CHAPTER 5

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5.1 Growth Pattern

S. baccularia and *S. swartzii* occurred all year round at Cape Rachado, Port Dickson. Generally, the growth pattern for both species studied in Cape Rachado can be described briefly as having three phases; a growth phase (increase in thallus length), a reproductive phase (appearance of the receptacles), and a decaying phase (decrease in thallus length).

The growth pattern of *S. baccularia* was as followed :

1. Growth phase : April-June 1995 and December 1995-March 1996.
2. Reproductive phase : January-February 1995 and June-August 1995.
3. Decaying phase : January-April 1995 and June-December 1995. This phase can be considered as an inactive phase too as there is not much of variation in the length of the tagged plants.

The growth pattern of *S. swartzii* was as followed :

1. Growth phase : April-June 1995, December 1995-March 1996.

2. Reproductive phase : January-March 1995, mid May-early November 1995 and March 1996.
3. Decaying phase : January-April 1995 and June-November 1995.

The reproductive phase coincided with the decaying phase for both *Sargassum* species. This is due to the shedding of the branches after the receptacles were developed which resulted in the decrease in size (die-back). The plants will enter into the growth phase when the environment is favourable for growth. This growth pattern is a phenomenon common to *Sargassum* species which involves an embryonic phase, a growth phase, a reproductive phase, a degenerative or "deciduous" phase and a regenerative phase (Chauhan & Krishnamurthy 1971; Raju & Venugopal 1971; Tsuda 1972; De Wreede 1976; Norton 1977; Prince & O'Neal 1979; McCourt 1984; Ang 1985; Price 1989; Rao & Indusekhar 1989; Martin-Smith 1993; Schaffelke 1997).

S. baccularia attained the highest growth rate (3.01 ± 3.36 mm day^{-1}) in June 1995, followed by the maximum thallus length (98.23 ± 66.00 mm). The same happened in February 1996. A zero growth rate was observed between November-December 1995 where plants had the shortest thallus length recorded in December 1995 (26.75 ± 16.85 mm). Similar pattern was observed in *S. swartzii* (Highest growth rate of 3.31 ± 3.12 mm day^{-1} in

June 1995, followed by the maximum thallus length of 95.35±56.97 mm). This pattern was reported by Ang (1985) in the reef flat of Balibago, Philippines for *S. siliquosum* and *S. paniculatum*. *S. siliquosum* exhibited the highest growth rate of 16.5±8.2 mm day^{-1} in July-August and maximum length attained in September (126.7±38.3 cm). *S. paniculatum* exhibited high growth rate of 3.8±5.2 mm day^{-1} from July-October and attained maximum length in November (88.7±23.9 cm).

Analysis of length classes reveals that the two populations of *Sargassum* species are mainly young plants, with a high percentage in the length classes which is less than 199 mm (Figures 13, 17, 23 & 32). The average thallus length of *S. swartzii* plants are relatively longer than *S. baccularia* plants. The same goes to the percentage of length classes where *S. swartzii* population have higher percentage of plants in length classes less than 99 mm (66% in nondestructive sampling, and 54% in destructive sampling) as compared to *S. baccularia* population, where most of the plants fall into the length classes of less than 49 mm (50% in nondestructive sampling, and 54% in destructive sampling). Koh *et al* (1993) recorded small size classes for *S. thunbergii* over the whole year in Korea. The author pointed out that the occurrence of higher frequency in the smaller size class indicates a size reduction of the object plant after the growing period.

Figure 24 shows the percentage frequency of *S. baccularia* in various length classes for every destructive sampling from January 1995 to April 1996. In January 1995, length classes 50 - 99 mm shows the highest percentage frequency (54%) and gradually reduce to about 20% in July 1995, October 1995 and January 1996. On the other hand, length classes 0 - 49 mm shows a reverse trend. In January 1995, percentage frequency for length classes 0 - 49 mm is less than 10% and gradually increase to about 70% in October 1995. It reaches the maximum (80%) in January 1996 and reduces back to about 70% in April 1996. There is also a shift of maximum size frequency of *S. baccularia* population to the larger size classes from April 1995 to July 1995. If the growth rate obtained in the permanent quadrats studies was considered, then the shift is caused by the growth of the plants as the maximum growth rate was obtained in June 1995 (Figure 11a). On the other hand, the highest degenerative rate was obtained in July 1995 (Figure 11b), then again the maximum size frequency of the population tends to shift to the smaller size classes from July 1995 to October 1995. This shows a continuous recruitment of new plants after the growth season.

A similar trend was observed for *S. swartzii* population (Figure 33). Highest growth rate was obtained in June 1995 and February-March 1996 (Figure 15a) and the population had a higher size frequency in larger size classes in July 1995 and April 1996 (Figure 33). The highest degenerative rate obtained in September-October 1995 (Figure 15b), again the maximum size frequency was found in the smaller size classes. Thus, figures 24 and 33 show clearly the period of growth, reduction and recruitment of *S. baccularia* and *S. swartzii* populations although the lag period is three months.

Mean thallus length for both *Sargassum* species (*S. baccularia* = 66 mm and *S. swartzii* = 107 mm, in destructive sampling) in this study is lower than reported in other countries (Please refer Table 2). This is because of long desiccation periods occurring at the study site. The site is exposed during daytime lowtide (0.3 m or less above sea level) for about one to three hours for 145 times over the monitoring period. Exposure to air during daytime low tide results in loss of water from the thallus. Furthermore, daytime low tides are much more damaging during hot weather. This situation cause desiccation stress to the intertidal seaweeds especially those seaweeds found nearer to the shore where the plants are exposed longer to desiccation. As observed in the field, *S. baccularia* plants are more concentrated nearer shore. This explains why *S. baccularia* plants have a much shorter mean thallus length than *S. swartzii* plants. Hodgson (1984) noted that the growth rates decrease as a result of even a mild desiccation, and repeated exposures are even more deleterious than a single, more severe episode. Studies by DeRuyter Van Stevenick and Breeman (1987) also showed that wave exposure together with desiccation stress are probably responsible for high turnover rates that may cause the relatively small size of the intertidal plants of *S. polyceratium*.

5.2 Reproduction

In this investigation, the best growth and reproductive of *S. swartzii* occurred during period of higher water temperature (Table 14) and sunshine (Table 12), but not for *S. baccularia*. Thus, the *S. swartzii* population behave more like the *Sargassum* species reported by Tsuda (1972) in Guam, Prince & O'Neal (1979) in Florida, Ang (1985) in Philippines and De Ruyter Van Stevenick and Breeman (1987) in Curacao, Netherlands Antilles. However, this observation was in contrast to the generalisation made by De Wreede (1976) and McCourt (1984); most tropical *Sargassum* species reached maximum growth and fertility in the cooler months of the year. Please refer to Table 6 for more details on the seasonality of *Sargassum* species reported.

Over the 15-months monitoring period, *S. baccularia* was fertile only twice (January-February 1995 and June-August 1995, Figure 12) whereas *S. swartzii* was fertile three times (January-March 1995, May-November 1995 and March 1996, Figure 16), shortly after maximum size was attained. Ang (1985) reported that most *Sargassum* species in Balibago, Calatagan, Philippines were fertile from August to January except for *S. baccularia* (March-April). Studies by Rao and Indusekhar (1989) in India shows *S. Johnstonii* plants were fertile twice (December-January and May-June) whereas *S. tenerrimum* only fertile once (December-February). Another study by Martin-Smith (1993) shows reproductive maximal for the populations of *S. fissifolium* (Mertens) J. Agardh, *S. oligocystum* Montagne *and S. tenerrimum* J. Agardh in Magnetic Island, Australia, all occurred in February-May, and none or very few plants were fertile from June-December. Whereas for *S. linearlifolium* (Turner) C. Agardh, the reproductive maximal occurred in September/October and there was little reproduction between February and July (Martin-Smith 1993). This shows that the time of fertility and maximum thallus length are not necessarily the same from one year to another (De Wreede 1976).

Besides, De Wreede (1976) reported that biannual production of receptacles is rare in *Sargassum*. McCourt (1983) explained that the existence of two fertile periods in *S. sinicola* is an important feature of its phenology compared to a single season in *S. herporhizum* and *S. johnstonii*, and it might be caused by the different growth strategies adopted by the plants. Another study (Rao & Indusekhar 1989) shows relationship between the carbon (C), nitrogen (N) and phosphorus (P) ratios with the life cycle. The authors found that the N:P atomic ratio trend is opposite to C:N trend in *Cystoseira indica* and *S. johnstonii* with two reproductive stages in their life cycles (one year); whereas in *S. tenerrimum* with a single reproductive stage in its one year life cycle does not show this trend.

The percentage fertility is very low for *S. baccularia* compared to *S. swartzii*. The above observation might be attributed to the different distribution of both of the species on the reef flats. The *S. baccularia* plants were usually found nearer to the shore whereas *S. swartzii* plants were usually found 50 m from the shoreline and seaward. This is contrary to the earlier research done on the same site in 1987-1988 by Phang (1995), where the author found that *S. oligocystum (= S. swartzii)* dominated the heavily sediment areas whereas *S. baccularia* preferred the cleaner waters near the reef edge.

Generally, the lower limits of intertidal species are governed by biotic factors such as competition and predation (Schonbeck & Norton 1980) whereas upper limits are usually determined by physical constraints and in particular physical stresses due to exposure to the air (Schonbeck & Norton 1978). In this recent investigation, it was observed that *S. swartzii* plants could not withstand the long hours of exposure time to the sun as compared to *S. baccularia*. This might be attributed to the morphological appearance of the plants. The branches of *S. swartzii* plants are flattened which means a larger surface area will be exposed as compared to

S. baccularia plants. As pointed out by Dromgoole (1980) that water loss is more closely associated with the ratio of evaporating surface area to volume of a thallus.

S. swartzii plants had been observed in the field under severe desiccation when the reef flats were exposed during daytime (tides = 0 or 0.1 m above sea level). When the tide returns, the waves tend to break the branches from the plants. As for *S. baccularia* plants, the plants were usually covered by epiphytes which provide protection from excessive desiccation (Ang 1985). Phang (1989) recorded the highest occurrence of epiphytes at Cape Rachado in March. This period coincided with the longest exposure time where the reef flats are completely exposed to the sun about one to three hours (tide = 0.3 m or less above sea level) for seventeen times in March 1995 and sixteen times in March 1996. This might explained why *S. swartzii* plants preferred a seaward habitat where the plants can be always submerged in the water. Thus, the species have a longer period of fertility.

As for *S. baccularia,* the environment did not favour a long period of fertility. Therefore, the plants as seen in the field, reproduce vegetatively where new plants arise from the rhizoid. This will avoid the massive loss of biomass in the sexual reproduction (Espinoza & Rodriguez 1987) besides having a strong hold onto the substrate (dead corals).

Furthermore, vegetative branches grow five times faster than branches bearing sexual structures (Norton 1977).

Besides, as observed in the field, seasonal algae like the browns (*Dicyota, Padina* and *Turbinaria)* and the green (*Caulerpa*) species appear at the reef flats and dominate from January 1996 to February 1996. As pointed out by McCourt (1983), regrowth from a prostrate mat of haptera is probably adaptive in recolonising an area after any kind of disturbance that does not kill entirely. For example, *S. herporhizum* with its rhizoidal holdfast and ability to rapidly and effectively grow over the substrate, may be competitive dominant for space in this type of habitat.

Therefore, there are two modes of reproductive pattern involved :

(a) reproduce vegetatively through haptera encroachment of basal holdfast as shown in *S. baccularia* (with only a small percentage of plants bearing receptacles). This mode of reproduction enable the species to strive better in the extreme intertidal area.

(b) sexually through the shedding of fertile, receptacles-bearing branches as shown in *S. swartzii* plants. This enables the branches to float and disperse propagules to a greater distance (Deysher & Norton 1982). The same incident was observed by Ohno (1984), where the floating seaweeds (*Sargassum* species) appear mainly at the time of maximum growth and reproduction of each species.

Similar reproduction strategies are seen in three *Sargassum* species in Hawaii. *S. herporhizum* invests mostly in vegetative reproductive structures (holdfast haptera) and engages in relatively little sexual reproduction, whereas *S. sinicola* and *S johnstonii* display a reversed pattern of reproductive tissue production (McCourt 1985).

A significant positive correlation was found between the number of plants bearing receptacles and mean thallus length for both *Sargassum* species. Thus, the plants became fertile when the longest thallus length was attained. McCourt (1984) explained that the reproductive output in a growing season could be minimized if plants became fertile after maximum size is reached; larger plants bore more fertile branches with receptacles. Same phenomenon was noted for *S. polycystum* in Guam (Tsuda 1972), *S. siliquosum* and *S. paniculatum,* (Ang 1984) and *S. siliquosum* and *S. polycystum* (=*S. myriocystum*) (Largo & Ohno 1992) in Philippines, *S. fissifolium, S. oligocystum, S. tenerrimum and S. linearifolium* in Australia (Martin-Smith 1993).

Both *Sargassum* species investigated have lower percentage fertility (*S. baccularia* : 16% in permanent quadrats studies and 0.44% in destructive sampling, *S. swartzii* : 60%, in permanent quadrat studies and destructive sampling) as compared to other tropical species reported. Ang (1985) recorded 78% fertility (October) for *S. siliquosum* and 82%

fertility (late November) for *S. paniculatum* in Philippines. 100% receptacles occurrence were recorded in November for *S. siliquosum* in Cebu, Central Philippines (Largo & Ohno 1992). Espinoza and Rodriguez (1987) explained that *S. sinicola* plants in Las Pacas are less reproductive because of their smaller size considering that reproduction individuals can be restricted or are more frequent in larger plants (Fletcher & Fletcher 1975; McCourt 1985). Average thallus length for both *Sargassum* species investigated, either from the permanent quadrats or destructive sampling, are shorter than reported in the literature (Please refer to Table 2).

5.3 Standing Crop

Both *Sargassum* species attained two peaks in standing crop over the 15-month quarterly monitoring. *S. baccularia* population peaked in January 1995 and July 1995, whereas *S. swartzii* population peaked in July 1995 and April 1996. The lowest standing crop for both *Sargassum* species was attained in January 1996.

De Wreede (1976) found that twelve of the fifteen tropical *Sargassum* species reviewed, showed seasonal peaks in standing crop, length and/or fertility between November and March. Contrary to the findings, Ang (1985) found seasonal peaks in growth, standing crop and subsequent reproduction in *S. siliquosum* and *S. paniculatum* between July and

November in Philippines; and De Ruyter Van Steveninck and Breeman (1987) found peak growth rates and biomass of *S. polyceratium* in August-September in Curacao, Netherlands Antilles. In Australia, Martin-Smith (1993) showed that maximum increase in biomass occurred for *S. fissifolium* in October, *S. linearlifolium* in May, *S. oligocystum* in November and *S. tenerrimum* in September.

The value of the highest standing crop obtained for *S. baccularia* (0.5 kg WW m^{-2}, 0.06 kg DW m^{-2}, July 1995), and for *S. swartzii* (0.7 kg WW m^{-2}, 0.08 kg DW m^{-2}, April 1996) are relatively low (approximately 10 times lower) as compared to the standing crop of *Sargassum* species reported in Philippines (Table 14). The results are comparable to the studies done by Phang (1995) at the same site in 1987-1988.

Table 14. Standing crop reported in Philippine and Cape Rachado.

Location	Species	Standing crop	References
Philippines	*Sargassum*	0.4 kg DW m^{-2}	Ang 1984
Philippines	*S. crassifolium* *S. polycystum* *S. cristaefolium* *S. oligocystum*	0.6 kg DW m^{-2} 0.4 kg DW m^{-2} 0.4 kg DW m^{-2} 0.3 kg DW m^{-2}	Trono & Luisma 1990
Philippines	*S. siliquosum* *S. polycystum*	7 kg WW m^{-2} 3 kg WW m^{-2}	Largo et al 1994
Cape Rachado (Site C)	Algal biomass	0.1 kg DW m^{-2}	Phang 1995

The number of plants collected during the peak biomass for *S. baccularia* (14 g AFDW m^{-2}, July 1995) and *S. swartzii* (15.25 g AFDW m^{-2}, April 1996) are 373 and 67, respectively (Appendix 8 and 11). There is a difference exists in the mean thallus length (*S. baccularia* = 127.92 mm and *S. swartzii* = 160.91 mm). Although the standing crop attained for both *Sargassum* species is almost the same, the number of plants involved for *S. swartzii* are almost 5.6 times lower than *S. baccularia*.

This observation can be explained by :

a) The morphological appearance : *S swartzii* plants are usually larger in appearance and with more lateral branches as observed in the field. Therefore, standing crop increase appear to be contributed by the increase in the weight of the individual plants.

b) The plants are usually submerged in the water (usually found seaward, Figure 30), this prevents severe desiccation when the reef is exposed during the extremely low tides. Thus, a longer mean thallus length was recorded. Phang (1995) found that biomass nearer to the shore was lower than that nearer the reef edge, possibly arising from the effect of the longer duration of exposure at low tides. This is true for *S. swartzii* population (Figure 29) where significant difference was found between biomass nearer to the shore and further from the shore in all destructive samplings except in January 1996 (Table 11).

c) The presence of receptacle-bearing lateral branches at this time (60% plants are fertile). Largo and Ohno (1992) observed that the standing crop of *S. myriocystum* and *S. siliquosum* increases as the plants became fertile.

d) The distribution of the seaweeds. The seaweeds were physically smaller and shorter near the shore. In this case, refer to *S. baccularia.* Same observation was seen by Phang (1995) at the same site for *S. baccularia, Turbinaria conoides* and *Padina* where the plants are usually physically damaged.

A strong correlation was found between the standing crop and mean thallus length and number of plants bearing receptacles for *S. baccularia* (r=0.9777, 0.7302, respectively) and *S. swartzii* (r=0.8593, 0.6267, respectively). Results are based on ash-free dry weight as it is a more accurate measurement and show a better estimate of growth as compared to the wet weight and dry weight (Brinkhuis 1985). Therefore, the peaks occurred at the same time for the standing crop, thallus length and reproductive period, and vice versa. This is a phenomenon typical to *Sargassum* species as reported by various authors. Tsuda (1972) reported that *S. duplicatum* (=*S. cristaefolium*) peaked in size and abundance at the same month in Guam. De Wreede (1976) reported that the *Sargassum* species have a peak fertility coinciding with the peak in abundance. De Ruyter Van Steveninck and Breeman (1987) recorded the peak biomass, growth rates, plant size and proportion of fertile *S. polyceratium* plants occurred between late summer to early autumn in Curacao, Netherlands Antilles.

Generally, the biomass for both *Sargassum* species peaked in July 1995 and the lowest in January 1996; another peak occurred in January 1995 for *S. baccularia* and April 1996 for *S. swartzii*. Cross-correlation analysis (Table 15) showed a strong correlation between the biomass for both *Sargassum* species with the water and ambient temperature, and rainfall. Phang (1989) recorded that the peak abundance of *Sargassum* and *Turbinaria* species at Cape Rachado occurred in the intermonsoon seasons. Again, studies carried out in 1987-1988 revealed that the algal biomass at Cape Rachado peaked around August and March which correspond to the hot and dry inter-monsoon periods (Phang 1995). Tsuda (1971) reported that the disappearance of *S. duplicatum* in August on the reefs of Guam probably attributable to the onset of the rainy season and exposure from the sun. Thus, the wet season (July-November) would not be a favourable season for the growth of the intertidal species (Tsuda 1971; 1977 in Payri 1987). In contrast, Thomas and Subbaramaiah (1991) recorded significant positive correlation between *S. wightii* plants with rainfall. This study showed peak biomass for both *Sargassum* species occurring in the high water temperature (33°C in July) and wet season (306 mm rainfall in July) which supported the observation made by

Thomas and Subbaramaiah (1991) but contrary to the others observations reported. This observation is questionable as only quarterly sampling (every three months) was done, and there might be another peak in between, but the effect of rainfall as an important factor governing the seasonality in *Sargassum* abundance and reproduction cannot be denied as shown in the simple correlation and cross-correlation analyses (Table 14 and 15), where the increase in fertility rate was influenced by the increase of rainfall (r = 0.7619 for *S. baccularia* and r = 0.8686 for *S. swartzii).*

5.4 Environmental Parameters

Environmental factors have long been recognised controlling the seasonality of seaweeds (Luning 1990; Luning & Dieck 1989; Lobban & Harrison 1994; Chapman 1995).

Environmental factors did not show a strong effect in the growth rates of both *Sargassum* species in the nondestructive (permanent quadrats) studies as revealed by the simple correlation analysis (Table 12), whereas the environmental factors seemed to play an important role in biomass, thallus length and reproduction in the quarterly destructive sampling (Table 14). In order not to overlook the effect of the environmental factors , a time series analysis, cross-correlation was done for both nondestructive sampling (Table 13) and destructive sampling (Table 15). The results are interesting, because the effect of some of the factors which are not shown in the simple correlation analysis was given by the cross-correlation with a lag period.

Doty (1971) reported that the size of a standing crop may be closely related with the past environmental conditions than with those measured concurrently with the harvest. McQuaid (1985) recorded highest correlation with abiotic factors after a lag period for six of the nine species (*Gelidium pristoides, Gigartina radula, Porphyra capensis, Gigartina stiriata, Pterosiphonia cloiophylla, Arthrocardia* sp., *Centroceras clavulatum, Nothogenia erinacea and Ulva* sp.), indicating that biomass correlated more closely with conditions prior to, rather than during, collection. The author also reported the closest correlation with all three abiotic factors (tide, light and temperature) which occurred at 0 - 4.5 months lag. The highest level of significance for both total crop and *S. polyphyllum* in Hawaii was found when regression was done against temperature three to four weeks antecedent to harvest (Glenn *et al.* 1990). The authors indicated that the proportion of variability in the standing crop that could be explained by temperature was only 0.23 to 0.29 when the concurrent week's temperature were used, but rose to 0.65 when the third antecedent week's temperatures were used.

November is the monsoon month with heavy rain (318.7 mm) and strong waves, with a high turbidity (field observation) which are detrimental to the growth of seaweeds. Biomass for both *Sargassum* species is the lowest in January 1996 with a high percentage of plants (79% for *S. baccularia* and 71% for *S. swartzii*, Figure 24 and 33) in length classes 0 - 49 mm. On the other hand, the lowest mean thallus length is recorded in December 1995 for *S. baccularia* (27 mm, Figure 10) and in late November for *S. swartzii* (16 mm, Figure 14) in permanent quadrat studies. Similar observation was noted by Phang (1989) at Cape Rachado where the author found that heavy rains accompanied by strong waves, especially in November are detrimental to both macroalgae and their epiphytes and the abundance of both was observed to be very low at this time. De Paula and De Oliveira (1982) found that the *S. cymosum* C. Agardh population in the rocky intertidal area of Sao Paulo, Brazil are smaller and shorter in wave exposed situations. Ohno *et al.* (1995) noted that a high percentage of lost branches can be due to the mechanical tearing by water moments, grazing by certain organisms or attachment of epiphytes.

Increase in standing crop and mean thallus length of *S. swartzii* population are influenced by the increase in water temperature, and decrease in ammonia and nitrate content (Table 14) in the seawater, but not for *S. baccularia* population. *S. sinicola* from two study sites in the southern

Gulf of California, Mexico reached greater lengths when nitrate concentration and temperature were minimal (Espinoza & Rodriguez 1987). In contrast, *S. pteropleuron* from southern Florida reached annual maximum growth rate when nitrate concentration and water temperature were high (Prince & O'Neal 1979).

S. baccularia population is influenced by different environmental factors compared to *S. swartzii* population. Increase in standing crop and mean thallus length of *S. baccularia* population are influenced by the increase in water phosphate content, and decrease in pH and solar radiation.

The increase of mean thallus length of *S. baccularia* population are significantly correlated to the increase of water phosphate content ($r = 0.6254$, Table 14), but not for *S. swartzii* population. Same findings are seen in the *Sargassum* species reported in Philippines by Ang (1985) where significant correlation was found between the maximum plant growth and high water phosphate content.

The increase in biomass of *S. baccularia* population is significantly correlated to the decrease of pH and radiation. In contrast, Thomas and Subbaramaiah (1991) reported significant positive correlation between biomass of *S. wightii* plants with pH.

5.5 Appraisal Of Project / Future Areas For Research

Brown seaweeds have a very high commercial value as sources for alginic acid, fertiliser and animal feed besides serving as an important spawning, nursery, feeding ground for many marine organisms. Seaweed beds also protect the coastline from excessive erosion. This research involved *Sargassum* species which serve as an important source of alginic acid, fertiliser and animal feed in India (Shunula 1988; Thomas & Subbaramaiah 1991) and Philippines (Ang 1984,1985; Trono & Lluisma 1990). Besides, this species has medicinal value (Tseng & Chang 1984).

This is the first phenological studies on seaweeds in Malaysia. This preliminary study will provide some baseline data on the general behaviour of seaweeds in the west coast of Peninsular Malaysia realizing the lack of information on this rich resource found along the coastline of Malaysia (Arumugam 1981; Crane 1981; Phang 1984, 1986, 1988, 1995).

The *Sargassum* species investigated in this study show seasonality in the growth, standing crop and reproduction. The environmental factors show strong influence in governing the seasonal cycle of these species. Information on standing crop indicates if the population biomass is enough for collection from the wild populations or cultivation needs to be carried out. The seasonality shown by the species serve as an important baseline data in establishing the best time for harvest without destroying much of the wild stocks. Knowledge of the natural behaviour of the seaweeds and the controlling factors (environmental factors) involved are important for the successful cultivation or seaweed farming (mariculture) programmes. Furthermore, these information are very useful for both conservation and the sustainable use of this species for commercial purposes.

The study site, Cape Rachado is a very important ecosystem (coral reef flats) that still exist on the west coast of Peninsular Malaysia. The mangrove forest that once existed here has already given way to the rapid development and construction in the area. But, the coral reef still harbours a high diversity of marine organisms like the soft and hard corals, fishes, sea cucumber (Goh & Sasekumar 1980), marine epiphytic algae (Phang 1989) and algae (Phang 1995). Unfortunately, this is also a tourist destination, so human activities and water sports that are popular at this site are detrimental to the life-forms here as the reef flats are easily accessible. This area should be categorized under conservation status and enforcement should be carried out by the Fisheries Department to conserve the valuable resources that still exist.

The life history of the seaweeds is an important aspect in the cultivation or mariculture and harvest of this resource. Extensive research and mariculture has been carried out by countries like China, Japan, Korea, Philippines and Indonesia where seaweeds are an important source for the industries. Therefore, seaweeds have a great potential for industrial exploitation with increasing demand in the national and international markets. Malaysia with its rich resources is still lacking behind compared to the other countries. Therefore, more effort and research should be focused on utilising these resources.

Areas for future research :

1. Establish the importance of the seaweeds bed as an alternative nursery ground for fisheries to the mangrove ecosystem.
2. Study the use of seaweeds in establishing artificial reefs to maintain a high diversity of marine organisms as well as in controlling coastal erosion.
3. Screen for useful bioactive compounds that can be found in the seaweeds for future pharmaceutical and industrial purposes.
4. Study the ecological aspects like the interaction between the predators and plants (herbivory) which are very important aspects in the mariculture.