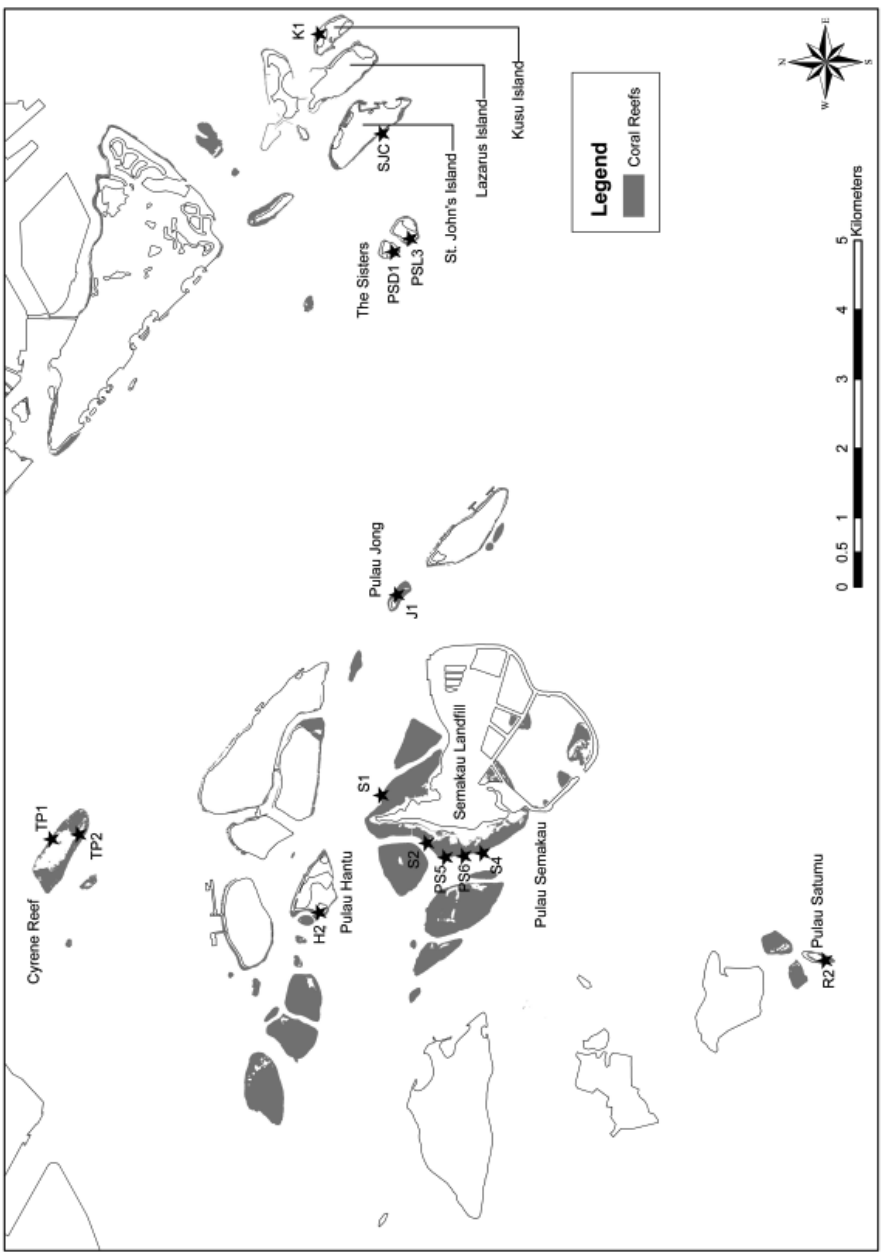

Figure 1. Sites where new specimens of Sargassum were collected, showing Cyrene Reefs (TP1 and TP2); Pulau Hantu (H2); Pulau Semakau (S1, S2, S4, PS5 and PS6); Pulau Jong (J1); Sisters Islands (PSD1 and PSL3); St John's west (opposite TMSI's pumping station) (SJC); Kusu Island (K1); and Raffles Lighthouse west (R2). Map courtesy of NParks.

All materials collected were pressed, dried and mounted on herbarium sheets, and deposited at the SBG Herbarium.

Seasonal variation in *Sargassum* growth

Growth of *Sargassum* was studied at two sites, Pulau Semakau (PS5) and Pulau Hantu south (H2) (Fig. 1). *Sargassum siliquosum* was the dominant species at these sites.

A 30m parallel-to-shore transect tape was laid at the reef crest to set the boundaries for the site. The length of the longest primary branch of *Sargassum* at roughly one meter intervals on the transect tape was measured (Figs. 2 & 3). In addition, they were examined for the presence of receptacles. If receptacles were observed, fragments were collected for microscopic examination in the laboratory to determine the sex and maturity of the reproduction organs.

One-way ANOVA was carried out between samples at each site, and between sites to test for significance in growth (Table 6).

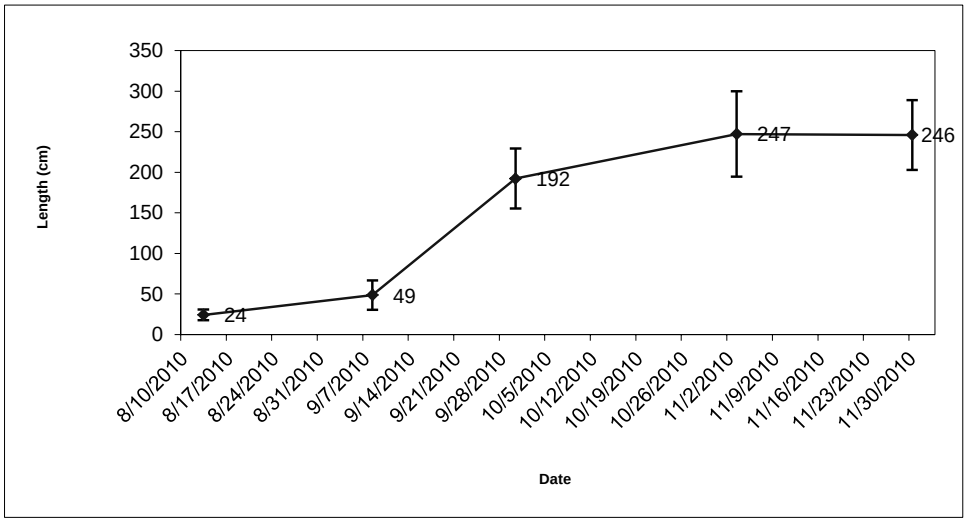

Figure 2. Length measurements of *Saragssum siliquosum* at Pulau Semakau site PS5

Results and Discussion

Taxonomic status

A total of 42 *Sargassum* species with valid names have been documented to occur in Singapore (Table 2). Voucher specimens for 11 species exist in the two local herbaria, of which three are reported here for the first time. Specimens from only 4 species were collected from 14 sites during this study.

Examination of Algaebase showed fifty species of *Sargassum* documented from Singapore, extracted from records by Teo & Wee (1983), Phillips (1995), Silva *et al*. (1996), Ajisaka (2002) and Tseng & Lu (2002). Many of the species listed are now known to be synonyms (Mattio & Payri, 2009; Mattio *et al.*, 2010) or misidentifications (Ajisaka, 2002). For example, *S. binderi* is the synonym for *S. aquifolium* (Mattio *et al.*, 2009), and *S. myriocystum* for *S. polycystum* (Mattio & Payri, 2009). These synonyms were noted, and applied to the herbaria specimens.

The collections from these two herbaria were found to be very different. The SBG Herbarium collection is mainly from the late 1800s and early 1900s with a few collected from the mid 2000s. These specimens had limited information from where they were collected but were still in surprisingly good condition. Some specimens were without holdfasts and most were of non-fertile individuals. The older specimens had to be handled very carefully as they were brittle and prone to breakage. The SINU Herbarium specimens were collected more recently (mid to late 2000s), but the collection is much smaller. Most of the specimens were labelled as *Sargassum* sp., but upon examination, showed to comprise mainly of *S. polycystum*, *S. aquifolium* and *S. siliquosum*.

A total of 11 *Sargassum* species are recorded from the local herbaria after applying the current valid name for the species. It should be noted that the collection by Silva *et al*. (1996) is at the Bishop Museum of Natural History, Hawaii, and that all the material evidence for Teo & Wee (1987) could not be located. Despite this, however, Ajisaka *et al*. (1999) reported several misidentifications by Teo & Wee (1983), presumably based on their drawings. It was determined that *S. duplicatum* should be *S. siliquosum* and that *S. spathulaefolium* and *S. asperifolium* should be *S. polycystum*. Algaebase's database has not updated its records for *S. asperifolium* and still lists it as occurring in Singapore.

Furthermore, three species in the SBG Herbarium records, *S. grevillei* J. Agardh, *S. latifolium* var. *seychellarum* and *S. vulgare* C. Agardh, were not recorded in Algaebase and are reported here for the first time. It is unclear why these three records were not reported previously and it could be that either their identity was in question or that they were simply overlooked. Also, in the case of *S. latifolium* var. *seychellarum*, it may be a misspelling of *S. latifolium* var. *seychallense* Grunow, although Algaebase does not list this species as occurring in Singapore.

Only four species were observed during surveys and collection from the study sites, namely, *S. aquifolium*, *S. siliquosum*, *S. granuliferum* and *S. polycystum*. These species could easily be differentiated from each other by their stem shape and size of leaves and vesicles: *S. aquifolium* exhibits compressed (flattened) branches, with lance-like leaves, vesicles which are mucronate with winged pedicles; *S. polycystum* has cylindrical stems that are muricated; *S. siliquosum* has cylindrical stems with large leaves and vesicles; while *S. granuliferum* has cylindrical branches with small lance-like leaves and many small vesicles.

It is not clear how many of the remaining 38 species are still extant, given that the marine environment in Singapore has been modified significantly by coastal development since the mid 1990s (Chia *et al*., 1988; Chia, 1992; Hilton & Manning, 1995). Also, because the sampling area for fresh material was limited to the islands south of Singapore, it may not fully cover all the habitats that *Sargassum* may be found in. It was not clear from the herbarium records how abundant some of these species were locally (some of them were collected as "jetsam"). Increasing the number of areas sampled might shed some light on the whether the other species are still present.

The collection by Silva *et al.* (1996) would be worth examining as they list Singapore as the type locality for no less than 8 species, which are also not recorded from anywhere else. Singapore is also documented as type locality for *S. siliquosum* (Agardh, 1820), but the holotype cannot be located (Phang *et al.*, 1995).

The updated *Sargassum* species list will provide a useful reference point for future study. In particular, greater efforts should be made in collecting representative voucher specimens to document the wide range of variable morphological characters. Making such information widely available (for example, through Algaebase), would be beneficial to resolving many of the difficulties in identification of specimens within the region.

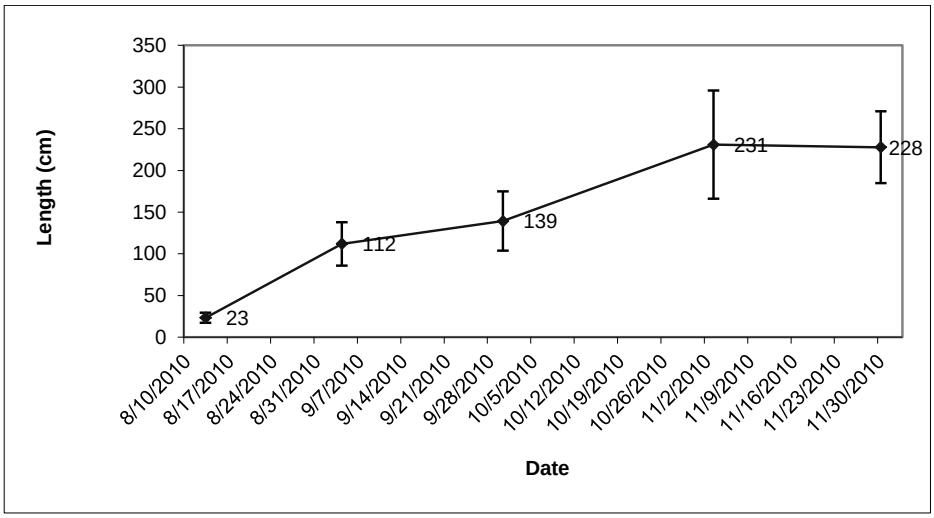

Figure 3. Length measurements of *Sargassum siliquosum* at Pulau Hantu south, site H2

Distribution and habitat type

Sargassum was historically collected from many locations on mainland Singapore and at some of the offshore islands (Table 4). Presumably, most of these sites were easily accessible (for example, Labrador) or had some significant landmark for a visit (for example, Raffles Lighthouse). A large proportion of the collection comprises specimens of *S. polycystum* and *S. siliquosum*, and an amorphous group of as yet unidentified specimens. The unidentified specimens were typically material that was not in very good condition as they often lacked a hold fast or possessed only a few vesicles or leaves.

Very little information was specified on the herbarium sheets about habitat type, the zone it was collected from, or how it was collected (by scuba or during an inter-tidal walk) (Table 3). More than two thirds of the specimens had no habitat data at all.

In the field surveys of the reefs around the islands south of Singapore, only four species were observed, with the most commonly occurring species being *S. siliquosum* (Table 4). During its growth cycle, it typically formed a thick, almost impenetrable wall crowning the reefs at most of the study sites (Fig. 3). This wall rarely extended beyond the reef crest, although an occasional individual or two may be found on the reef slope (Table 5). Why this is so is not clear. It could be that sediment load and its effect on light attenuation are factors that limit the growth of *Sargassum* at depth. Singapore reefs are subjected to high sediment loads (Todd *et al*., 2004) and sedimentation rates between 10 to 41 mg/cm^2/day have been recorded (Lane, 1990; Low & Chou, 1994, Todd *et al*., 2004). The resulting effect of decreasing light levels at the reef slope (Tun, 1994; Todd *et al*., 2004) could severely limit the survival of the perennial basal axes of the *Sargassum* outside of its seasonal growth spurts. In addition, the smothering effect of the sediment may also contribute to limiting the occurrence of this alga to the shallower, more sunlit areas of the reef.

The distribution of *Sargassum* is not uniform throughout the reef flat of each site. Each reef seemed to have its own feature. For example, *Sargssum* was relatively sparse at Cyrene Reefs, and comprised mainly *S. aquifolium* and *S. polycystum*, despite anecdotal evidence suggesting that *S. siliquosum* "blooms" there as well. Environmental conditions may have changed, as indicated by a recent seagrass monitoring trip by TeamSeagrass (Tan, pers. com)

who observed a drastic change in the cover of usually luxuriant seagrass growth to a sparse, sand-dominated habitat. However, since physical parameters and sand movement are not continuously logged or tracked at the site, it cannot be ascertained what these environmental changes were due to. A combination of heat stress from the recent mass coral bleaching event in mid-2010 (Tun *et al*., 2011) or the movement of sand or a combination of both effects could have resulted in the sparse cover of *Sargassum*.

Similarly, the reef at St John's Island (SJC) has undergone a drastic change (based on personal observations) from a coral dominated site in the late 1990s, to a now barren rocky sediment-covered substrate that features *S. aquifolium* as the main life form.

Figure 4. Underwater view of *Sargassum* at the peak of its growth cycle

Seasonal variation in S*argassum* growth

The length measurements obtained (Figs. 2 & 3) showed significant growth at both sites between August and early November (Table 6). However, both sites showed significant differences as to when the growth spurt occurred. In the case of site H2, this occurred in early August, while at PS5, this only occurred in early September.

It should be noted that the number of algae measured was not even between measurements (n=28 for the initial survey, n=17-19 for the later surveys). A greater number of individuals could be measured when the algae were small. However, as the primary branches and the secondary branches as well grew in length, they became twisted and tangled with other adjacent branches from the same plant, or from neighbouring plants. Untangling the primary branch from the mass took an average of 10-15 minutes each, which would have amounted

to a bottom time of between 290 and 435 minutes. Comparatively, other growth studies (for example, Ang, 1985) involved individuals no more than 1.5m.

The growth season for *S. siliquosum* is similar to that reported in the Philippines (Ang, 1985; Largo & Ohno, 1996), although the average maximum lengths reported in those studies only ranged between 48cm and 150cm. The reasons for such a drastic difference in growth extensions are not known but it can be speculated that factors affecting *Sargassum* growth could be biological (for example, predation) or environmental (for example, sediment load in the water).

The effect of predation can be significant in determining survival and recruitment of *Sargassum* where environmental factors are not considered limiting (McCook, 1997). It would be logical to assume that such predation would limit the growth of the algae as well. However, grazers were hardly in evidence during the surveys, therefore it is likely that environmental factors were pivotal in determining growth as well as distribution. The sediment load and sedimentation rates in Singapore waters are high (Lane, 1990; Low & Chou, 1994, Todd *et al*., 2004) and are the most likely influence on growth and distribution. As such, studies into the photosynthetic physiology of *Sargassum* may provide some answers, as photosynthesis is the basis for *Sargassum* survival and growth (Saroussi & Beer, 2007).

No reproductive structures were observed during these surveys despite reports of their occurrence in August (Ang, 1985; Largo & Ohno, 1992). However, their reproductive state could last several months up to January or February (Ang, 1985; Norisakar, pers. comm.).

More questions than answers

The results of the study so far raise more questions that require additional observations and experiments. While the field surveys hinted at a more conservative species composition than previously thought, more work needs to be done to resolve their taxonomic status, in particular, on the molecular aspects. Why does *Sargassum* only grow up to the reef's edge and no further? What are the factors that influence growth, and what causes such massive growth spurts? What are the reproductive cycles like for the extant species?

Manipulative experiments, such as relocation from shallow to deeper water, studies to determine their photo-physiology and more regional collaboration on taxonomy could shed some light on these questions, and will be the focus for future work.

Table 1. *Sargassum* species documented from Singapore. Species with specimens lodged at the Singapore Botanical Gardens Herbarium and the NUS SINU Herbarium are in bold typeface, and marked *1 and *2 respectively.

Species	**Remarks**	**Source**
Sargassum angustifolium C. Agardh	Name is valid (algaebase.org).	Silva et al. (1996)
Sargassum aquifolium (Turner) C. Agardh *1 *2	Valid name for S. echinocarpum J. Agardh, S. binderi Sonder ex J. Agardh, S. biserrula J. Agardh, S. odontocarpum Sonder (Mattio et al., 2009). Only specimens of S. binderi from the SBG Herbarium were examined.	Silva et al. (1996); Ajisaka (2002); Tseng & Lu (2002);
Sargassum assimile Harvey *1		Silva et al. (1996)
Sargassum baccularia (Mertens) C. Agardh	Tseng & Lu (1992) indicate that Singapore is the type locality, but Silva et al. (1996) indicated some uncertainty in this statement. Teo & Wee (1983) reported this species for Singapore, but misidentified it as Sargassum asperifolium Hering & G. Martens ex J. Agardh (Ajisaka et al., 1999). No physical record of the specimen collected by Teo and Wee (1983) could be found. This misidentification is currently not updated in Algaebase.	Tseng & Lu (1992); Phillips (1995); Silva et al. (1996); Ajisaka (2002)
Sargassum baccularia var. *subcompressum* Grunow	Type locality is Singapore and only know locality record is Singapore.	Silva et al. (1996)
Sargassum belangeri Bory de Saint-Vincent	Name is still valid (algaebase.org).	Silva et al. (1996)
Sargassum biserrula var. *singapoorense* Grunow	Type locality and only known locality record is Singapore.	Silva et al. (1996)
Sargassum brevifolium var. *pergracile Grunow*	Silva et al. (1996) suggested that this species falls within the circumspection of S. polycystum.	Silva et al. (1996)
Sargassum cervicorne Greville	The name is still valid (algaebase.org).	Silva et al. (1996)
Sargassum cinereum J. Agardh	First documented by Teo & Wee (1983), but voucher specimen could not be located.	Teo & Wee (1983); Phillips (1995); Silva et al. (1996)
Sargassum filifolium C. Agardh	Valid name (algaebase.org).	Silva et al. (1996)
Sargassum gaudichaudii Montagne	Valid name (algaebase.org).	Silva et al. (1996)
Sargassum glaucescens J. Agardh *1	Valid name (algaebase.org).	Silva et al. (1996)

Species	Remarks	Source
Sargassum glaucescens var. *ivanii* (Montagne) Grunow	The type locality is listed as “near Macau” (Silva et al., 1996). The only locality record for the Southeast Asia region is Singapore.	Silva et al. (1996)
Sargassum gracile J. Agardh	Valid name (algaebase.org).	Phillips (1995); Silva et al. (1996)
Sargassum granuliferum C. Agardh *1	Valid name (algaebase.org).	Silva et al. (1996)
Sargassum granulilerum var. *dubiosum* Grunow	Valid name (algaebase.org).	Silva et al. (1996)
Sargassum grevillei J. Agardh *1	This species is reported for Singapore for the first time, based on a specimen in the SBG Herbarium. The specimen was collected at Tuas, on 29 Jan 1890 by HN Ridley.	
Sargassum ilicifolium (Turner) C. Agardh	This species seems to exhibit a very plastic morphology, as well as having a wide geographic range (see algaebase.org). Matteo et al. (2009) confirmed this as the valid name for Sargassum cristaefolium C. Agardh, Sargassum duplicatum Bory de Saint-Vincent and Sargassum duplicatum J. Agardh, S. berberifolium J.Agardh, S. ilicifolium var. venustum Grunow, S. ilicifolium var. venustum Grunow and Sargassum duplicatum J.Agardh. Teo & Wee (1983) documented both S. duplicatum J. Agardh and S. ilicifolium (Turner) C. Agardh as occurring in Singapore, but no physical evidence could be found in either herbaria.	Teo & Wee (1983); Phillips (1995); Silva et al. (1996).
Sargassum ilicifolium var. *pseudospinulosum* Grunow	Valid name (algaebase.org).	Silva et al. (1996)
Sargassum latifolium (Turner) C. Agardh	Valid name (algaebase.org).	Silva et al. (1996)
Sargassum latifolium var. *seychellarum* *1	This is the first mention of this specimen from Singapore. Determined by Setchell (1929), this species may be a mis-spelling of S. latifolium var. seychallense Grunow.	
Sargassum microcystum f. *dilatatum* Grunow	Singapore is listed as the type locality for this species, as well as the only locality record.	Silva et al. (1996)

Species	Remarks	Source
Sargassum myriocystum var. *grandifolium* Grunow	Type locality is listed as “near Singapore”, and only known record is from Singapore.	Silva et al. (1996)
Sargassum microphyllum C. Agardh		Silva et al. (1996)
Sargassum obtusifolium var. *reichelii* Grunow	Type locality is listed as “near Singapore”, and only known record is from Singapore.	Silva et al. (1996)
Sargassum oligocystum Montagne *1	Valid name (algaebase.org).	Silva et al. (1996); Ajisaka (2002)
Sargassum oocyste var. *chierchii* Grunow	Singapore is the type locality, and also the only location from which this species is known. Currently a valid name in algaebase.org.	Silva et al. (1996)
Sargassum parvifolium (Turner) C. Agardh	Valid name (algaebase.org).	Silva et al. (1996)
Sargassum plagiophyllum C. Agardh	Is the heterotypic synonym of S. stolonifolium S.-M.Phang & T.Yoshida (Mattio et al., 2010).	Silva et al. (1996)
Sargassum plagiophyllum var. *hebetatum* Grunow	Type, and so far only, locality is Singapore.	Silva et al. (1996)
Sargassum plagiophyllum var. *singapoorense Grunow*	Type locality is Singapore; only recorded from here.	Silva et al. (1996)
Sargassum polycystum C. Agardh *1 *2	S. polycystum is the valid name for S. myriocystum (Mattio & Payri, 2009).	Teo & Wee (1983); Phillips (1995); Silva et al. (1996); Ajisaka (2002)
Sargassum pseudocystocarpum Grunow	Type locality is Singapore; only recorded from here.	Silva et al. (1996)
Sargassum pulchellum Grunow	Valid name (algaebase.org).	Silva et al. (1996)

Species	Remarks	Source
Sargassum siliquosum J. Agardh *1 *2	Singapore is the type locality for this species (Tseng & Lu, 1992), but the holotype specimen from Singapore as described by Agardh (1848) cannot be located (Phang et al., 1995). The sex of the type specimen was not stated, but has been reported as baring only male receptacles (Ang & Trono, 1987) as well as male and female receptacles (Yamada, 1942). There is strong agreement, however, that the "strongly triquetrous and twisted female receptacles" is the distinguishing feature of S. siliquosum (Ang & Trono, 1987; Trono, 1992).	Tseng & Lu (1992); Phang, Noro & Yoshida (1995), Silva et al. (1996); Ajisaka (2002)
Sargassum squarrosum Greville	Valid name (algaebase.org).	Silva et al. (1996); Tseng & Lu (2002)
Sargassum subspathulatum (Grunow) Grunow	Valid name (algaebase.org).	Silva et al. (1996)
Sargassum swartzii C. Agardh *1	There is some confusion over the occurrences of this species in Singapore. It was first documented by Teo & Wee (1983) as Sargassum spathulaefolium J. Agardh, which is a heterotypic synonym of S. swartzii C. Agardh (Mattio et al., 2010). However, based on the description by Teo & Wee ("stems densely muricated"), Ajisaka et al. (1999) concluded that this specimen was misidentified and should be S. polycystum.	Teo & Wee (1983); Phillips (1995); Silva et al. (1996).
Sargassum torvum J. Agardh	First documented by Teo & Wee (1983) for Singapore, although they were unsure of its identity. No archival record of this species could be found in either herbaria.	Teo & Wee (1983); Silva et al. (1996)
Sargassum virgatum C. Agardh	Valid name (algaebase.org).	Silva et al. (1996)
Sargassum vulgare C. Agardh *1	This species is reported for Singapore for the first time, based on voucher specimen at the SBG Herbarium. A seemingly circum-global species (see algaebase.org), but perhaps not so common locally.	

Table 2. Locations from which *Sargassum* had been collected, compiled from herbarium records of SBG Herbarium and SINU Herbarium. Species in bold were also observed in field in this study.

	Sargassum aquifolium	*Sargassum assimile*	*Sargassum glaucescens*	*Sargassum granuliferum*	*Sargassum grevillei*	*Sargassum latifolium var. seychellarum*	*Sargassum oligocystum*	***Sargassum polycystum***	***Sargassum siliquosum***	*Sargassum sp.*	*Sargassum swartzii*	*Total*
?Unknown	3						1	4		3		11
?Toas / Tg. Gul					1			2				3
Bedok										1		1
Changi							1	1	1	2		5
Cyrene Reefs									1			1
East Coast Park								2				2
Labrador	1	2		2				15	20	3		43
Pasir Panjang / West Coast Park / Tg Pejuru	2		2					1	4			9
Pulau Biola		1	1				1	3		1		7
Pulau Hantu	2						2	1	3			8
Pulau Pawai										3		3
Pulau Sakra									4	1		5
Pulau Subar Darat				2					2	3		7
Pulau Subar Laut								2	2	2		6
Punggol										1		1
Raffles Lighthouse	8	5	15				6	15	14	7	11	81
Royal Sing. Yacht Club Anchorage										1		1
Sentosa	4							1		18		23
St John's Island	2					1	1	2		2		8
Tanah Merah	1											1
Tg. Pasir Laba								4	6	1		11
Tg. Punggol										2		2
Grand Total	23	8	18	4	1	1	12	53	63	54	11	248

Table 3. Habitat descriptors used for herbarium specimens.

Description	Percent
Low tide (eg. edge of high water mark, low tide mark)	2.0
Underwater (depth)	0.4
Attached to something (eg. Attached to subsrtae)	4.4
Habitat (eg. coral reef, reef flat)	8.9
“In sea” (literal)	14.1
Floating (eg. drifting)	2.8
Unknown (no record entry)	67.4

Table 4. *Sargassum* species observed during this study (also refer to Fig. 1).

Site	*S. aquifolium*	*S. granuliferum*	*S. polycystum*	*S. siliquosum*
Cyrene Reef (TP1 and TP2)	X		X	
Semakau (S2, S4, PS5, PS6)				X
Semakau (S1)		X		X
Pulau Hantu (H2)				X
Pulau Jong (J1)	X			X
St John’s Island (SJC)	X			
Pulau Subar Laut (PSL4)			X	X
Pulau Subar Darat (PSD1)		X		X
Kusu Island (K1n)				X
Raffles Lighthouse (R2)	X			X

Table 5. Percent cover of *Sargassum* on the reef flat, crest and slope at Pulau Semakau and Pulau Hantu.

Site	**Date**	**Reef flat**	**Reef crest**	**Reef slope**
Pulau Semakau S1	1 Dec 2010	50.1	26.4	0.8
Pulau Semakau S2	29 Aug 2010	54.2	6.4	0.2
Pulau Semakau S4	22 Aug 2010	49.6	22.4	0.0
Pulau Semakau PS5	8 Sep 2010	42.2	28.7	0.0
Pulau Semakau PS6	30 Sep 2010	47.4	31.6	0.0
Pulau Hantu H2	20 Feb 2010	26.5	22.1	0.3

Table 6. One-way ANOVA on the growth measurements of *Sargassum siliquosum* at Pulau Semakau (PS5) and Pulau Hantu (H2).

Site	Date sampled	Mean length (cm)	Std Dev	P-value	P-value between sites
Pulau Semakau (PS5)	13 Aug 2010	24.3	6.6		0.56
	8 Sep 2010	48.3	18.0	<0.05	<0.05
	30 Sep 2010	192.4	37.1	<0.05	<0.05
	3 Nov 2010	247.2	52.7	<0.05	0.41
	30 Nov 2010	247.1	43.0	0.95	0.21
Pulau Hantu (H2)	13 Aug 2010	23.3	6.0		
	4 Sep 2010	111.9	26.1	<0.05	
	30 Sep 2010	139.4	35.6	<0.05	
	3 Nov 2010	230.9	64.9	<0.05	
	30 Nov 2010	227.8	43.0	0.86	

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