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Phenology of Two Species of Brown Seaweeds, *Sargassum myriocystum* J. Agardh and *Sargassum siliquosum* J. Agardh (Sargassaceae, Fucales) in Liloan, Cebu, in Central Philippines

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Abstract : Two species of *Sargassum* (*S. myriocystum* J. Agardh and *S. siliquosum* J. Agardh) were studied for their seasonal variation in length, weight and reproductive conditions in Liloan, Cebu in central Pilippines from August 1988 to July 1989. *Sargassum myriocystum* varies in length of the lateral branches from 29 to 68 cm (average of 42 cm) while *S. siliquosum* has a range of 32 to 74 cm (average of 48 cm). Both species attained their maximum length in December during the period of low water temperature. In terms of wet weight *S. myriocystum* attained its maximum of 533.93 ± 29.57 g in December coincidng with the period of maximum length. In Contrast *Sargassum siliuosum* reached its maximum weight of 184.87±75.14g in November when the plants have 100% receptacle occurrence and high number of lateral branches. Increase in length and biomass in both species were hampered by monsoon- generated waves in which the area is exposed to. High percentage of incomplete plants, however,can be attributed both to the plants' period of decline after full maturation starting in August to November for *S. myriocystum* and from October to February for *S. siliquosum.*

Key words : Ecology ; *Sargassum myriocystum* ; *Sargassum siliquosum* ; Philippines

Introduction

Sargassum grows abundantly in the tropics where it attain very higih biomass. *Sargaassum* beds are known as important nursery grounds where a large number of animal organisms including species of commercial value such as fishes, shrimps, crabs, molluscs and others live. They are an important source of alginates and alginic acids used in many industrial products such as fabrics, cosmetics foods, etc. In view of these importance, it is necessary to know the ecology of this seaweed.

The genus *Sargassum* has about 400 species distributed in the subtropical and tropical waters in the world (Noro, 1989). The Philippines has about 80 species (Silva et al. 1987). Growth rate studies of this genus in the Philippines is very limited perhaps, in part, due to the difficulty of their taxonomy and their being usually found in wave-tossed habitat. This report is a year study of the *Sargrassum* communities in Central Visayas, specifically in Liloan, Cebu coastal water. Previous ecological surveys were made in Mactan Is. in November, 1985 (Ohno et al, 1987) and again in January to February in 1988 (Ohno et al, 1989) and in Zamboanga in Mindanao, Palawan, and Pangasinan in Luzon from January to February, 1988 (Ohno, et al, 1989).

Materials and Methods

The study site was in Liloan, about 15 km north of Cebu City (Fig. 1) where *Sargassum* is a common tidal seaweed. Two common species were observed in this area namely, *Sargassum myriocys-*

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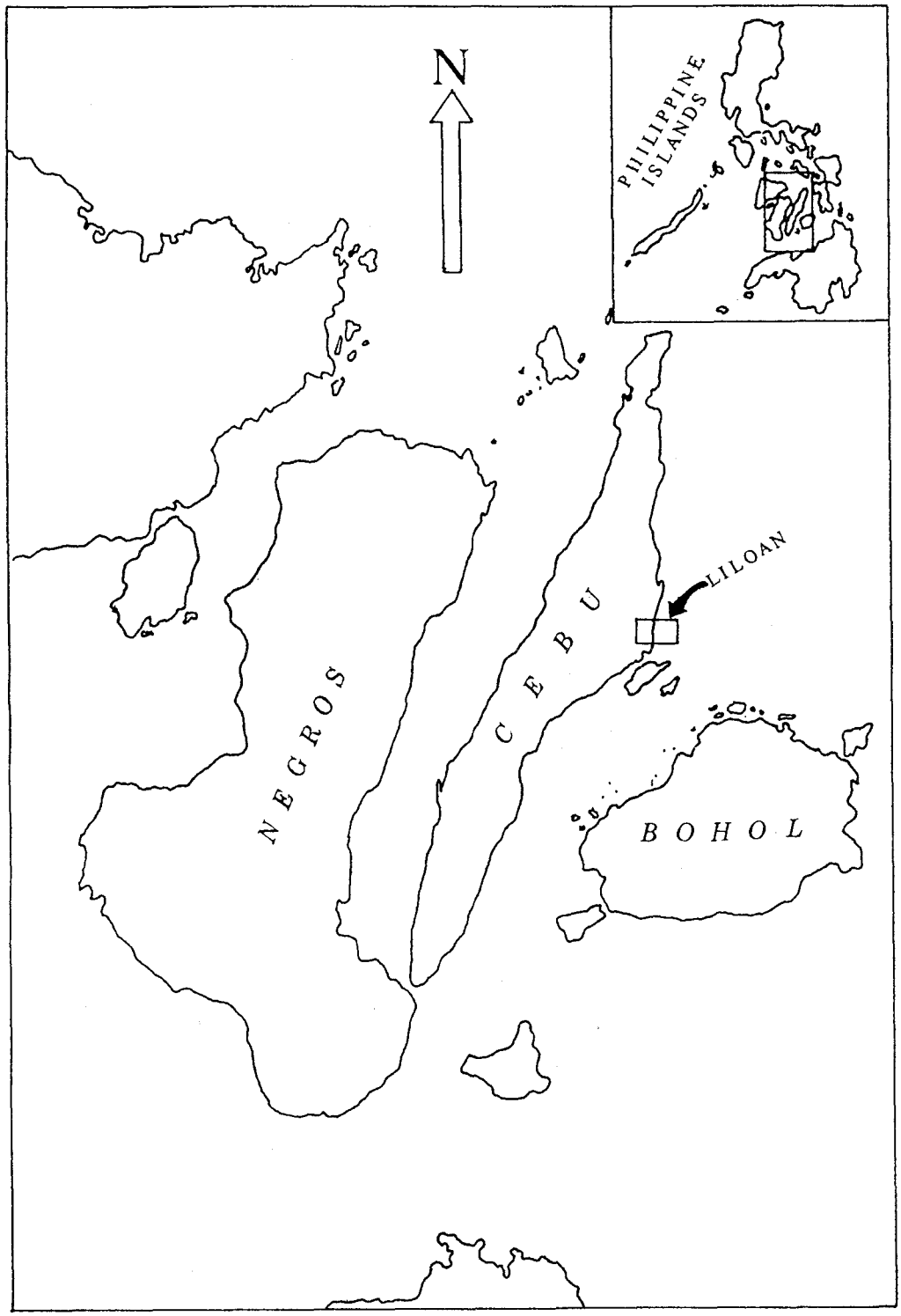

Fig. 1. Map of Central Philippines showing the study area.

tum and *Sargassum siliquosum* (Fig. 2). The two species were studied for their growth in terms of length and weight, and their reproductive state from August 1988 to July 1989. About 10 plants of each species were collected randomly each month. Soon after collecting the materials were brought to the University of San Carlos Marine laboratory at Talamban campus where measurements were made. Growth was determined by measuring the thallus length from the stipe to the tip of the primary lateral. Individual weight of each branch and number of lateral branches arising from the stem or stipe were also measured. Finally, water temperature and salinity in the area were measured during the monthly sampling.

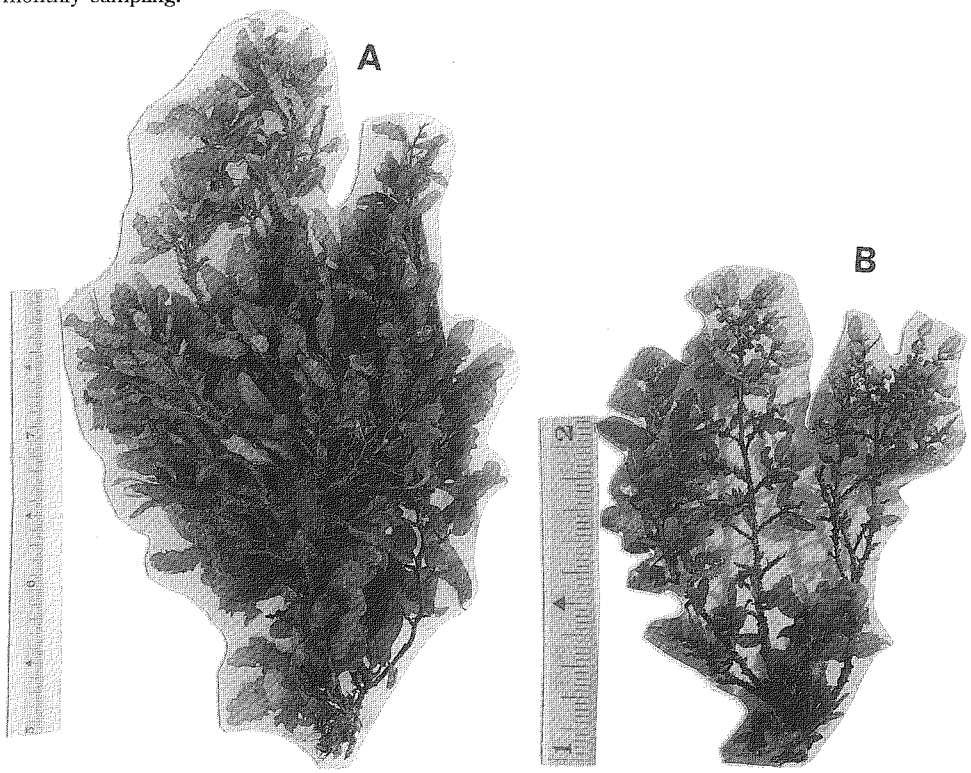

Fig. 2. A : *Sargassum siliquosum* J. Agardh. B : *Sargassum myriocystum* J. Agard from Cebu.

Results

Monthly measurements of water temperature and salinty over a year period in Liloan are shown in Table 1. Temperature ranged from 27 to 32 ℃ wherein the lowest were in the months of December 1988 to March 1989. This period coincides with the so-called Siberian cold front (cold southeasterly winds coming from continental Eurasia). High temperatures were recorded between April and September. Salinity have a narrow range from 33 and 35 parts per thousand which could be due to the well-mixed condition of the shallow water. In tidal pools, however, salinity could be as high as 45 parts per thousand.

The tidal area in Liloan (Fig. 3) is divided into three distinct zones namely, a seagrass zone (mainly *Cymodocea rotundata*) starting about 10 meter from the shore, followed by a rocky flat with some algal growths mainly *Padina* (50 - 100 m), then followed by the *Sargassum* zone that extends to the subtidal water at about 4 meters depth (110 - 155 m). The *Sargasssum* bed in turn is divided into 2 distinct species zone. That of the lower intertidal portion is dominated by *Sargassum myriocystum*

Table 1. Monthly temperature and salinity of surface water in the study site from August 1988 to July 1989.

Date	Temperature ℃	Salinity ‰	
August 27	31	35	
September 17	31	35	
October 19	30	34	NE monsoon
November 16	29	34	NE monsoon
December 11	27	34	NE monsoon
January 14	28	34	NE monsoon
February 20	28	34	
March 12 27	33		
April 7	31	35	
May 7	32	33	
June 10	30	34	
July 15	31	35	

followed in the upper subtidal mainly by *Sargassum siliquosum.*

Other species of *Sargassum* (e.g. *S. oligocystuem*) and other brown algae were also present although they are of less significance.

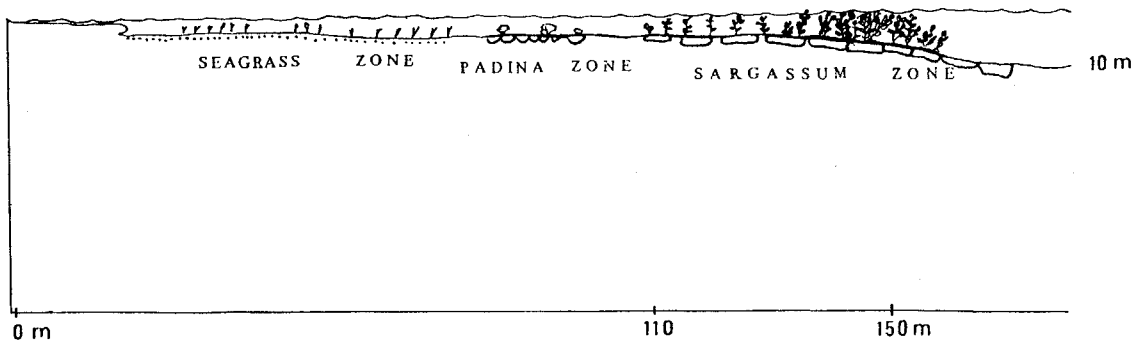

Fig. 3. Vertical profile ilustration of the tidal zone in Liloan.

The two species of *Sargassum* were present in the study area all year round with seasonal variation in lengths of the lateral branches (Fig.4)

In *Sargassum siliquosum,* the average length was 48.04 cm but showed a wide range from 32.61 cm 74.61 cm while for *Sargassum myriocystum,* the average length 42.64 cm with a range of 29.54 to 68.96 cm was recorded. Both species grew to their maximum lengths in December 1988 where the water temperatures were at the lowest. From the initial sampling month in August 1988, an increasing trend in the length of the lateral branches were noted for the two species. Slight drops were observed in September and November also for both species. The latter month coincides with the onset of the monsoon season. During the month of December, *Sargassum siliquosum* attained its maximum length of 74.61 ±26.02 cm. It declined abruptly to 51.52 ±23.66 cm in January 1989, and furthermore towards April where it reached its minimum length of 32.61 ± 8.95 cm. The decline period coincided with warm summer months and post-maturation period of this species.

Sargassum myriocystum had a primary lateral measured at 30.4 ± 6.08 cm during the first sampling in August 1988. This length declined early to its shortest of 29.54 ± 5.96 cm in September.

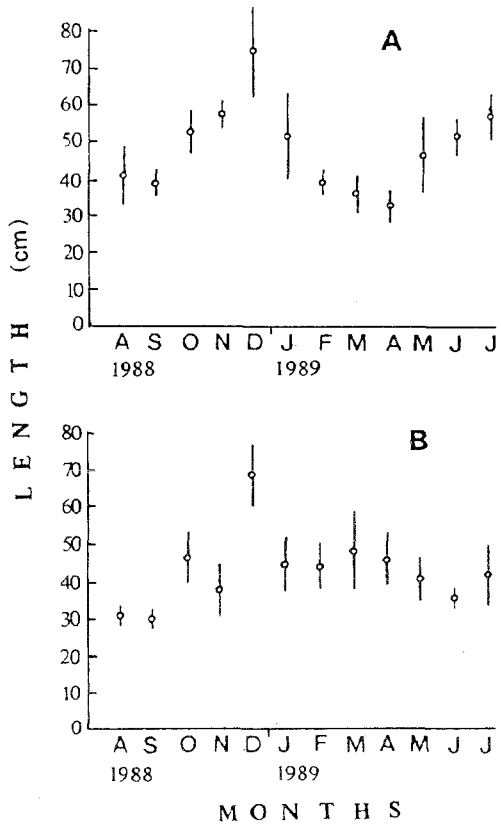

Fig. 4. Monthly variation in the mean length of *Sargassum siliquosum* (A) and *Sargassum myriocystum* (B) from August 1988 to July 1989. Vertical lines represent standard deviation.

It then increased abruptly in October with length of 46.26 ±14.17 cm. With the onset of the monsoon season it dropped again to 37.31 ±14.46 cm in November. Its maximum length was likewise attained in December (65.71 ±17.96 cm) but was followed by an abrupt decline in January 1989 with 44.34 ±16.49 cm, and further, slightly, to February with 43.62 ±12.61 cm. Another slight increase was noted in March (48.02 ±21.10 cm) and, again, followed by a consistent decrease towards June, with 35.08 ±6.47 cm before it grew once more in July with 41.81 ±17.80 cm.

In terms of length classes, the structure of the population of the two *Sargassum* species also varied seasonally (Figs.5.6). For *Sargassum siliquosum*,the lateral branches seem to cluster in between 10 and 60 cm length classes, with high frequency in the 30 and 40 cm length classes. Monthly measurements revealed an increasing trend in length classes towards the period of maximum primary lateral lengths (August - January) and a drop in periods of decreasing lengths of lateral branches (February -May 1988). In contrast to *Sargassum siliquosum*, *Sargassum myriocystum* has plants which are distributed in the various length classes without coinciding with the periods of increasing and declines in lengths of primary laterals.

There seems to be differences in the seasonal variations in weight of the two species studied (Fig. 7) and these appeared to be related to the changes in the number of lateral branches (Fig.8), the appearance of receptacles, the condition of the lateral branches (whether complete or incomplete), and to some extent, the appearance of epiphytic algae. In *Sargassum siliquosum*, maximum

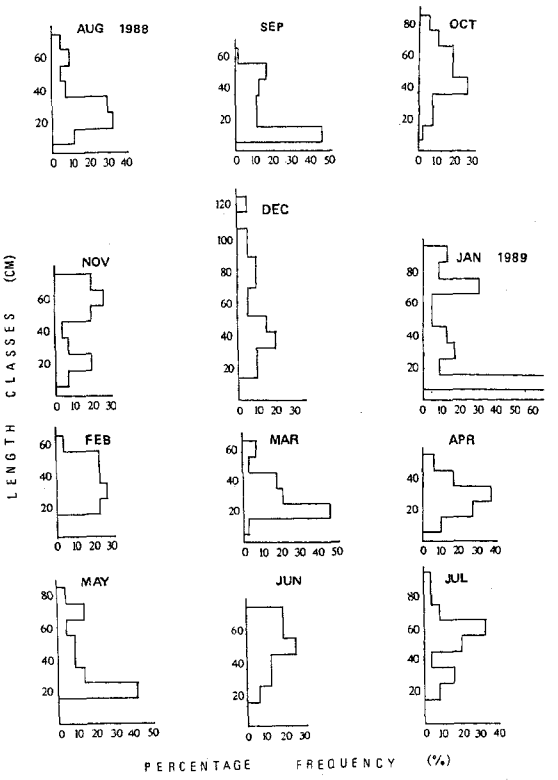

Fig. 5. Percentage frequency of length classes of *Sargassum siliquosum from* August 1988 to July 1989.

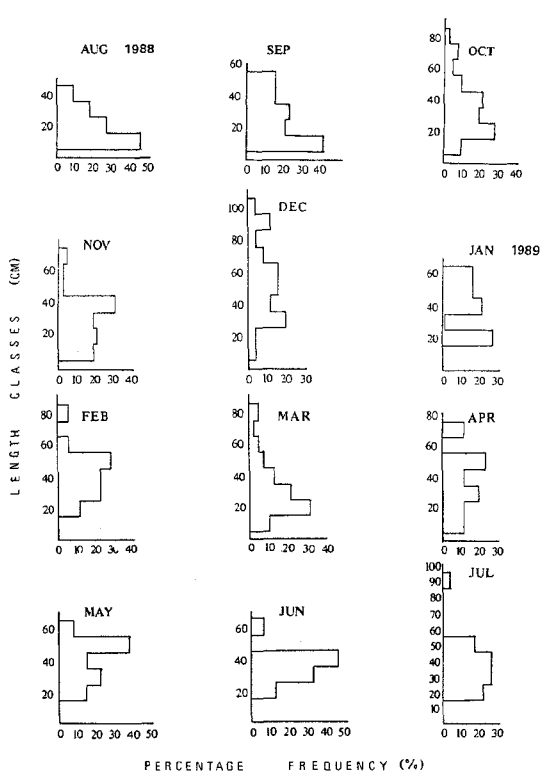

Fig.6. Percentage frequency of length classes of *Sargassum myriocystum* from August 1988 to July 1989.

wet weight (184.87 ±75.14 g) which was attained in November coincided with a relatively high number of lateral branches and a high occurrence of receptacles (100%). The weight decreased considerahly in the succeeding months where it reached its minimum in January (53.03 ±41.60 g) when the monsoon-generated waves have cropped a large proportion of the primary and second-order laterals. A shift in biomass production was recorded in the succeeding months from February to April (second peak, with 117.17 g) with a relatively high standard deviation (±63.11 g). In May, another drop was recorded (56.38 ±46.97 g) due to a decrease in the number of lateral branches and the decline of the mature plants. As a result of the increasing length of lateral branches and a more stable water movement in summer, gradual increase were recorded in the succeeding months until then last sampling period in July.

For *Sargassum myriocystum*, weight variations followed fairly closely with the variations in length (Fig. 9.10). There were two peaks observed. First was on December (39.61 ±15.46 g) which coincided with the maximum length, and the second and the maximum, on March (33.93 ±29.57 g) which coincided with the second maximum length. Mximum weight was attained with the full maturity of the plants (100% receptacle occurrence). A decline in weight in the following months until it reached its lowest in May (13.58 ±8.73 g) is attributed to the declining length and the plants long summer exposure at low tide. *Sargassum myriocystums* upper distribution limit is in the lower intertidal zone which is more exposed to dessication especially in the summer sunlight. The upward trend in June to the last sampling period in July likewise coincided with the increase in length cou-

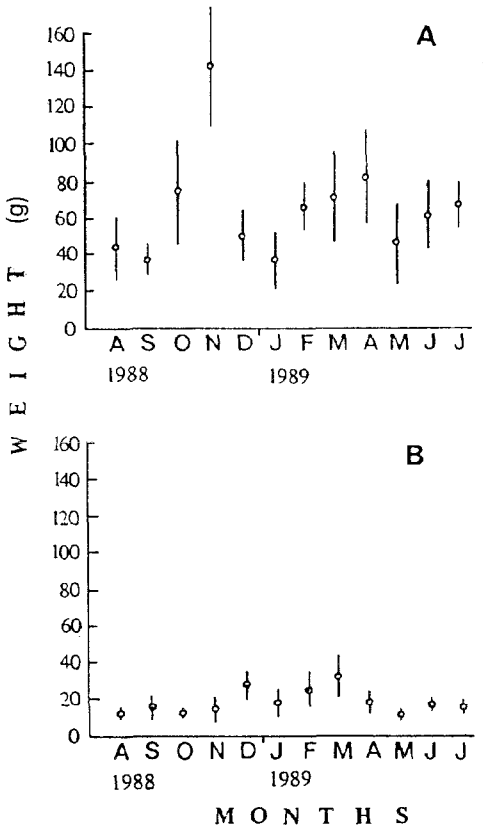

Fig. 7. Monthly variation in the mean weight of the main lateral branches of *Sargassum siliquosum* (A) and *Sargassum myriocystum* (B) from August 1988 to Jly 1989. Vertical lines represent standard deviation.

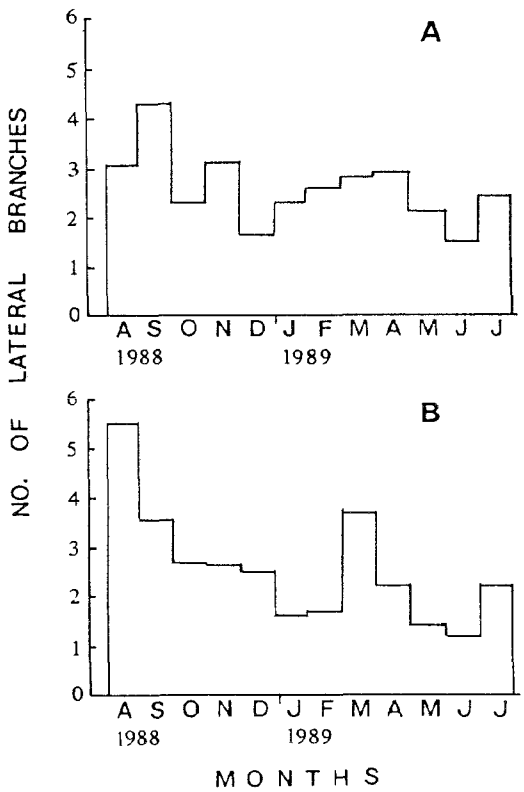

Fig. 8. Monthly variation in the number of lateral branches of *Sargassum siliquosum* (A) and *Sargassum myriocystum* (B) from August 1988 to July 1989.

pled with a more stable water condition in this period.

Stipe-plus-holdfast varies in length and weight with short down- and uptrend which could be likely due to sampling population from different patch. In *Sargassum siliquosum*, shortest lenghs were observed in February to April (11 mm) which abruptly grow in the succeeding months, until it reached its peak in July (3.70 cm). Weight increase did not seem to be related with increase in length. After plants declined, new growths replace old ones on the same holdfast. Weight increased with new individuals recruited few months earlier on the same holdfast. *Sargassum myriocystum* had maximum weight in August with yet newly recruited individuals (period of shortest length). Weight decreased with increasing length in stipe and lateral branches.

The two species of *Sargassum* did not reach full maturity at the same time based on the frequency of occurrence of their receptacles (Fig.11-12). *Sargassum siliquosum* started to produce receptacles in August. It became fully mature in November (100% receptacle occurrence) and started to decline in March to June. In July, no reproductive plants were observed. The abrupt low frequency of occurence in September could be a result of sampling at different plots. In contrast to the former

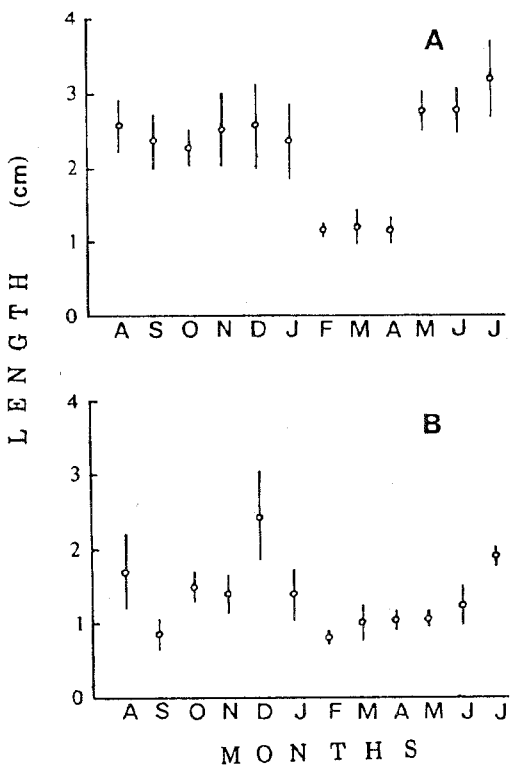

Fig. 9. Monthly variation in the mean length of stipe- plus-holdfast of *Sargassum siliquosum* (A) and *Sargassum myriocystum* (B) from August 1988 to July 1989. Vertical lines represent standard deviation.

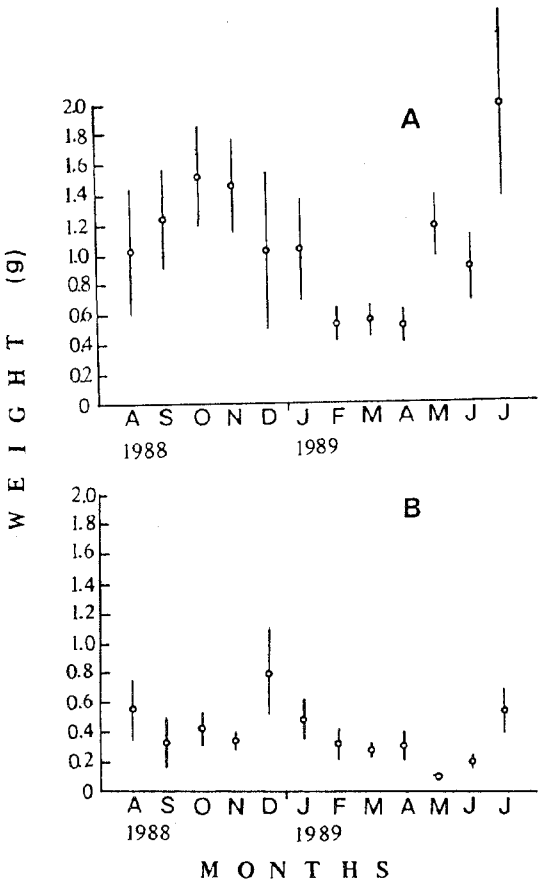

Fig.10. Monthly variation in the mean weight of stioe-plus-holdfast of *Sargassum myriocystum* (A) and *Sargassum myriocystum* (B) from August 1988 to July 1989. Vertical lines represent standard deviation.

species, *Sargassum myriocystum* started to produce receptacles in September. Full maturity, however, did not occur until March, although this could have started early in December. Nevertheless, maturity of this species was protracted until July in contrast to the other species. In August the plants were replaced by immature individuals. The absence of receptacles in November is difficult to explain but could be an overlook during observation and examination. In the later part of the reproductiv period the main branches of the two species started to decay from their tips.

The frequency of incomplete plants (Fig.12) is closely related to the maturity of the plants in both species and monsoon-generated water movements. The lateral branches of *Sargassum siliquosum* plants were "cut off" by violent wave action in October and November resulting to high frequency of incomplete plants tips in November (80%). *Sargassum myriocystum* had a high frequency of incomplete plants in April and May (both with 90%) which is attributed to enhanced decay of plant parts by exposure to high water temperature during these summer months.

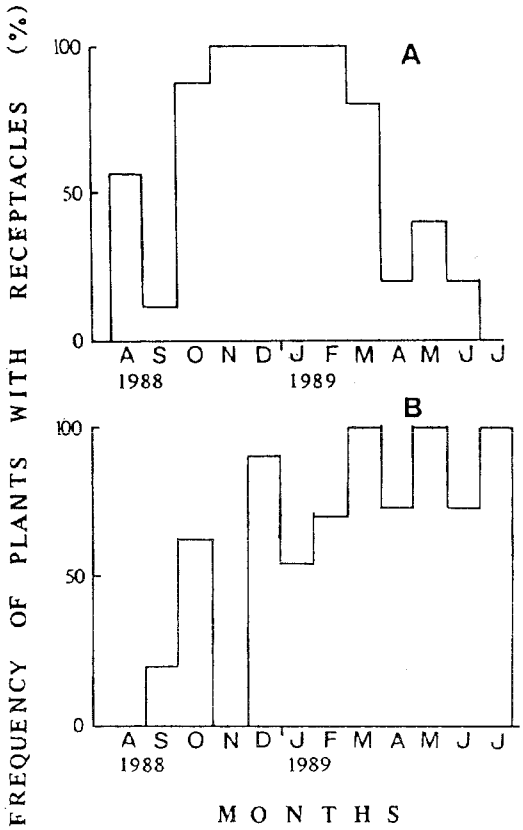

Fig.11. Percentages of plants of *Sargassum siliquosum* (A) and *Sargassum myriocystum* (B) with receptacles from August 1988 to July 1989.

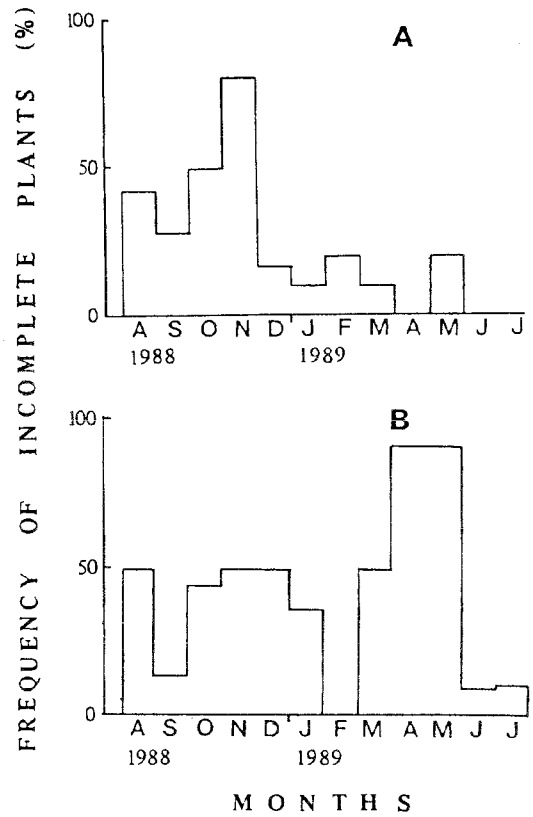

Fig.12. Percentages of incomplete plants of *Sargassum. siliquosum* (A) and *Sargassum. myriocystum* (B) from August 1988 to July 1989.

Discussion

Sargassum myriocystum and *Sargassum siliquosum* occur all year round in Liloan, Cebu where temperature and salinity are in the optimal range. However, active growth in this area takes place during the colder months. Both species attained their maximum length in December and slowed down in the following months (February to April) when the thalli start to become senescent. In a previous study on the *Sargassum* community in Mactan Is. in 1985 by Ohno (1987), the average thallus lengths of *Sargassum* species which ranged from 16 to 78 cm is quite similar to this study. In another studies, however, it varies according to species. For instance in Balibago, Calatagan, *S. siliquosum* and *S. paniculatum* attained maximum length of 126.7 ±38.3 cm and 88.7 ±23.9 cm, respectively in November (Ang 1985). Some other species in the same area attained maximum length in September.

Sargassum siliquosum in this study which is limited in the subtidal portion only, starts to regenerate in summer with less than 10% of the plants and is in the 30 - 50 cm length classes. *Sargassum myriocystum* which extends from the lower intertidal to the upper subtidal portion, starts to regener-

ate only in late summer. This is because extended period of exposure in spring low tides during these months resulted in dessication and delayed regrowth of vegetative plants. It is interesting to note that the growth rate of *Sargassum* in tropical and temperate regions (such as the southern part of Japan) is faster when the temperature is around 26 to 29 ℃ which coincides with the last quarter of the year (autumn and winter seasons) in the tropics and spring to summer months in the subtropical region (Kimura et al. 1987). *Sargassum thunbergii* in Maizuru Bay, Japan has its growth rate increased and maximum length and weight attained in summer at 27- 29℃ (Umezaki, 1974, cited by Kimura, et al 1987). This would seem to support the observation of Hanisak and Samuel (1987) that *Sargassum*, in an experiment under controlled laboratory condition, would grow faster at 24 - 30℃, corresponding to the lower and higher extreme of temperature range in the Philippines and southern Japan, respectively. Three species of *Sargassum* in Hawaii (*S. oligocystum, S. obtusifolium and S. polyphyllum)* had longer thalli at the lowest temperature at 22 to 25℃ (De Wreede, 1976, as cited by Kimura et al. 1987).

The period of maximum length is also revealed by the increase in the number of length classes at 40 to 60 cm in *Sargassum siliquosum*. For *Sargassum myriocystum*, however, length classes have no specific attributes to the maximum length which could be due mainly to their limited growth in the more exposed upper intertidal portion.

Increase in length of the lateral branches is hampered by strong wave action generated by the northeast monsoon occurring from October to January. This resulted from slight to a considerable drop in length in November just right after the onset of the monsoon season. *Sargassum* is quite resistant to strong wave action as provided by their strong holdfast. The branches that remain continue to grow until it reaches its peak in December. In Liloan, *Sargassum siliquosum* and *Sargassum myriocystum* retained most of their holdfast where vegetative regrowth could take place when water movement is more or less stable as shown by short shoots over the old holdfast in summer (heavier holdfast but shorter stipe and branches). It seems that vegetative reproduction is the method of reproduction of *Sargassum* in Liloan. However spore germination cannot be discounted because of the presence of young germlings growing on small stones and coral rubbles observed two to four months after full maturation of the plants (observed in September). Umezaki (1984) recognized two methods of reproduction in *Sargassum* (e.g. *S. miyabei*), one is sexual by egg germination, and the other by vegetative means where new shoots arise directly from the old holdfast. The weight of the lateral branches did not closely follow the changes in length. For instance in *Sargassum siliquosum*, maximum weight was attained in November before maximum length was reached. This is understood to be due to the loss of some secondary branches in December by wave action without necessarily cutting off the tips of the primary branches. Another possible reason for this disparity is the appearance of epiphytes (especially the calcareous Jania) in mature thalli, especially in *Sargassum myriocystum* which mainly resulted to an additional biomass of the lateral branches.

Receptacles begin to appear when the plants are growing but become fully mature just after they reach their maximum length with the exception of *Sargassum siliquosum* where full maturity occur earlier than its maximum length. This coincides well with the observations on other *Sargassum* species by other authors cited in Kimura et al. (1987). Decline or senescence in *Sargassum* is characterized by the gradual decomposition of branches and blades. This is shown well for *Sargassum myriocystum* in its high percentage of incomplete plants after periods of full maturation. Low percentage of incomplete plants of *Sargassum siliquosum* especially in summer after full maturation is due to the high number of new plants in the samples. High frequency for the same species, however, was observed right after summer months due to high temperature and monsoon cropping in October and November.

Salinity which is stable in Liloan study area, have no influence on the growth of *Sargassum* except perhaps during periods of high evaporation in summer affecting most especially *Sargassum myriocys-*

tum which are distributed in the lower intertidal portion.

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